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Contents

REVIEW ARTICLE

UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Blended Learning Mobility Approach and English Language Learning

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ABSTRACT

Although the benefits of blended learning have been well documented in educational research, relatively few studies have examined blended mobilities in education in Kurdistan region government and in Iraq. This study discusses a blended mobility approach for a teacher training program designed for in-service English language teachers (ELT) and investigates its effectiveness by comparing the latest participation of the University of Human Development for computer science and proposing the same program for training English for lecturers and students. The research involved proposes new mobility program for teaching and learning English language and using their language skills in an ongoing business project using several software for communication and management of their projects. Results will show the framework for new blended learning and blended mobilities of many different English language teaching (ELT) aspects.

Index Terms: Blended Aim, Blended Learning, Blended Mobility, Language Learning Strategies, E-Learning, Virtual Mobility

1. INTRODUCTION

The significance of student mobility and interuniversity exchange programs is incomprehensibly expanding, and the issue at present involves a huge spot in the motivation of instructive arrangement creators and advanced education establishments. In 2007, Erasmus program commended its 20th anniversary. The Erasmus program is presumably one of the best-known activities of the European Commission, empowering students just as staff versatility, and intending to improve the quality and to fortify the European component of advanced education. University of Human Development participated with Erasmus as an associative partner in Erasmus program to help students and staff receive more practical mobility experience to accomplish specific tasks related to their profession [1]. Mobility in space, land portability, "genuine" mobility, and physical mobility are for the most part terms used to allude to students and instructors in advanced education, "physically" moving to another establishment inside or outside their very own nation to study or instruct temporarily. In the accompanying passages, distinctive perspectives or kinds of mobility, for example, level and vertical mobility, free-mover and program portability are recognized and probably the most well-known programs are quickly depicted. The majority of the variations of geological mobility exhibited are types of physical mobility. Students' mobility can be arranged by the length of the investigation time frame abroad. When students just spend some portion of their examination program abroad or at an alternate institution in a similar nation, and just total a few modules or courses, however not entire degrees, it is alluded as flat portability (likewise called transitory, credit or non-degree mobility). Most national and European mobility programs advance this variation of portability. The greatest mobility timeframe for students and graduates in such projects is normally 1 year. With the usage of the Bologna

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procedure and the expanding presentation of the lone ranger and Ace projects in Europe, numerous higher instruction foundations are likewise expecting an expansion in what is known as vertical mobility (additionally called degree or confirmation mobility). Here, students think about abroad for a full degree, accomplishing, for instance, their first degree at an organization in one nation (for the most part their nation of origin) and their second degree at another foundation, either in their nation of origin or abroad (for example a 4-year certification at home – Ace degree abroad). The EU Erasmus Mundus program, for instance, underpins vertical mobility in a methodical way [2]. Another meaning of Blended mobility is a term used to depict an instructive idea that consolidates physical scholastic mobility, virtual mobility, and mixed learning. It is expected to advance employability of advanced education understudies. Since 2009, it has advanced from virtual mobility, keeping the worldwide estimation of scholastic versatility, and yet giving a solid response to conceivable family related, monetary, mental and social hindrances of physical mobility [3], [4].

The virtual mobility part of mixed mobility is, for the most part, upheld using data and correspondence innovations (for example, Skype, Adobe Connect, Slack, Google Hangout, and Trello) to remain associated with the educators or potentially understudies who might be arranged at numerous far off areas. The physical mobility part is ordinarily of momentary length, extending from 2 to 14 days. There may exist numerous times of momentary portability. Brief times of physical mobility empower members to the center for several days, just on the genuine undertaking, which is troublesome in everyday life in a nearby domain [5].

Early uses of a mixed mobility configuration can be found back in 2009. Through this venture a domain was made which energizes the advancement of understudies' delicate aptitudes, for example, cooperation and correspondence, in a universal setting by methods for an inventive guidance worldview to improve such abilities without costly and broad curricular changes [6].

2. LITERATURE REVIEW

2.1. Blended Learning

Blended learning has turned into a trendy expression in numerous instructive conditions as of late, generally alluding to courses that utilize a blend of eye to eye and web-based learning [7]. The term started in work environment learning and writing but, on the other hand, is presently broadly utilized in advanced education, regularly portraying courses that have had an online segment added to them [8]. Some consideration has been paid to the utilization of blended learning in language educating overall [9]-[11]; however, next to no work has been done explicitly in English Language Teaching (ELT) settings. In fact, with reference to ELT [12], features are needed for further research to be directed into what makes a powerful blend.

Fig. 1 explains some components of blended learning.

Joining the upsides of e-learning and conventional learning situations has prompted another learning condition regularly alluded to as "blended learning," which unites customary physical classes with components of virtual learning [13]-[15]. One of the fundamental ideas hidden in this methodology is that:

The individuals who utilize mixed methodologies base their instructional method on the suspicion that there are inborn advantages in face-to-face interactive (both among students and between student and teacher) just as the understanding that there are some inherent advantages in utilizing the web strategies in the learning process. Consequently, the point of those utilizing blended learning approaches is to locate an agreeable harmony between online access to learning and face-to-face human interaction [16], [17]. In a survey of research on mixed learning [18], numerous examinations were recognized that uncovered positive impacts of mixed learning on (1) students performance [19]; (2) student interest and inspiration [20]; (3) expanded access and adaptability [21], (4) cost-viability [22]; and (5) progressively dynamic and deeper learning in examination with conventional classes [23].

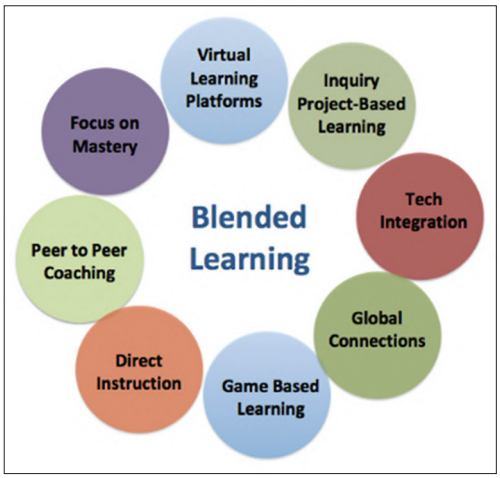

Fig. 1. Blended Learning Components

While trying to exploit blended learning, colleges have started advertising courses joining customary up close and personal instructional components with internet learning segments [24] in different scholarly fields, for example, the board [25] and business [26]. Nonetheless, little research has been done on mixed learning in educator instruction explicitly [27], and distributed work has concentrated for the most part on understudies assessments and the mechanical applications presented [28]. Be that as it may, mixed learning may be able to possibly improve instructor instruction regarding both availability and quality. Blended learning has turned out to stand out amongst the most well-known approaches to educate English as a Foreign Language (EFL) due to its two-fold segment, which coordinates vis-à-vis classes with virtual learning so as to offer students a wide scope of materials and assets sorted out methodologically. Thinking about the past viewpoints, in numerous instructive settings BL is a device accessible to students with the end goal for them to go past the homeroom and work on various intelligent exercises as an expansion of the immediate educating classes. Through all the mechanical assets they have around them, students can find out about various subjects and societies, surf the web and use the technological device they access, for example, iPods, ipads, PCs, Mp3s and Mp4s, among others. Notwithstanding, students are attacked by a lot of data from various sources. In this way, they get confounded and do not have the foggiest idea what to see first, which obstructs the proper utilization of the virtual material that may add to their English learning process. Along these lines, EFL instructors have the test of arranging virtual learning conditions that are engaging their students. This will enable them "to arrange" their EFL learning procedure and supplement up close and personal classes or the different way can utilize the virtual stage self-governing to get readied for the eye to eye classes. Along these lines, FL instructors are responsible for the methodological arranging of mixed courses which could be utilized to engage the EFL students. In spite of the fact that there are a few models with which to sort out a Mixed Course, we consider the accompanying model recommended by Khan [29], as shown in Fig. 2.

The institutional perspective is the primary component educators need to consider since it relies on the institutional strategies about the educational modules, the design of the material, and the organization and money related zone.

The second segment, the mechanical one, is the fundamental thought when educators plan both the disconnected and online exercises. Educators need a wide scope of mechanical assets so as to pull in their students' consideration: If the

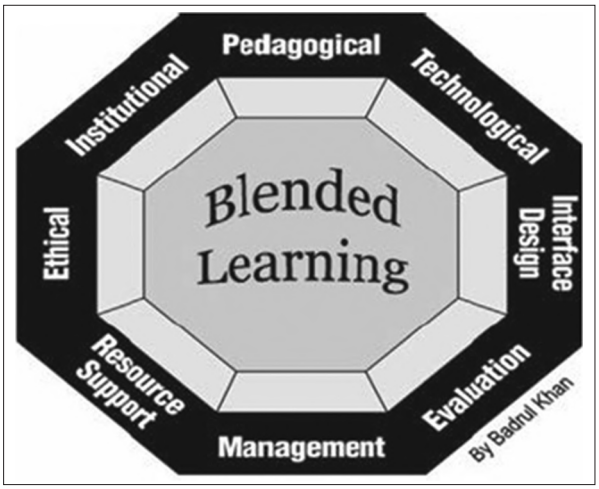

Fig. 2. Blended learning model.

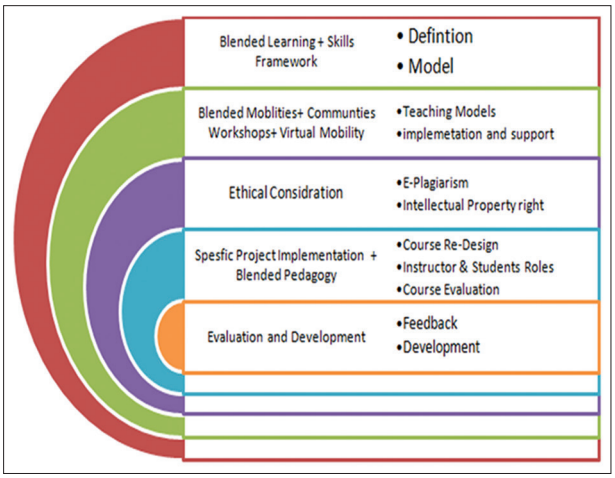

Fig. 3. Blended mobility framework.

face-to-face classes and the virtual ones are not testing, students may feel exhausted or baffled. It is important to show points and activities which are engaging them.

The third factor to hold up under as a primary concern is a pedagogical segment, which no uncertainty is the most critical one in these cross breed courses. In the event that instructors have a methodological arrangement to sort out both their up close and personal classes and the online viewpoint, it will lead the language students to prevail in their learning procedure and acquire better outcomes since they appropriately compose the two segments.

2.2. Students Mobilities

In last century in Europe, mobility of students, educators, and staff has been a be noticeable among the most universities and education system. As the colleges of Europe changed

to better approaches for working in the previous decades, they have kept on supporting this profitable convention. Student mobility can be characterized by the length of the examination time frame abroad. When students just spend some portion of their investigation program abroad or at an alternate foundation in a similar nation, and just total a few modules or courses, however not entire degrees, it is alluded to as level mobility (additionally called brief, credit, or non-degree versatility). Most national and European mobility programs advance this variation of mobility. The most extreme mobility time frame for students and graduates in such projects is typically 1 year.

With the implementation of the Bologna process and the expanding presentation of Single guy and Ace projects in Europe, numerous higher instruction foundations are likewise expecting an expansion in what is known as vertical mobility (additionally called degree or certificate portability). Here, students ponder abroad for a full degree, accomplishing, for instance, their first degree at an establishment in one nation (generally their nation of origin) and their second degree at another foundation, either in their nation of origin or abroad (e.g., Bachelor certificate at home – Ace degree abroad). The EU Erasmus Mundus program, for instance, bolsters vertical portability in a methodical way [30].

Mobility can likewise be characterized by the method of association of the examination time frame abroad. Program understudies are portable students partaking in a sorted out mobility program. "Free-movers" then again do not profit by any sort of students among foundations and do not partake in a composed mobility program. "Free-mover" versatility is the most seasoned type of scholastic portability. Since the center of the 1970s composed mobility has increased expanding significance, with the ascent of organized national limited time programs (see for instance the DAAD grants) and European portability programmes. Organized or program mobility is, these days, viewed as the real mobility engine for students, graduates, doctoral hopefuls and showing staff in Europe (for example Erasmus, Leonardo, Marie Curie) and, progressively, the whole world (for example Erasmus Mundus) [30]. The topographical mobility of free-movers can occur inside a nation or crosswise over national fringes. Free-mover mobility can likewise be seen on an overall scale and is commonly not restricted to specific areas or target Nations. Interestingly, program mobility ordinarily centers on specific areas (for example, Ceepus, Nordplus…) or on specific mainlands (for example, Europe on account of Erasmus, Marie Curie) [30]. The significance and prominence of specific versatility plots frequently vary among nations and in certain nations free-mover mobility still assumes an extensive job.

Aside from the free-mover mobility and the universal participation facilitated by explicit remotely supported projects, numerous higher instruction organizations participate with one another on a reciprocal basis. Bilateral understandings between foundations are sorted out so as to fire up joint activities or increase existing contacts, and more often than not additionally make open doors for understudy and staff versatility. The upsides of such respective concurrences as to portability are for instance simplicity of utilization, smooth credit exchange, and acknowledgment of studies. Two-sided understandings can exist both on the dimension of the organization and the dimension of resources or divisions. At last, mobility can likewise be upheld in the structure of systems of advanced education foundations or understudy systems. The Coimbra Gathering Understudy Trade System for instance is a mobility plot supplementing the conventional Erasmus Mobility.

3. BLENDED MOBILITY PROPOSED FRAMEWORK

3.1. University of Human Development

3.1.1. Blended

Aim is one of those international projects that is supported and funded by the European Union in the context of scientific exchange hosted by European universities. The projects are dedicated to fourth-grade students. From each university, two students and one supervising teacher participate. The participants, both the students and the supervisor, meet twice a year in one of the member universities to present any advancement in their project and plan for future projects. The students work virtually to finish the project. The students get ECTS for their works according to their university's instructions.

We suggest that the University of Human Development get intensively involved in this unique opportunity by fitting in our university in this project as it gets bigger and bigger, and it could require enlarging our team.

3.1.2. Calling in other colleges

University of Human Development is participating in the blended aim project for 2018–2019 with other colleges regarding the Erasmus project calling.

3.2. Virtual Mobilities

With the developing noteworthiness of distance learning and e-learning, virtual mobility has turned out to be progressively

critical in the course of the most recent couple of years. It is since the second 50% of the 1990s that the idea of virtual mobility has picked up many with regard to the internationalization of advanced education foundations. Be that as it may, what is comprehended by virtual portability?

The elearningeuropa.info entry characterizes it as: "The utilization of data and correspondence innovations (ICT) to get indistinguishable advantages from one would have with physical mobility yet without the need to travel"[20].

This definition obviously demonstrates the two distinct components of virtual mobility. Virtual mobility is typically compared to the virtual mobility of "academic plagiarism" and adds to the internationalization of training by empowering (cross-border) collaboration between various instruction establishments. Besides, it is connected to the new conceivable outcomes opened using data and correspondence innovation (ICT) bolstered situations that incorporate, for instance, video conferencing, live spilling, community-oriented workspaces, and computer-mediated conferencing.

In the system of the Being Portable task, components, for example, the improvement of (inter-) social comprehension were added to the

definition to feature the wealth of the experience and the likenesses with the Erasmus trade program: "Virtual portability is a type of realizing which comprises virtual parts through a completely ICT bolstered learning condition that incorporates cross-border coordinated effort with individuals from various foundations and societies working and contemplating together, having, as its fundamental reason, the upgrade of intercultural understanding and the trading of information" [31], [32].

The typology is, for the most part in light of the kind of movement and the conditions in which the virtual mobility movement happens:

- A virtual course or workshop (arrangement): Students in an advanced education foundation participate in virtual mobility for a solitary course (as a component of an entire investigation program) or a course (arrangement) and the remainder of their learning exercises happen face-to-face generally;
- A virtual report program: A whole virtual investigation program is offered at one advanced education establishment, giving understudies from distinctive nations the opportunity to take this investigation program without traveling to another country for an entire scholastic year;
- A virtual mobility position: Student's situations are sorted out between a higher education foundation and an organization (now and again in an alternate nation). In the virtual mobility students use ICT to bolster their temporary position, giving them a real-life involvement in a corporate setting without the need to move from the grounds to the organization or to move to another nation for a specific period of time, and giving them a down to earth planning for new methods for working through (global) synergistic cooperation;
- Virtual help exercises to physical trade: Virtual mobility empowers both better planning and follow-up of students who take an interest in physical trade programs. Preliminary exercises could incorporate understudy determination at a separation through video- or web conferencing (for checking social and language aptitudes), furthermore, online language and social combination courses. Follow-up exercises will assist students with keeping in contact with their companions, dispersed the world over, to complete their normal research work as well as desk work. They could likewise appear as a so-called "Virtual Alumni" association, foster lifelong friendships, and networks.

In spite of the fact that the term "virtual mobility" is generally new, the European Commission has effectively advanced virtual mobility in the previous years, for the most part through the money related help of ventures inside the Socrates/Minerva and the e-learning and deep-rooted learning projects.

A portion of the later tasks managing the subject incorporate the above-mentioned Being Versatile undertaking, REVE (Genuine Virtual Erasmus), EMOVE (An operational origination of virtual portability), and More VM (Prepared for Virtual mobility), each focusing on various parts of virtual portability for various gatherings of members [3], [33].

3.3. Blended Mobility

While much of the time, virtual mobility speaks to an important elective answer for physical mobility, there is by all accounts general understanding that its anything but a substitute for physical mobility. Virtual mobility is, then again, ending up progressively well-known as help and supplement to conventional genuine mobility programs. It can offer extra arrangements and is an approach to additionally improve the current conventional projects, for example, Erasmus. At the point when parts of physical and virtual mobility

are consolidated so as to boost the benefits of both, it is characterized as "blended mobility" or – whenever connected to the EU Erasmus program – "blended Erasmus."

This blended methodology is in accordance with the consequences of, for instance, the Eureca Venture, completed by the European understudy affiliation AEGEE, which suggests in addition to other things that "Erasmus understudies could be arranged as of now at their home colleges in 'active workshops' from one viewpoint, yet could likewise 'trade encounters' consequently classes" then again. The report additionally expresses that "each understudy ought to reserve the option to go to a language course that empowers him/her to pursue the scholastic program" at the host college and that "short-term trades and virtual trades could be developments." In addition, the report of the workshop on "bologna and the difficulties of e-learning and separation instruction" [34] places uncommon accentuation on the strong capacity virtual versatility can play for physical portability and show that "virtual versatility must be utilized to enhance and bolster physical versatility by better setting it up, giving powerful follow-up intends to it, and offering the likelihood to remain in contact with the home foundation while abroad. It can likewise offer (in any event part of) the advantages of physical mobility for the individuals who are generally unfit to go to courses abroad" European undertakings, for example, SUMIT (supporting mobility through ICT), ESMOS (upgrading understudy mobility through online help), triumphant (virtual educational program through dependable interoperating college frameworks) and others, recommend that the European Commission has additionally recognized virtual mobility as a help instrument in physical portability as an imperative subject. (See add II for more information). In addition, the VM-BASE venture (virtual mobility when student exchanges), in which this manual displays the outcomes, intends to raise the nature of student exchange by offering virtual help to physical mobility. In VM-BASE virtual help is utilized to plan and follow-up the portable understudy, as a supplement to the current trade programs. The venture in this way bolsters instructors in training trade understudies at a separate (e-coaching).

Student exchanges can set themselves up for their stay at a host college through, among other help exercises, virtual classes between the home and host college. Preliminary language or social courses for the understudies could be given customarily at the home college or by means of ICT from the host college before they remain. Amid their stay at the host college, they could remain associated with understudies, partners, or instructors at the home college. Furthermore, on their arrival, they could broaden their stay "essentially" by staying in touch with the host college by virtual methods.

As it shows in Fig. 3 the framework of blended mobility it a combination of blended learning and mobility learning, which is added to blended learning pedagogy in general .

4. ENGLISH LANGUAGES SKILLS AND INFORMATION AND COMMUNICATION TECHNOLOGY

4.1. A. Listening

Interactive activities to sight and multimedia assets. Listening skills are best learned through simple, engaging activities that focus more on the learning process than on the final product. Regardless of whether you are working with a huge gathering of students or a little one, you can utilize any of the accompanying guides to build up your own techniques for showing students how to listen well.

Listening skill/comprehension is an important as well as complex process of language learning. It plays a significant role in second language competence. The process and the act of comprehension are lessened and eased through the context and the purpose. Linguistic knowledge and experiential knowledge are also key ways listeners make use of it to comprehend. There are many tools one can make use of such as computer-assisted language learning [15].

There are several techniques for listening activities developments:

- Interpersonal activities, for example, mock meetings and storytelling. Assign the students to little gatherings of a few, and after that, give them a specific listening activity to achieve.
- Bigger group exercises likewise fill in as a supportive technique for showing listening aptitudes to students.
- You can likewise train listening abilities through sound portions of radio projects, online digital recordings, instructional addresses, and other sound messages.
- Another helpful resource for teaching listening skills is video segments, including short sketches, news programs, documentary films, interview segments, and dramatic and comedic material.

4.2. Speaking

Technology can stimulate the playfulness of students and drench them in an assortment of situations. Innovation

allows students to take part in self-coordinated activities, open doors for self-managed cooperation, protection, and a sheltered situation wherein blunders get redressed and explicit input is given. Input by a machine offers extra an incentive by its capacity to track oversights and connection the understudy quickly to practices that attention on explicit errors. Studies are rising that demonstrate the significance of subjective criticism in programming projects. At the point when connections are given to find clarifications, extra assistance, and reference, the estimation of technology is additionally increased.

Present day technologies accessible in instruction today are:

- Correspondence lab
- Discourse acknowledgment programming
- Interne to technology-enhanced language learning
- Podcasting
- Quick Link Pen
- Quicktionary.

As English today is ranked number one in the worlds in terms of a number of users, the ability to speak fluently has turned into an aptitude of foremost centrality to acquire. An online foreign language speaking class, virtual classes are structured having at the top of the priority list, standards of ELT and e-learning, alongside systems that raise connection, incorporating vocabulary and utilization of English, while giving a calm situation so as to inspire even withdrawn students take an interest and produce spoken language. Use of Oovoo and Skype, Slack, Google Hangout, Trello separated from empowering clients to cooperate with pre-recorded messages, additionally give students the choice of synchronous talk, permitting the formation of a virtual class of three to six clients, contingent on the sort of membership – free or paid, respectively. Another advantage given by these two instruments is that students can profit by real learning encounters as opposed to their standard everyday practice, which will thus inspire them to request all the more genuine correspondence subsequently, more opportunities to disguise language [8].

4.3. Reading

Online reading perusing is an errand that has all the hallmarks of being important for the 21st-century understudies. Along these lines, the production of an Electronic perusing program called "English reading online" was made to limit the hole among perusing and understanding utilizing web-based perusing procedures. The successful utilization of perusing procedures is known to enhance peruser's understanding. As innovation has infiltrated our lives, the impression of perusing for cognizance through innovation needs to transform into a groundbreaking method for doing as such a definitive objective is to empower students to use procedures spontaneously. Notwithstanding, perusing procedures has a few advantages, as well as confinements. For example, the dimension of the members, the study hall settings, and the arrangement of procedures need to be mulled over before connecting with training. Vital perusing guidance benefits all understudies even those of scholastic level. This may be a consequence of lacking secondary school arrangement or little planning amid their time as students. As understudies gain a lot from perusing through procedures which improve their scholastic execution, having it offered through an innovation improved condition increases its impact on understanding while it enables them to figure out how to utilize technology. The assets offered to the understudies through a learning content administration framework called "varsite" enabled them access to a bigger assortment of writings of those found in the college library. This fundamentally gives every understudy the self-rule to get to these assets as per their timetable, empowering them to screen their adapting far and away superior.

4.4. Writing

Writing can be perplexing for many students since it requires the correct utilization of language. In contrast to spoken language, composed language cannot utilize motions or non-verbal communication to clarify what it is that should be comprehended or passed on. Played out an investigation where they attempted to recognize the most ideal way an educator can use to show the Latent Voice marvel. They utilized three sorts of classes. The first was "the customary up close and personal way," the second was the "integrative way" where both customary instructing and web-based instructing were utilized, and the third sort was the "online way" where the main sort of educating and materials was electronic What they found was that the coordinated route ended up being the most advantageous for the students, just as that sexual orientation assumes a non-noteworthy job since the outcomes were not unique. It was likewise discovered that the dimension of the understudies changed toward progress after the utilization of the incorporated strategy, in this manner consequences of the post-test essentially varied from the aftereffects of the pretest. This investigation enables us to see that teachers should utilize electronic material as they do improve their students' level utilizing a free and simple to utilize apparatus. The utilization of blog programming and Tweeter are devices that can enable understudies to rehearse composed language, draw in with the language they wish to learn and obviously to share their considerations or emotions

and think about them [11]. Advancing composition guidance through such an engaging way empowers more generation of composed language which may not have created something else. Students writes blogged instead of going to an in-class session appeared better outcomes from the individuals who just got in-class composing guidance. Instructors should utilize this device as it upgrades composing execution while it is not constrained inside school dividers as it can happen anyplace. The outcome the students who blogged appear to have was an improvement over the individuals who did not, which demonstrates the estimation of the mix of this device. Tweeting likewise is by all accounts a significant device to start the production of network bonds, henceforth permitting the students to discover increasingly about one another also, assemble network bonds. Likewise, while executing gatherings, online journals and wikis in the meantime, this appears to have positive outcomes on understudies' learning progress since this mixed methodology enables them to consider the contrasts which may happen in methods for communicating in English when utilizing composed language.

5. CONCLUSIONS AND RECOMMENDATIONS

One of the primary reasons for higher education organizations is to give students the urgent apparatuses to prevail in the worldwide work market. Blended learning has turned out to be a standout among the most well-known approaches to educate EFL because students can find out about various subjects and societies, surf the web and use the technological device they access, for example, iPods, ipads, PCs, Mp3s, and Mp4s, among others. Proficient life is these days heavily relying on mobility and requests experts to exceed expectations in relational abilities at a global, culturally diverse condition. Such activities have multiple benefits, both for the staff who participate and for their schools such as enhanced language skills, innovative teaching methods, and cultural awareness.

The main advantages for students can be

- Social Skills development
- Developing organizational skills
- Learn to use online communication tools
- Does not disturb regular home activities
- Learn how to work as a member of a team of students, international, and/or interdisciplinary
- Develop the skills of self-management and work on a project or proof-of-concept assigned by a company, resulting in real-world, innovative projects
- Experience cultural differences and similarities
- Practice languages other than mother tongue
- Integrated more easily in English language curriculum.
- It provides opportunities to participants with special needs (e.g., online assistance software, medical treatment.,...).

There also some disadvantages such as:

- It is challenges to communicate in a virtual way, especially if not mother tongue
- It is difficult with long-term mobility, but not equivalent
- Cultural communication issues may arise earlier and faster
- Student must have disciplines
- Students need to have a certain level of independence is required

In any case, delicate abilities, just as global presentation, are once in a while tended to college classes. Blended mobility defeats the run of the mill obstructions to mobility, in this way enabling students to exploit the advantages that mobility and worldwide presentation offer. Notwithstanding, paying little respect to its additional esteem, mixed mobility is not really utilized and scarcely perceived as a genuine option with incredible potential to defeat the normal troubles of global mobility.

The blended-aim project sets the basis to support and structure mixed mobility as a rule. In concrete, mixed point enables universal blended-AIM and employability by giving the assets – including preparing, supporting apparatuses and data – to help students and organizations facilitating entry-level positions and by streamlining inventive instructing ideal models intended to build up students' delicate abilities in a worldwide domain. The framework of blended mobility is a combination of blended learning and mobility learning, which is added to blended learning pedagogy. In general, we hope the higher education in Kurdistan can adapt this system in new bologna process.

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REVIEW ARTICLE | UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Performance Analysis and Prediction Student Performance to Build Effective Student Using Data Mining Techniques

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ABSTRACT

In this period of computerization, schooling has additionally remodeled itself and is not restrained to old lecture technique. The everyday quest is onto discover better approaches to make it more successful and productive for students. These days, masses of data are gathered in educational databases; however, it stays unutilized. To be able to get required advantages from such major information, effective tools are required. Data mining is a developing capable tool for examination and expectation. It is effectively applied in the field of fraud detection, marketing, promoting, forecast, and loan assessment. However, it is an incipient stage in the area of education. In this paper, data mining techniques have been applied to construct a classification model to predict the performance of students. For the classification model, the cross-industry standard process for data mining was used as the classification model, the decision tree algorithm used as the main data mining tool to build the classification model.

Index Terms: Classification, Data Mining, Decision Tree, Naïve Bayes, Student Performance

1. INTRODUCTION

A decade ago, the quantity of higher education universities and institutes has multiplied manifolds. Massive numbers of graduates and postgraduates are produced consistently. Universities and institutes can also comply with the quality of the pedagogies; but nevertheless, they face the problem of dropout students, low achievers, and jobless students.

Understanding and breaking down the variables for negative overall performance is a complex and unremitting procedure, hidden in beyond and present facts congregated from educational overall performance and college students' behavior. Effective tools are required to research and expect the performance of college students scientifically.

Although universities and institutions gather a huge amount of students' information, this fact remains unutilized and does not help in any decisions or coverage making to enhance the performance of college students.

If universities could distinguish the circumstance for low execution prior and can predict students' conduct, this knowledge can help them in taking genius dynamic activities, to enhance the execution of such students.

It will be a win circumstance for every one of the partners of universities and institutions, i.e. administration, educators, students, and parents. Students could be able to

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pick out their shortcomings in advance and can enhance themselves.

Teachers could be in a position to plan their lectures as according to the need of students and can give better direction to such students.

Data mining includes a fixed set of methods that can be utilized to extract appropriate and exciting knowledge from data. Data mining has numerous responsibilities, for instance, prediction, classification, association rule mining, and clustering. Classification strategies are supervised learning procedures that classify data object into a predefined class name. It is a standout among the most helpful strategies in data mining to create classification models from an input data set. The utilized classification procedures usually construct models that are utilized to predict future data patterns. There is the various algorithm used for data classification, for instance, Naïve Bayes classifiers and decision tree. With class, the created model could be able to predict a class for given data relying on earlier learned data from historical data.

Decision tree is a standout amongst the most utilized methods since it makes the decision tree from the records given utilizing clear conditions depending principally on the calculation of the gain ratio, which gives naturally a type of weights to attributes utilized, and the researcher can certainly distinguish the best attributes on the anticipated target. Due to this procedure, a decision tree would be worked with classification rules created from it.

Another classification method is Naïve Bayes classifier that is utilized to predict a target class. It relies on in its calculations on probabilities, particularly Bayesian theorem. Due to this use, the outcome from this classifier is more precise and efficient, and more delicate to new data added to the dataset.

Investigation and prediction with the assistance of data mining systems have demonstrated imperative outcomes in the area of predicting consumer conduct, fraud detection, financial marketplace, loan assessment, intrusion detection, bankruptcy prediction, and forecast prediction. It may be extremely powerful in education system also. It is a very effective tool to uncover hidden patterns and valuable information, which otherwise may not be identified and hard to discover and recognize with the assistance of statistical techniques.

In general, this paper tries to use data mining ideas, especially classification, to assist the universities and institutions directors and decision makers by assessing student' data to think about the primary characteristics that may influence the student' performance. This paper is organized as follows in section 2; literature review is discussed, in section 3 an entire detail of the study is introduced, in section 4 modeling and experiments are discussed, and in section 5 results and discussion presented. Finally, section 6 presents our conclusions.

2. LITERATURE REVIEW

All researches conducted previously, discover some huge areas in the education sector, where expectation by data mining has gained benefits; like, finding some students with weak points [1], select the points that students such as the exact course [2] evaluation of college [3], overall student evaluation [4], [5], class teaching language behavior [6], expecting students' retraction [7], [8], plan for course registration [9], guessing the enrollment headcount [10], and cooperate activity evaluation [11].

Some researchers indicate that there have been strong relationships between the student's personality likings and their work characteristics [12]. It is detected that there is detailed expertise needed to have once graduates to gain occupation and that these expertise are important to academic education generally. Characteristics such as sensitive cleverness, self-management development, and life work experience also are significant reasons for work development [13]. Employers try to differentiate the highest and lowest importance with soft skill and academic reputation [14]. Using machine learning techniques to predict the performance of a student in upcoming courses [15]. Overview of the data mining techniques that have been used to predict students' performance [16]. The performance of the students is predicted using the behaviors and results of previous passed out students [17].

3. BUILDING THE CLASSIFICATION MODEL

The fundamental target of the planned methodology is to fabricate the classification model that tests certain attributes that may influence student performance. To achieve this goal, the cross-industry standard process for data mining was used to construct a classification model. It comprises five stages that include: Data understanding, preparing data, business understanding, modeling, assessment, and deployment, as seen in Fig. 1.

3. 1. Data Classification Preliminaries

In general, data classification consists of two-advanced process. In the initial step, which is known as the learning step, a model that describes planned classes or ideas is constructed by examining a set of training dataset instances. Each instance is pretended to have a place with a predefined class. Within the second step, the model is tested utilizing an alternate different dataset that is utilized to assess the classification accuracy of the model. If the accuracy of the model is viewed as adequate, the model can be utilized to classify future data instances for which the class label is not notable. Ultimately, the model goes about as a classifier within the decision-making process. There are many strategies which can be utilized for classification, for instance, Bayesian techniques, Neural Networks, rule-based algorithms, and decision tree.

Decision tree classifiers are very well known procedures because the development of tree does not need any parameter setting or domain knowledgeable data and is acceptable for exploratory data discovery. A decision tree can deliver a model with rules that are comprehensible and interpretable. The decision tree has the benefits of simple clarification and understanding for decision makers to match with their domain information for approval and justify their decision. A number of decision tree classifiers are C4.5/C5.0/J4.8, NBTree, etc.

The C4.5 method is a type of the decision tree families that can deliver decision tree and rule sets, and develop a tree to improve expectation accuracy. The C4.5, C5.0, and J48 classifier is among the most famous and effective decision tree classifiers. C4.5 makes an initial tree utilizing the partition and Conquer algorithm. The entire depiction of the algorithm can be discovered in data mining or machine learning books, for example, C4.5: Programs for Machine Learning.

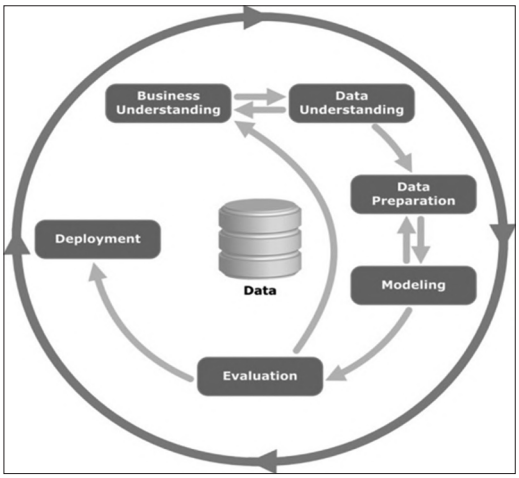

Fig. 1. Cross-industry standard process for data mining.

Weka contains a collection of machine learning and data mining algorithms for analyzing data and predicting modeling, together with the graphical user for simple access to these functions. It developed at the University of Waikato in New Zealand written in Java. WEKA contains tools for classification, regression, clustering, association rules, data pre-processing, and visualization.

3. 2. Data Collection Process and Data Understanding

While the concept of the paper came into mind, it means to apply a classification model for predicting performance relying on a dataset from a certain educational institute. With the goal that some other factors in regard to the studying environment, administration, conditions, and colleagues would have a comparable impact on all students, the impact of gathered attributes would be more evident and less difficult to classify. The data collected from three different educational institutes. To gather the necessary data, a questionnaire was organized and delivered either by email or manually to the students of all institutions. Then, it was additionally shared on the web, to be filled by students in any university or institutions. The survey was filled by 130 students, from the first, the second, the third institutions, and the rest from a few different institutions using the net questionnaire.

In the questionnaire, several attributes have been asked that may expect the performance class. The rundown of the gathered attributes is presented in Table 1.

3.3. Data Preparation

After the surveys were gathered, the method of preparing the data was completed. First, the information inside the questionnaires has been conveyed to (arff) to be appropriate with the WEKA data mining tool.

3. 4. Business Understanding

We have defined a classification model to predict if a student might show excellent performance. This issue is interesting since there are many universities/institutions interested in recognizing students with outstanding performance. For the input records for the prediction, the model use the data describing pupil conduct and the data defined student behavior as described in the previous table. The dataset includes 260 instances. Our model class label is a binary attribute, which separated students passed from first attempt exam (label value 1), for the students passed from second attempt exam (label value 0).

TABLE 1: Description of attributes used for predicting the student performance

Attribute	Description	Possible values
Gender	Student's Gender	Male, female
Time	Coming time to class	Never, once a week, twice a week, More than twice a week
Punishment	Number of punishment	I have never been punished, about twice, more than 3 times, very often
Family	Total number of family members	Between 3 and 5, between 6 and 10, more than 10
Parent live	My father and mother live harmoniously	Strongly agree, agree, natural, disagree
Parent education	Parent's education levels	Up to university, up to diploma, up to secondary school, up to primary, did not go to school
Parent financial	Parent's financial levels	Strongly agree, Agree, Natural, Disagree
Environment	The community around supports building of classrooms, library, toilets, etc.	Strongly agree, agree, natural, disagree
Encouragement	Our teachers inspire us to work hard	Strongly agree, agree, natural, disagree
Absent	Our teachers are never absent without a good reason	Strongly agree, agree, natural, disagree
Help	Our teachers are available and wiling to assist us in our studies	Strongly agree, agree, natural, disagree
Father	Does your father alive?	Yes, No
Mother	Does your mother alive?	Yes, No
Love	Do you have relationship love?	Yes, No
Accommodation	Are you stay at home or dormitory	Home, dormitory
Work	Are you working with your study?	Yes, No
Study	How many hours do you study per a day?	About 1 h, about 2 h, about 3 h, more than 3 h
Sleeping	Are you sleeping well?	Yes, NO
Pass	Are you passing in the first trial or second trial?	Yes, No

The fundamental usage of this model could identify well-performing students on a course. Individuals who ought to gain this model would be:

1. Instructors, for the qualification of students who can work together with;
2. Students, for checking if there is a requirement for more attempt to accomplish better outcomes;
3. Business people, for early attractive with students who are probably going to end up outstanding on a selected subject.

4. MODELING AND EXPERIMENT

After the data had been arranged, the classification model has been created. Utilizing the decision tree method on this technique, the gain ratio measure is used to signify the weight of influences of every attribute at the tested class, and thus, the ordering of tree nodes is specified. The results are discussed in the below section.

Referring to the analysis of earlier studies, and as defined in Table (1), a set of attributes has been selected to be tested against their influence on student performance.

These attributes consist of (1) personal information such as gender, love, sleeping, (2) education environment such as number of punishment, coming time to class, (3) parent information such as parent's education levels, and parent's financial levels. These attributes were used to predict student performance.

TABLE 2: Accuracy rate for predicting performance

Method	10-fold cross validation (%)	Hold-out (60%)
C4.5 (J4.8)	42.3	48.1
Naïve bayes	40.7	44.2

Three types of the technique have been applied to the dataset reachable to construct the classification model. The techniques are The Naïve Bayes classifier and decision tree with version ID3 (J4.8 in WEKA). The experiment, accuracy was assessed using 10-folds pass-validation, and hold-out technique. Table 2 shows the accuracy rates for each of those techniques.

The time attributes, which is student attendance to the class, have the maximum gain ratio, which made it the starting node and most efficient attribute. Other attributes cooperate inside the decision tree were parent lives, which is student's parent live, father, parent education, study, and accommodation. Rest of other attributes appeared in other parts of the decision tree.

The tree demonstrated that every one of these attributes has a type of impact on the student performance, but

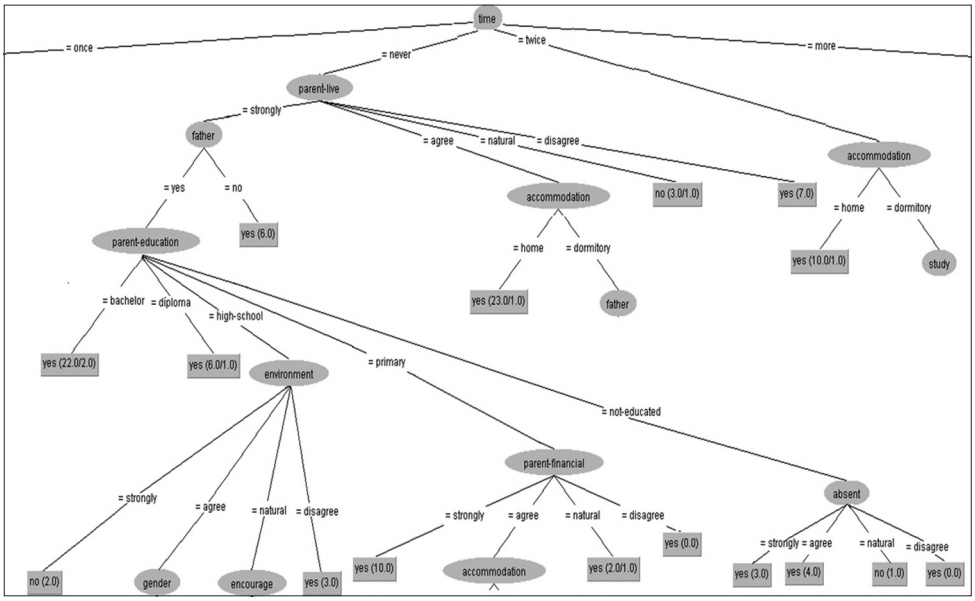

Fig. 2. A decision tree generated by the C4.5 algorithm for predicting performance.

the biggest attributes had been: Time, parent live, father, accommodation and parent education, as seen in Fig. 2, according to the dataset we collected in three different institutes and universities. It means if a student is never late to class, his or her parents live together harmoniously; their father is not dead, students stay at home not in a dormitory and their parents educated those students are passed in the first trial exam. The death of their mothers also impact student's performance, but in Iraqi Kurdistan, father's death affects students' performance more because fathers are the main financial providers for the family usually.

Wherever love (romantic relationship) is considered, students who do not fall in love have better performance than those having romantic relationship. Furthermore, the interesting attribute, which is home study (homework) does not have big effect, because if a student does not have a good environment no matter how many hours she or he studies, it does not have much effect to students' performance, as shown in a Fig. 3

The tree produced the use of the C4.5 algorithm showed that the time attribute is the most effective attribute. The Naïve Bayes classifier does not demonstrate the weights of every attribute incorporated into the classification; however, it has been used in comparison with the consequences generated from C4.5, as shown in Table 2, it can be seen that the efficiency percentage ranges about 36%–45%, which are low percentages.

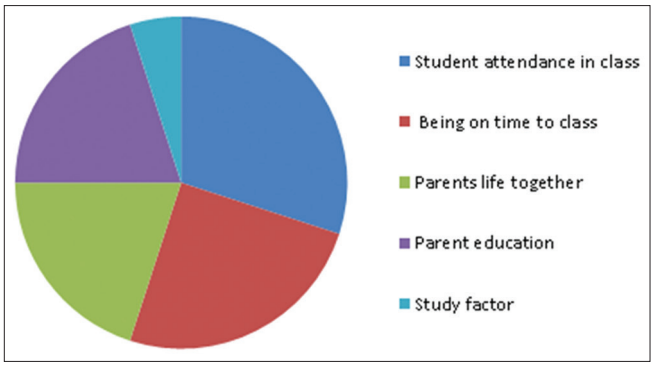

Fig. 3. High impact factors on students' performance.

Due to deep of the tree produced by J4.8 in WEKA, the visualization tree image is not clear here, we could show only a part of it, but if anyone is interested, they can download the dataset from the link [25] to do the experiment in WEKA.

5. RESULTS AND DISCUSSION

The study has shown that numerous elements may have a high impact on students' performance. A standout among the best is the student attendance in class. Various family factors also seemed to have an influence on the students' performance. A parent living together is one of the greatest positive factors in performance. It means if students' parents live within a good relationship, students' performance also increase because experiment

indicates that those students whose parents live together harmoniously are passed in the first trial exam. In addition, some other attributes after time and parents life attributes are father and mother education. If a student is never late to class, their parents are living together, their father is not dead and their parents have bachelor degree are in the second rank passed in the first trail, as explained before here in our community in Iraqi Kurdistan, fathers usually take financial responsibility of family not mothers, it means students do not need to work, otherwise students should work to pay for their life.

The rank attribute has shown an interesting influence on performance; it was not included as a high-efficiency factor. It was noticed in the experiment, the study factor. This is natural as no matter how long a student might study or prepare himself if they are not living in a good and secure house; they still perform very poorly in the exams.

6. CONCLUSION AND FUTURE WORK

This paper has focused on the probability of constructing a classification model for predicting student performance. Numerous attributes had been tested, and a number of them are found powerful on the performance prediction. The student attendance in class was the strongest attribute, then the parent living together harmoniously, father and mother education level, with the moderate impact of student performance.

The student punishment, sleeping hours, and family members did not show any clear effect on student performance while the no love relationship, parent strong financial status and student encouragement to study beside teachers have shown some effect for predicting the student performance.

For universities and institutes, this model, or an enhanced one, can be utilized in predicting the newly applicant student performance.

As future work, it is recommended to gather more appropriate data from several universities and institutions to have the right performance rate for students.

When the proper model is collected, the software could be created to be used by the universities and institutions, including the rules generated for foreseeing the performance of students.

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REVIEW ARTICLE

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The State of the Art in Feature Extraction Methods for Electroencephalogram Epileptic Classification

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ABSTRACT

Epilepsy is a neurological disease that is common around the world, and there are many types (e.g., Focal aware seizures and atonic seizure) that are caused by epileptic seizures. An epileptic seizure is a transient of symptoms because of abnormal excessive or synchronous neural activity in the brain. Electroencephalogram (EEG) is a common way to record brain activity brain activities generated by nerve cells in the cerebral cortex. Automatic epileptic seizure detection or prediction system can classify normal from abnormal EEG signal. Selection of discriminant features is a matter of the performance of an automatic system. In this paper, we review several features extracted from the time, frequency, and time-frequency domains proposed by different researches for the purpose of epileptic seizure detection, also analyze, and compare the performance of the proposed features.

Index Terms: Classification, Electroencephalogram, Epileptic Seizure Detection, Feature Extraction, Time-frequency Analysis

1. INTRODUCTION

An epileptic seizure is one of the most common neurological disorders caused by brain activity impulses that escape their boundaries and affect other areas of the brain through creating a storm of electrical activities [1-3]. An epileptic seizure is the result of excessive neuronal spontaneous and synchronized discharge in the group of the brain cells. To detect symptoms of epileptic seizure in a patient, electroencephalography (Electroencephalogram [EEG]) is used commonly [3,4]. EEG measures the electrical activity of the brain and generates a dynamic visual image of the brain activities that can be scanned for abnormalities that may indicate whether the patient is suffering from epileptic seizure or not.

Visually inspection of EEG recordings is time consuming and requires specialists such as neurophysiologists to analyze the recordings and diagnose the case. To facilitate the detection of epileptic seizure signs with high accuracy and reduce the time taken to make diagnostics, it is essential that an automated computer-based system to be utilized [5,6].

To use EEG recordings and make a diagnostic, the following steps will have to be taken:

1. Preprocessing
2. Analyzing EEG recordings using the time, frequency, and joint time-frequency domain
3. Identify patterns that indicate seizure activities (feature extraction)
4. Classify identified patterns to make correct diagnostics.

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Feature extraction as an important step in automatic epileptic seizure detection system has attracted lots of attentions. Some of the researchers such as [7] used time domain to extracts features from EEG data; [8] used frequency domain for feature extraction; and the combination of time and frequency domains are also used by researchers in Boubchir *et al.* [6], Boubchir *et al.* [8], and Boubchir *et al.* [9]. Reference Mohammadi *et al.* [10] proposed time-frequency features to detect epileptic seizure using EEG recordings. Depend on the selected domain, different features have been proposed for epileptic seizure detection.

Amplitude modulation (AM)-frequency modulation (FM) signals can be used to model real-life signals and the model is normally recognized by attributes such as instantaneous phase, instantaneous frequency (IF), and instantaneous amplitude (IA); these attributes, when extracted, can yield good classification outcomes [11,12]. To extract IF or IA, methods such as TED and empirical mode decomposition can be used [13], as for differentiating signals with high signal energy, measures such as Renyi entropy and time-frequency flatness are good choices of use. The two measures are types of time-frequency entropy measures that are good indicators of seizure activity when EEG signals are considered [12]. In identifying seizure activities, the shape and direction of energy distribution in time-frequency signals are important; these features can be extracted using directional or wavelet decomposition filters and the features can be captured in a number of images. The images can later be used to obtain statistical features [14]. There are other methods that can be used for the same extraction purpose, such as dimensionality reduction methods proposed by Sameh and Lachiri [14].

In this paper, we analyze and compare different features that have been proposed by various researchers as proofs for seizure activities and classifications. We found out that the features extracted from the joint time-frequency domain provide more advantageous than those extracted from either time or frequency domain. The structure of the paper is as follows:

In the following, we discuss the framework for EEG classification. In the next section, we review the feature extraction methods, and then, we discuss the performance of several EEG features. Finally, we conclude the paper.

2. EEG SEIZURE DETECTION AND CLASSIFICATION FRAMEWORK

In this section, we explain the steps of seizure detection process using EEG that includes five steps as below:

2.1. The Preprocessing Stage

In this stage, we remove noise and excess features from EEG recordings, using techniques such as band-pass filtering and Bayesian denoising [15]. This stage will prepare the data for processing and facilitate correct seizure-related signal detection and clears away the unwanted artifacts that may distort the real result.

2.2. EEG Signal Representation

To ensure that the best EEG signal representation is used in seizure diagnostics, it is necessary to decide in what representation domain signals are analyzed. The typical representation domains used by researchers are time, frequency, and joint time-frequency domains. (Fig. 1a) shows a normal EEG signal in the time domain. (Fig. 1b) shows the time-frequency representation of the same signal in the joint time-frequency domain. Fig. 2a shows an abnormal EEG signal and its time-frequency representation. From (Fig. 2b), we can observe a train of spikes in the time-frequency representation of an epileptic EEG signal.

2.3. Feature Extraction

At this stage features and patterns, indicating seizure activities are extracted from the preprocessed EEG data. The common features that are proposed by researchers are classified into four categories. The first is known as (amplitude-based) extracted from EEG signal in time domain, the second is (spectrum-based) extracted in the frequency domain, the third is (IF) extracted in the time-frequency domain [9], and the fourth is (image descriptor-based) extracted in time-frequency domain [6,8].

2.4. Feature Selection

As a result of the previous steps, a number of features are extracted; however, not all features are decisive in seizure diagnostics as there will be redundant or irrelevant features in the extraction. In this step, it is required to filter the most irrelevant features and eliminate the unwanted ones to ensure the quality and correctness of the final seizure diagnostics and classification.

2.5. Classification

The features extracted and filtered in the previous step are now ready to be used for the final diagnostics and classification. In this step, several classifiers such as an artificial neural network and support vector machine are used for the classification. A cross-validation method is used to evaluate the performance of the classifier. The leave-one-out technique can be used for validation, which gives an almost unbiased approximation of the true generalization error.

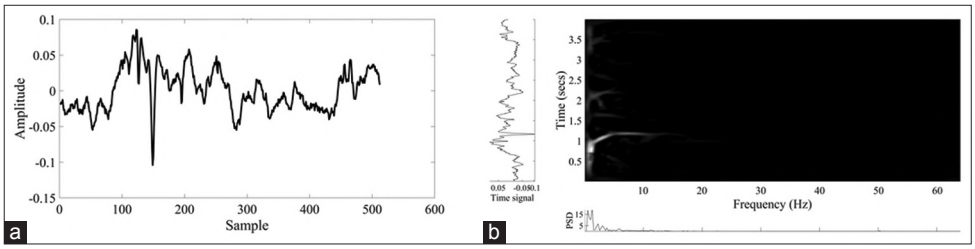

Fig. 1. (a) An electroencephalogram signal with normal activity and (b) time-frequency representation of the signal.

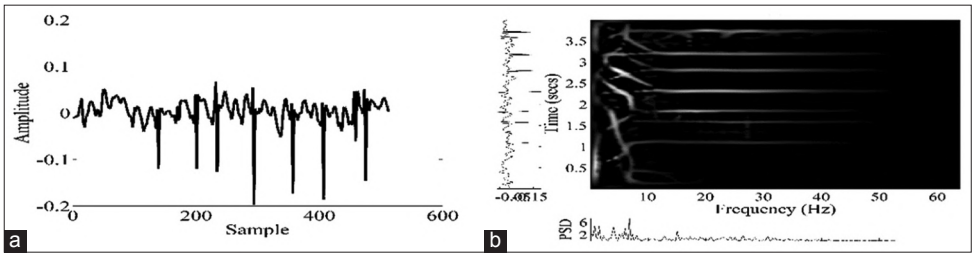

Fig. 2. (a) An electroencephalogram signal with epileptic seizure activity and (b) time-frequency representation of the signal.

The performance of the classifier can be assessed based on specificity, sensitivity, and total accuracy.

$$\text{Specificity} = \frac{\text{True Negative}}{\text{Total Number of True Negatives}}$$

$$\text{Sensitivity} = \frac{\text{True Positive}}{\text{Total Number of True Positives}}$$

$$\text{Total Accuracy} = \frac{\text{True Positive} + \text{True Negative}}{\text{Total Number of Examples}}$$

Fig. 3 shows a flowchart indicating the input, computational steps, and output of a classification system.

3. EEG FEATURE EXTRACTION REVIEW

Features extracted form time, frequency, or t-f representations are the most widely proposed features for EEG seizure detection; in this section, we present a brief literature review of the features.

A. Time-domain features: To extract seizure indicator features, the median absolute deviation or root mean square or inter-quartile range of the amplitude of EEG signals are scanned in the time domain [16-18]. Below we present some other features that are suggested by researchers for extraction such as statistical moments [16,17,19].

1. Features based on statistical moments:
   - First moment and second central moment of EEG signal [16,19]

Mean:

$$F_1^{(t)} = \mu = \frac{1}{N}\sum_{n=1}^{N} |x[n]| \tag{1}$$

Variance:

$$F_2^{(t)} = \sigma^2 = \frac{1}{N}\sum_{n=1}^{N} (\mu - |x[n]|)^2 \tag{2}$$

   - Normalized moments: Third and fourth central moments of EEG signal [16,19]

Skewness:

$$F_3^{(t)} = \frac{1}{N\sigma^3}\sum_{n=1}^{N} (|x[n]| - \mu)^3 \tag{3}$$

Kurtosis:

$$F_4^{(t)} = \frac{1}{N\sigma^4}\sum_{n=1}^{N} (|x[n]| - \mu)^4 \tag{4}$$

   - Coefficient of variation of the EEG signal [19]

$$F_5^{(t)} = \frac{\sigma}{\mu} = \sqrt{\frac{F_2^{(t)}}{F_1^{(t)}}} \tag{5}$$

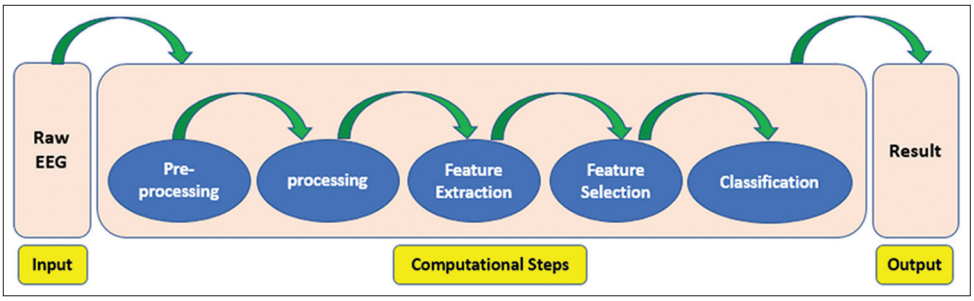

Fig. 3. The flowchart of electroencephalogram classification system.

2. Features based on amplitude:
   - Median absolute deviation of EEG amplitude [16]

$$F_6^{(t)} = \frac{1}{N}\sum_{n=1}^{N}(|x[n]-\mu|) \tag{6}$$

   - Root mean square amplitude [17]

$$F_7^{(t)} = \sqrt{\frac{\sum_{n=1}^{N}x[n]^2}{N}} \tag{7}$$

   - Interquartile range [18]

$$F_8^{(t)} = x[\frac{3(N+1)}{4}] - x[\frac{(N+1)}{4}] \tag{8}$$

3. Features based on entropy:
   - Shannon entropy [16,17,20]

$$F_9^{(t)} = -\sum_{n=1}^{N}x[n]\log_2(x[n]) \tag{9}$$

B. Frequency domain features: The frequency representation of EEG signal is scanned in this domain to identify seizure indicator features based on spectral information (e.g., power spectrum, spectral Roll-Off) [16,17,19]. Below we summarize some features extracted in frequency-domain.

1. Features based on power spectrum:
   - Maximum power of the frequency bands [17,19]

$$F_1^{(f)} = \sum_{k=1}^{\delta}|Z[k]|^2 \tag{10}$$

$$F_2^{(f)} = \sum_{k=\delta+1}^{M}|Z[k]|^2 \tag{11}$$

   - M corresponds to the maximum frequency

2. Features based on spectral information:
   - Spectral centroid: Average signal frequency weighted by the magnitude of spectral centroid [16]

$$F_3^{(f)} = \frac{\sum_{k=1}^{M}k|Z[k]|}{\sum_{k=1}^{M}|Z[k]|} \tag{12}$$

   - Spectral flux: Difference between normalized spectra magnitudes [16]

$$F_4^{(f)} = \sum_{k=1}^{M}(Z^{(t)}[k]-Z^{t-1}[k])^2 \tag{13}$$

Where $x^{(i)}$ and $x^{(i-1)}$ are normalized magnitude of the Fourier transform at i and $i-1$ frames

   - Spectral flatness: Indicates whether the distribution is smooth or spiky [16]

$$F_5^{(f)} = (\Pi_{k=1}^{M}Z[k])^{\frac{1}{M}}(\sum_{k=1}^{M}Z[k]^{-1} \tag{14}$$

   - Spectral Roll-Off: Spectral concentration below threshold λ [16]

$$F_6^{(f)} = \lambda\sum_{k=1}^{M}|Z[k]| \tag{15}$$

3. Feature based on entropy:
   - Spectral entropy: Measures the regularity of the power spectrum of EEG signal [17]

$$F_7^{(f)} = \frac{1}{\log(M)}\sum_{k=1}^{M}P(Z[k])\log P(Z[k]) \tag{16}$$

C. Time-frequency domain features: The joint time-frequency domain representation is more informative for the analysis of real-life signals. This indicates that if the additional information provided by the time-frequency representation is properly extracted in the form of time-frequency features, then better classification accuracy can be achieved. In this domain, the EEG signals are scanned for features that indicate seizure activities based

on information extracted from both time and frequency domain.

Several techniques are available for the extraction, and the most widely used ones are:

1. IF features: Many real-life signals can be modeled as AM-FM signals. Such signals are completely characterized by the parameters of the AM-FM model that is the instantaneous phase, I), IA, and a total number of components. For such signals, parameters extracted from the IF or IA can lead to good classification results [15-18]. The IF or IA related parameters can be extracted either from time-frequency distributions (TFDs) or empirical mode decomposition based methods [9,18,19].
2. Using image descriptors and image processing techniques such as shape and texture descriptor and local binary pattern (LBP) descriptor to scan time-frequency image representation of EEG signals for seizure indicator features [6,8].
3. Entropy features: Time-frequency entropy measures such as Renyi entropy, time-frequency flatness can be used for discriminating signals having a high concentration of signal energy from signals having energy spread in the time-frequency domain [9,21], for example, in the case of EEG signals, seizure activity is sparse in the time-frequency domain, while the background is not.
4. Texture features: Texture time-frequency features are related to the direction and shape of energy distribution. These features can be obtained by, convolving a TFD with a set of convolution masks such as wavelet decomposition filters or directional filters to obtain a number of filtered images.
5. Other approaches include dimensionality reduction methods for directly extracting features from given TFDs, time-frequency matched filtering and statistical features [10,20,22,23].

In the following, we describe the relevant t-f EEG features that we have identified. These features are based on IF [5], entropy [5], flux, flatness, and energy information of EEG signal (e.g., sub-bands energies and energy localization) [9,5]; which are computed from ϱ. Time-frequency image related-features: Other time-frequency features have been recently proposed based on image descriptors capable to describe visually the seizure activity pattern observed in the TFD of EEG signal, ϱ, considered and processed as an image using image processing techniques. The proposed time-frequency image features include shape and texture descriptors [6], Haralick descriptor [24], and LBP descriptor [8].

1. Features based on energy:
   - Sub-bands energies [9]:

$$F_1^{(tf)} = \sum_{n=1}^{N} \sum_{k=1}^{M_\delta} \rho[n,k] \tag{17}$$

$$F_2^{(tf)} = \sum_{n=1}^{N} \sum_{k=M_\delta+1}^{M_\delta} \rho[n,k] \tag{18}$$

Where $M_\delta = M/f_\delta$ and M corresponds to a maximum frequency component in the signal ($f_\delta/2$)

   - Energy localization [5]:

$$F_3^{(tf)} = \frac{\left(\prod_{n=1}^{N}\prod_{k=1}^{M}\rho[n,k]\right)^{\frac{1}{NM}}}{\sum_{k=1}^{M}\sum_{n=1}^{N}\rho[n,k]} \tag{19}$$

2. Features based on IF:
   - Mean and deviation of IF of EEG signal

$$F_4^{(tf)} = \frac{1}{N}\sum_{n=1}^{N} f_i[n] \tag{20}$$

$$F_5^{(tf)} = \max f_i[n] - \min f_i[n] \tag{21}$$

Where $f_i[n] = \frac{f_\delta}{2M}\frac{\sum_{k=1}^{M} k\rho[n,k]}{\sum_{k=1}^{M}\rho[n,k]}$

3. Feature-based on entropy:
   - Re'nyi entropy of order α [10]

$$F_6^{(tf)} = \frac{1}{1-\alpha}\log_2\left(\sum_{n=1}^{N}\sum_{k=1}^{M}\rho^{\alpha}[n,k]\right) \tag{22}$$

   - Normalized Renyi entropy

$$TFRE = -\frac{1}{2}\log_2\sum_{n=1}^{N}\sum_{k=1}^{N}\left(\frac{\rho[n,k]}{\sum_n\sum_k\rho[n,k]}\right)^3 \tag{23}$$

   - Time-frequency flatness

$$TF_{Flatness} = N^2\frac{\prod_{n=1}^{N}\prod_{k=1}^{N}\rho[n,k]}{\sum_{n=1}^{N}\sum_{k=1}^{N}\rho[n,k]} \tag{24}$$

4. Time-frequency flux:

$$TF_{FLUX} = \sum_{l=1}^{N}\sum_{m=1}^{N}\rho[n+l,k+m]-\rho[n,k] \quad (25)$$

4. ANALYSIS AND DISCUSSION

We have compared and analysis the EEG seizure detection and classification methods that use the EEG features described in Section III. We have considered here only the state-of-the-art methods that have been assessed on Bonn University EEG database [23] and Freiburg EEG dataset [25] which are public free database widely used. This database includes five EEG sets referred to as sets A-E where each set contains 100 artifact-free EEG signals of 23.6 s duration acquired from normal subjects and patients with epileptic seizures. All the EEG signals in the database have been recorded at fs = 173.6 Hz sampling rate thus resulting in 4096 samples (= 23.6 × fs) and have the spectral bandwidth varying from 0.5 to 85 Hz (see [23] for more detail). For all the methods considered in this review, which used the bone database, the desired classification is given in two different classes of EEG signals: Normal and seizure, denoted by N and S, respectively. The Class N includes Set A, which contains 100 EEG signals. The Class N includes Set A, which contains 100 EEG signals without seizure acquired from five healthy volunteers with eye open while the Class S includes Set E which contains 100 EEG signals with seizure acquired from five patients.

The Freiburg dataset includes 24 h-long continuous pre-surgical invasive recordings of 21 patients suffering from epilepsy. The sampling rate of the recorded data is 256 Hz. A 16-bit analog to digital converter is used to record the data over 128 channels. Out of these channels, six of them are selected based on the visual analysis of an EEG specialist. For each patient, there are at least three Ictal files such that at least one of them contains a seizure event. Among Ictal files, the files preceding the seizure event are called pre-Ictal signal files, and the ones which come immediately following the seizure segment are called post-Ictal. Ictal files have recordings of signals that are at least 50 min far from seizure events. Both Ictal and inter-Ictal files are stored in ASCI format and contain six channels of EEG time series.

Table 1 presents a comparison of the performance of some state-of-the-art methods in terms of best total classification accuracy (ACC) using EEG database {N, S}. By analyzing the ACC results in the table, we notice that the methods using time-frequency features such as the methods in Boubchir *et al.* [8] and Boubchir *et al.* [24] provide a higher ACC (up to 99.33%) than the methods using time-domain features and/or frequency-domain features – such as the methods in Redelico *et al.* [20], Kannathal *et al.* [26], and Polat and Günecs [27]. This indicates that the time-frequency features are the relevant and discriminate features allowing to improve significantly the classification results. Moreover, the use of time-frequency image related features [6,8,24] achieves the best performance than the use of time-frequency signal related-features [22]. In addition, other types of time-frequency features based on wavelet coefficients was proposed in Subasi [28], providing an ACC result (of 95%) less than the result achieved by the time-frequency features and used in Boubchir *et al.* [6], Boubchir *et al.* [8], Boubchir

TABLE I: Performance comparison of different method using different features.

Method	EEG representation	Feature extraction	Classification	Best ACC (%)
Redelico *et al*. (2017) [20]	Time domain	Entropies-based features	Logistic regression	94.5
Polat and Günecs (2007) [27]	Frequency domain	Fourier transform-based features	Decision tree	98.72
Kannathal *et al*. (2005) [26]	Time domain/frequency domain	Time-domain features/ Frequency-domain features	ANFIS	92.22
Subasi (2007) [28]	Time-frequency domain	Wavelet-based features	ME network	95
Boubchir *et al*. (2014) [22]	Time-frequency domain	Combined time-frequency signal and time-frequency image related-features	SVM	97.5
Boubchir *et al*. (2014) [17,24]	Time-frequency domain	Haralick descriptor-based features	SVM	99
Boubchir *et al*. (2015) [6]	Time-frequency domain	image texture descriptor-based features	SVM	98
Boubchir *et al*. (2015) [8]	Time-frequency domain	LBP descriptor-based features	SVM	99.33
Mohammadi *et al.* (2017) [10]	Time-frequency domain	Time-frequency flux, time-frequency flatness, and time-frequency entropy		97.5

SVM: Support Vector Machine, EEG: Electroencephalogram, LBP: Local binary pattern

et al. [22], and Boubchir *et al*. [24]. Finally, the method in Boubchir *et al*. [8] and Mohammadi *et al*. [10] is the most promising methods for detecting and classifying the EEG seizure with high accuracy; the time-frequency flux is the best performing time-frequency feature as it achieved the AUC of 0.94 in Mohammadi *et al*. [10].

5. CONCLUSION

A discriminant feature plays a crucial rule in the performance of an automatic epileptic seizure detection system. Feature can be extracted from the time, frequency, and joint time-frequency domains. Different features such as IF, entropy, texture, and statistical features have been proposed by different researchers. In this paper, we proposed a review of EEG features that have been proposed to characterize the epileptic seizure activities for the purpose of EEG seizure detection and classification. The analysis of these features has shown that time-frequency features, especially those based on time-frequency image description, are the most relevant and discriminate features for detecting and classifying the EEG seizure with high accuracy. Our future work will focus on adapting the EEG time-frequency features to classify the epileptic seizure activities with their degree of severity.

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REVIEW ARTICLE

UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Efficient Biometric Iris Recognition Based on Iris Localization Approach

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ABSTRACT

Biometric recognition is an emerging technology that has attracted more attention in recent years. Biometric is referred to physiological and behavioral characteristics to identify individuals. Iris characteristic is related to physiological biometric characteristics. Iris recognition approaches are among the most accurate biometric technologies with immense potential for use in global security applications. The aim of this research is to implement an efficient approach to process the diseased eye images to verify the second iris examination for the same person by inserting an improvement step to the iris recognition system. The improvement step makes a correction of boundary around the pupil and removes the corrupted regions. This approach demonstrates its ability to detect the inner limit of the iris. The obtained results show that 90% success in the detection of diseased eye images, which make the iris recognition system more accurate and safe.

Index Terms: Biometric recognition, Iris Localization, Iris Recognition, Template Matching

1. INTRODUCTION

Biometric identification is a new technology to recognize a person based on a physiological or behavioral characteristic that attracting a lot of attention recently [1-3]. As the level of counterfeit and deceptive transactions increases rapidly, so this causes the need for highly secure identification technologies and personal verification [4-6]. The existing methods of shared secrets such as PINs or passwords, key devices, and smart cards, these are not sufficient in many applications [7-9]. Biometric characteristic can realize this issue that is unique and realize the characteristic of a human [10-12]. The use of biometrics for personal authentication becomes practical and considerably more accurate than the current methods [13-15].

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The biometric characteristics are classified into two main categories [16,17]: Physiological characteristics related to the shape or part of the body, such as iris, fingerprint, face, DNA, retina, and the geometry of the hand [18-20]. The behavior characteristics are related to the human behavior, such as gait, voice, signature, and keystroke dynamics [21-23]. Biometrics can be applied in companies, governments, military, border control, hospitals, banks …, etc. [24-26]. These characteristics are used to verify the identity of a person for allowing access to certain information [27-29].

The most important characteristics of the iris do not change the texture of the iris through a person life [30,31]. This stability of iris features over a long time, leading to guarantees the long period of validity of the data and it does not need to update; in addition, iris characteristics are well protected from the environment [32-34]. This advantage allows iris identification as the most accurate and reliable biometric identification [35-37]. In the entire human population, there is no similarity two irises in their mathematical details, even between identical twins [38-40]. The probability of finding

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two people with an identical iris is almost approach zero, and the probability that two irises are similar; it is approximately 1 in 10^{10} [41-43].

Iris recognition is an effective aspect of human identification for its dissimilarity between iris characteristics. These research aims are to introduce an efficient biometric iris recognition approach based on iris localization method. This approach tries to improve the identification process through certain processes on iris image.

2. IRIS RECOGNITION

The recognition of the iris is an automatic method of biometric identification that uses mathematical techniques of pattern recognition in video images of one or both irises of an individual's eyes [44,45]. The complex iris patterns are unique, stable, and visible from a distance [46,47]. The iris recognition technology determines the identity of an individual through many steps, as shown in Fig. 1 [48,49]. These steps of iris recognition are as follows:

- Iris image acquisition: This step deals with using of electronic devices that converting the object into digital images such as digital camera and digital scanner [50,51].
- Image preprocessing: The iris image is preprocessed to obtain a useful region iris image such as to illustrate the detection of the inner and outer boundaries of the iris. This step detects and removes the eyelids and eyelashes that may cover the eye image [52]. The iris image has low contrast and uneven illumination caused by the position of the light source, so preprocessing try to recover these aspects. All of these factors can be compensated in the image preprocessing step [53].

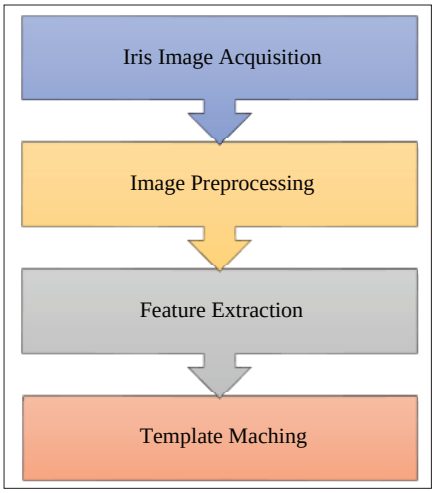

Fig. 1. Iris recognition system.

- Feature extraction: This step deals with generating of features applying the texture analysis method to extract features from the normalized iris image [54]. Important features of the iris are extracted for precise identification purposes [55].
- Template matching: This step deals with comparing the user model with the database models using a corresponding matching statistic [56]. The corresponding metric will give a measure of similarity between two iris models or template. It provides a range of values when comparing models of the same iris and another range of values when comparing different iris models [57]. Finally, a high confidence decision is made to identify whether the user is authenticated or not [58].

3. LITERATURE REVIEW

Many literature reviews are published related to iris recognition. This section introduces some of the updated researches related to iris recognition subject.

Rai and Yadav (2014) considered a new method for recognition of iris patterns using a combination of Hamming's distance and support vector machine. The zone of the zigzag collar of the iris is selected for the extraction of iris characteristics because it captures the most important areas of the complex iris pattern and a higher recognition rate is achieved. The proposed approach also used the detection of parabolas and the cut medium filter for the detection and removal of eyelids and eyelashes, respectively. The proposed method is efficient from a computer and reliable point of view, with a recognition rate of 99.91% and 99.88% based on the image data of Cassia and Check, respectively [59].

Hamouchene *et al.* (2014) implemented a new iris recognition system using a new feature extraction method. The proposed method, Neighborhood-based binary pattern, compares each neighbor of the center pixel with the next neighbor to code it for 1 if it is greater than the center pixel or 0 if it is smaller than the center pixel. The resulting binary code is converted into a decimal number to build the NBP image. To deal with the problem of rotation, we propose a coding process to obtain an invariant image by rotation. This image is subdivided into several blocks and the average of each block is calculated; then, the variations of the averages are encoded by a binary code [60].

Santos *et al.* (2015) focused on the biometric recognition in mobile environments using iris and periocular information

as main characteristics. This study makes three main contributions: First demonstrated the utility of an iris and a set of periocular data, which contains images acquired with 10 different mobile configurations and the corresponding data of iris segmentation. This data set allows us to evaluate iris segmentation and recognition methods, as well as periocular recognition techniques; second reported the results of device-specific calibration techniques that compensate for the different color perceptions inherent in each configuration; and third proposed the application of well-known iris and periocular recognition strategies based on classic coding and matching techniques, as well as the demonstration of how they can be combined to overcome the problems associated with mobile environments [61].

Umer *et al.* (2015) proposed a new set of characteristics for personal verification and identification based on iris images. The method has three main components: Image preprocessing, feature extraction, and classification. During image preprocessing, iris segmentation is performed using the Hough restricted circular transformation. Then, only two disjoint quarters of the segmented iris pattern are normalized, which allow the extraction of characteristics for classification purposes. Here, the method of extracting characteristics of an iris model is based on a morphological operator of multiple scales. Then, the characteristics of the iris are represented by the sum of the dissimilarity residues obtained by the application of a morphological top-hat transform [62].

Thomas *et al.* (2016) in this work, our system introduces a more accurate method called Random Sample Consensus to adjust the ellipse around the non-circular iris boundaries. You can locate the iris boundaries more accurately than the methods based on the Hough transformation. We also use the Daugman rubber sheet model for iris normalization and elliptical unpacking, and correspondence based on the correlation filter for in-class and interclass evaluation. Peak side lobe ratio is the measure of similarity used for the corresponding models. Through these, the recognition process improves with the Daugman method. The WVU database is used to perform experiments and promising results are obtained [63].

Hajari *et al.* (2016) showed that iris recognition is a difficult problem in a noisy environment. Their main objective is to develop a reliable iris recognition system that can operate in a noisy image environment and increase the rate of iris recognition in the CASIA and MMU iris datasets. They proposed two algorithms: First, a new method to eliminate the noise of the iris image and, second, a method to extract the characteristics of the texture through a combined approach of the local binary model and the gray level cooccurrence matrix. The proposed approach provided the highest recognition rate of 96.5% and low error rate and required less uptime [64].

Soliman *et al.* (2017) introduced a rough algorithm to solve the computational cost problem while achieving an acceptable precision. The gray image of the iris is transformed into a binary image using an adaptive threshold obtained from the analysis of the intensity histogram of the image. The morphological treatment is used to extract an initial central point, which is considered the initial center of the iris and pupil boundaries. Finally, a refinement step is performed using an integrodifferential operator to obtain the centers and the final rays of the iris and the pupil. This system is robust against occlusions and intensity variations [65].

Naseem *et al.* (2017) proposed an algorithm to compare the vanguard spatial representation classification with Bayesian fusion for several sectors. The proposed approach has shown that it overall performs the implemented algorithm in standard databases. The complexity analysis of the proposed algorithm shows a decisive superiority of the proposed approach. In this research, the concept of class-specific dictionaries for iris recognition is proposed. Essentially, the query image is represented as a linear combination of learning images of each class. The well-conditioned inverse problem is solved using the least squares regression and the decision is judged in favor of the class with the most accurate estimate [66].

Llano *et al.* (2018) presented a robust and optimized multisensor scheme with a strategy that combines the evaluation of video frame quality with robust segmentation fusion methods for image recognition and simultaneous image iris recognition. As part of the proposed scheme, they presented a fusion method based on the modified Laplacian pyramid in the segmentation stage. The experimental results in the Casia-V3-Interval, Casia-V4-Mile, Ubiris-V1, and MBGC-V2 databases show that the robust optimized scheme increases recognition accuracy and is robust for different types of iris sensors [67].

Zhang *et al.* (2018) implemented a generalized stimulation framework to solve some problems of practical recognition of the iris at a distance, namely, the detection of the iris, the detection of the poor location of the iris, the detection of iris, and iris recognition. This solution takes advantage of a set

of carefully designed features and well-adjusted stimulation algorithms. Basically, there are two main contributions. The first is an exploration of the intrinsic properties of remote iris recognition, as well as robust features carefully designed for specific problems. The second important contribution is the methodology on how to adapt AdaBoost's learning to specific problems [68].

4. RESEARCH METHODOLOGY

4.1. Iris Image Dataset

The construction of iris image dataset is a difficult job due to many reasons such as distance, lighting, and the resolution of the used device. This research needs to collect iris images of real patients those have some diseases on their iris. The captured iris images are of 8-bit gray images with a resolution of 480*640. In general, the iris is approximately form a circular shape. The diameter of the iris in the captured image in this dataset is about 200 pixels. Twenty eye images of 10 patients infected with anterior uveitis are applied in this research.

4.2. Implemented System

During a brief reviewing in this field, you can find many systems and algorithms are implemented for biometric recognition including iris recognition. The proposed implemented approach for iris recognition contains the following components (Fig. 2):

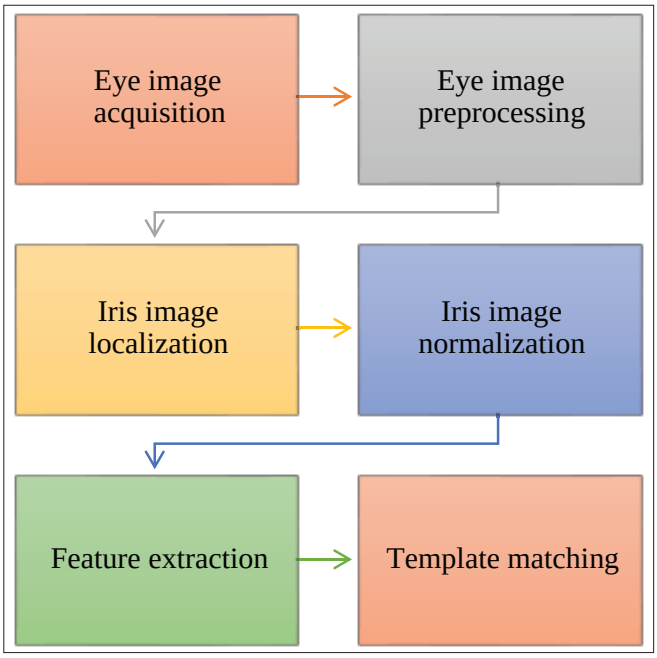

Fig. 2. Implemented approach of iris recognition.

- Eye image acquisition: In this step, the eye object is captured using sensitive device to convert the real iris object into digital image contains of number of effective pixels.
- Eye image preprocessing: In this step, the acquired digital image is converted into standard image that can be adapted for the next step of processing. This step passed into many processes such as converting the image into gray scale image, image filtering, and image resizing.
- Iris image localization: In this step, the diseased eye image is enhanced to track the iris region to detect and localize the iris region.
- Iris image normalization: In this step, the iris image is normalized and then converted into gray scale to generate a standard iris image to be adequate for the next step for processing.
- Feature extraction: This step deals with the generation of features or characteristics related to the indicated iris image. Feature is extracted using two-dimensional discrete wavelet transform (2D DWT). 2D DWT is performed through passing low-pass filter and high-pass filter for both rows and columns of the image as shown in the following two equations:

$$x_{low} = \sum_{k=-N}^{N} x[k]\, g[2n-k] \quad (1)$$

$$x_{high} = \sum_{k=-N}^{N} x[k]\, h[2n-k] \quad (2)$$

Where, x represents the input array and both g and h represent low-pass and high-pass filters, respectively.

- Template matching: In this step, the template matching is generated that can be used to decide the personal authentication based on the selected threshold.

4.3. Detection of Diseased Eye

There are many differences between diseased eye and normal eye as shown in Fig. 3. One important issue is to identify the diseased eye, in which the pupil of the diseased eye with anterior uveitis is not circular and may cause changes in iris architecture or atrophy. In this study, two factors are considered to separate between diseased and normal eyes:

- To localize the pupil boundary or iris boundary as a circle, its radius must fall within the specific range. In the specified database, the range of iris radius value is within 90–150 pixels, while the pupil radius ranges are within 28–75 pixels.
- The pupil is always within the iris region; hence, the pupil boundary must be within the iris boundary for normal

eyes, while in the diseased eyes, the pupil boundary is localized away from iris region. This gives an evidence that the eye is diseased and an enhancement must be introduced before iris localization step.

4.4. Enhancement of Iris Image

When decision is taken that the eye is infected or diseased, then the procedure goes directly to the enhancement process. The enhancement process helps to localize the pupil boundary. The enhancement process is implemented through the following steps:

1. Determine the upper boundary of iris, which leads to cover the area within the pupil (Fig. 4). At this process, three parameters are stored: The upper radius (R_{upper}), X_{upper} boundary of the iris (X_{upper}), and Y_{upper} boundary of the iris (Y_{upper}).
2. Resizing the eye image to isolate the iris image as shown in Fig. 5. The pupil boundary will be localized within the iris region instead of the whole eye region. Hence, the new iris image will be determined as below:
$$P_1 = (X_{upper} - R_{upper}, Y_{upper} - R_{upper}) \quad (3)$$
$$P_2 = (X_{upper} + R_{upper}, Y_{upper} + R_{upper}) \quad (4)$$
3. Adjusting the intensity of iris image according to the incident light as shown in Fig. 6.
4. Adjusting the threshold value to create the binary image as shown in Fig. 7.
5. Discriminate the irregular pupil by determining the minimum and maximum points on each axis as shown in Fig. 8. Four points must be calculated in this step:
$P_{x\,min}$ *refers to the minimum point on X-axis found in pupil pixels* (5)
$P_{y\,min}$ *refers to the minimum point on Y-axis found in pupil pixels* (6)

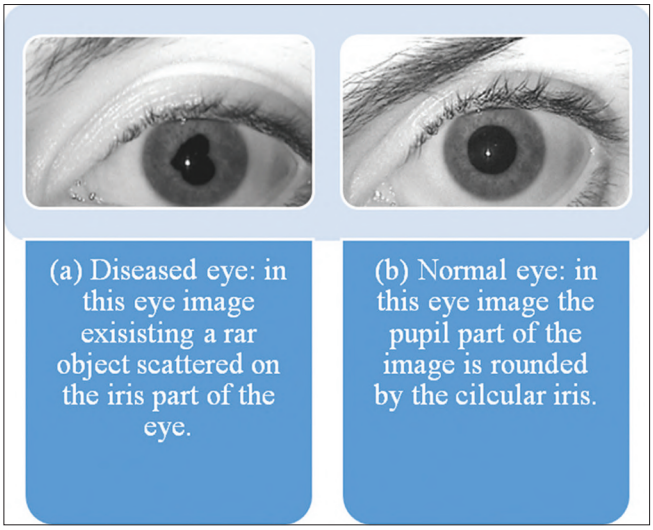

Fig. 3. Diseased and normal eyes.

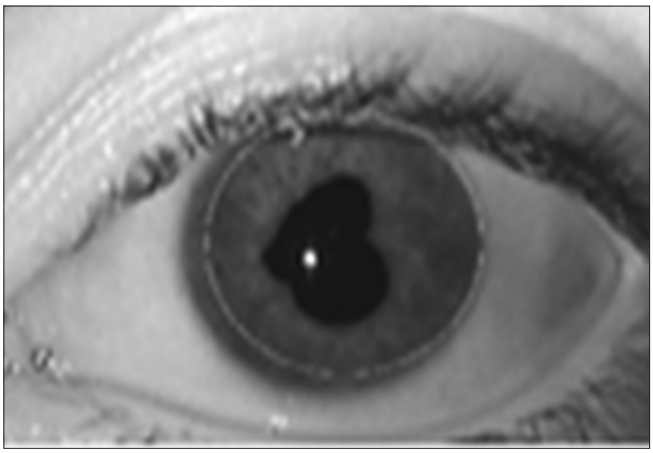

Fig. 4. Iris boundary localization.

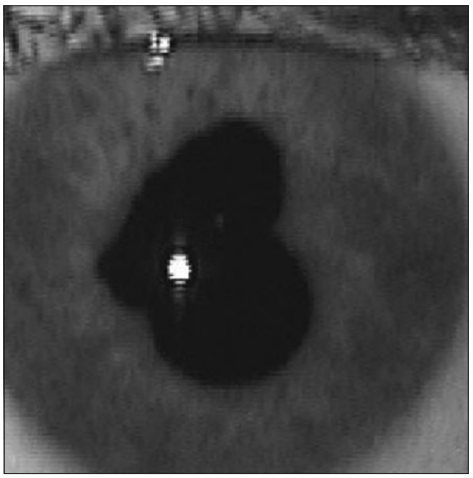

Fig. 5. Iris resizing.

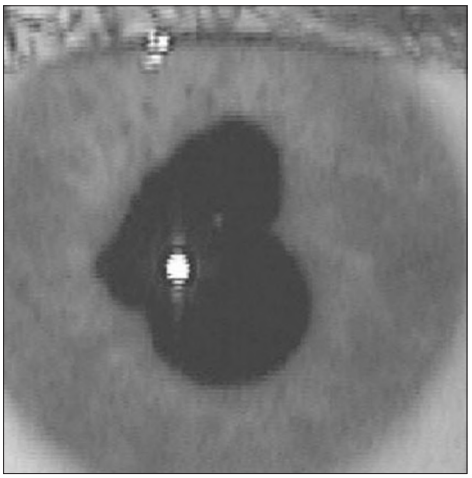

Fig. 6. Adjusting iris image.

$P_{x\,max}$ *refers to the maximum point on X-axis found in pupil pixels* (7)

$P_{y\,max}$ *refers to the maximum point on Y-axis found in pupil pixels* (8)

6. Round the irregular pupil area by a rectangular shape as shown in Fig. 9. This rectangular shape contains all the pixels of the irregular pupil. Two points must be calculated in this step:

$$P_{1\,min} = (X_{px\,min}, Y_{py\,min}) \quad (9)$$

$$P_{1\,max} = (X_{px\,max}, Y_{py\,max}) \quad (10)$$

7. Calculate the center of the rectangular according to the previous step:

$$P_{center} = (X_{center}, Y_{center}) \quad (11)$$

8. Draw a circle around the pupil to complete the circular form of the pupil as shown in Fig. 10.
9. Update the iris image to the same position on the original image.
10. Compare the processed image with the images stored in the database to identify the person.

5. RESULTS AND DISCUSSION

Hamming distance measures the fraction of disagreeing bits resulting from bit-by-bit comparison of the two regions of interest. The obtained result indicated that the criterion is chosen to be 0.40, which means that a matching decision is never declared between two iris codes if it is exceed 40% of the disagreed bits. Fig. 11 illustrates that the change in Hamming distance before and after applying the proposed approach; in addition, it is clear that applying this approach causes significant decreasing in the Hamming distance value.

Fig. 12 illustrates a comparison between the Hamming distance of the diseased eye images before and after treatment

Fig. 7. Thresholding of iris image.

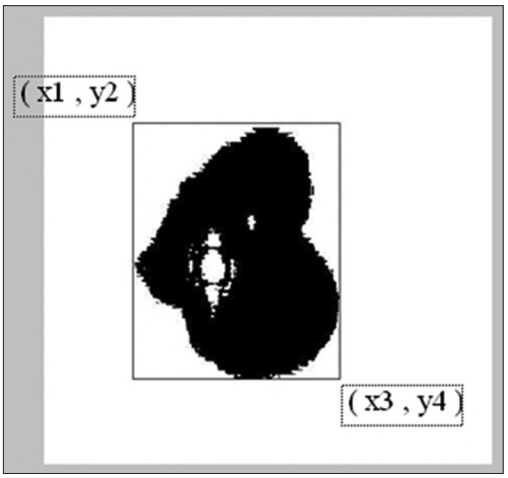

Fig. 9. Round the irregular pupil area by a rectangular shape.

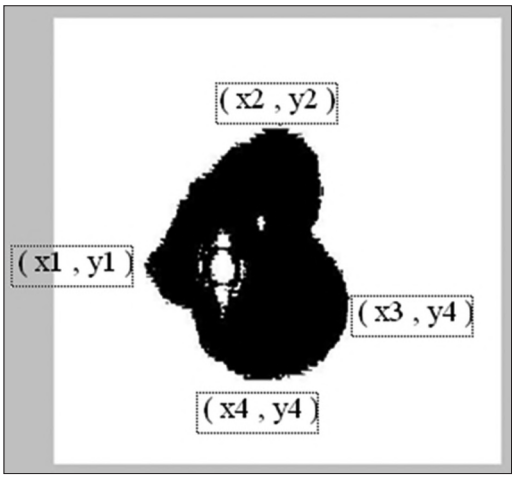

Fig. 8. Determine rectangular dimensions.

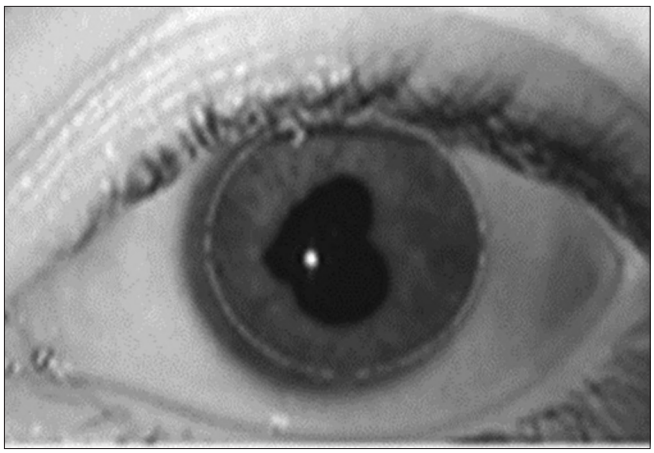

Fig. 10. Drawing a circle around the pupil.

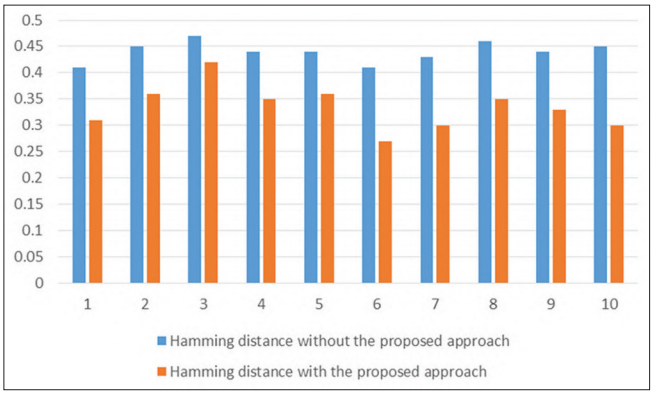

Fig. 11. Change in Hamming distance before and after applying the proposed approach.

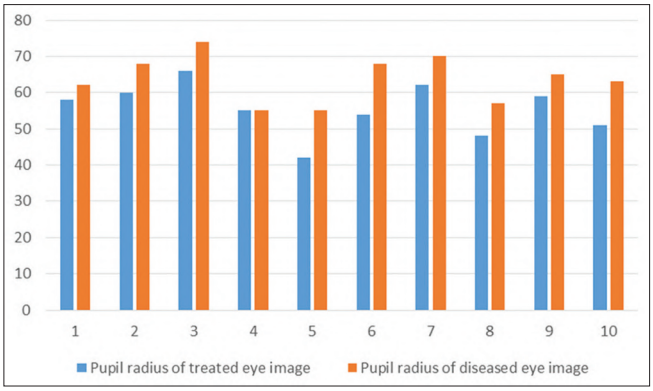

Fig. 12. The Hamming distance outcomes of the diseased eye images before and after treatment and the Hamming distance outcomes for the images of the same diseased eye after treatment.

and the Hamming distance for the images of the same diseased eye after treatment. This figure indicated that the Hamming distance values for the two diseased eye images after treatment are less than the Hamming distance values for the images of the diseased eye before and after treatment. These results are caused by the pupil of the treated eyes seem normal unlike diseased eyes whose pupil becomes a little larger after applying the proposed enhancement method.

Fig. 13 indicated the differences in pupil radius values between the images of the diseased eyes after applying the enhancement and the images of the same diseased eyes after receiving the processed image. According to pupil distortion in the diseased eyes, the size of the pupil will enlarge affecting the size of iris region which should be considered when calculating Hamming distance in iris recognition algorithm; this caused increasing the Hamming distance values.

The implemented approach is evaluated through performance evaluation in terms of false rejection rate (FRR) and false

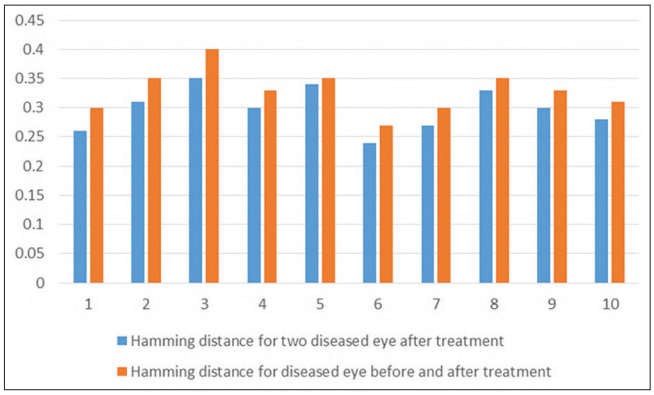

Fig. 13. Pupil radius values of diseased and treated eyes.

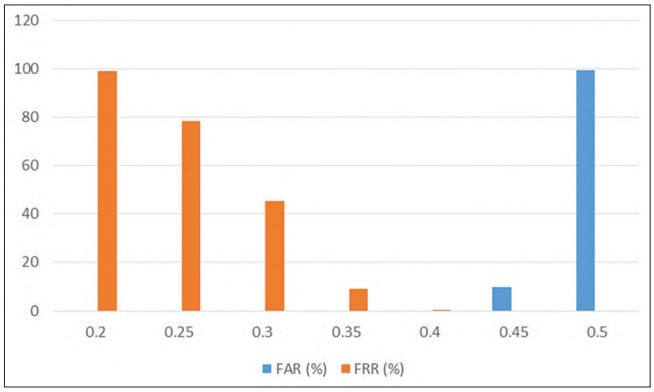

Fig. 14. Performance evaluation in terms of false rejection rate and false acceptance rate.

acceptance rate (FAR). FAR and FRR are shown in Fig. 14 based on the Hamming distance. Perfect recognition is not possible due to the overlapping distributions. An accurate recognition rate is achieved through threshold of 0.40, in which a false accept rate and false reject rate of 0.000% and 0.100%, respectively, are obtained.

6. CONCLUSIONS

Iris recognition is an effective method for biometric human identification. The implemented iris recognition approach is passed into many steps to achieve good system performance. This research studied the effects of infected eye on the recognition process through introducing different types of eye images. In addition, treating and enhancing processes are inserted in the overall approach to prepare an adequate iris image for processing. The obtained results indicated that the recognition performance of the implemented approach is 90%. The experimental results show that the proposed method is an effective approach in iris recognition.

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ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Employing Data Mining Techniques for Predicting Opioid Withdrawal in Applicants of Health Centers

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ABSTRACT

Addiction to narcotics is one of the greatest health challenges in today's world which has become a serious threat for social, economic, and cultural structures and has ruined a part of an active force of the society and it is one of the main factors of growth of diseases such as HIV and hepatitis. Today, addiction is known as a disease and welfare organization, and many of the dependent centers try to help the addicts treat this disease. In this study, using data mining algorithms and based on data collected from opioid withdrawal applicants referring to welfare organization, a prediction model is proposed to predict the success of opioid withdrawal applicants. In this study, the statistical population is comprised opioid withdrawal applicants in a welfare organization. This statistical population includes 26 features of 793 instances including men and women. The proposed model is a combination of meta-learning algorithms (decorate and bagging) and J48 decision tree implemented in Weka data mining software. The efficiency of the proposed model is evaluated in terms of precision, recall, Kappa, and root mean squared error and the results are compared with algorithms such as multilayer perceptron neural network, Naive Bayes, and Random Forest. The results of various experiments showed that the precision of the proposed model is 71.3% which is superior over the other compared algorithms.

Index Terms: Addiction, Data Mining, Decision Tree, Meta-learning Algorithm

1. INTRODUCTION

Today, addiction to narcotics is one of the main health challenges of the world resulting in serious threats for social, economic, and cultural structures destroying a part of the active force of the society. On the other hand, it is one of the main factors of growth of diseases such as HIV and hepatitis. According to the social analyzers, addiction to narcotics is one of the complicated problems of the current age resulting in many social damages and violations. In other words, the relationship of addiction with social issues is two-sided; on the one hand, addiction results in recession and degeneration of the society. On the other hand, it is a phenomenon originating from social, economic, and cultural issues [1].

Today, addiction is known as a disease and there are some centers for its treatment which have complete information about addicts. Therefore, despite the large volume of data, data mining can be used to explore knowledge in data, and its results can be used as the knowledge database of the decision support system to prevent and treat addiction. Data mining tools analyze data and explore data pattern which can be used in applications to determine the strategy for business,

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knowledge database, medical, and scientific studies. The gap between data and information has necessitated data mining tools to convert useless data into useful knowledge [2-4].

In this study, data mining techniques such as Neural Network, Bayesian Network, and Decision Tree are used to present prediction models to predict the success of opioid withdrawal applicants referring to a welfare organization. In this paper, also a hybrid prediction model comprised J48, Decorate, and Bagging algorithms are proposed for predicting the success of opioid withdrawal applicants to the welfare organizations. The statistical population of this study is comprised opioid withdrawal applicants referring to a welfare organization.

The rest of this paper is organized as follows: Section 2 reviews related works and in Section 3, we have introduced the dataset. Section 4 introduces the proposed model to predict the success of opioid withdrawal applicants, while Section 5 presents the simulation results. The paper is concluded in Section 6.

2. RELATED WORK

In Lu *et al.* [5] authors obtained data from Reddit, an online collection of forums, to gather insight into drug use/misuse using text snippets from user's narratives. They used users' posts to trained a binary classifier which predicts a user's transitions from casual drug discussion forums to drug recovery forums. They also presented a Cox regression model that outputs likelihoods of such transitions. Furthermore, they founded that utterances of select drugs and certain linguistic features contained in one's posts can help predict these transitions.

In Fan *et al.* [6], a novel framework named AutoDOA is proposed to automatically detect the opioid addicts from Twitter. The authors first introduced a structured heterogeneous information network (HIN) to model the users and posted tweets as well as their rich relationships. Then, a meta-path based mechanism is used to formulate similarity measures over users, and different similarities are aggregated using Laplacian scores. Finally, based on HIN and the combined meta-path, a classification model is proposed for automatic opioid addict detection to reduce the cost of acquiring labeled examples for supervised learning.

In Zhang *et al.* [7], an intelligent system named iOPU has been developed to automate the detection of opioid users from Twitter. Like Fan *et al.* [6] authors first introduced a HIN; then they used a meta-graph based technique to characterize the semantic relatedness over users. Furthermore, they have integrated content-based similarity and relatedness obtained by each meta-graph to formulate a similarity measure over users. Finally, they proposed a classifier combining different similarities based on different meta-graphs to make predictions.

In Kim [8] authors used a text mining approach to explore how opioid-related research themes have changed since 2000. The textual data were obtained from PubMed, and the research periods were divided into three periods. While a few topics appear throughout each period, many new health problems emerged as opioid abuse problems magnified. Topics such as HIV, methadone maintenance treatment, and world health organization appear consistently but diminish over time, while topics such as injecting drugs, neonatal abstinence syndrome, and public health concerns are rapidly increasing.

The study Kaur and Bawa [9] is aimed at uncovering and analyzing a range of data mining tools and techniques for optimally predicting the numerous medical diseases to endow the health-care section with high competence and more effectiveness. After preparing the dataset, data are loaded into the WEKA tool. Then, Naïve Bayes, Decision Tree (J48), multilayer perceptron (MLP), logistic regression are selected to build the prediction models. Data are then cross-validated using performance classifier measure; the results of each algorithm are then compared to each other.

In Rani [10], neural networks have been used to classify medical data sets. Back propagation error method with variable learning rate and acceleration has been used to train the network. To analyze the performance of the network, various training data have been used as input of the network. To speed up the learning process, parallelization is performed in each neuron at all output and hidden layers. Results showed that the multi-layer neural network is trained faster than a single-layer neural network with high classification efficiency.

In Shajahaan *et al.* [11], the application of decision trees in predicting breast cancer has been investigated. It has also analyzed the performance of conventional supervised learning algorithms, namely, Random tree, ID3, CART, C4.5, and Naive Bayes. Then, data are transferred to Rapid Miner data mining tool and breast cancer diagnosis for each sample in the test set is predicted with seven different algorithms which are Discriminant Analysis, Artificial Neural Networks (ANN), Decision Trees, Logistic Regression, Support Vector Machines, Naïve Bayes, and KNN. Results showed that random tree achieves higher accuracy in cancer prediction.

In Kaur and Bawa [12], the motive is proposing an expert system which can predict whether the person is addicted prone to drugs so as to control and aware every drug abuser as they can test repeatedly to cure them without hesitation. The proposed expert system is developed using decision tree ID3 algorithm.

In Ji *et al*. [13], a framework has been developed to predict potential risks for medical conditions as well as its progression trajectory to identify the comorbidity path. The proposed framework utilizes patients' publicly available social media data and presents a collaborative prediction model to predict the ranked list of potential comorbidity incidences, and a trajectory prediction model to reveal different paths of condition progression.

In Salleh *et al*. [14], ANN algorithms have been used to propose a framework for relapse prediction using among drug addicts at Pusat Rawatan Inabah. The data collected will be mining through ANN algorithms to generate patterns and useful knowledge and then automatically classifying the relapse possibility. Authors have been mention that among the classification algorithms, ANN is one of the best algorithms to predict relapse among drug addicts.

3. DATASET OF STUDY AND PRE-PROCESSING

The statistical population employed in this study is comprised the opioid withdrawal applicants of a welfare center. Samples include 793 applicants including men and women. The

TABLE 1: Features and their values in the dataset of study.

Feature	Value
City	Two different cities
Welfare center name	12 different centers
Welfare center type	Private-admitted, private-outpatient, government-admitted, government-outpatient, community treatment, drop-in, midterm resident recovery
Age	17–70 years
Sex	Man-woman
Place of residence	City-village
Number of children	0–8
Education	Illiterate, primary, middle school, high school diploma, associate degree, bachelors, masters, PhD
Marital status	Single-married
Job	Worker, farmer, service jobs, urban driver, Inner City Driver, unofficial jobs, storekeeper, unemployed, housewife, soldier, student, retired, self-employed, other
Housing situation	Lease or mortgage, father's house, father-in-law's house, organizational, other
Income	0–6000 (USD)
Consumption	Opium, heroin, crack, cannabis, ecstasy, Buprenorphine, LSD, Cocaine, tramadol, burnt water, methadone, combination
Consumption method	Smoke, eat, inject, snuff, drink, inhalation, other
Consumption frequency	Daily, weekly, monthly, a few times
Consumption amount	Half (gram), one, one and a half, two, two and a half, three, four, five, more
Average cost of supplying narcotics in the last week	0.7–134 (USD)
The first one who offered narcotics	Strangers, friends, without offer, coworkers, family member, relatives
Where was the first consumption	Family party, friends party, park, school or university, street, casern, workplace, home, other
History of consumption in the family members	None, spouse, father, mother, sister, brother, two or more
History of injection	Yes-No
History of joint injection	Yes-No
Prisoner history	Yes-No
Type of previous withdrawals	Outpatient referral to the doctor's office, admission in private ward, referring to outpatient centers, residence in rehabilitation centers, residence in rehabilitation camps, anesthesia method, conventional method, self-helping groups, licensed centers, other
Side effects	Physical effects, mental effects, financial effects, pregnancy, pressure, legal problems, marriage, physical, mental and financial effects, others
The number of previous withdrawals	0–10 times

number of features in this dataset is 26. Table 1 shows the features of this dataset and the value of each feature.

Here, some necessary preprocessing is provided on the dataset to increase the efficiency of the prediction models:

I. The output field of this dataset is "the number of referrals" which is obtained by a small change in the field of "the number of previous withdrawals." The purpose of this study is to predict the number of referrals of the addicts to withdrawal centers. This knowledge helps us understand that an individual succeeds to withdraw after how many referrals to the opioid withdrawal centers. To calculate the output filed, it is sufficient to add a unit to the field of "the number of previous withdrawals." Then, the output field is converted into four classes, as shown in Table 2.
II. The field "family income" includes a numerical value between 0 and 6000 USD. To increase the efficiency of the proposed prediction model, the values of this field are divided into 10 degrees. In other words, individuals are categorized into 10 groups in terms of family income. This categorization is represented in Table 3.
III. The field of "average cost of supplying the narcotics in the last week" also includes values in the range of 0.7–134 USD. All of these samples are also categorized into eight groups, as shown in Table 4.
IV. The field of "age" includes values between 17 and 70. In another categorization, all samples are categorized into six different groups, as given in Table 5.
V. Field of "side effects" includes the same value for all samples. Therefore, this feature cannot affect prediction results. Thus, it is eliminated from the dataset.
VI. Furthermore, the value of some features such as housing situation, amount of consumption, and consumption frequency is missing for some individuals which are called missing value, and random initialization is used to resolve this problem.

TABLE 2: Classifying the output field of the dataset.

The number of referrals	Class
1	A
2.3	B
4.5	C
$x>5$	D

TABLE 3: Categorizing the samples into 10 degrees in terms of "family income.

The family income (x) per USD	Group
$x=0$	J
$0<x\leq34$	I
$34<x\leq100$	H
$100<x\leq167$	G
$167<x\leq334$	F
$334<x\leq666$	E
$666<x\leq1000$	D
$1000<x\leq1666$	C
$1666<x\leq3333$	B
$3333<x$	A

4. THE PROPOSED MODEL

The proposed prediction model for determining the type of addicts in terms of the classes presented in Table 2 is a hybrid model of J48, Decorate, and Bagging algorithms. The structure of the proposed hybrid model is as follows:

$$Decorate(Bagging(J48(Dataset)))$$

4.1. J48

This algorithm is the implementation of the C4.5 decision tree. In this algorithm, additional grafting branches are considered on a tree in a post-processing phase. The grafting process tries to capture some of the capabilities of ensemble methods such as Bagged and Boosted trees, while a single structure can be maintained. This algorithm identifies areas that are either empty or only contains misleading classified samples and Elores another (alternative) class [3,4].

TABLE 4: Categorizing the samples in terms of "average cost of supplying the narcotics in the last week" into eight groups.

The average cost of supplying the narcotics in the past week (x) per USD	Group
$x\leq3$	H
$3<x\leq7$	G
$7<x\leq10$	F
$10<x\leq14$	E
$14<x\leq17$	D
$17<x\leq34$	C
$34<x\leq165$	B
$x>165$	A

TABLE 5: Categorizing the samples in terms of "age" in six different groups.

Age (x)	Group
$x\leq20$	A
$20<x\leq25$	B
$25<x\leq30$	C
$30<x\leq40$	D
$40<x\leq50$	E
$x>50$	F

4.2. Decorate

Ensemble learning is to use a set of classifiers to learn partial solutions for a given problem and then integrate these solutions using some strategies to construct a final solution to the original problem. Recently, ensemble learning is one of the most popular fields in data mining and machine learning communities and has been applied successfully in many real classification applications. Diverse Ensemble Creation by Oppositional Relabeling of Artificial Training Examples (Decorate) is simple meta-learning that can use any strong learner as a base classifier to build diverse committees in a fairly straightforward strategy. The motivation for Decorate is based on the fact that to combine the outputs of multiple classifiers is only useful if they disagree on some inputs. The Decorate is designed to use additional artificially generated training data, and add different randomly constructed instances to the training set to generate highly diverse ensembles [2,15,16]. The Decorate can also be effectively used for the following [16]:

I. Active learning, to reduce the number of training examples required to learn an accurate model;
II. Exploiting unlabeled data to improve accuracy in semi-supervised learning;
III. Combining both active and semi-supervised learning for improved results;
IV. Obtaining improved class membership probability estimates, to assist in cost-sensitive decision-making;
V. Reducing the error of regression methods; and
VI. Improving the accuracy of relational learners.

Furthermore, the advantages of Decorate are as follows [16]:

- Ensembles of classifiers are often more accurate than its component classifiers if the errors made by the ensemble members are uncorrelated. Decorate method reduces the correlation between ensemble members by training classifiers on oppositely labeled artificial examples. Furthermore, the algorithm ensures that the training error of the ensemble is always less than or equal to the error of the base classifier; which usually results in a reduction of generalization error; and
- On average, combining the predictions of Decorate ensembles will improve on the accuracy of the base classifier.

4.3. Bagging

This algorithm was proposed in 1994 by Leo Breiman to improve the classification by combining randomly generated training sets. This methodology is a meta-algorithm designed to improve the stability and accuracy of machine learning algorithms used in statistical classification and regression. Variance is reduced and over-fitting is improved through the use of this algorithm. Bagging implicitly creates ensemble diversity by training classifiers on different subsets of the data. Although this method is used in the decision tree, it can be used in any kind of model. Bagging is a special case of model averaging approach. Bagging can be applied to the prediction of continuous values by taking the average value of each vote, rather than the majority [2,17,18]. The advantages of Bagging are as follows [16]:

- Bagging works well if the base classifiers are unstable;
- It increased accuracy because it reduces the variance of the individual classifier;
- Bagging seeks to reduce the error due to the variance of the base classifier; and
- Noise-tolerant, but not so accurate.

5. SIMULATION RESULTS

In this section, we first present the simulation model for the proposed model and other algorithms. Then, the common evaluation metrics in data mining problems are introduced. Finally, the experiment results of the proposed model and some common algorithms are presented.

5.1. Simulation Model

In this research, the Weka tool is used to perform pre-processing operations and construct the proposed predictive models. This software has been developed at Waikato University in New Zealand and is an open-source tool implemented by the object-oriented programming language. This tool includes several machine learning and data mining algorithms such as regression, classification, clustering, exploring association rules, pre-processing tools (filters), and selection methods for attributes.

Furthermore, to train and test the proposed model, *K*-fold ($K = 10$) method is employed. In this type of test, data are classified into *K* subsets. From these *K* subsets, a subset is used for test, and *K*-1 subsets are used for training. This procedure is repeated *K*-times and all data are once used for test and once for training. Finally, an average of these *K* times test is selected as the final estimation. In the *K*-fold method, the ratio of each class in each subset and the main set is the same [19].

5.2. Evaluation Metrics

One of the common tools used for evaluating classification algorithms is to employ the confusion matrix. As shown in Table 6, the confusion matrix includes the results of

predictions of the classifier algorithm in four different classes including True positive, false negative, false positive, and true negative. True positive refers to the positive samples that were correctly labeled by the classifier. True negative refers to the negative samples that were correctly labeled by the classifier. False positive is an error in data reporting in which a test result improperly indicates the presence of a condition, such as a disease (the result is positive), when in reality it is not present. False negative is an error in which a test result improperly indicates no presence of a condition (the result is negative) when, in reality, it is present.

Considering the confusion matrix, the following measures can be defined and evaluated:

- Precision is the fraction of retrieved instances that are relevant. This measure is calculated by Equation (1):

$$\frac{TP}{TP + FP} \tag{1}$$

- Accuracy is the proportion of true results (both true positives and true negatives) among the total number of cases examined. This measure is calculated by Equation (2):

$$\frac{TP + TN}{TP + TN + FP + FN} \tag{2}$$

- Recall is the fraction of relevant instances that are retrieved. This measure is calculated by Equation (3):

$$\frac{TP}{TP + FN} \tag{3}$$

$$\frac{2 \times Recall \times Precision}{Recall + Precision} = \frac{2 \times TP}{2 \times TP + FP + FN} \tag{4}$$

- F-Measure combines precision and recall (harmonic mean), which is calculated by Equation (4):
- Root mean squared error (RMSE) is a frequently used measure of the differences between values predicted by a model or an estimator and the values observed. The RMSD represents the square root of the second sample moment of the differences between predicted values (p_i) and observed values (a_i) or the quadratic mean of these differences. This measure is calculated by Equation (5):

$$\sqrt{\frac{(p_1 - a_1)^2 + \ldots + (p_n - a_n)^2}{n}} \tag{5}$$

- Mean absolute error (MAE) measures how far predicted values (p_i) are away from observed values (a_i) and is calculated by Equation (6):

$$\frac{|p_1 - a_1| + \ldots + |p_n - a_n|}{n} \tag{6}$$

TABLE 6: The confusion matrix.

	Predicted	
Observed	**True**	**False**
True	TP	FN
False	FP	TN

5.3. Experiment Results

Periment results in Fig. 1 show that the precision of the proposed model is 71.3% which has improved compared to J48, Random Forest, Naive Bayes, and MLP neural network with precisions of 66%, 65.3%, 51.2%, and 56.3%, respectively. Furthermore, the results show that using hybrid models based on meta-learning algorithms of Decorate and Bagging increases the precision of the prediction models. For instance, the precision of J48 alone is 66% while its combination with Decorate and Bagging algorithm increases the precision to 69% and 66.7%, respectively. In the proposed model, since features of J48, decorate and bagging are employed, higher precision is obtained.

Fig. 2 shows the experiment results in terms of recall. The results show that the proposed model has a recall of 71.5% which is higher than J48, Random Forest, Naive Bayes, and MLP neural network with recall of 66%, 65.2%, 50.9%, and 56.2%, respectively. Besides, the proposed hybrid model gives better results compared to hybrid algorithms of Decorate-J48 and Bagging-J48 with recalls of 69.1% and 67%.

Moreover, in terms of F-measure, as shown in Fig. 3, the proposed model has obtained an F-measure of 71.2% which

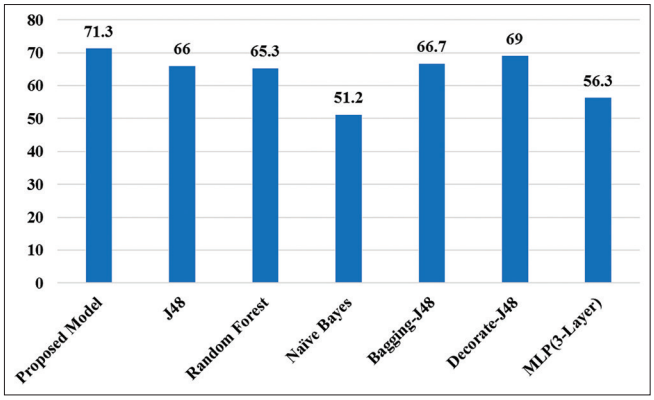

Fig. 1. Comparing the proposed model with other algorithms in terms of precision.

outperforms J48, Random Forest, Naive Bayes, and MLP neural network with F-measures of 65.5%, 64.9%, 50.9%, and 56.2%, respectively. Furthermore, combining J48 with Decorate and Bagging algorithms has increased F-measure but not more than the hybrid proposed model.

Furthermore, the proposed model is compared with other models in terms of Kappa in Fig. 4. The experiment results show that the Kappa values obtained for J48, Decorate-J48, and Bagging-J48 are 0.50, 0.54, and 0.56, respectively, while its value for the proposed model is about 0.58, which indicates the superiority of the proposed model over the other models.

Furthermore, Fig. 5 compares the performance of the proposed model with other algorithms in terms of MAE. In terms of MAE, J48 outperforms other algorithms with a value of 0.1884. The MAE of the proposed model is 0.2427 which is a bit higher than J48. Indeed, this negligible shortcoming of the proposed model can be ignored compared to its superiority in terms of other measures.

In addition, the proposed model is compared with other algorithms in terms of RMSE. The results presented in Fig. 6 show that the proposed model with RMSE of 0.3265 has the minimum RMSE along with Decorate-J48 with RMSE of 0.3239 compared to other model indicating the desirable performance of the proposed model.

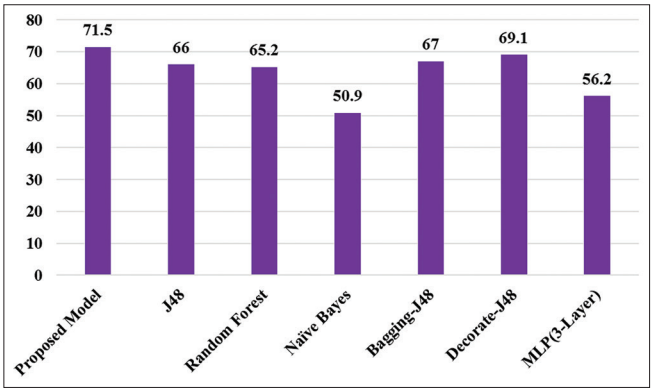

Fig. 2. Comparing the proposed model with other algorithms in terms of precision.

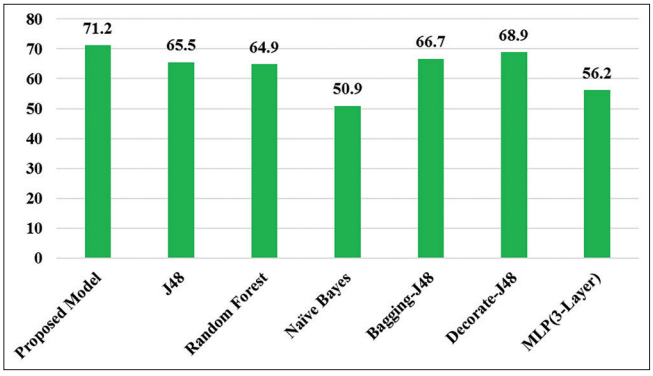

Fig. 3. Comparing the proposed model with other algorithms in terms of F-measure.

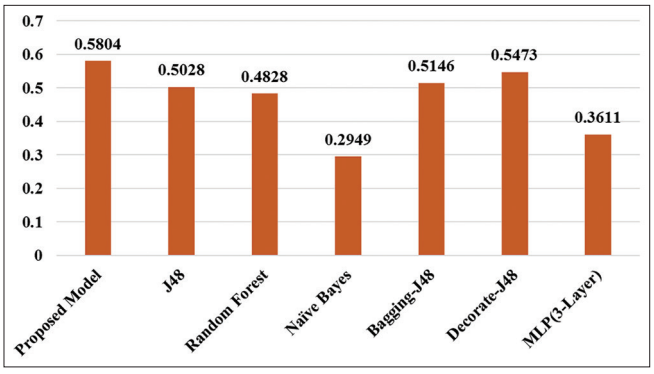

Fig. 4. Comparing the proposed model with other algorithms in terms of Kappa.

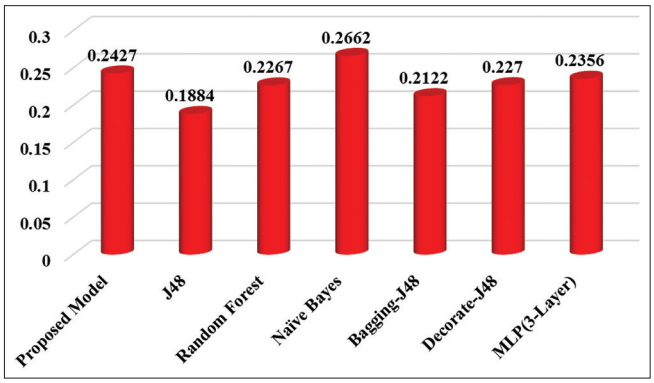

Fig. 5. Comparing the proposed model with other algorithms in terms of mean absolute error.

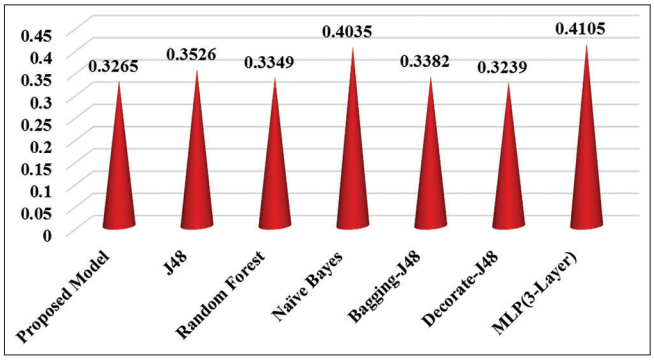

Fig. 6. Comparing the proposed model with other algorithms in terms of root mean squared error.

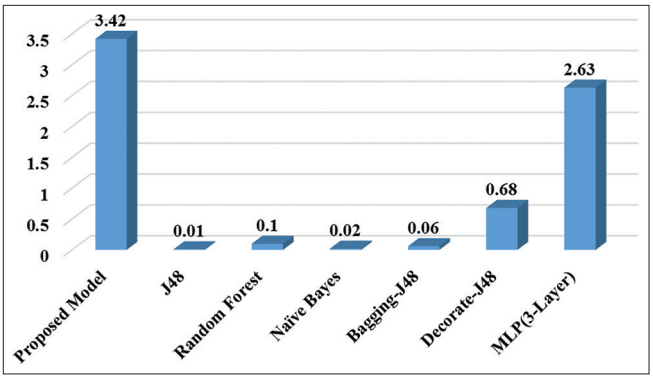

Fig. 7. Comparing the proposed model with other algorithms in terms of the time required to build the model.

Finally, the proposed hybrid model is compared with other algorithms in terms of time required to build the model. The results of this experiment in Fig. 7 showed that the time required to build the proposed model is 3.42 s while this time is less for other algorithms. The reason is very clear because the proposed model is based on a combination of three different algorithms, and therefore, it takes longer to construct.

6. CONCLUSION

In this paper, a hybrid prediction model based on data mining techniques is proposed to predict the number of times that opioid withdrawal applicants refer to welfare organizations. The statistical population of this study is comprised opioid withdrawal applicants referring to a welfare organization. The proposed model is a combination of Decorate, Bagging, and J48 algorithms, which benefits from the advantages of all three algorithms. The efficiency of the proposed hybrid model is evaluated in terms of precision, recall, F-measure, Kappa, RMSE, and MAE. The results show that the proposed model with a precision of 71.3% outperforms other algorithms such as Random Forest, Naïve Bayes, and MLP neural network.

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REVIEW ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Epileptic Seizure Detection using Deep Learning Approach

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ABSTRACT

An epileptic seizure is a sign of abnormal activity in the human brain. Electroencephalogram (EEG) is a standard tool that has been used vastly for detection of seizure activities. Many methods have been developed to help the neurophysiologists to detect the seizure activities with high accuracy. Most of them rely on the features extracted in the time, frequency, or time-frequency domains. The performance of the proposed methods is related to the performance of the features extracted from EEG recordings. Deep neural networks enable learning directly on the data without the domain knowledge needed to construct a feature set. This approach has been hugely successful in almost all machine learning applications. We propose a new framework that also learns directly from the data, without extracting a feature set. We proposed an original deep-learning-based method to classify EEG recordings. The EEG signal is segmented into 4 s segments and used to train the long- and short-term memory network. The trained model is used to discriminate the EEG seizure from the background. The Freiburg EEG dataset is used to assess the performance of the classifier. The 5-fold cross-validation is selected for evaluating the performance of the proposed method. About 97.75% of the accuracy is achieved.

Index Terms: Electroencephalogram, Epilepsy, Epileptic Seizure, Long- and short-term Memory, Seizure Detection

1. INTRODUCTION

Epilepsy is a chronic central nervous system disorder that makes life trouble for more than 50 million people over the world, as reported by the World Health Organization [1]-[5]. It characterizes by a rapid, unpredictable, and temporary change in the electrical activity of the brain able to affect human functionality at all age [6]-[8]. It may be a partial occur in the left or right part of the brain only or could affect both hemispheres of the brain.

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Electroencephalogram (EEG) is one of the most effective techniques to track and record brain wave patterns. Neurologist read and analyzes these EEG records to detect and categorize the type of epilepsy diseases [4]. The EEG examination is a visual process that needs too many hours to examine 1-day of recording. It is time consuming, and tiredness also requires the services of an expert; this is lead to put a heavy load on the neurologist and reduces their efficiency [1], [5].

These encourage the researchers to develop automated seizure detection with machine learning methods, using epileptic multi-channel EEG signals including EEG signal acquisition, preprocessing, features extraction, and classification [2], [5]. Most of the proposed systems rely on feature extraction techniques to discriminate abnormal signals from the background. Selection of discriminative features

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is a matter of the performance of such systems [6]. Deep neural networks enable learning directly on the data without the domain knowledge needed to construct a feature set.

Deep learning is a part of machine learning allows multi-layered computational models to learn data representations with various abstraction levels. Higher representation layers amplify input components for classification procedures that are crucial for discriminating characteristics. Deep learning technique has greatly improved object detection in many fields, such as seizure detection. There are several challenges that face-off deep learning; first, most conventional deep learning models separately feed each channel into seizure classifier and ignore the connection between them, so the general signal types could not be recognized well. Second, most channels in multi-channel EEG signals are unconnected in the brain activity signals, such as seizure starts. These disconnected channels contain noise data that affect performance and decrease the learning method. Third, always good performance is not produced using a simple design of traditional deep learning features with unbalanced datasets or rare events. Finally, seizures type in EEG signals may have different important across patients and even overtime for the same patient, which imply difficulty to develop automatic cross-patient detector [5].

Several studies tried to propose machine learning models for detecting epileptic seizures in EEG signals. They attempt to use a distinct learning method to classify EEG signals into seizure and non-seizure because detecting seizures are a complex classification process that contains many seizure-like activities throughout the entire EEG recordings.

Although there are lots of good practices regarding epileptic seizure detection, the research still ongoing as few of them has been realized. Hence, new methods and efforts attempt to attain more practicable, reliable, accurate, and low complex automatic seizure detection system. The novelty of this research is proposing a long- and short-term memory (LSTM) model to detect an epileptic seizure. The proposed model can be realized on the programmable logic Zynq 7020 FPGA from Xilinx [7]. We offer an automatic seizure detection system to address the challenges mentioned above for classifying EEG signals into normal and abnormal using LSTM algorithm.

2. RELATED WORK

Different domains, such as time, frequency, and time-frequency [8] domains, have been used to analyze EEG signals. Most of them rely on the discriminate features extracted from the signal in the analyzed domain. Previous research showed that the features extracted from a time-frequency domain such as instantaneous frequency [9], [10], spikes characteristic [11], [12], Harlik descriptors [13], and time-frequency flux [14] provide the best performance for classifying EEG signals. Several attempts have been made to develop an automatic epileptic seizure detection method for classifying EEG signals using the deep neural network in which the features are extracted automatically. Ghaderyan, Abbasi and Sedaaghi [15] proposed an optimized novel way using K-nearest neighbor-based on sampling put together with support vector machine (SVM) classifier achieved a sensitivity of 100%. Zheng *et al.* [16] proposed a way for patient-specific seizure detection systems, and greatly help clinical staff to automatically mark seizures in long-term EEG with high performance and an average sensitivity of 92%. Correa *et al.* [17] used spectral power and wavelet analysis to assist detecting seizures in long-term EEG with high performance and sensitivity of 85.39% achieved. Yuan *et al.* [18] developed a novel algorithm to detect seizures within long-term EEG signal recordings and using Log-Euclidean Gaussian kernel-based sparse representation high epoch-based sensitivity of 95.11% achieved. Geng *et al.* [19] proposed a method that depends on improved wavelet neural network is for automatic seizure detection in long-term EEG. The algorithm achieved an average sensitivity of 96.72% and 98.91% of specificity. Parvez and Paul [20] proposed a new method for seizure prediction using phase correlation depending on the spatiotemporal relationship of EEG signals provides a prediction accuracy of 91.95%. Jukic and Subasi [21] used multiscale principal component analysis for removing noises and wavelet packet decomposition (WPD) for feature extraction from the EEG signals. Sharif and Jafari [22] proposed a new approach in automatic seizure prediction using Poincare plane and fuzzy rules for feature extraction depends on the frequency distribution of fuzzy rules. Then, SVM classifier used for separating normal from abnormal EEG signals. The average sensitivity of this method was 91.8–96.6%. Hussein *et al.* [3] used LSTM network for discriminating EEG signal features with using Softmax function for classifying of these features into normal and abnormal. This approach was shown to be robust in noisy real-life conditions compared to other methods that are quite sensitive to noise. The proposed approach achieved high performance with classification accuracies more than 90.00%. Mohammadi *et al.* [14] developed a patient-independent algorithm for automatic seizure detection, and the features extracted from high-resolution time-frequency distributions (TFDs). Then modified highly adaptive TFD

used for classification of normal from abnormal EEG signals. They achieved an accuracy of 98.56%. Alfaro-Ponce *et al.* [23] proposed a method to design an automatic classifier for electroencephalographic information used a parallel associative memory classifier depending on recurrent neural networks, although they achieved 97.2% accuracy. Hussein *et al.* [24] used both LSTM network and fully connected (FC) layer to learn the high-level representations for distinct EEG patterns then rely on FC to extract EEG features which are related to epileptic seizures. They achieved classification accuracies 100.00%, 95.20%, and 90.00%, respectively, for two, three, and five classes of classification. Li *et al.* [25] used two entropy methods; fuzzy entropy (FuzzyEn) and distribution entropy (DistEn) to classify interictal and ictal EEG from normal EEG and classify ictal from interictal EEG with using an analytic single window with different window lengths. The accuracy 92.80% with fuzzy entropy and 95.33% with distribution entropy achieved.

The rest of this study organized as follows: The description of the dataset used in this paper is given in section three; the methodology and experimental design is given in section four; the result presented and analyzed in section five. The discussion and conclusion of this study are shown in section six and seven, respectively.

3. DATASET

Our seizure detection system has been trained and tested on the EEG recording and recorded throughout pre-surgical epilepsy observation at the Epilepsy Center of the University Hospital Freiburg, Germany. The data contained or obtained from the invasive recording of 21 patients and their ages different from 12 to 50 years, which they have a hardship from medically intractable focal epilepsy. It has 24 h-long continuous of pre-surgical recording also include eight males patient and remaining are females. The data were consisting of six intracranial EEG channels (three focal and three extra-focal electrodes). The position and kind of seizure very different in patients, however, medically intractable focal epilepsy is shared among all the patients. The EEG data were acquired with 128 channels, 256 Hz sampling rate, and 16 bits analog to digital converter. The data collected and saved into two files; one of them contained ictal, which was seizures data, and the other was inter-ictal, which was normal data with no seizures event. Both ictal and inter-ictal files were saved in ASCI format and contain six channels of EEG time series. The onset and offset times of seizures marked up by EEG experts. The EEG database of 11 patients was used as authors have access to only this portion of the database for this study.

4. METHODOLOGY

The proposed method consists of two significant folds; preprocessing and processing, as illustrated in Fig. 1. The preprocessing includes three stages, which are the normalization of the EEG data, applying appropriate filters to select the interesting parts of the data, and data management (splitting, concatenating, and reshaping). The detail will be discussed in Section A. After preprocessing; the preprocessed data are used to train the LSTM network followed by a Softmax function is used to classify the inputs data into normal and seizure data.

For this study, we used six channels from Freiburg EEG dataset. Figs. 2 and 3 show a part of each file's components.

4.1. Preprocessing

4.1.1. Normalization

The data are normalized as the recordings are related to different patients. To this aim, the mean and standard deviation is computed using the following equations:

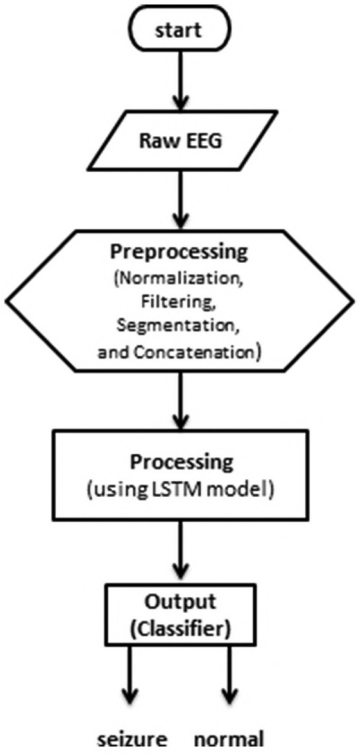

Fig. 1. The flowchart of the proposed system.

$$\overline{X} = \frac{1}{n}\left(\sum_{i=1}^{n} Xi\right) = \frac{X1 + X2 + X3 \ldots\ldots + Xn}{n} \quad (1)\ [26]$$

And

$$\delta = \sqrt{\frac{\sum_{i=1}^{N}\left(Xi - \bar{X}\right)^2}{N-1}} \quad (2)\ [27]$$

Where N is the total number of measurement per raw, and, $\bar{X}$ is the mean. We have standard deviation values for normal and seizure data denoted by δ_n and δ_s, respectively.

After determining both mean and standard deviation value for each signal (normal and seizure) $\overline{X}_n$, $\overline{X}_s$, and δ_n, δ_s, the normalization operation of electroencephalogram data done using the following equations:

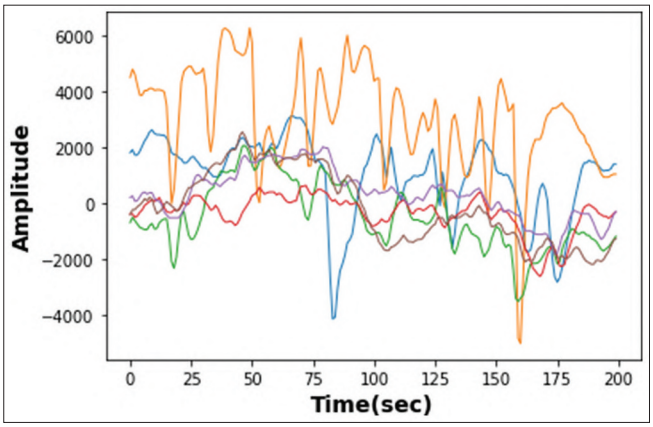

Fig. 2. The plot of six channels electroencephalogram recording brain activity without seizure.

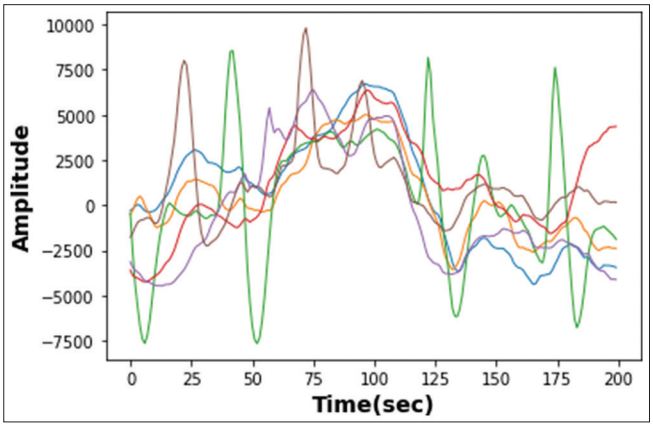

Fig. 3. The plot of six channels electroencephalogram recording of brain activity which has a seizure.

$$Nor_n = \frac{\bar{X}_n}{\delta_n} \quad (3)$$

Where Nor_n is the normalized normal signal, as shown in Fig. 4.

$$Nor_s = \frac{\bar{X}_s}{\delta_s} \quad (4)$$

And Nor_s is normalized seizure EEG, as shown in Fig. 5.

4.1.2. Filtering

There are popular and different types of EEG artifacts by applying various filter operations that can identify and removing them. The following points are the most significant sources of artifacts.

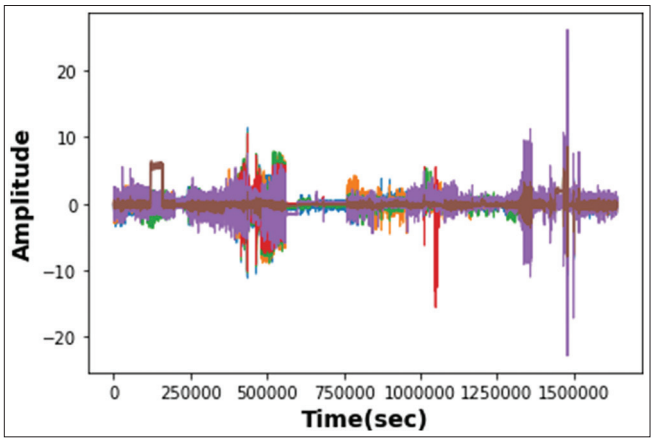

Fig. 4. The plot of a normalized normal data of six-channel electroencephalogram signals.

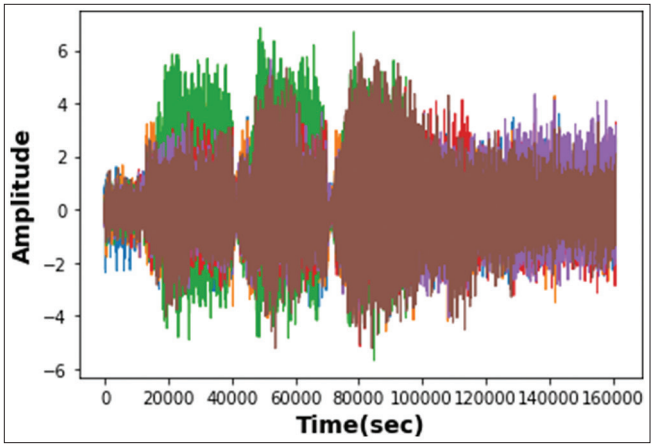

Fig. 5. The plot of a normalized seizure data of six-channel electroencephalogram signals.

Eye movement and blinking are activities that can catch and record during EEG signal recording. Skeletal muscles are producing the signals which are electrical action and interfere with the EEG at the time of recording. There are other noises that involve the EEG signal such as electricity line and environmental noise also dominated as white noise. These artifacts affect the performance for detecting seizure in our model.

The interesting frequency bands of EEG signals are located in the range of 0.01 Hz through 100 Hz. EEG signal recording will be contaminated by those artifacts mentioned above. Removing those undesired artifacts from the EEG is a major preprocessing step after the normalization process for our model. We apply the following filters on the EEG signals:

1. Butterworth low-pass filter used to cutoff and remove high frequencies.
2. Butterworth High-pass filter used to cutoff DC component and remove low frequencies.
3. A notch filter used to remove and cutoff 50 Hz frequency.

The bandpass filters between 0.5 and 100 Hz only allow the frequencies of interest and remove the noise frequencies produced by undesired activities such as head movements identifying by high-frequency activity (>20 Hz) [28]. The notch filter is used to remove exactly 50 Hz power line noise produced by electrical devices. Thus, the objective of the effective removing and attenuation of artifacts are to develop an application specific algorithm with better time and accuracy efficiency.

As mentioned before, we use filtering operations for both normal and seizure data. Figs. 6-8 show EEG signals after applying different filtering operations on the normal signals. Figs. 9-11 show various filtering operations on the seizure signals.

After filtering, we compute the average of the six channels, as shown in Figs. 12 and 13 to produce a single-channel signal for both normal and seizure EEG data.

4.1.3. Data management

The final steps of preprocessing include shuffling, segmenting, and reshaping the data. Each time a series of EEG single channel in seizure and normal file are shuffled and divided into smaller non-overlapping segments. The purpose of this operation is to provide the same probability for each sample to be selected for training or testing.

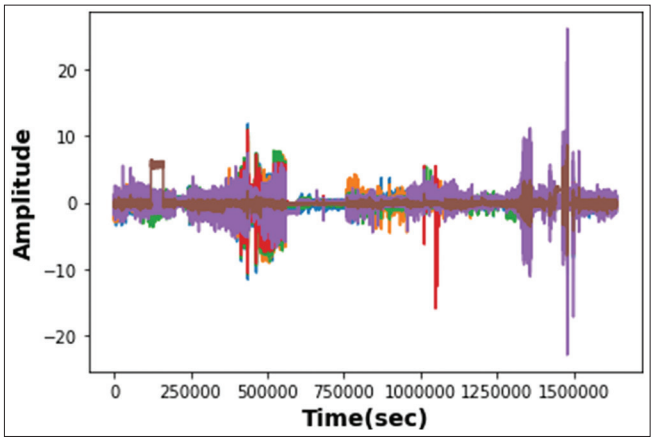

Fig. 6. The plot of a filtered normal electroencephalogram data with Butterworth low-pass filter.

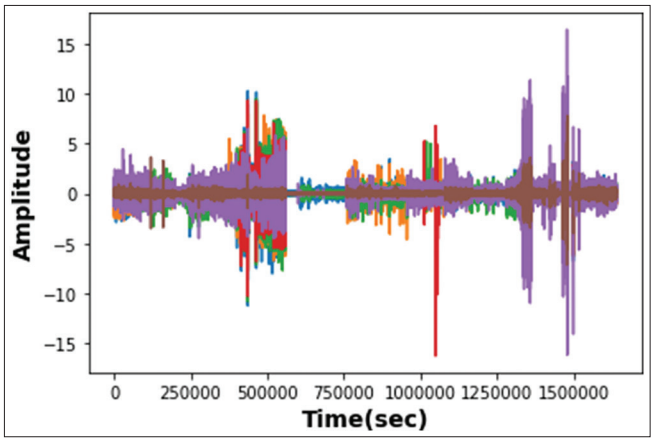

Fig. 7. The plot of a filtered normal electroencephalogram data with Butterworth high-pass filter.

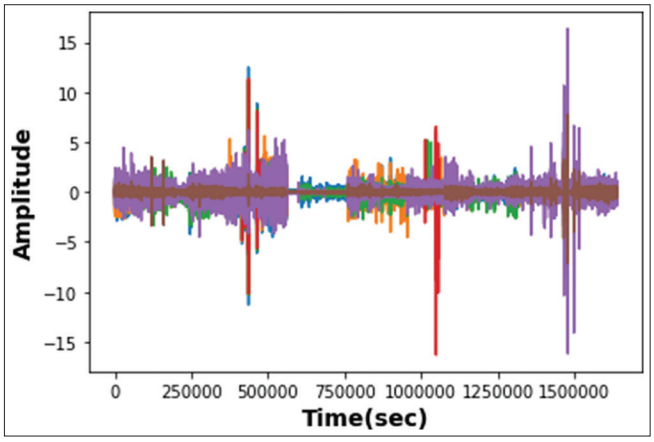

Fig. 8. The plot of a filtered normal electroencephalogram data with a notch filter.

Furthermore, each non-stationary signal is divided into sub stationary signals.

Each EEG raw is reshaped into T x L matrix, where L is the length of each segment, and T is the number of time-steps which is obtained as:

$$T = \frac{D}{L} \quad (5)$$

Thus, the input data of the LSTM model will take shape (D, T, and L).

4.2. Processing

Deep learning is a part of machine learning allows multi-layered computational models (multiple hidden layers) to learn data representations with various abstraction levels. Higher layers of representation amplify elements of the input for classification processes that are essential for discrimination and eliminate irrelevant features. The data representation learning is a collection of techniques allowing a machine to be fed with raw data and to learn the representations automatically which is required for detection [29]. Deep learning method has dramatically improved object detections

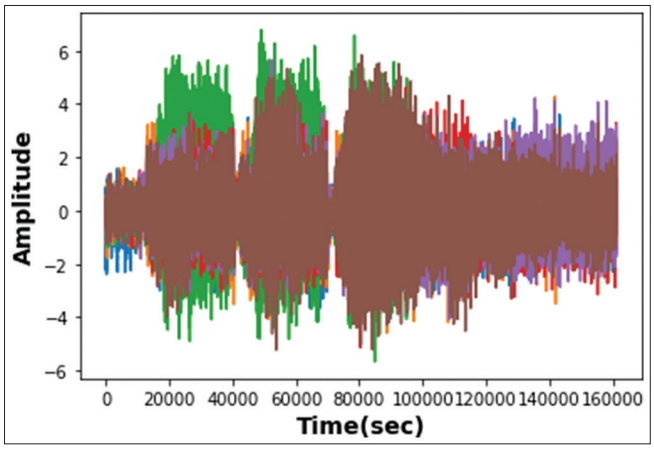

Fig. 9. The plot of a filtered seizure electroencephalogram data with Butterworth low-pass filter.

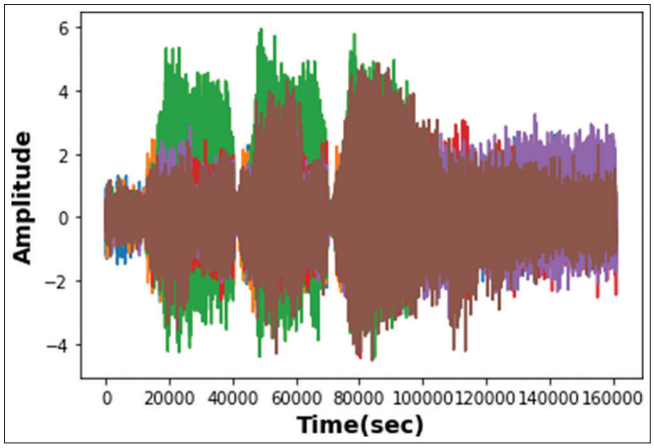

Fig. 10. The plot of a filtered seizure electroencephalogram data with Butterworth high-pass filter.

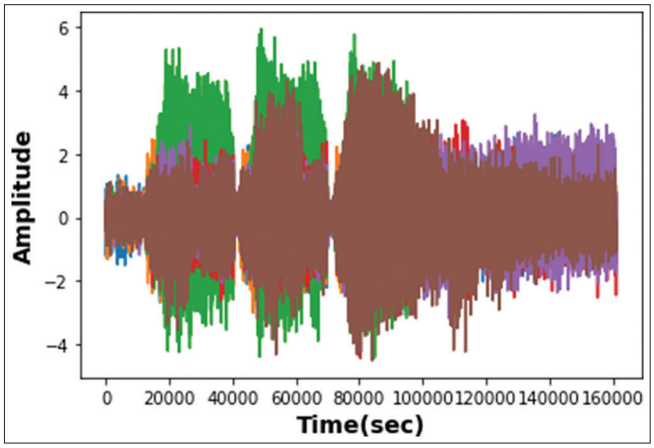

Fig. 11. The plot of a filtered seizure electroencephalogram data with a notch filter.

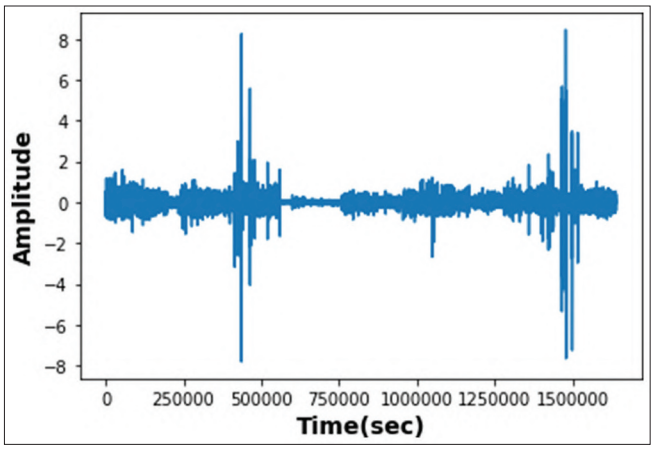

Fig. 12. The plot a single channel of electroencephalogram (EEG) normal signal after computing average of six EEG channels.

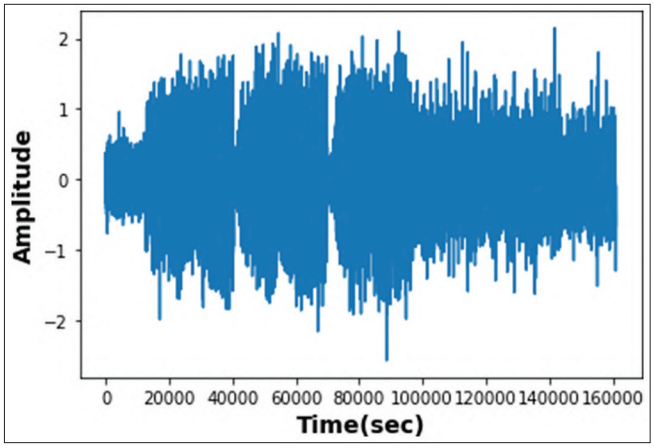

Fig. 13. The plot a single channel of electroencephalogram (EEG) seizure signal after computing average of six EEG channels.

in many domains such as seizure detection which arrange to take out discriminate properties of epileptic seizures in EEG time-series signals.

We use the LSTM network for this work. It works best on time-series with short- and long-term dependencies [24]. Each block of this network has three gates (input, forget, and output); every block output is connected again to the block input [30]. The LSTM cell has the input layer X_t, output layer, the cell input state $\overline{C}_t$, the cell output state C_t, and the previous cell output state C_{t-1}. The LSTM has the gated structure can deal with long-term dependencies to allow useful information to pass through the LSTM network or ability to control a memory cell. The LSTM cell has three gates, including an input gate, a forgotten gate, and an output gate. The output gate is needed to read out the entries from the cell. The input gate is required to decide when to read data into the cell. We need a mechanism to reset the contents of the cell, governed by a forget gate. The motivation for such a design is to be able to decide when to remember and when to ignore inputs into the hidden state through a dedicated mechanism. The gated structure, especially the forget gate, helps the LSTM to be an effective and scalable model for several learning problems related to sequential data. The input gate, the forget gate, and the output gate denoted as I_t, F_t, and O_t, respectively. Fig. 14 shows the architecture of the LSTM block in detail.

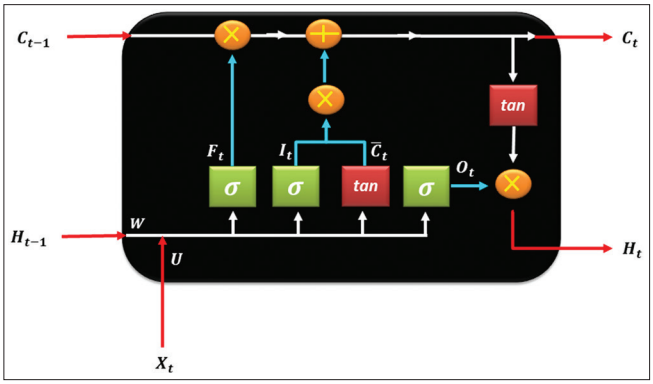

Fig. 14. The detail of schematic architecture of the long- and short-term memory block [35].

Our proposed detection system is described step by step in Fig. 15. After the preprocessing operation, the preprocessed EEG segments are fed into the LSTM cells to learn about deep-level characterizations of the EEG signals at each segment. The outputs of the LSTM cells are used as an input to the time-distributed layer (dense layer).

Our deep neural network design consists of two layers and, with using (Softmax activation function) on the top of the system. In the beginning, the segment of data entered to the LSTM layer, which it passed through 100 cells. In order, the short- and long-term memory learns about the overlapping between each segment in the same EEG signal and dissimilar EEG signal of the same class.

The best characteristic of the LSTM is the retaining information for an extended period and makes the LSTM the strongest nominee for handling long-term EEG signals. Then, the output of the LSTM layer entered as an input into the time distributed layer (dense). Finally, the dense layer output is used as an input to the Softmax layer to classify the incoming data at the output.

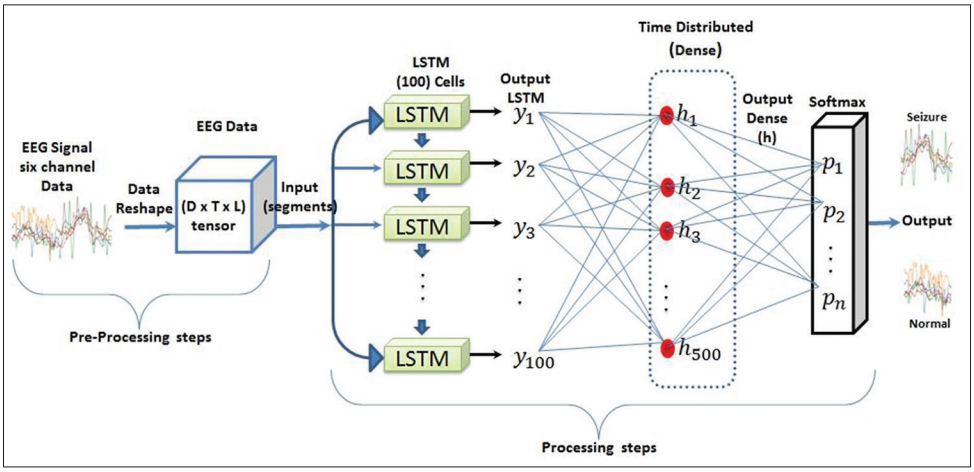

Fig. 15. Overall seizure detection system schematic diagram describes the proposed entire system: (y) is the output of long- and short-term memory layer; (h) stand for units of time distributed layer; (p) represents the probability distribution produced by Softmax.

We use k-Fold cross-validation (CV) to determine the best measure of our model performing over the entire dataset.

5. RESULTS

The data are normalized and preprocessed to select the desired part of the EEG recording. Then, a dataset containing 312 EEG segments with a length of 1024 samples for both normal and seizure with 4s duration for each segment. These segments are fed into the LSTMs model for training. The proposed model has 100 LSTM cells learn about the signal feature spikes at each segment and discriminated from the backgrounds of the signals. The time distributed layer converting this information into meaningful properties. In this study, we use (500) time distributed unit to translate learned information comes from the LSTM turned to meaningful features. Then, the Softmax classify the property of each sample into normal and seizure. All the experiments were executed in the Anaconda Navigator environment on an Intel Core i3 processor with 2.1 GHz.

To evaluate the performance of the proposed method, we use the accuracy measurement calculated and defined as follows:

$$Accuracy = \frac{True\ Positive + True\ Negative}{Total\ number\ of\ samples} \quad (6)$$

Where *True Positive* is the number of seizure segments that are correctly detected by the algorithm, and *True Negative* is the number of normal (non-seizure) segments that the algorithm correctly recognized.

We used recordings of 11 patients in the freiburg EEG database. To determine the performances of the suggested approach, 5-fold CV method was used, which is a standard mode implemented to compare the various EEG seizure detection approaches. In 5-fold CV, the dataset is divided into five different mutually exclusive folds having the same sizes. Four folds used for training and the remaining one used for testing.

This procedure was repeated 5 times. At the end of each iteration, individual accuracy was computed. The average of five obtained individual accuracies was accuracy. The total classification accuracy of 97.75% was achieved for this method. Table 1 contains the results achieved from the five-fold CV method applied to the database.

Fig. 16 shows the accuracy (accuracy based on testing) and the value of accuracy (accuracy based on testing) results of our proposed model with 5-Fold CV approach.

6. DISCUSSION

The automatic seizure detection is important in epilepsy diagnosis that can also help reduce the medical team's heavy workload. Conventionally, computing valid features that can effectively characterize the behavior of EEG signals and selecting appropriate classifier are critical but difficult and time consuming for a seizure detection system to compute valid features.

This study proposes a method to automatically perform the EEG classification. We represent an approach to detect seizures with LSTM algorithm that has been evaluated on Freiburg EEG dataset. The selecting features from the database are a great importance and appropriate characteristics that can improve the performance of classification as well. The ability of the algorithm to detect these features correctly can be measured based on the accuracy value. Therefore, it is important to detect seizures with high accuracy. In general, the classification of the seizure and non-seizure EEG signals is complex because they are nonlinear and irregular in nature

TABLE 1: Result of our proposed model with the 5-Fold CV that determines the classification accuracy

No. of fold	Folds result (%)
1	100.00
2	98.41
3	93.55
4	96.77
5	100.00
Total accuracy	97.75

CV: Cross-validation

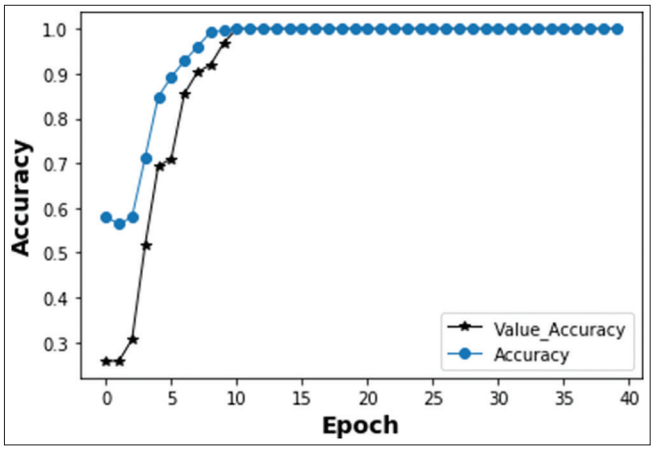

Fig. 16. The plot of showing the result of the proposed system accuracy using 5-fold cross-validation approach.

TABLE 2: The comparison of the state-of-the-art techniques with our proposed method

Method	Year	Database	Classifier	Training and testing	Acc (%)
Xie and Krishnan, 2012 [33]	2012	Freiburg and Bonn database	1-NN	10-fold cross-validation	99 100
Yu *et al*., 2018 [32]	2018	Freiburg and Bonn database	Kernel R-ProCRC	10-fold cross-validation	99.98 99.3
Alickovic *et al*., 2018 [31]	2018	Freiburg database CHB-MIT	Random forest	10-fold cross-validation	100
Tzimourta *et al*., 2019 [34]	2019	Freiburg database Bonn database	Random FOREST	10-fold cross-validation	97.74 95.60
This work	2019	Freiburg database	LSTM	5-fold cross-validation	97.75

LSTM: Long- and short-term memory, R-ProCRC: Robust probabilistic collaborative representation-based classifier

and contain many seizure-like activities throughout the entire recording. To prepare for the consequence of classification, the preprocessing was employed to process the raw EEG signals. The preprocessing on the data is important to raise the performance of the model because it removes noise and undesired parts of the signal, which leads to low complexity and higher performance. The obtained accuracy by the model using the 5-Fold CV for training and testing to determine the best measure of our model performing over the entire dataset is 97.75%.

Table 2 shows the results of seizure detection achieved by the proposed and other state-of-the-art methods based on the accuracy; the best results achieved by Alickovic *et al.* [31]. Many previous papers on seizure detection adopt the used database in this research to evaluate their algorithm. Alickovic, Kevric and Subasi [31] worked on both Freiburg (intracranial EEG) and CHB-MIT (scalp EEG) databases. They used multiscale principal component analysis for de-noising the EEG data and empirical mode decomposition, discrete wavelet transform (DWT) or WPD to decompose EEG signals. 10-fold CV was used to determine performances of the model with 8s length for each segment and 2048 samples. The model achieved an accuracy of 100%. Yu *et al.*, 2018 [32], used kernel version of the robust probabilistic collaborative representation-based classifier for the detection of epilepsy in EEG signals. This method was evaluated based on two EEG datasets (Freiburg and Bonn) with using 10-fold CV achieved 99.98% and 99.3% accuracy. Xie and Krishnan, 2013 [33], developed a wavelet-based sparse functional linear model with a simple classifier (1-NN) to classify EEG signals. They earned result 99% and 100% of accuracy than those obtained using other complicated methods for both Freiburg and Bonn EEG databases. Furthermore, 10-fold CV was used to identify the performance of the model with 16s length for each segment (4096 samples). Tzimourta *et al.*, 2019 [34], they used automated seizure detection based on DWT for feature extraction then fed into random forest classifier to separate between ictal and interictal data. They used 10-fold CV to select performances of the model with 2s length for each epoch (512 samples). They earned above 97.74% of accuracy.

To determine the performance of our method, we used 5-fold CV with 4s length for each segment (1024 samples) and achieved fourth-best performance. Although we achieved a relatively poor performance compared to others, we tackle more challenging problems of discriminating the seizure part from the background, where the pre- and post-seizure parts of the signal are placed in the background.

7. CONCLUSION

We present a method to detect epileptic seizure from EEG recordings. An LSTM block with 100 cells followed by 500-time distributed unit is used to be trained by EEG recordings. The Freiburg EEG dataset is used to train and test the model. The EEG data are bandpass to 0.5 Hz through 100 Hz to remove the noise and capture the interesting data. A notch filter is used to remove the power line noise. The EEG recordings are segmented to 4s and reshaped into images as the inputs to the LSTM. The trained model is used to detect epileptic seizure from the background. 5-fold CV is used to assess the performance of the proposed method. About 97.75% of the accuracy was achieved. For the future study, we test the proposed method using other EEG datasets.

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REVIEW ARTICLE | UHD JOURNAL OF SCIENCE AND TECHNOLOGY

A Restricted Multipath Routing Algorithm in Wireless Sensor Networks Using a Virtual Cylinder: Bypassing Black hole and Selective Forwarding Attacks

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ABSTRACT

In this paper, a simple and novel routing algorithm is presented to improve the packet delivery in harsh conditions such as selective forwarding and black hole attacks to the wireless sensor networks. The proposed algorithm is based on restricted multipath broadcast based on a virtual cylinder from the source node (SN) to the sink node (SK). In this algorithm, when a packet is broadcast by a SN, a virtual cylinder with radius *w* is created from the SN to a SK. All the nodes located in this virtual cylinder are allowed to forward the packet to the sink. Thus, data are forwarded to sink through multiple paths, but in a restricted manner so that the nodes do not consume a high amount of energy. If there are some compromised nodes in this virtual cylinder, the packets may be forwarded to the sink through other nodes of the virtual cylinder. The proposed algorithm is simulated and evaluated in terms of packet delivery rate and energy consumption. The experiment results show that the proposed algorithm increases packet delivery rate 7 times compared to the single path routing method and reduces energy consumption up to 3 times compared to flooding routing method.

Index Terms: Black hole attack, Restricted multipath, Routing, Selective forwarding attack, Virtual cylinder, Wireless sensor network

1. INTRODUCTION

Today, wireless sensors networks are used in many areas such as environment, military operations, and explorations. Since the sensor nodes have low processing, energy, and memory capabilities and it is important to establish security in such networks due to their application in critical environments especially military, this area has attracted the attention of many researchers Yick *et al.* [1] and Jamshidi *et al.* [2].

So far, various attacks [2]-[11] have been proposed against these networks. Each type of attack has a different mechanism with a different destructive effect and affects various operations and protocols; thus, each one has a different defense mechanism. Two of such dangerous attacks which are very common include black hole (BH) and selective forwarding (*SF*) attacks [10], [11]. To establish these attacks, the adversary enters the network environment, captures one or several legal nodes of the network, reprograms and injects them in the network as

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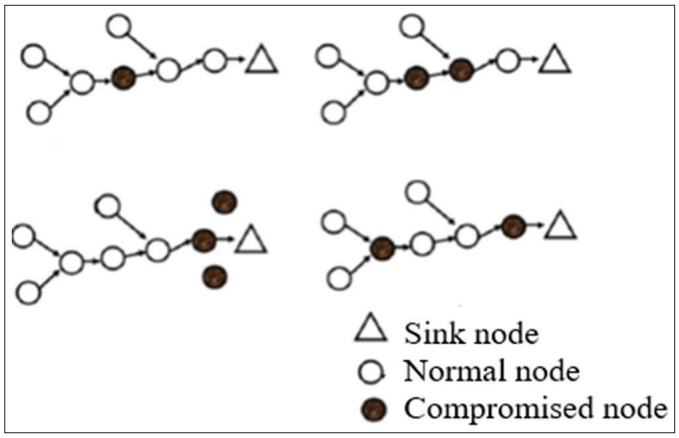

Fig. 1. Different cases of establishing selective forwarding and black hole attacks [11].

compromised nodes. As shown in Fig. 1, such compromised nodes are located along data paths to prevent the packets to reach the sink. That is, the received packets are not forwarded to the sink or base station, but they are dropped. In the *SF* attack, the compromised node only drops some of the received packets, but in the *BH* attack, the compromised node drops all of the received packets.

These two attacks are very destructive for the multi-hop routing algorithms, particularly, if the compromised nodes are located along the data flow paths. On the other hand, establishing these two attacks are very simple and low cost for the adversary. Because the compromised nodes which start these two attacks do not need to perform suspicious operations such as injecting incorrect packet to the network, manipulate data, broadcast false or multiple IDs, and establish a high-speed link; they only need to refuse to forward some of the received packets to the destination. In most cases, even if there is no compromised node in the network, the packets are dropped due to various reasons such as collision [10], [11].

The algorithms which have been proposed to defend against these two attacks like [10], [12]-[23] employ methods such as multiple flow topologies and nodes with special capabilities and multi-hop verification. In general, problems of the presented algorithms include non-scalability, security, complexity, high cost, and slow reaction.

In this paper, a restricted multipath routing algorithm is presented for reliable and low-cost delivery of the data to the destination and defending against *SF* and *BH* attacks in wireless sensor networks such that shortcomings of the previous algorithms are resolved and it can be employed in resource-constraint sensor networks.

2. RELATED WORK

SF attack was first presented in Karlof and Wagner [10], and the first approach to defend against this attack is to use multipath routing protocols. In this method, the packets are forwarded from the source node (SN) to the destination through n independent paths. This method is completely robust against *SF* attack until maximum of n-1 nodes is captured by the adversary; but, if more than n+1 nodes are captured, this method might not operate properly.

It has been mentioned in Satyajayant *et al.* [12] that the *BH* attack is one of the dangerous attacks against wireless sensor networks which can be easily established by the adversary with a low cost. Then, an algorithm has been presented to defend against this attack which is based on multi-sink to protect data flows against *BH* attacks. In this algorithm, sensor nodes employ a set of control messages throughout the network to explore a subset of the sinks. Then, they transmit data to accessible sinks.

In Abasikeleş-Turgut *et al.* [13], an algorithm has been presented to defend against *BH* and sinkhole attacks. This algorithm can be applied to low-energy adaptive clustering hierarchy clustering-based sensor networks. In this study, three different models have been considered, and different mechanisms have been presented to handle them.

In Sheela *et al.* [14], it has been mentioned that *BH* attack is one of the Denial of Service attacks which drops packets. Then, an algorithm based on mobile agents has been proposed to defend against this attack. A mobile agent is a program segment with self-controllability which can be applied to distributed applications, especially dynamic networks. The agents proposed in this study are loaded on several sinks and detect the compromised nodes by patrolling the network.

In Nitesh and Diwaker [15], another algorithm has been proposed based on multiple sinks to defend against *BH* attack. The purpose of this study is to ensure that data are delivered to at least one sink node (SK) by establishing several sinks in different areas of the network and transmitting data to different sinks, simultaneously.

In Deepali and Gupta [16], an adaptive exponential trust-based algorithm has been proposed for calculating the trust factor of each node in each computational cycle for detecting the balckhole *(BH)* attack. Furthermore, it has been claimed that the proposed mechanism not only reduces energy

consumption but also it reduces the time required to detect the *BH* attack. Furthermore, an adaptive threshold has been used to reduce false alarm rates.

In Baishali [17], an algorithm has been proposed to defend against *BH* attack in mobile *ad hoc* networks. This algorithm can detect the compromised nodes in a network which employs the *Ad hoc* On-Demand Distance Vector algorithm. In this algorithm, nodes use a timer to wait for the acknowledgment (ACKs) to return. If the timer is reset and the ACK is not received, *BH* attack along data transmission path is detected.

In Shila *et al.* [18], a channel-aware algorithm has been proposed, which detects compromising behavior of the nodes from the bad behavior of the transmission channel. This algorithm is based on channel estimation and traffic monitoring strategies. If the supervised missing rate is higher than the estimated normal missing rate, those nodes are detected as an adversary.

In Li *et al.* [19], an algorithm based on sequential mesh test based has been presented for detection of *SF* attack in sensor networks. This scheme is centralized and operates on cluster-based networks. The sensor node u transmits its packets to the next hop, node v, and if node v does not transmit the packet in constant time, node u reports to the cluster head that the packet has been dropped. After receiving packet drop reports, the cluster head applies the sequential mesh test based on the suspicious node.

In Hu *et al.* [20], a secure routing algorithm based on monitoring node and trust mechanism has been proposed. In this algorithm, trust is adjusted based on the transmission rate of the packets and residual energy of the node. This detection and routing algorithm is general because it considers both the lifetime of the network and its security.

In Yu and Xiao [21], another algorithm has been presented in which a multi-hop acknowledgment scheme is used considering the responses received from the intermediate nodes to broadcast the warning messages in the network. In this algorithm, each intermediate node along the data transmission route cooperates in detecting the compromised node. If an intermediate node observes a bad behavior from its upstream or downstream node, it generates an alarm packet and transmits it to the SN or the base station. Then, the SN and the base station can make a decision and respond using a complicated intrusion detection system.

In Xiao *et al.* [22], a technique has been proposed for detecting the compromised nodes in the *SF* attack. This algorithm is the improved version of the previous technique [21]. In this algorithm, some of the intermediate nodes along the route are selected as checkpoint nodes randomly which have to generate ACKs for each received packet. Furthermore, each node requires a one-way hash key chain to ensure that the packets are authenticated. Furthermore, delay mechanisms are used to transmit this one-way hash key. In this algorithm, each intermediate node along the packet transmission route has the potential to explore the packets which are lost abnormally, and if the intermediate node does not receive enough ACKs from the downstream checkpoints, it can detect the compromised nodes.

3. MULTI-SINK ARCHITECTURE

In each wireless sensor network, there is usually one or more sensor nodes called SK which collects total data of the network. Destination of all reported packets in sensor networks is the SKs. When sensor nodes observe a determined event, they generate the required report packets and deliver them to the sink through multi-hop routing algorithms. Considering the number of the SKs, their location, and they are being mobile or stationary, various architectures are created in the network which might change mechanism of the routing algorithms [23,24].

One of the common architectures is multi-sink architecture. In this architecture, as shown in Fig. 2, there are several SKs established on one side of the network. The SKs might either communicate directly with each other or communicate with the base station (where the network manager is located). In this architecture, the sufficient condition for data delivery is that data are delivered to at least one of the sinks. In other words, the packet generated by one sensor node does not have to be delivered to a specific SK, but it is sufficient that is delivered to one of the sinks. This architecture has three main advantages [23,24]:

3.1. Increasing Network Lifetime

If there is only one sink in the network, its neighboring sensor nodes transmit high traffic, and their energy is discharged very soon, which reduces network lifetime. However, if the multi-sink architecture is used, this problem is resolved.

3.2. Load Balancing

Multiple sinks in the network might result in several routing trees in the network which might balance load among nodes of the network.

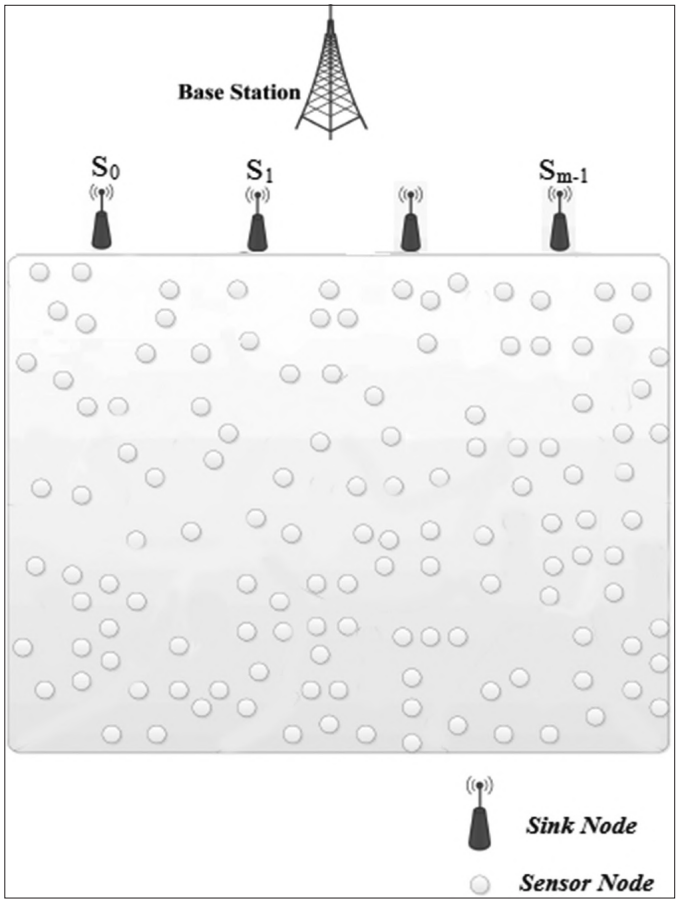

Fig. 2. An example of a sensor network with multi-sink architecture.

3.3. High Packet Delivery Rate

It is obvious that when there are several sinks in the network, the probability of delivering the packets to the destination increases because of the probability that there exists a route from the source to the destination (sink), especially in low-density networks, increases.

Considering the features and advantages of the multi-sink architecture, it is used in this paper to design the proposed routing algorithm to defend against *SF* and *BH* attacks.

4. SYSTEM ASSUMPTIONS

Sensor networks are categorized into three main groups including SKs, SNs, and forwarding nodes (FNs). The SNs generate the report packets. The packets generated by the SNs are delivered to the SKs through FNs. For instance, SNs might be deployed in the boundary areas or the adversary environment and generate the required reports in case of adversary operations and deliver the reports to the sink through multiple hops. Each node has a unique ID and is aware of its location. The network area of interest is a 2D environment in which SNs, SKs, and FNs are deployed randomly. All nodes have the same radio range equal to r. Furthermore, it is assumed that the nodes communicate with each other through the wireless radio channel and employ the omnidirectional broadcast. Furthermore, it is assumed that the SNs are not only aware of their location but also they are aware of the location of the SKs. The network environment is not safe, and the adversary can capture some sensor nodes and reprogram them as compromised nodes.

5. THE PROPOSED ALGORITHM

Although using single-path approaches for delivering data to the destination in sensor networks imposes low overhead to the nodes, it cannot ensure that parasite generation, etc., is not established in the network particularly in case of *SF* and *BH* attacks. Also, the flooding method, although more reliable, imposes much overhead on the nodes of the network. Thus, they are not cost-effective. In this section, a restricted multi-path approach is proposed for reliable and cost-effective delivery of data to the destination such that it overcomes *SF* and *BH* attacks in the sensor network and delivers data to the sinks with high reliability.

In the proposed method, a virtual cylinder (with diameter $2w$) is created from the SN to a SK and only the nodes in this cylinder are allowed to forward packets to the destination. Each SN inserts its spatial coordinate (L_s) in the packet while generating a data packet. Then, the packet is broadcast so that all of its neighbors receive it. However, only the nodes adjacent to the virtual cylinder forward the received packet. Each node which has received the packet, for example, node v, first extracts the spatial coordinate of the SN which has generated this packet and compares it with its own spatial coordinate, L_v, to find out if it is in the virtual cylinder or not. If node v is inside the virtual cylinder, it forwards the packet; otherwise, it drops the received packet. This process is continued until the packet is delivered to the sink through restricted multiple paths. Therefore, if there is a compromised node along one path, the packets can be delivered to the sink through adjacent paths using the proposed method.

In the following, details of the proposed algorithm are described considering Fig. 3. It is assumed that the SN A intends to transmit a report packet to the sink S_1. In this case, the routing vector is defined as $\overrightarrow{AS_1}$. The packet is passed

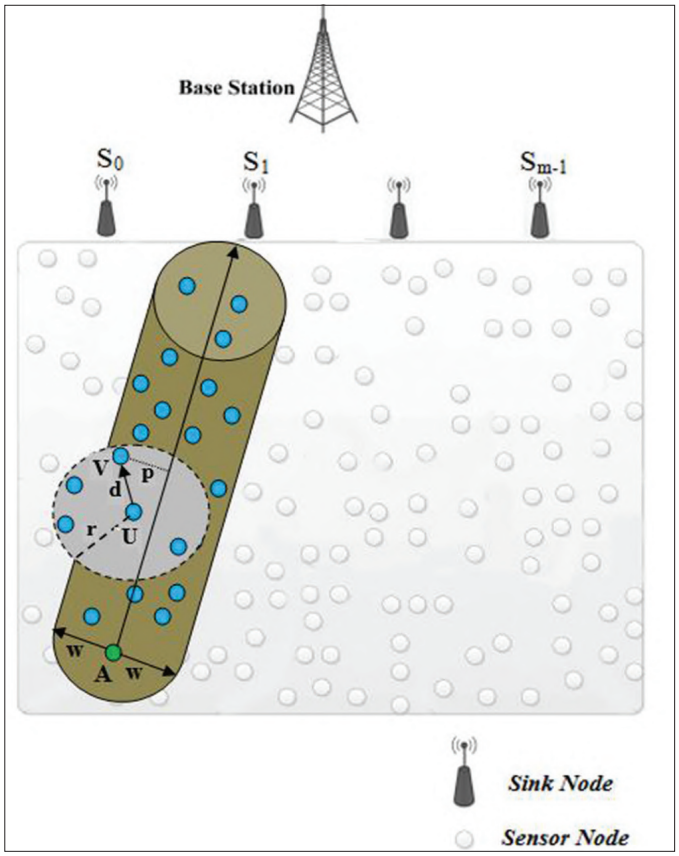

Fig. 3. The proposed virtual cylinder.

in the range of the routing vector from a virtual routing cylinder with a predetermined radius of w to reach the destination.

Assuming that the SK S_1 is located in the spatial coordinate of $(x_s - y_s)$ and the SN A is located in the spatial coordinate of $(x_A - y_A)$, then the equation of the line passing through these points and the vector passing center of the virtual cylinder are calculated as Equation (1):

$$y - y_0 = m\ (x - x_0) \tag{1}$$

$$y_s - y_A = m\ (x_s - x_A)$$

Here, m is the slope of the line calculated using Equation (2):

$$m = \frac{y_A - y_s}{x_A - y_s} \tag{2}$$

The SN A calculates the equation of the line passing from itself and the SK S_1 and inserts it along with the report data in a packet and broadcasts it. This packet is forwarded to the sink by the nodes located in the virtual cylinder. Assuming that the radio range of the nodes is r, the packet broadcast by each sensor node is broadcast in the radius of r, and each node which is located in this area receives the packet.

Each node which receives the report packet extracts the equation of the line inserted in this packet and calculates its distance from this line. It should be noted that the line equation is calculated only once by the SN, and it is inserted in the report packets. The FNs do not need to calculate the line equation, but it is sufficient to calculate their distance from the line. When a packet is transmitted by a node inside the virtual cylinder, like node U in Fig. 3, all nodes located in its radio range, receive the packet. Node U has four neighbors where two of them are outside the virtual cylinder and two other nodes are inside the virtual cylinder. Each node adjacent to node U, like node V, calculates its distance from the central line of the virtual cylinder, P, according to theorem 1.

Theorem 1: Assuming that $\vec{A}$ and $\vec{B}$ are two points on the 2D space of the line $\vec{L}$ and $\vec{P}$ is an independent point which is not on this line, the line vector equation is as (3):

$$\vec{A} + t\vec{M} \tag{3}$$

Here,

$\vec{M}$ is the direction vector obtained using (4):

$$\vec{M} = \vec{B} - \vec{A} \tag{4}$$

And t is a running parameter calculated according to (5):

$$t = \frac{\left(\vec{P} - \vec{A}\right) \bullet \vec{M}}{\vec{M} \bullet \vec{M}} \tag{5}$$

Now, the distance of $\vec{P}$ from line $\vec{L}$ is calculated as (6):

$$p = \left| \vec{P} - (\vec{A} + t\vec{M}) \right| \tag{6}$$

Proof of this theorem is given in Equation [25].

For each node V which receives the report packet, if its distance from the central line of the virtual cylinder is smaller than w, means $p \leq w$, the receiver node V is inside the virtual cylinder and it is allowed to forward the received packet. Otherwise, $p > w$, node V is outside the virtual cylinder and should not forward the received packet.

Furthermore, in the proposed algorithm, each sensor node has a buffer which stores the ID of the last packet forwarded from each SN as a result of which the sensor node refuses to repetitive packets. Since all the SNs located in the virtual cylinder forward the packets, a packet moves toward the corresponding sink through multiple paths (inside the cylinder). Thus, if some of the nodes located inside the cylinder are compromised by an adversary and drop the report packets (*SF* and *BH* attacks), it is still probable that the packets are delivered to the sink through other paths. On the other hand, multipath is controlled by the virtual cylinder to prevent a packet from being broadcast in the whole network and prevent high energy consumption.

6. SIMULATION RESULTS

In this section, the proposed algorithm is evaluated and its simulation results are presented. MATLAB is used to simulate the proposed algorithm.

6.1. Simulation Model

In the simulation model, the network is comprised of $N = 300$ sensor nodes which are deployed in a 100×100 m area, randomly. The network includes three SNs where each SN generates a packet at each simulation instant and transmits it to the sink. The nodes have GPS and are aware of their location. SNs are located in a fixed and specific location of the boundary area of the network. The network includes $m = 3$ SKs which are located in the network environment. SNs are aware of the location of the SKs. The radio range of the nodes is $r = 10$ m. The radius of the virtual cylinder is w meters. Furthermore, it is assumed that the network is comprised of *SF* compromised nodes which establish the SF attack and *BH* compromised nodes which establish the *BH* attack. The compromised nodes which establish the *BH* attack drop all the received packets but the compromised nodes which establish the *SF*, drop only 50% of the received packets. The initial energy of every node is set to be 10 Joules. Energy consumption for transmission and reception of the packet is 0.016 and 0.0016 joules. Each experiment is repeated 50 times, and the final result is the average of these 50 runs.

6.2. Evaluation Metrics and Compared Algorithms

The evaluation metrics are as follows:

6.2.1. Packet delivery rate

Packet delivery rate is the number of the packets received by the sinks to the number of the packets generated by the SNs.

6.2.2. Average residual energy

Average residual energy is the average residual energy of sensor nodes after simulation time. To calculate this metric, the energy of the compromised nodes and SKs is not considered. It is assumed that the compromised nodes and SKs have no energy limitation.

Since the proposed algorithm is a restricted multipath algorithm; that is, packets are only transmitted to the sinks through the nodes located on the virtual cylinder. Thus, its efficiency is compared with the single-path and flooding methods. In the single-path algorithm, the SN transmits data to a SK through one path (shortest path). In the flooding method, packets are broadcasted in the whole network to reach the SKs. It is clear that in the single-path method, the minimum energy is consumed, but the packet delivery rate might be low especially if the compromised nodes of the *SF* or *BH* attack exist along the data path. However, in the flooding method, the data delivery rate is high even when there is a large number of compromised nodes in the network, but the energy consumption of this algorithm is very high. The proposed algorithm is between these two algorithms. That is, it tries to control energy consumption and keep the packet delivery rate at an acceptable level when there exist *SF* and *BH* attacks, by adopting a restricted multipath method.

6.3. Experiment Results

6.3.1. Experiment 1

In this experiment, the efficiency of the proposed algorithm is evaluated in terms of packet delivery rate and energy consumption, and the results are compared with single-path and flooding methods. In this experiment, $SF = 25$, $BH = 25$, and $w=15$, this experiment is executed for periods of 25–100 s. At each simulation instant, each SN generates and broadcasts a packet.

The results of this experiment in terms of packet delivery rate and average residual energy are given in Figs. 4 and 5, respectively. The results show that the packet delivery rate of the flooding algorithm is almost 100% while it is 90% and 12% for the proposed algorithm and the single-path algorithm, respectively. In the flooding algorithm, since each packet is broadcast in the network, it is forwarded to the sinks through different paths. Thus, despite *SF* and *BH* attacks, at least one version of this packet reaches one of the sinks. However, as shown in Fig. 5, the flooding algorithm discharges energy of the nodes significantly because there are a large number of transmission and reception operations for one packet in the network.

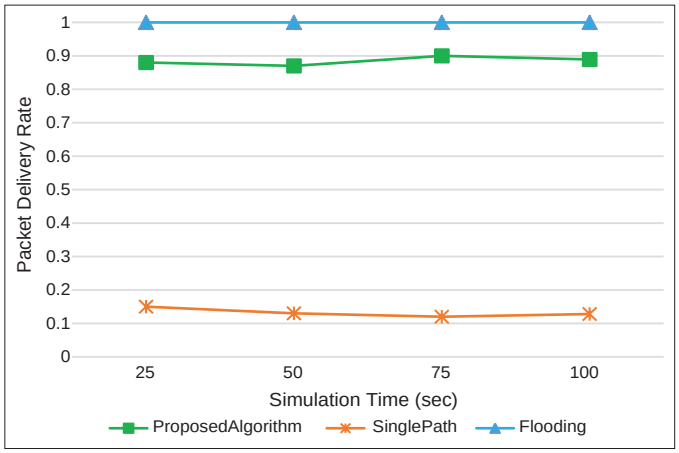

Fig. 4. Comparing the efficiency of the proposed algorithm with the single-path and the flooding algorithms in terms of the packet delivery rate.

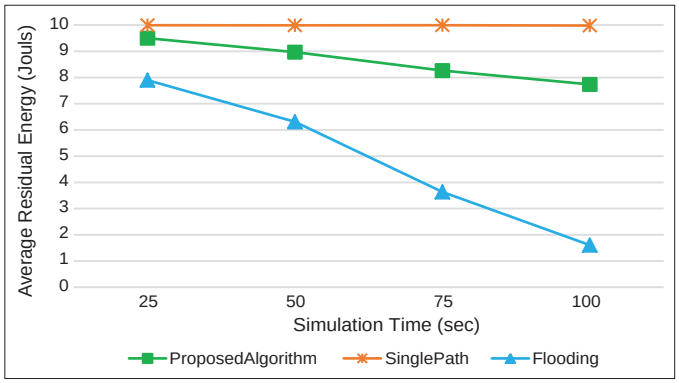

Fig. 5. Comparing the efficiency of the proposed algorithm with the single-path and the flooding algorithm in terms of the average residual energy.

In the single-path algorithm, packets are forwarded to a SK through the shortest path greedily. Thus, if there is a compromised node along this path, it prevents the packet to reach the destination as a result of which the packet delivery rate is reduced significantly. However, as shown in Fig. 5, this method is very optimal in terms of energy consumption because no additional or repetitive packet is broadcast in the network.

However, the proposed algorithm tries to forward the packets through restricted multiple paths and the virtual cylinder toward a SK. Hence, even if there exist compromised nodes, the packets can be delivered through different paths. Therefore, the packet delivery rate is acceptable. On the other hand, energy consumption is much less than the flooding algorithm.

6.3.2. Experiment 2

In this experiment, the effect of the radius of the virtual cylinder, w, on the efficiency of the proposed algorithm in terms of packet delivery rate and the energy consumption is investigated. In this experiment, SF = 25, BH =25, and w = 5~20 and its effect on the efficiency of the proposed algorithm are investigated. The simulation time is considered to be 50 s. The results of this experiment are given in Fig. 6 and Fig. 7 for the packet delivery rate and average residual energy of the nodes, respectively.

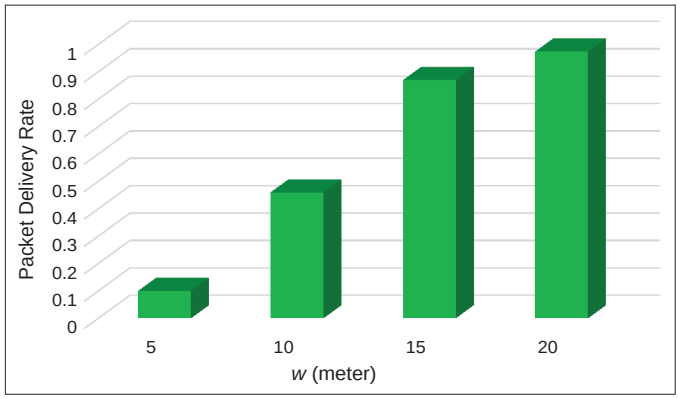

Fig. 6. The effect of the radius of the virtual cylinder, w, on the packet delivery rate of the proposed algorithm.

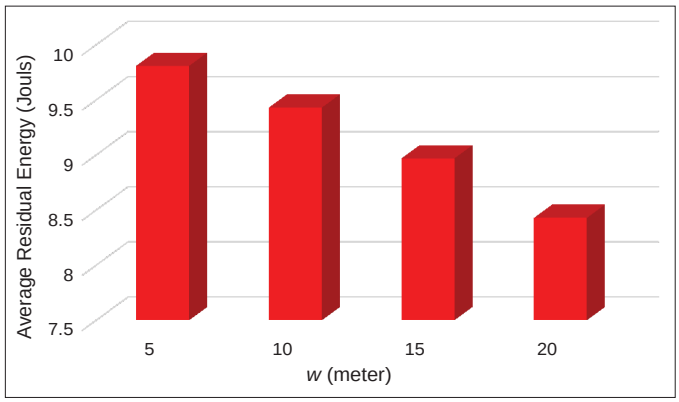

Fig. 7. The effect of the radius of the virtual cylinder, w, on the average residual energy of the proposed algorithm.

As can be seen, w affects the efficiency of the proposed algorithm, significantly. By increasing w, the radius of the virtual cylinder becomes larger and covers more nodes as a result of which, packets are forwarded to the sink through more paths which increase packet delivery rate and energy consumption.

7. CONCLUSION

In this paper, a novel and simple routing algorithm is presented to reduce the destructive effects of these attacks.

The proposed algorithm is based on restricted multipath broadcast based on a virtual cylinder from the SN to the SK. In this algorithm, when a packet is broadcast by a SN, a virtual cylinder is created from the SN to one of the SKs of the network. All the nodes located on this virtual cylinder are allowed to forward packets to the sink. Thus, data are forwarded to the sinks through multiple restricted and adjacent paths. The proposed algorithm is simulated and evaluated in terms of packet delivery rate and energy consumption. The results of the proposed algorithm are compared with single-path and flooding algorithms. The comparison results show that the proposed algorithm is 7 times better than the single-path algorithm in terms of packet delivery rate, and it is 3 times better than the flooding algorithm in terms of energy consumption.

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ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

An Interactive and Predictive Pre-diagnostic Model for Healthcare based on Data Provenance

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ABSTRACT

The future of health care may look completely different from the current clinic-center services. Rapidly growing and developing technologies are expected to change clinics throughout the world. However, the health-care delivered to impaired patients, such as elderly and disabled people, possibly still requires hands-on human expertise. The aim of this study is to propose a predictive model that pre-diagnose illnesses by analyzing symptoms that are interactively taken from patients through several hand gestures during a period of time. This is particularly helpful in assisting clinicians and doctors to gain a better understanding and make more accurate decisions about future plans for their patients' situations. The hand gestures are detected, the time of the gesture is recorded, and then they are associated with their designated symptoms. This information is captured in the form of provenance graphs constructed based on the World Wide Web Consortium provenance data model. The provenance graph is analyzed by extracting several network metrics and then supervised machine learning algorithms are used to build a predictive model. The model is used to predict diseases from the symptoms with a maximum accuracy of 84.5%.

Index Terms: Hand Gesture Detection and Recognition, Pre-diagnosis Disease, Data Provenance, Provenance Network Analytics, Machine Learning Algorithm

1. INTRODUCTION

As technology has become a part of human's life for decades, the study of the relationship between humans and computing technology in so-called human-computer interaction (HCI) is essential to serve the human's needs [1]. While many developed countries gradually step into population aging, many researches on elderly people have been conducted, especially about the interaction with computers for seniors [2]. The number of disabled people is also rising due to wars [3]. Therefore, it is really imperative to consider how computing technology will be able to meet the needs of these important users. Moreover, with the widespread popularity of computing technology in modern society, information technology becomes continuously incorporated into the daily lives of people [2], [4]. Nowadays, the use of technology such as computers in health care is significantly developing and growing, becoming an essential part of clinical services [5].

With the development of ubiquitous computing technology, end-user interaction approaches with traditional mouse and keyboard and electronic pen are not sufficient [6]. Therefore, we have to think about other ways to interact or communicate with computing technologies, especially for these two types of users (elderly and disabled) who may not

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be able to communicate with technologies normally due to several body problems that limit their movements. There are several gestures that can be used to interact with technologies, such as head, face, hand, and finger movements [4], [5]. These gestures might be used in various fields, namely health care [7], speaking, listening [8], gaming [9], and many others. In this research paper, hand gesture is chosen instead of sign language to make a communication between these two types of users and computing technologies since it has the advantages of simplicity, requiring less learning time, and it can be attractive and make applications more accessible [1]. However, sign language is more complex for elderly and disabled patients because it requires knowledge and more training to learn.

The World Wide Web Consortium (W3C) standardized provenance (PROV) data model defines data provenance as a technique that describes the origin and history of data [10]. Data provenance has been successfully employed in a variety of applications, including description of patient's historical information [11]. The primary role of data provenance is to connect pieces of data with the processes that have made the data and to document how data are transformed during their life cycle [12]. This paper used provenance graphs to represent relationships between symptoms and related diseases, and also to record patients' history information, because according to Asan and Montague [7] and Shickel *et al.* [13], recording health information provides a great potential that can be used to improve the quality of care. In addition, in health-care data setting, provenance is able to deliver audibility and transparency and accomplish trust in software systems [11]. Machine learning classification algorithms are currently well appropriate for analyzing medical data. Furthermore, there is a lot of work done in medical diagnosis for specific diagnostic problems [14].

In this paper, we propose a system that is capable of predicting pre-diagnosis of potential diseases based on data provenance with machine learning algorithms. The main idea is to help clinicians in Kurdistan Region of Iraq (KRI) to monitor and take care of elderly and disabled patients. In particular, this model is helpful for physicians to make better, faster, and more accurate decisions about patients' health conditions. The pre-diagnosis process is conducted using a series of symptoms provided by the user using a set of hand gestures. Each hand gesture is associated with a symptom. Different patterns of hand gestures are captured and processed by an HCI sub-module. The hand gestures, the time of their occurrence, and their relationships with the patient and the diseases are stored as provenance graphs. Network metrics are extracted from these provenance graphs as aggregate information. This information is fed to a prediction model that uses three supervised machine learning algorithms, namely, decision tree classifier (DTC), K-nearest neighbor (KNN), and support vector machine (SVM). The highest accuracy rate is produced by the DTC algorithm with approximately 84.5%, which is higher than the results of prior studies that are discussed in experimental results section.

The rest of the paper is organized as follows: The related work on designing medical applications based on data provenance with machine learning, and diagnosis diseases are reviewed in section 2. Section 3 provides a theoretical background which gives an explanation for the conceptual view of data provenance, and introduction for different types of machine learning algorithms. In Section 4, the study method for the proposed work is illustrated by providing the recognition of hand gestures, representing provenance graphs, and examining machine learning algorithms. Constructing the dataset of the system and building a predictive model are discussed in Section 5. Experimental results are discussed in Section 6. Finally, in Section 7, the conclusions and directions for future work are presented.

2. THEORETICAL BACKGROUND

In this section, provenance and several types of supervised machine learning algorithms are explained.

2.1. Conceptual View of Data Provenance

Data provenance is the technique that illustrates what influenced the generation of an object that would be physical, digital, or conceptual [11]. It has become a very significant topic in many scientific communities since it displays the data movement in systems [15], [16]. Furthermore, given information about the place data originated from, how they come in their present states, and who or what acted on them helps users to establish trust in the data. Provenance can show resources and relations that have affected the construction of the output data and are commonly expressed as directed graphs (digraphs) [17]. The primary aim of the W3C standardized provenance is to enable the extensive publication and exchange of provenance over the web [18]. The provenance data model is subject to a set of constraints and inference rules [19], which are useful in validating the provenance information [20] and are essential for preserving graphs integrity when converting provenance graphs [21], [22]. To establish trust of data, these properties must be maintained when capturing provenance information and constructing provenance graphs [23].

The graph-based model is built on three main concepts, namely, entity, activity, and agent. Entity can be defined as real or imaginary, or any kind of things, physical, or digital. Activity is a procedure that happens over a period of time and may affect the state of entities and generate new ones. The agent is something that takes some form of responsibility for an activity, or for another agent's process. The relationships that normally occur between entities, agents, and activities can be described by the means of the graph, as shown in Fig. 1.

Fig. 1 represents the core provenance data model components. Each activity can start and finish at a particular time; these processes are described using two relations: *prov: startedAtTime* and *prov: endedAtTime*. In addition, during activities lifetime, they can use and generate a variety of entities, which are presented with *prov: used* and *prov: wasGeneratedBy,* respectively. To provide some dependency information, an activity *prov: wasInformedBy* another activity without providing activities' start and end times. *prov: wasDerivedFrom* relation can be used to form a transformation from one entity to another. In addition, agents have responsibilities for any activity and entity within provenance which is described using relations: *prov: wasAssociatedWith* and *prov: wasAttributedTo,* respectively. Finally, agents can be responsible for other agents' actions which express as the influencing agent *prov: actedOnBehalfOf* another.

2.2. Machine Learning Algorithms

Machine learning algorithms are a group of algorithms or processes that help a model to adapt to the data [24]. Furthermore, machine learning algorithms usually specify the way the data are transferred from input to output, and how the model learns the appropriate mapping from input to output. The following are three types of supervised machine learning algorithms that are introduced.

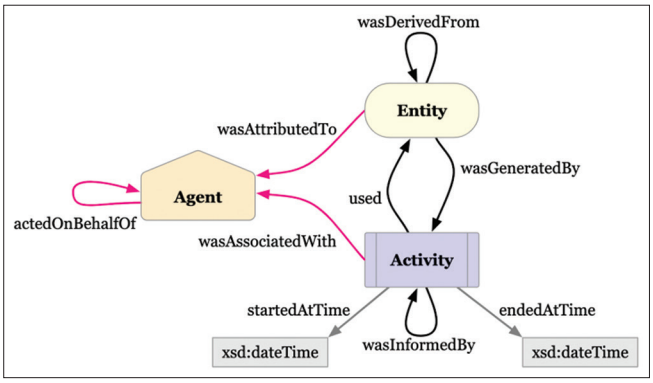

Fig. 1. Core provenance data provenance [16] (Relationships between entity, agent, and activity).

2.2.1. DTC

It is a supervised learning algorithm that is typically applied for classification problems. DTC breaks down data into small subsets at the same time, a related decision tree will be incrementally developed [24].

2.2.2. KNN

It is a simple algorithm that stores all accessible cases and groups new cases by a majority vote of its "K" neighbors [25], [26]. The case being allocated to the class is the most common among its KNN measured by distance functions, which would be "Manhattan," "Euclidean," "Minkowski," and "Hamming Distance" [25].

2.2.3. SVM

SVMs are well-known supervised classification algorithms that separate various groups of data [27], [28]. These vectors are grouped by optimizing a specific line so that the neighboring point in each group will be the farthest away from each other. SVM can be used for both regression and classification problems [29], [30].

3. RELATED WORK

Huynh *et al.* [12] proposed a number of network metrics for provenance information, and then they applied machine learning techniques over metrics to build predictive models for several key properties of the data. They adopted the provenance data model in their analytics. They discovered 22 metrics as features that were presented as a generic and principled data analytics method for analyzing data provenance graphs. Then, they used this method through the DTC technique to construct predictive models based on the provenance information. Moreover, they applied this method on the real-world data from three different applications, which, respectively, conducts the owner's identification of provenance documents, evaluates the quality of crowdsourced data, and describes the instructions from chat messages in an alternate reality game.

Choudhury and Gupta [14] presented diabetes disease detection through applying five supervised machine learning techniques. The dataset contains a total number of 768 samples and 9 attributes. There are two types of classes in their study, which are: Positive class (shows the person is diabetic) and negative class (indicates the person is not diabetic). In addition, their study presents a comprehensive comparative study on several machine learning algorithms based on a number of parameters, such as accuracy, recall,

precision, and specificity. Eventually, they found that the Logistic Regression algorithm provides the best accuracy result to classify the diabetic and non-diabetic samples.

Enriko [31] performed a comparative study of heart disease diagnosis systems using ten data mining classification algorithms, such as DTC, SVM, KNN, Naive Bayes, and Logistic Regression. Medical record data are gathered from a cardiovascular hospital. Based on several parameters that were taken from patients, including blood pressure, chest pain, shortness-of-breath, palpitation, and cold sweat, machine learning algorithms are used to analyze a sample of cardiovascular patients' data and predict the heart disease type they may suffer. After applying the algorithms, they stated that the KNN algorithm provides attractive results since it is always one of the top three algorithms for accuracy and performance.

The diagnosis of liver disease at the primary stage is essential for better treatment. However, it will be very difficult task for doctors if the symptoms become apparent when it is too late. To overcome this issue, Lavanya *et al.* [32] proposed a method that can be used for diagnosing liver diseases in patients using machine learning algorithms. The techniques were used include SVM, Ada Boost, DTC, and Naive Bayes. Furthermore, the major objective of their work is to use different classification algorithms to identify patients who have liver disease or not. They used a multivariate dataset that contains ten variables, namely, age, gender, total Bilirubin, and direct Bilirubin which are information about participants. All values are real integers. It contains records of liver patients up to 416 and non-liver patient records of up to 167. According to their results, the Ada Boost technique resulted highest accuracy of 75.6%.

Diabetes is a set of diseases in which the human body cannot control the level of sugar in the blood. Alaoui *et al.* [33] proposed a system to classify female patients into two groups: Having diabetes or not. They used a dataset that is related to diabetes in women of 21 years or older. The major aim of this paper is to make a comparative study between four machine learning classification algorithms, namely, Naive Bayes, Neural Network, SVM, and DTC, to select the best algorithm that classifies patients more accurately. They also used two different types of data mining tools: Weka and Oranges to run the selected algorithms [34]. They have made a comparison between selected classification algorithms. According to the accuracy results that they gained, SVM has the highest accuracy result, so they use it to classify the above two groups.

The above prior studies are the most related to the proposed system and also the results of some of them are compared with the results of the proposed system in section experimental result.

4. THE PROPOSED SYSTEM

In this section, our proposed method for pre-diagnosing diseases is discussed in detail. Patients can interact with the system using non-verbal communication to understand the patient's situation through five hand gestures. Each gesture represents a specific type of symptom, as shown in Fig. 2.

- One-finger hand gesture: It shows that the patient has a headache symptom.
- Two-finger hand gesture: This hand sign indicates that the patient has a shortness of breath problem.
- Three-finger hand gesture: It shows that the patient has a chest pain symptom.
- Four-finger hand gesture: Four-Finger hand sign represents that the patient has a vomiting issue.
- Five-finger hand gesture: Abdominal symptom represented through the five-finger gesture.

The steps of the proposed system are summarized in Fig. 3. The system performs various processes to identify the disease that the patient suffers from. The steps are as follows:

1. Reading, detecting, and recognizing hand gestures.
2. Relating each gesture to the symptom that it represents.

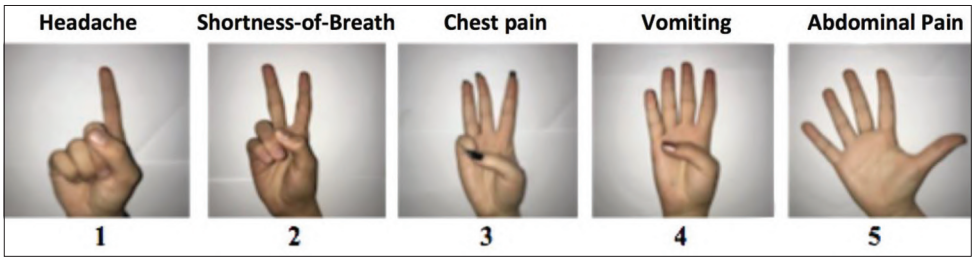

Fig. 2. Sign language digits dataset from 1 to 5 hand signs.

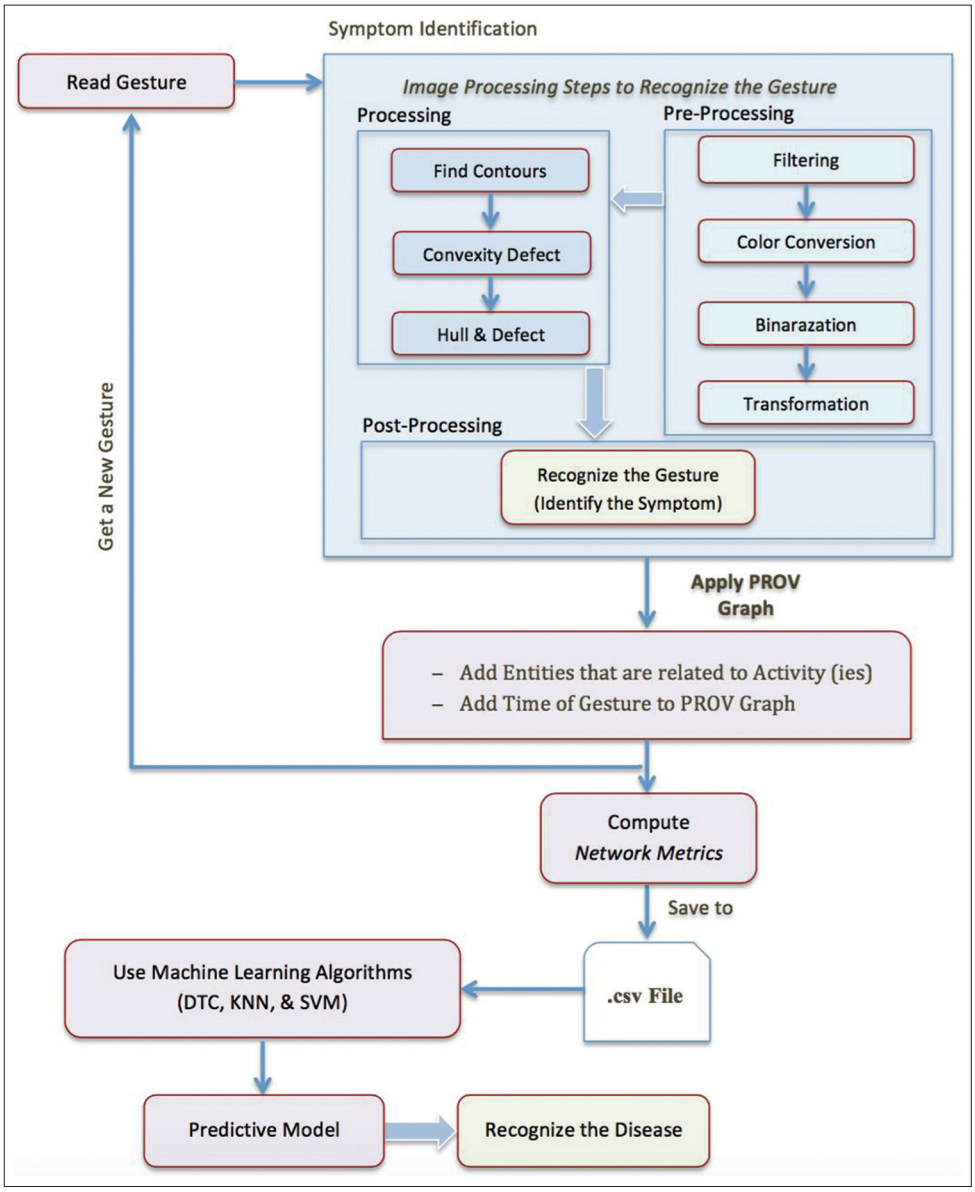

Fig. 3. Block diagram of the proposed system.

3. Constructing a provenance graph that represents the relationships among patients, symptoms, and diseases.
4. Extracting various network metrics from the provenance graph.
5. Using a variety of machine learning techniques to build a predictive model based on the network metrics.

4.1. Detecting and Recognizing Hand Gesture

The hand gesture recognition process is divided into three major steps, namely, pre-processing (Detection), processing (Feature Extraction), and post-processing (Recognition) [1], [35]. Each step works on the result of the previous step.

In the pre-processing detection step, several image filters, such as Gaussian blur, erosion, and threshold are implemented to detect the hand region of the images by converting the skin color of the hand to white and the rest of the image to black. Fig. 4 illustrates the results of the pre-processing step.

Feature extraction is implemented by the convexity defect technique on the images, which is initiated through discovering the contour of the hand. Then, the convex hull process is applied to describe the shape of the hand as a polygon, as shown in Fig. 5. After that, we find the variance between the contour and convex hull which defines as

convexity defect to find the number of defects of the hand gestures. As a result, these features are stored to be used in the last process to recognize hand gestures.

In the post-processing step, the numbers of defects that can be used to find the angle between two fingers are found. Furthermore, the parameter counter of the angle is calculated when the value of the angle is equal to or smaller than 90°, and the counter value is incremented until it reaches the maximum number of defects for one hand, which is four. The counter should be incremented by one for each gesture, since when the counter equals to zero, it means that the gesture has one finger, and it is true for all the other gestures.

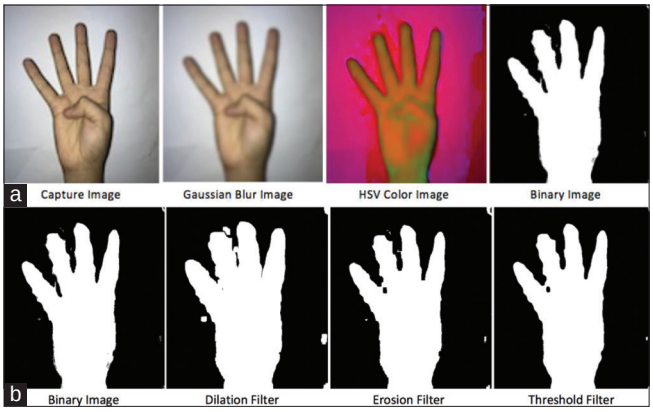

Fig. 4. The results of the pre-processing step. (a) Captured image from original to binary image, (b) applying several types of filtering on the binary image.

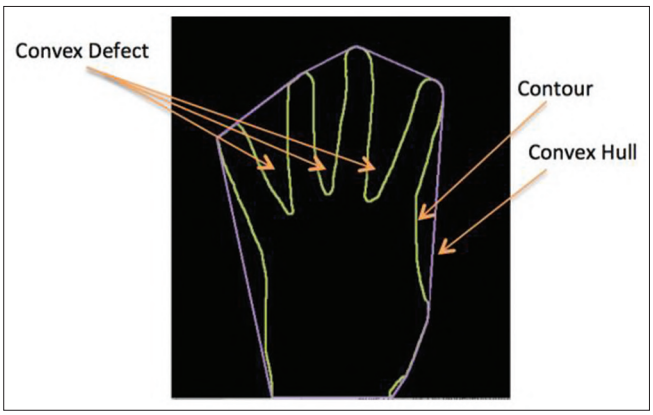

Fig. 5. Handshape with contour and convex defect.

4.2. Constructing Provenance Graphs Based on Different Types of Symptoms

4.2.1. Identification of symptoms and related diseases

A symptom, or side effect, is any illness, or mental change that is caused by a particular disease [36]. Health care experts use symptoms as clues that could help to analyze diseases. In this research work, we focus on five different types of symptoms: Headache, shortness of breath, chest pain, vomiting, and abdominal pain. Each symptom may relate to several diseases, as illustrated in Table 1 (all these data have been gathered by face-to-face interviews with three health care experts at different hospitals in KRI). A disease can cause more than one symptom, for example, anemia can cause headache and shortness of breath. Furthermore, two or more diseases may share the same symptoms, for instance, each of migraine, hypertension, and anemia can cause headache.

4.2.2. Constructing Provenance Graphs

The third step is the process of constructing a provenance graph from the symptoms. The system uses different provenance graphs for various symptoms; therefore, each symptom has a specific provenance graph that is different from the others. The provenance graph shown in Fig. 6 presents the headache symptom that is represented by one-finger gesture. When these symptoms occur, their provenance graphs will be merged into one single graph, which will be used for computing the network metrics.

On the one hand, it is possible for a user to enter the same hand gesture, which represents a specific symptom, many times repeatedly. On the other hand, there is possibility to have two or more different symptoms over a specific period of time. In the constructed provenance graph, symptoms are represented as activity nodes connected to entity nodes that represent the diseases. The patient who records the symptoms is represented as an agent node. The provenance graph shown in Fig. 7 illustrates a situation when a patient (the agent node *Patient: Ali*) suffered from symptoms represented

TABLE 1: Relationships between symptoms and diseases

Symptom	Disease		
Headache	Migraine	Hypertension	Anemia
Shortness of breath	Asthma	Myocardial infarction (MI)	Anemia
Chest pain	Pneumonia	Asthma	Myocardial infarction (MI)
Vomiting	Gastric ulcer	Migraine	Gastric
Abdominal pain	Gastric ulcer	Rental Stone	

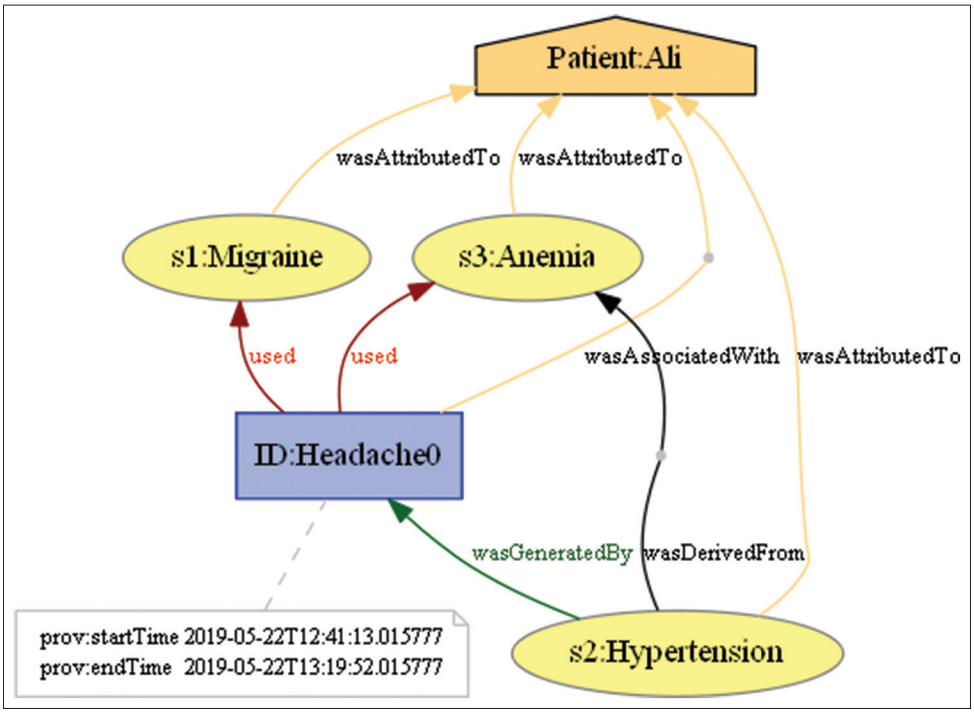

Fig. 6. Provenance graph for headache symptoms with its diseases.

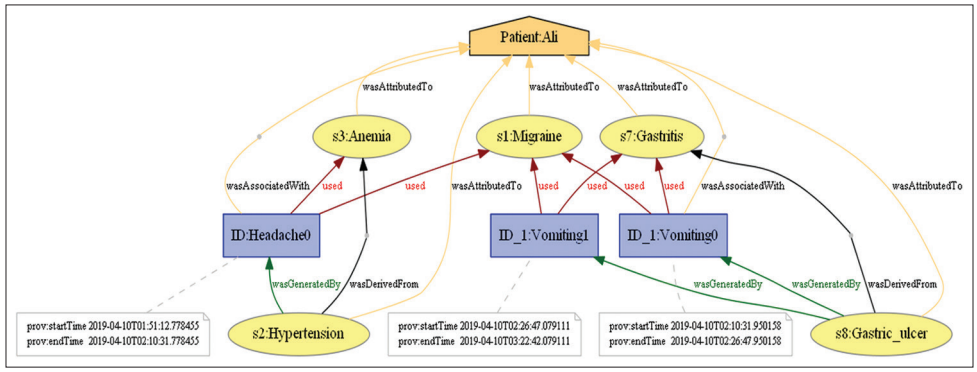

Fig. 7. Provenance graph for two types of symptoms with their diseases at specific duration time.

by the activity nodes *ID: Headache0*, *ID 1:Vomiting0,* and *ID 1:Vomiting1*. The start and end time of each activity node represents the period of time that each symptom lasts. Each symptom may affect or be affected by some diseases, which are depicted as the entity nodes *s1:Migraine*, *s2:Hypertension*, *s3:Anemia*, *s7:Gastritis*, and *s8:Gastric Ulcer*.

4.3. Provenance Network Metrics

Provenance network analytics is a novel data analytics approach, which can assist inferring properties of data, such as importance or quality, from their provenance Huynh *et al.* [12] and Roper *et al.* [15]. In the proposed system, several metrics are calculated by applying the equations that are presented below. These metrics are helpful in analyzing the patients' data and identifying patient disease.

The following equations are the metrics that are used in this research work:

- Time-duration (*TD*): It is the amount of elapsed time between the start and end of each similar symptom.

$$TD = EndStateTime - StartStateTime \quad (1)$$

In Fig. 7, there are two different types of symptoms: Headache and Vomiting. Using the start and end time of each symptom, the time durations (in minutes) of these two symptoms are:

$TD_{Headache}$ = (2:10:31) - (1:51:12) = 0:19:19 = 19 min

$TD_{Vomiting}$ = (3:22:42) - (2:10:31) = 1:12:11 = 72 min.

These indicate that the headache and vomiting symptoms lasted for 19 and 72 min, respectively.

- Similar symptom count (*SSC*): It is a number of similar symptoms (Hand Gestures) over a specific period of time.

So, $SSC_{Headache} = 1$, and $SSC_{Vomiting} = 2$ from 01:51:12 to 3:22:42.

- Symptom average time (*SAT*): It depends on the duration time and the number of similar symptoms. It represents the average time of the same gesture over a period of time and can be found using the following equation:

$$SAT = TD/SSC \quad (2)$$

Therefore,

$SAT_{Headache}$ = 19/1 = 19 min
$SAT_{Vomiting}$ = 72/2 = 36 min.

If a symptom does not exist in the provenance graph, then its $SAT = 0$.

- Total average time (*TAT*): It is the total of the average times of all the symptoms and it can be found using the equation below:

$$TAT = \sum_{k=1}^{5} SAT_k \quad (3)$$

Where each symptom is represented by a number k from 1 to 5, and SAT_k is the average time of the k^{th} symptom. In our example $TAT = 19 + 36 = 55$ min.

- Symptom percentage (*SP*): It is a ratio of the average time of a specific symptom (*SAT*) to the *TAT*. The system uses the *TAT* to find the percentage of each symptom using the following equation:

$$SP = (SAT/TAT) * 100 \quad (4)$$

Therefore,

$SP_{Headache}$ = (19/55) * 100 = 34.5%
$SP_{Vomiting}$ = (36/55) * 100 = 65.5%.

We compare these ratios that have been extracted from the provenance graph for each disease to other ratios, refer to as disease ratio, that have been gathered from three experienced physicians of two local hospitals in KRI. Table 2 presents the value of disease ratio for each disease with its symptoms.

- Percentage diseases ratio (*PDR*): It is a percentage of each disease, which has been taken from the percentage of the symptoms (*SP*) and disease ratios. We calculate it by the following equation:

$$PDR = (SP * Disease\ ratio)/100 \quad (5)$$

If a symptom is not related to a disease, then the percentage is zero. According to disease ratios are shown in Table 2, we find the *PDR* of all diseases that are related to the symptoms in the provenance graph of Fig. 7:

Headache symptom:

$PDR_{Migraine}$ = (34.5 * 60)/100 = 20.7%
$PDR_{Hypertension}$ = (34.5 * 30)/100 = 10.35%
PDR_{Anemia} = (34.5 * 10)/100 = 3.45%

Vomiting symptom:

$PDR_{Gastric\ Ulcer}$ = (65.5 * 35)/100 = 22.925%
$PDR_{Migraine}$ = (65.5 * 15)/100 = 9.825% ⇒ (9.825 + 20.7 = 30.525%)
$PDR_{Gastric}$ = (65.5 * 50)/100 = 32.75%

These diagnosis results show that the patient probably has Gastric disease due to the highest ratio.

5. BUILDING DATASET OF THE PROPOSED SYSTEM AND PREDICTIVE PRE-DIAGNOSTIC MODEL

In this research, Sign-Language-Digits-Dataset[1] [37], [38], [39] that contains ten different types of gestures is used. From that dataset, we use only five types of gestures (Fig. 2) to build

1 Sign-Language-Digits-Dataset is prepared by group of students who studied at Turkey Ankara Ayranc Anadolu High Schools in 2002.

TABLE 2: Symptoms with the value of disease ratios for each disease

Symptom	Disease					
	Disease ratio (%)		Disease ratio (%)		Disease ratio (%)	
Headache	Migraine	(60)	Hypertension	(30)	Anemia	(10)
Shortness of breath	Asthma	(50)	Myocardial infraction (MI)	(30)	Anemia	(20)
Chest pain	Pneumonia	(40)	Asthma	(20)	Myocardial infraction (MI)	(40)
Vomiting	Gastric ulcer	(35)	Migraine	(15)	Gastric	(50)
Abdominal pain	Gastric ulcer	(60)	Rental stone	(40)		

our dataset of metrics that are used as input to the machine learning algorithms. After recognizing the gestures, the system computes several network metrics about the diseases based on the symptoms, as discussed in the previous section. The dataset contains exactly 1123 records; then they divided into 15 fields which includes information on the patients' IDs and symptoms, network metrics, and types of diseases which patients suffer during a period of time, as shown in Table 3. We divided our dataset into two.*csv* files: training and test. The training file contains exactly 914 records, and it is used to build a predictive model that recognizes diseases. The test file, on the other hand, includes 209 records that are used to test the model.

In the last step of the proposed system, we choose three different supervised machine learning techniques to train our model [24], [25], which are used for both classification and regression problems [40]. We apply them in terms of classification problem since our data are split based on different conditions, the results of these algorithms are better for the proposed system compare the others, and according to previous studies these algorithms are applied in terms of diagnosis disease.

5.1. DTC

In our system, DTC builds a classification model that can be used to diagnose diseases. Data are classified into feature variables, which are the network metrics, and target variables that contain different types of symptoms. To create the predictive model, the system applies DTC in this specialization where criterion technique is entropy, which controls how DTC decides to split the data, and further it actually affects how DTC draws its boundaries. Furthermore, the tree max depth is five on the training data. The reason why we choose five for the maximum tree depth is that almost leaf nodes are obtained at Level 5. Besides, if the maximum tree depth is smaller or greater than five, the accuracy decreased. Next, the test .csv file is applied to the model to find the accuracy of the system. The visualization of the DTC in our system is depicted in Fig. 8.

Fig. 8 Illustrates the entire structure of the DTC. All the nodes, except for the terminal (leaf) nodes, contain four parts:

1. Questions asked about the data based on the value of a feature; the answer to each question is either true or false.
2. Average weighted entropy represents the impurity of a node and it should be decreased as we move down the tree.

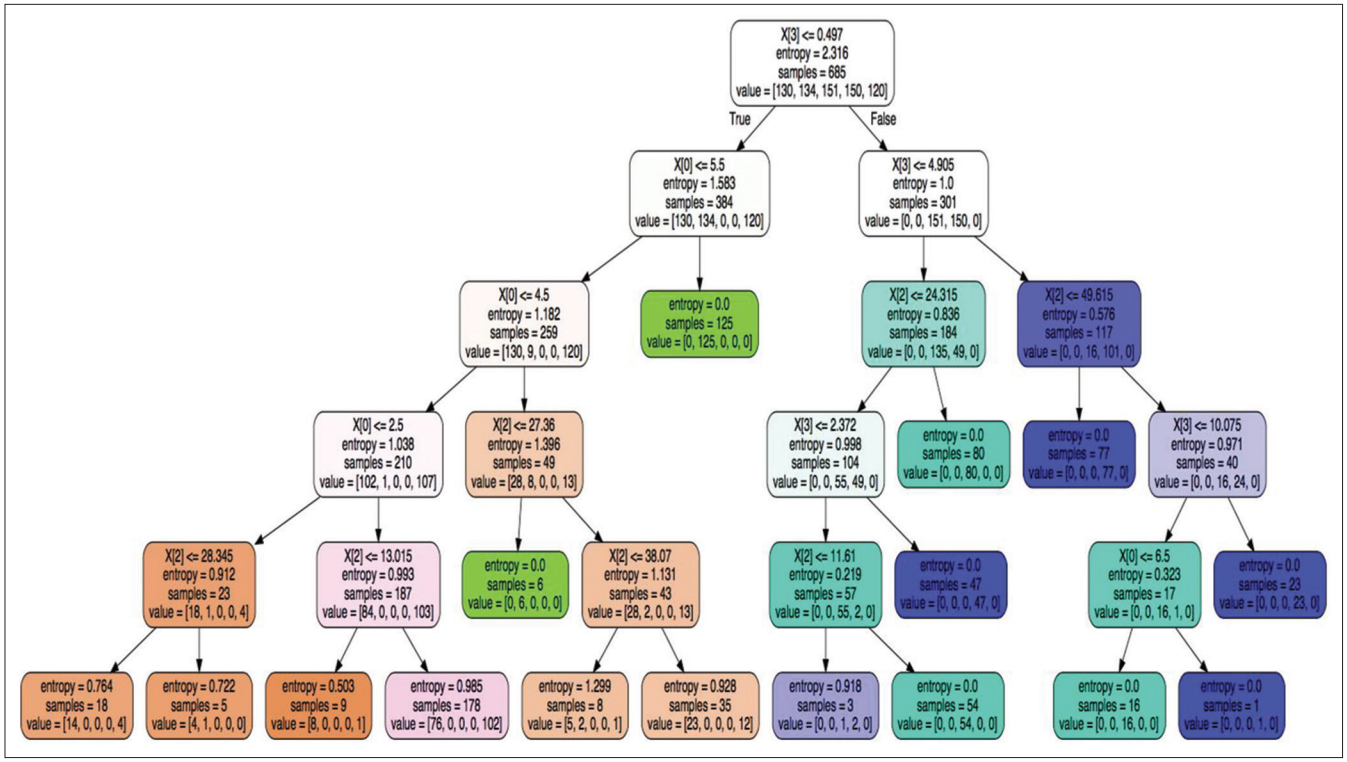

Fig. 8. Visualizing decision tree classifier for the .csv file of our training dataset with tree max depth = 5.

TABLE 3: A sample of the training dataset to build a predictive model

Patient State	Symptom name	*TD*	*SSC*	*SAT*	*SP*	Anemia	Asthma	Gastric	Gastric ulcer	Hypertension	Migraine	Myocardial Infraction	Pneumonia	Kental Stone
Person Fifteen	Headache	0:19:19	1	19	34.55	3.455	0	0	0	10.365	20.73	0	0	0
Person Fifteen	Vomiting	1:12:11	2	36	65.45	0	0	32.725	22.9075	0	9.8175	0	0	0
Person Nine	Headache	3:05:03	6	31	100	10	0	0	0	30	60	0	0	0
Person Fourty_ Five	Abdominal_ Pain	2:44:42	5	33	44.59	0	0	0	26.754	0	0	0	0	17.836
Person Fourty_ Five	Headache	2:47:45	6	28	37.84	3.784	0	0	0	11.352	22.704	0	0	0
Person Fourty_ Five	Vomiting	0:51:51	4	13	17.57	0	0	8.785	6.1495	0	2.6355	0	0	0

3. Samples are the number of observations in a node.
4. Values are the number of samples for each node.

We have four network metrics, namely, *TD*, *SSC*, *SAT*, and *SP* as feature variables and the symptoms as target variables; therefore, the data contains five samples for each node. Furthermore, the leaf nodes do not have a question, since they represent the last predictions that are made.

In addition, cross-validation is an important technique, which allows us to use our data better Breiman [40]. The primary goal of the cross-validation is to evaluate how the results of a model will generalize to an autonomous dataset and to limit problems such as overfitting and underfitting [12]. In our system, simple K-folds strategy is applied to split data into K number of splits, which are called Folds. K-Folds are only applied on DTC, which splits the training data into K parts, as shown in Fig. 9.

5.2. KNN

In this paper, we used Euclidean distance, and it should be noted that the Euclidean distance measures are only acceptable for continuous variables [41], as the data in this project's dataset. To calculate Euclidean distance, the below formula is used.

$$\text{Euclidean distance}(d(x, y)) = \sqrt{\sum_{i=1}^{k} (x_i - y_i)^2} \quad (6)$$

Where xi and yi are the variables of vectors x and y, respectively, in the two-dimensional vector space.

The reason of choosing Euclidean distance to calculate the distance between two data points is that the type of the data of this project is continuous data, and according to Kumar [29] and Huang *et al.* [41] it is one of the fastest methods to find the distance between two points. The value of K is crucial; therefore, a large value provides more precision since it reduces the noise, even though there is no guarantee. In our system, the prediction model gets better results for pre-diagnosing diseases with K = 3, as shown in Fig. 10.

5.3. SVM

In this study, multiclass SVM is applied to both training and test datasets to build a predictive model that is used to analyze the symptoms and diagnose diseases. Thus, SVM algorithm is applied on training data to create a model that allocates all linear samples into five different categories.

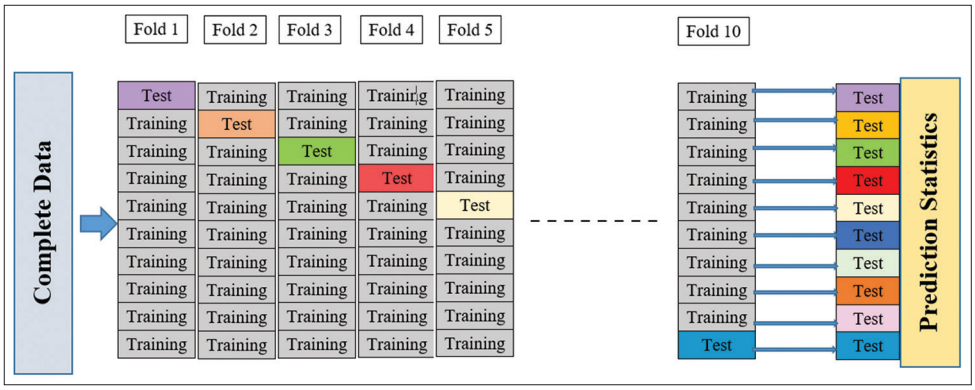

Fig. 9. Cross-validation technique with 10 K-folds.

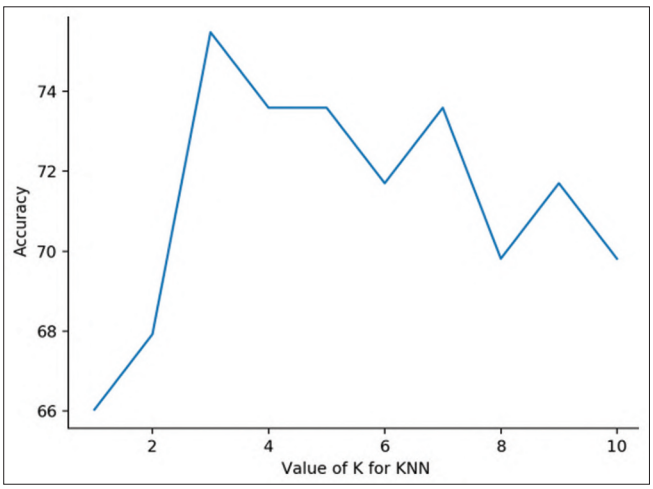

Fig. 10. K values with their accuracy results using K-nearest neighbor algorithm.

Then, new samples in the test data are assigned to a category that is already classified, and it is predicted. Fig. 11 depicts the visualization of SVM for the training and test data. The instances of five train classes and test classes are marked with red, green, blue, black, and yellow, and various shapes that represent different types of symptoms. As it can be seen, the SVM visualization of the training data contains more data than the SVM visualization of the test data, since the overall data are divided such that the part used for training represents 75%, and the part used for testing is 25%.

6. EXPERIMENTAL RESULTS

The system is trained using five types of gestures. Each gesture represents one type of symptom, as shown in Fig. 2. These gestures are read directly from the Sign-Language-Digits-Dataset. The training part uses three different machine learning algorithms: DTC, KNN, and SVM.

Network metrics are computed by applying the mathematical equations that are presented in section 5.3, and then they are stored in *.sv* files. Hence, after training the model, different *.csv* files are used to test the predicted model since the test file is different from the training file, but they contain the same network metrics. The reason why the test data have been separated from the training data is that the predicted model that has been built by the training data did not see the test data. Therefore, according to Dobbin and Simon [42] and Shafique and Hato [43], the result of the machine learning algorithms would be more accurate, reliable, and trustworthy, because they have been tested on new data for the prediction model.

We conducted our experiments using the above-mentioned three machine learning techniques. In addition, there must be measurements for the accuracy of the reorganization performance of the proposed system. One of the most valuable measurement units is the confusion matrix that can be used for recognizing the number of correctly and incorrectly classified instances [44]. The following are the main components of the confusion matrix, and the system uses them to classify the number of correct and incorrect symptoms.

- True positive (*TP*) – Is the classification of an instance with positive class value as a positive case, which means there is a type of symptom and the system predicts correctly.
- False negative (*FN*) – Is the classification of an instance with positive class value as a negative case, which means there is not any symptom and the system does not predict as well.
- False positive (*FP*) – Is the classification of an instance with negative class value as a positive case, which means there is not any symptom and the system is predicting.
- True negative (*TN*) – Is the classification of an instance with negative class value as a negative case, which means there is a symptom, but the system does not predict.

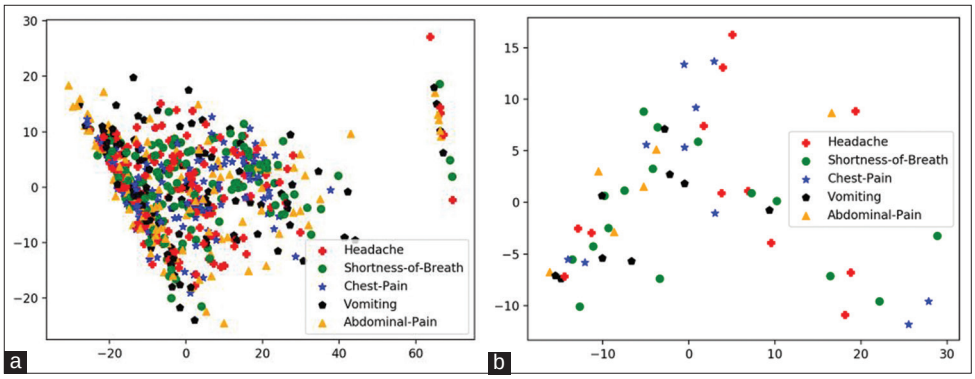

Fig. 11. Visualization of the support vector machine (SVM) for the .csv files of the training and test datasets. (a) Visualizing SVM for training data (b) visualizing SVM for testing data.

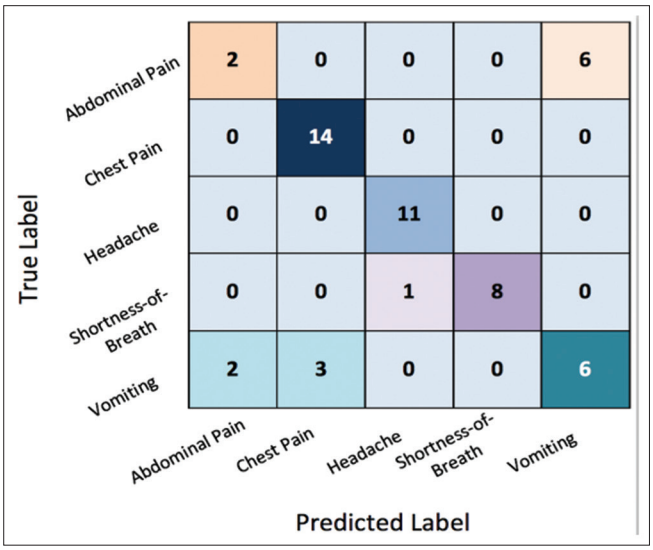

Fig. 12. Confusion matrix results for all types of symptoms.

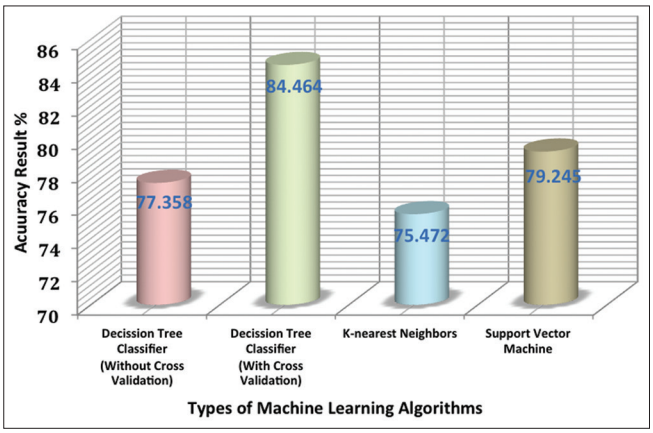

Fig. 13. Accuracy results of all types of machine learning algorithms.

TABLE 4: Confusion matrix classification report

Symptom	Precision	Recall	F1-score	Support
Abdominal pain	0.50	0.25	0.33	8
Chest pain	0.82	1.00	0.90	14
Headache	0.92	1.00	0.96	11
Shortness of breath	1.00	0.89	0.94	9
Vomiting	0.50	0.55	0.52	11

To achieve the most accurate results with the highest performance, the values of *TP* and *FN* must be increasing, and the values of *FP* and *TN* must be decreasing. As a result, the proposed system tries to increase the number of *TP* and *FN* to obtain accurate values. The equation below is used to find the accuracy using the confusion matrix for all three different types of machine learning techniques.

$$(TP/(TP + FN)) * 100 \quad (7)$$

Fig. 12 shows the experimental results in the form of a confusion matrix. It represents all possibilities of the four main components of the confusion matrix with symptoms.

The confusion matrix illustrates how many types of symptoms are correctly classified against misclassified ones. Consequently, the system uses a classification report to check the quality of the predictions of the classification algorithm. A simple example of a classification report is shown in Table 4.

The report explains the major classification metrics, which are precision, recall, F1-score, and support computed from the test dataset. These metrics are defined depending on the four confusion matrix components, which are: TP, TN,

TABLE 5: Comparison between the accuracy of the proposed system with the accuracy of the prior studies

S. No.	Authors	Data provenance	Machine learning algorithms	Accuracy results (%)
1.	Choudhury and Gupta (2019), [14]	NO	Logistic regression	77.61
			Naive Bayes	76.64
			SVM	75.68
			KNN	75.10
			DTC	67.57
2.	Enriko (2019), [31]	NO	Random forest	78.0
			KNN	71.6
			MLP	63.8
			Naive Bayes	50.4
			SVM	45.1
3.	Lavanya *et al*. (2019), [32]	NO	Ada boost	65.50
			SVM	62.93
			DTC	57.75
4.	Alaoui *et al*. (2019), [33]	NO	Neural network	76.73
			SVM	75.43
			Naive Bayes	74.23
			DTC	69.83
5.	Our research	YES	DTC	84.463
			SVM	79.243
			KNN	75.473

KNN: K-nearest neighbor, DTC: Decision tree classifier, SVM: Support vector machine

FP, and FN. From this confusion matrix, we have calculated accuracy for DTC, KNN, and SVM techniques. The accuracy percentages of DTC with and without using cross-validation are 84.464% and 77.358%, respectively. For KNN, the accuracy is 75.472%, and for SVM, it is 79.245%, as shown in Fig. 13. Out of the three techniques the DTC with cross-validation provides the best accuracy.

The accuracy of the results recorded by the proposed system is compared with four prior studies, which were reviewed in section related works. According to these comparisons, our accuracy results are higher than the previous results, as presented in Table 5. The reason for this improvement is the usage of data provenance since it helps the system to record patient's information in timely fashion and records the relations between entities, activities, and agents that would aid the system to make better decisions. Moreover, data provenance simplifies the complexity of huge datasets because of graph representation. Therefore, the novelty of our research is applying data provenance with machine learning algorithms to diagnose a disease.

7. CONCLUSIONS AND FUTURE WORK

Innovative HCI technologies, like gesture recognition, have a great potential for providing and improving the usability and accessibility in interactive systems for aging or disabled people. Moreover, electronic health record systems may incorporate a great deal of useful information about the history of patients' health conditions, which can be shared with clinicians as pre-diagnostic systems.

In this paper, a system is built to pre-diagnose diseases. It starts with the process of hand gesture recognition. Patients use hand gestures to interact with the system. Each gesture represents a symptom. After that, we determine the relations among symptoms and diseases, since symptoms could influence or be influenced by diseases. The symptoms and their relation to various diseases are recorded and stored as provenance graphs. However, our system does not suggest any examination or test for the patients or recommend any medications, rather it decides on which diseases are related to the symptoms by providing percentages that show the mutual

effects between symptoms and diseases. This information can help clinicians make successful decisions in three main terms: Effectiveness-in terms of selecting the least number of correct actions required per view, safety-in term of decreasing the number of incorrect actions, and productiveness-in term of implementing the tasks successfully and efficiently in less time.

Several case studies can be conducted in the future. We will build hand gesture recognition in a timely fashion to improve patient care in real-time, rather than simply recording past events. This will assist physicians to achieve tasks more efficiently and productively. In addition, our system uses provenance graphs to represent patients' health situations and comprehending provenance information would be a challenge to someone who is not an expert in computing technologies. Therefore, it is crucial to convert provenance graphs to textual explanations that could help clinicians to better understand the patient's situation and make more accurate decisions.

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REVIEW ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

An Empirical Evaluation of Metrics on Aspect-oriented Programs

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ABSTRACT

The quality evaluation of software metrics measurement **is** considered as the primary indicator of imperfection prediction and software maintenance in various empirical studies of software products. However, there is no agreement on which metrics are compelling quality pointers for new software development approaches such as aspect-oriented programming (AOP) techniques. AOP intends to enhance programming quality by providing fundamentally different parts of the systems, for example, pointcuts, advice, and intertype relationships. Hence, it is not evident if quality characteristics for AOP could be extracted from direct expansions of traditional object-oriented programming (OOP) measurements. Then again, investigations of AOP do regularly depend on established static and dynamic metrics measurement; notwithstanding the late research of AOP in empirical studies, few analyses been adopted using the International Organization for Standardization 9126 quality model as useful markers of flaw inclination in this context. This paper examination we have considered different programming quality models given by various authors every once in a while and distinguished that adaptability was deficient in the current model. We have testing 10 projects developed by AOP. We have used many applications to extract the metrics, but none of them could extract all AOP Metrics. It only can measure some of AOP Metrics, not all of them. This study investigates the suitable framework for extract AOP Metrics, for instance, static and dynamic metrics measurement for hybrid application systems (AOP and OOP) or only AOP application.

Index Terms: AspectJ, Aspect-oriented Development, Aspect-oriented Programming, Aspect-oriented Programming Metrics, Hybrid Application System, Software Quality Metrics

1. INTRODUCTION

The research aims to investigate new metrics of aspect-oriented programming (AOP) quality measurements. It has been used open-source tools for collecting static metrics. These static metrics will feed to external quality characteristics. The combination of other dynamic metrics will expand the quality measurement for the AOP system based on specific quality International Organization for Standardization standards. The theoretical contribution of other software quality frameworks has been discussed. This thesis proposed a unique software product quality for hybrid software applications (object-oriented programming [OOP] and AOP) to identify product quality metrics. Static measurements are used to evaluate the quality of computer code. Cohesion, for example, is the degree to which components of a module work together with each other. At present, there are not many measurements for aspect-oriented (AO) frameworks [1], for example, cohesion, and coupling, separation of concerns, size, and so forth. Cohesion is one of the essential quality properties for AO frameworks. Coupling measures the level of interaction between modules. Low coupling and high cohesion are considered necessary

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for good design. In Cazzola *et al.* [2], W. Cazzola inferred one structure given dynamic element metrics and run time execution of software reports from several research papers [3]-[5] and concentrates on element estimations dismissing static, traditional measurements. The importance of software measurement has been increasingly recognized object-oriented (OO) software engineers as the metrics have been proven to be pointers of vital quality properties, for example, the fault-proneness of the final system [4]. In this manner, the quality pointers for AOP can be gotten from direct expansions of traditional OO measurements. In any case, observational investigations of AOP do frequently depend on established coupling measurements.

2. STATE OF ART

In the past decades, many OO metrics have been proposed. The most well-known metrics are the Chidamber and Kemerer (C&K) metrics [6] and metrics for OO Design (MOOD) [7], which are applied to the quality of OOP at different stages. To be specified, C&K measurements are, for the most part, used to assess single classes, while MOOD measurements are used to survey entire frameworks. All the metrics can be divided into seven categories [8].

1. Size and complexity: Number of methods (NOM) and number of attributes (NOA) are used to measure the size of the class in terms of method and attributes. Weight method complexity (WMC) and class complexity are connected to measure classes and are used to measure total complexity by calculating the total number of functions/methods in different ways. Since classes are proposed to be designed as succinctly as possible, these measurements are required to be low in their qualities.
2. Cohesion: Cohesion is measured with four class level measurements, which are calculated in various approaches to reflect the collaborations between part function/methods. The four levels are Lack of Cohesion in Methods (LCOM), Tight Class Cohesion, Loss Class Cohesion, and information-based cohesion.
3. Reusability: Reuse ratio and specification ratio are both framework level reusability measurements. They are calculated as the ratios of subclasses to all classes and superclasses, separately. Since classes are relied on to be profoundly reused, extensive reusability metric qualities are desired.
4. Polymorphism: NMO overridden (NMO) by the class and polymorphism factor (PF) are polymorphism measurements at various levels. To be particular, NMO is a class level metric, which measures the NMO by a single subclass, while PF is a framework level metric, which measures the degree of method overriding in the entire system.
5. Inheritance: Number of children (NOC) and depth of inheritance tree (DIT) are class level measurements, which express class inheritance through the number of relatives and the depth of the inheritance, respectively. By comparison, method inheritance factor and attribute inheritance factor are framework level measurements, which refer to method inheritance and attribute inheritance.
6. Encapsulation: Method hiding factor and attribute hiding factor are indicators to show how well methods and attributes are hidden inside classes. These measurements are measured at the framework level.
7. Coupling: Five measurements are used to assess class coupling from other points of view. The coupling factor metric is used to determine the coupling of all classes at the framework level. By examination, the other four measurements measure coupling at the class level. Among these measurements, response for the class (RFC) and message passing coupling are utilized to survey technique coupling, data abstract coupling encapsulates information coupling among classes, and coupling between objects (CBO) indicates a coupling between class occurrences.

2.1. AO Metrics

Several reviews (Rønningen and Steinmoen, Zhang and Jacobsen, Mickelsson, Coady and Kiczales, and Tsang *et al.* [9]-[13]) have been conducted into the use of metrics within AOP, more often by applying the measurements characterized for OOP. Little work has been done to identify measurements suitable specifically to AOP. In his research, Mickelsson [11] concentrates on size measures such as several classes, functions, and source explanations. Coady and Kiczales [12] considered runtime costs and the position of hidden concerns in working framework code. Zhang and Jacobsen [10] utilized cyclomatic complexity, estimate, the weight of class, coupling amongst articles, and reaction time for their assessment. Tsang *et al.* [13] connected the C&K measurement suite in their evaluation of AO systems. They concentrated on the quality components understandability, viability, reusability, and testability, and the C&K meanings of measurements suited for measuring these elements. These measurements are weighted technique calls, DIT, NOC, the CBOs, the reaction for a class, and LCOMs. Zakaria and Hosny [14] described the C&K measurements suite and the impact of AO on these measurements. Burrows *et al.* [15]

utilized 10 metrics for their analysis. These measurements were characterized in Ceccato and Tonella's measurements suite and established OO measures proposed by C&K measures. Adding to that, they offered a new metric that evaluates coupling between the base and Aspect code, named base-aspect coupling. Burrows *et al.* [16] utilized the C&K metric for their review, and they concentrated on identifying coupling in AO developed systems. Dhambri *et al.* [17] proposed a complex AO software analysis using visualization techniques. The initial phase defines the characteristics and measurement for AOP programming, intended to measure the general principle of quality. They used the app metrics tool to extract many AOP Metrics based on OOP metrics extend to AOP. They have been used visualization techniques of the selected system for analysis of quality for large-scale software systems [17]. Dhambri *et al.* [17] suggested that metric definitions, as well as quality analysis, should be adapted in an AO form, and they have recorded some interesting open questions that are relevant to any related methodologies. Specifically, they attempt to formally characterize the advantages of AOP, such as the separation of concerns and (Un)pluggability.

Proposed an AOP Metrics tool measures all code written in the AspectJ language. The tool exploits a static analyzer developed in the source transformation tool TXL. The main module takes as inputs all the source classes, interfaces, and aspects and performs standard OO reverse engineering. The second module can then be run, performing further propelled reverse engineering. The next module of the tool identifies the method call relationship. Furthermore, it finds the field-access relationships between operations and fields. The fourth step is the most complex one. It finishes weaving by settling all the pointcuts in the aspect code, in this manner creating the comparable join points in the captured code. The last step concerns the calculation of the metrics. Their results show that essential properties, for example, the proportion of the system affected by aspects and the amount of knowledge an aspect has of the modules it crosscuts, are captured by the proposed metrics (CDA and coupling on intercepted modules [CIM], respectively).

2.2. Tools for AOP Metrics

The Ajatoo tool [18] has been evaluated for gathering the aspect metrics based on C&K [14] metric measurements by applying it to three different design patterns implemented in OOP and AspectJ (Observer, Decorator, and Adapter). As shown in Fig. 1, the software supports that various metrics include sizes (vocabulary size, NOA, number of operations, weight operator per component, lines of codes [LOC]) and coupling (DIT). No other metrics were supported or implemented yet. What is needed is a tool to help all AspectJ metrics and AOP Metrics generally.

It has been chosen projects developed by AOP, as shown in Fig. 2.

The drawback of Ajato tool does not support all versions of AO projects; it shows errors to extract and evaluate.aj extension files, as shown in Fig. 3.

A second tool is called AOP Metrics. This tool is developed in AspectJ. It measures many C&K measurements such as lines of class code, weighted operations in module, DIT,

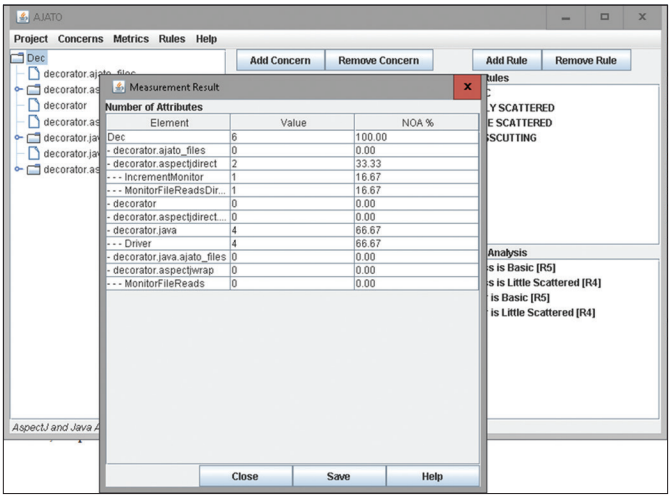

Fig. 1. Using Ajato tool.

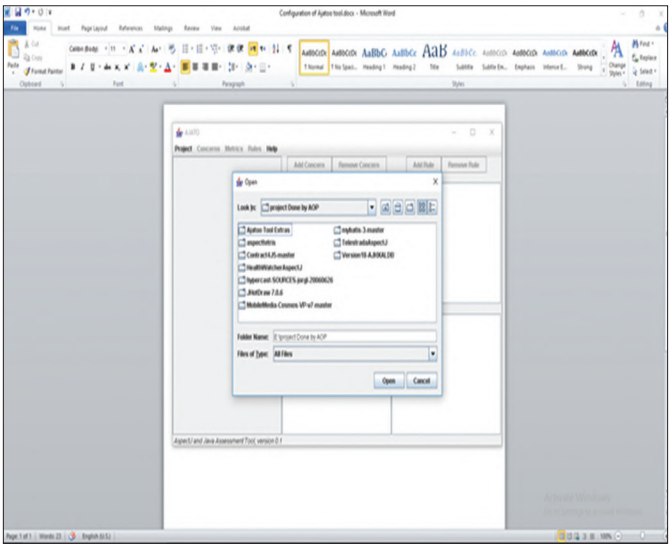

Fig. 2. Ajato tools read the projects.

NOC, lack of cohesion in operations, CIM, and package dependencies such as Abstractness (A) and number of types [Ref]. The drawback of the tool is developed with old versions for both AspectJ and Java and has not been updated for 8 years.

Moreover, it will not support aspect metrics to measure aspects independently [19]. Another tool Verifysoft's CMTJava [20] is a complexity measure apparatus expected to be a guide in testing, quality assurance, and implementing company standards for code complexity. CMTJava utilizations McCabe's cyclomatic number, lines of code measurements, number of semicolons, and Halstead's measurements in its computations. Another tool JDepend [21] plans to break down the design of the framework as far as extensibility, reusability, and practicality and is an aid to oversee and control the package dependencies. The tool proposed to utilize is to automatically watch that the designs display expected qualities while experiencing persistent refactoring by the engineers. JDepend gives measurements to Number of Classes and Interfaces, Afferent and Efferent Couplings, Abstractness, Instability, Distance from the Main Sequence, and Package Dependency Cycles. Adding more JMetric [22] is a result of an exploration extends at Swinburne University and expects to bring OO metrics and measurement research to the practitioners. JMetric gathers data from Java source documents and assembles a measurement display. The model is then populated with measurement data, for example, LOC, statement count, LCOM, and cyclomatic complexity. Measurements 1.3.5 are an open-source module for the Eclipse IDE [23]. It ascertains 17 unique measurements and gives a package dependencies analyzer, and is accordingly an overall apparatus.

Rapid miner tool has been tested for creating a new model design for process any rules design by the user. Our objective is to have AOP Metrics and shows statistical and graphical relationships between them. Unfortunately, it only takes text and CSV files, and we manually need to customize the rules, so it was not suitable for our experiments [24], as shown in Fig. 4.

Adding more there are very powerful texts engineering software called Gate has been tested for finding AOP source

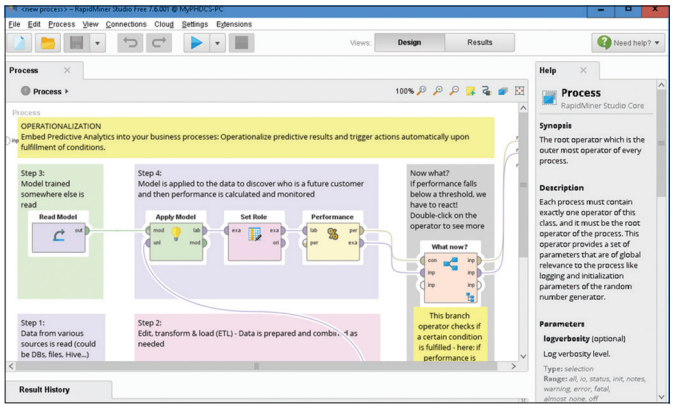

Fig. 4. Using rapid miner tool.

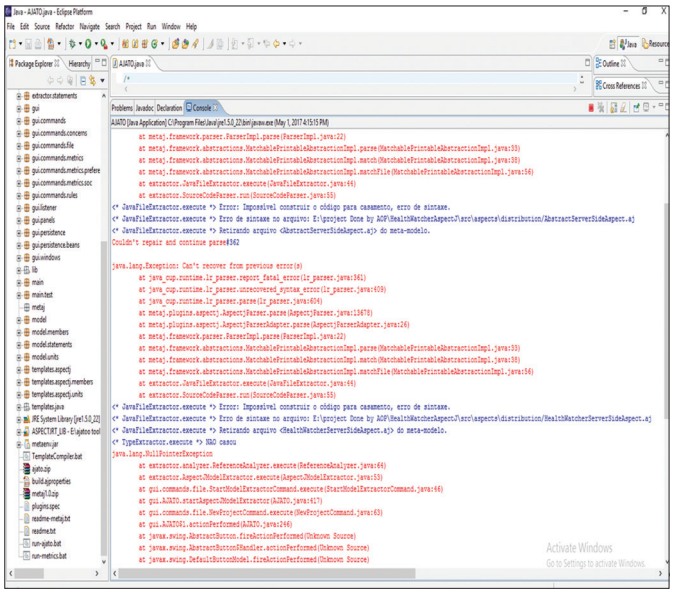

Fig. 3. Errors in Ajato tool.

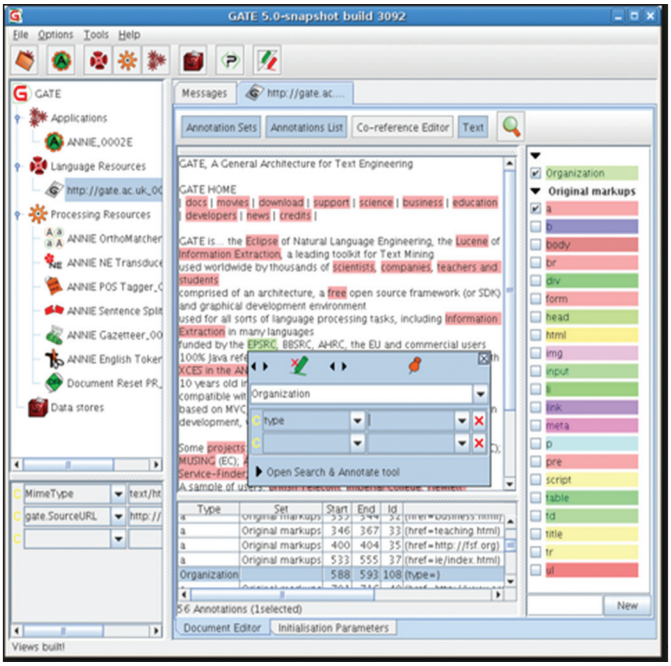

Fig. 5. Using gate text engineering tool.

code patterns. This tool help to find AOP Metrics and give statistical measures, after testing it shows some drawbacks, which is not given statistical information about each text pattern for each class and not read java file, as shown in Fig. 5.

3. AOP QUALITY METRICS

There are different models to evaluate the quality of OO and module arranged approaches. Various quality models for programming quality are given by Lincke *et al.*, [22], Yeresime and Pati [25], Eric and Bernstein [26], Lee [27]. However, less work is done to assess the quality attributes of the AO system. Different quality characteristic is complexity, coupling, reusability, changeability, maintainability, cohesion, and so forth.

- Complexity is the technique to analyze the code, endeavors required in change, and modification of modules
- Coupling is the level of relatedness among the modules that are an association between modules. Low coupling is needed
- Reusability is utilizing the module again to decrease the coding. There are different programming measurements for these qualities for inheritance systems. However, not very many measures are talked about for an AO system. Programming measurements go about as pointer of nature of a framework, i.e., give quantitative premise
- Maintainability is a change of programming item after delivery
- Cohesion is the level of relatedness among components of the modules. High cohesion is attractive.

There are numerous product quality models that propose approaches to integrate distinctive quality attributes each model aides in seeing how few quality components add to the entire variety. To assess the whole nature of the product item, we should see this large picture.

The objective of the AOP Metrics version 0.3 tool is to give a typical measurement instrument to the article arranged and the perspective situated programming. The task means to provide the following highlights (not executed ones are in italics):

The aspect arranged augmentations of the following measurements suite:

- C&K measurements suite (CK measurements)
- Robert Martin's measurements suite (package dependencies measurements)
- Henry and Li measurements suite.

Measurements actualized by AOP Metrics tasks can be connected to classes and aspects. Consequently, the module will be used as a typical term for classes and Aspects. Also, methods and advice will be demonstrated by the task term [28].

CK figures class level and metric level code measurements in Java extend by methods for static investigation (for example, no requirement for accumulated code). At present, it contains a massive arrangement of measures, including the celebrated CK.

This tool uses Overshadowing's JDT Center Library in the engine for AST development. At present, the consistency rendition is set to Java 11.

This apparatus will separate these static measurements:

- CBO: It tallies the number of conditions a class has. The device checks for any sort utilized in the whole class (field revelation, technique return types, variable statements, and so on). It overlooks conditions in Java itself (for example, java.lang.String)
- DIT: It tallies the quantity of "fathers" a class has. All classes have DIT at any rate 1 (everybody acquires java.lang.Object). Classes must exist in the undertaking (for example, if a class relies on X, which depends on a container/reliance document, and X relies on different classes, DIT is considered 2)
- Several fields: It checks the number of fields. Exact figures for an absolute number of fields, static, open, private, ensured, default, last, and synchronized fields
- Several methods: It checks the NOM. Explicit numbers for all outnumber of techniques, static, open, theoretical, private, secured, default, last, and synchronized methods
- Number of static summons: It checks the number of calls to static methods. It can just tally the ones that can be settled by the JDT
- Reaction for a Class (RFC): It checks the quantity of special strategy summons in a class. As summons are settled through static examination, these execution methods when a technique has overloads with the same number of parameters, however, various sorts
- Weight methods class (WMC) or McCabe's unpredictability: It checks the number of branch directions in a class

- LOC: It tallies the lines of the check, disregarding void lines
- LCOM: Figures LCOM metric. This is the absolute first form of metric, which is not stable. LCOM-HS can be better (ideally, you will send us a force demand)
- Amount of returns: The number of return instructions
- Amount of loops: The number of loops (i.e., for, while, do-while upgraded for)
- Amount of correlations: The number of examinations (i.e., ==)
- Amount of try/catch: The quantity of try/catch
- Amount of parenthesized expression: The amount of expression inside the bracket
- String literals: The number of string literals (e.g., "Kurd people"). Rehashed strings consider commonly as they show up
- Amount of number: The number of numbers (i.e., int, long, two-fold, skim) literals
- Amount of math tasks: The number of math activities (times, separate, leftover portion, besides, short, left poop, right move)
- Amount of variables: Number of announced variables
- Max settled blocks: The most astounding number of blocks decided together.

Amount of anonymous classes, subclasses need to be measure. It is important to check name of the class, count of each keyword in the class and all the when you execute the project. It recommended to Use of every factor, for instance, how much every element was used inside every method, adding more it recommended it need using of each field, and calculated inside every method [29].

McCall *et al.* [30] proposed a product quality factor structure and arranged the quality properties into three general classes:

i. Product task elements,
ii. Product amendment variables,
iii. Product change components.
    - Item task factors: The variables which add to item activity are rightness, unwavering quality, productivity, honesty, and ease of use
    - Item modification factors: The components which add to item update are practicality, adaptability, and testability
    - Item change factors: The variables which add to item progress are movability, reusability, and interoperability.

Boehm model is like the McCall model. Boehm spoke to their quality model as a various leveled tree and broken quality attributes into subqualities, which is given in Fig. 6. Boehm additionally incorporated the equipment yield attributes which were not considered in the McCall model. Utilizing this model, quality as a single parameter can be assessed due to the progressive nature of the model. This model does not give rules to quantify recorded attributes [31].

Dromey [32] proposed a quality model that gives a straightforward procedure for building quality conveying properties into programming. This model builds up the connection between unmistakable item qualities and less substantial traits. This model aids us where to search for imperfections and shows the properties that should be damaged to make abandons. This model tends to item quality by characterizing all the related sub-attributes so that they can be blended and amalgamated into higher-level qualities. The model backings are incorporating variety with programming, the meaning of language-specific coding benchmarks, efficient arranging quality deformities, and the advancement of mechanized code inspectors for identifying quality imperfections in programming. Dromey included reusability as a quality trademark in his model.

Deutsch and Wills [33] sorted programming quality as programming methodology quality and programming item quality. As a normal for programming item advancement process, programming strategy quality comprises programming designing related components such as technology, tools, workforce, association, and equipment. As a normal for programming item, programming item quality incorporates record transparency, trustworthiness, follow capacity, association, program rerisk, and test honesty. In this model, the direction has been given on what venture to follow to acquire the wanted item.

Word and Venkataraman [34] proposed that product quality measures may incorporate at least one of the accompanying: (i) Client based: As assessed by clients, programming quality alludes to the level of fulfillment of client desires. (ii) Item conveyance based: Determined by the item as evaluated by the originator, the level of framework viability, and program practicality; (iii) assembling based: The advancement procedure, stressing quality control, and the board; and (iv) authoritative control based: venture costs, generation time, asset control, and hazard the board.

Sharma *et al.* [35] proposed a quality model in the setting of Part Based Programming Improvement (CBSD) and have gotten their model from ISO/IEC 9126. In their model, they included reusability, intricacy, track capacity, and adaptability as new subqualities in the six attributes of ISO/IEC 9126.

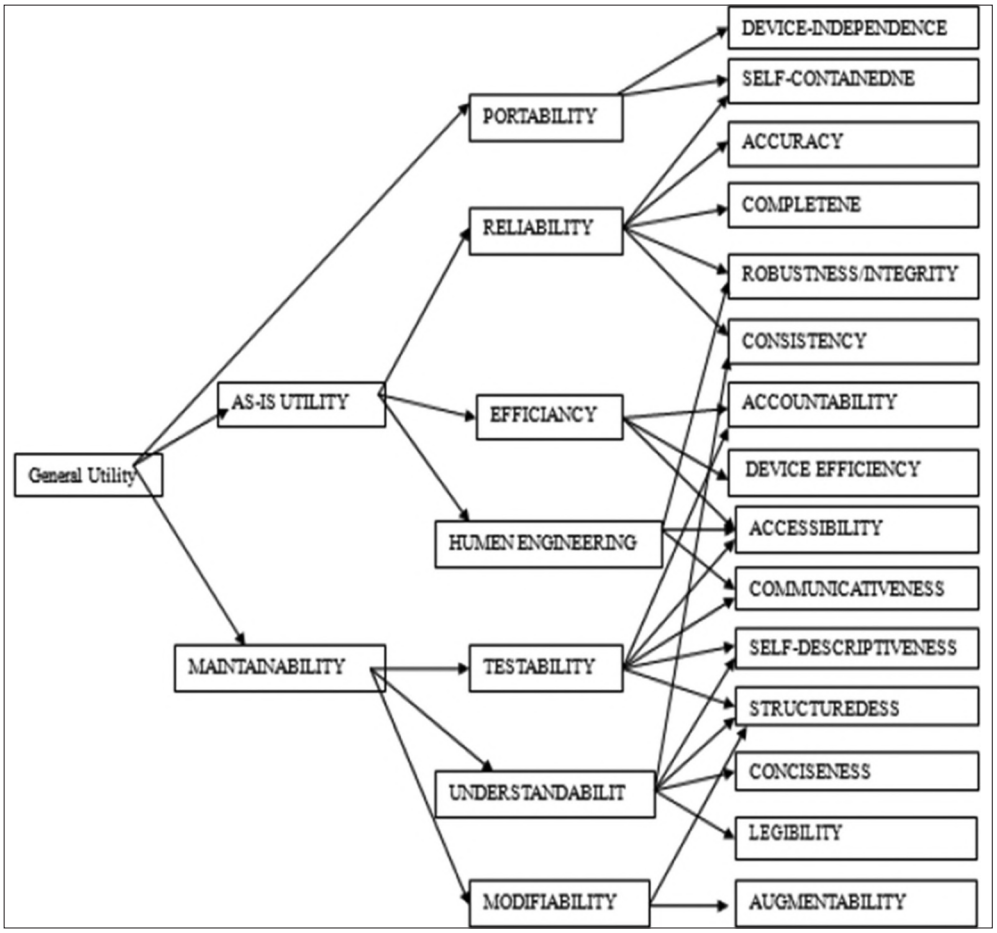

Fig. 6. Boehm quality model.

To assess the absolute nature of a segment, they utilized a systematic, progressive system process (analytic hierarchy process [AHP]), and for the weight estimations of value qualities and sub-attributes, an overview was led.

Chang *et al.* [36] gave rules to assess programming quality by incorporating a fuzzy hypothesis and AHP. They connected this new idea to the ISO/IEC 9126 quality model. Rather than taking the mean of gathered example information, they compared the fuzzy hypothesis to get relative loads of qualities and sub-attributes. They have not proposed any new quality model, yet have given rules to assess programming quality utilizing existing models [37], [38].

ISO/IEC 9126 tends to three programming quality aspects: (I) Process quality, (ii) item quality, and (iii) item being used quality. ISO/IEC 9126 arrangement guidelines have presented a various leveled model with six noteworthy quality attributes. These quality attributes are isolated into 21 sub-attributes, which add to the inner quality. ISO/IEC 9126 1 is concerned basically with the meaning of value qualities and sub-attributes in the last items. ISO/IEC 9126 2 gives external measurements to estimating traits of six external quality attributes characterized in ISO/IEC 9126 1. ISO/IEC 9126 2 distinguishes external measures; ISO/IEC 9126 3 describes internal sizes, and ISO/IEC 9126 4 characterizes quality being used measurements for the estimation of value attributes or the subqualities [39], [40]. Inward analyses estimate programming itself; outside measurements estimate conduct of the computer-based framework that includes the product, and quality being used sizes measured the impacts of utilizing the product in a particular set of utilization. ISO/IEC 9126 2:2003 is proposed to be used together with ISO/IEC 9126 1. ISO/IEC 9126 4 contains:

- A clarification of how to apply programming quality measurements;
- A fundamental arrangement of measurements for every trademark; and
- A case of how to apply measurements during the product item life cycle.

Even though the ISO/IEC 9126 quality model is genuinely detailed, it does not cover some significant quality attributes, which add to the nature of the AOP [41], [42].

To characterize the programming quality model, which should cover every one of the highlights of the AO programming framework, we need to see what are the new stresses and confinements of the latest technology as AO innovation is an expansion of MO or OO innovation. AO programming languages are additionally augmentations of local programming language, for example, perspective C is an expansion of C, Aspect C++ is an augmentation of C++, AspectJ is an expansion of Java, CaesarJ is an expansion of Java, Aspect XML is an expansion of XML, etc. Since AO technology cannot exist without anyone else, it will have every one of the highlights of the innovation from which it is determined. For instance, AspectJ has every one of the highlights of Java and extra highlights, which has been included AspectJ. At the end of the day, if AO Technology is gotten from OO Technology, at that point, it will have every one of the highlights OO innovation and extra highlights added to aspectual code. Other quality attributes/subqualities are required to be included, which can cover new highlights of crosscutting concerns (aspect(s)) and the combination of it with essential concerns (classes). The redefinition of existing attributes/subqualities, in the setting of AO innovation, is likewise required [43], [44].

The vast majority of the product quality models, which are proposed after the meaning of programming quality principles ISO/IEC 9126, have been gotten from ISO/IEC 9126. For instance, Rawashdeh and Matalkah [45] have included similarity as a sub-trademark to usefulness, unpredictability as a sub-trademark to ease of use and reasonability as a sub-trademark to viability in their product quality model. They evacuated subqualities strength and analyzability from practicality. They likewise included another brand in their quality model as partners, who are the individuals from the group in charge of creating, keeping up, incorporating, and utilizing the best framework. This model spotlights on the estimation of the nature of part based framework. Bertoia and Vallecillo [46] proposed a quality model, which characterizes attributes and sub-attributes in segment-based frameworks. In this model, sub-attributes have been partitioned into runtime and lifecycle classifications dependent on their inclination. They likewise included ability as a sub-trademark to usefulness, which demonstrates whether the previous variant of the part is perfect with its present form.

Quality Type	Characteristics	Sub-characteristics
Software Product Quality	Functionality:C1	Suitability:SC11
		Accuracy:SC12
		Interoperability:SC13
		Compliance:SC14
		Security:SC15
		Reusability:SC16
	Reliability:C2	Maturity:SC21
		Fault tolerance:SC22
		Recoverability:SC23
	Usability:C3	Understandability:SC31
		Learn-ability:SC32
		Operability:SC33
		Complexity:SC34
	Efficiency:C4	Time behavior:SC41
		Resource behavior:SC42
		Code-reducibility:SC43
	Maintainability:C5	Analyzability:SC51
		Changeability:SC52
		Stability:SC53
		Testability:SC54
		Modularity:SC55
	Portability:C6	Adaptability:SC61
		Install-ability:SC62
		Replace-ability:SC63
		Conformance:SC64

Fig. 7. Aspect-oriented software quality model.

Fig. 8. SQuaRE series of standards.

TABLE 1: The correlation of various qualities attributes in different programming quality models.

Model	Mcall (1977)	Boehm model (1978)	ISO9126 (1991)	FURPS model (1991)	Ghezzi model (1991)	ISO9126 V.4 (1992-2001)	Dromey (1995)	AOSQAMO (2009)	ISO/IEC 25010 (2010)	REASQ (2010)	AOSQ (2012)
Function											
Structure	Hierarchical	Hierarchical	Hierarchical	Hierarchical	Hierarchical	Hierarchical	Hierarchical	Hierarchical	Hierarchical	Hierarchical	Hierarchical
Number of levels	2	3	2	2	2	3	2	2	3	2	3
Advantage	Evaluation criteria	Hardware factors included	Evaluation criteria	Separation of FR and NFR	Evaluation criteria	Evaluation criteria	Evaluation criteria	Evaluation criteria	evaluation criteria	Evaluation criteria	Evaluation criteria
Disadvantage	Components overlapping	Lack Of criteria	Generality	Portability not considered	Lack of criteria	Lack of criteria	Comprehensiveness	Lack of criteria	Generality	Segments overlapping	Generality
Reliability	*	*	*	*	*	*	_	*	*	*	*
Efficiency	*	*	*	_	_	*	_	*	*	*	_
Integrity	*	_	_	_	_	_	_	_	_	_	_
Usability	*	_	*	*	*	*	_	*	*	*	_
Maintainability	*	*	*	_	_	*	_	*	*	*	_
Testability	*	*	_	_	_	_	_	_	_	_	_
Flexibility	*	_	_	_	_	_	_	_	_	_	_
Portability	*	*	*	_	_	*	_	*	*	*	*
Reusability	*	_	_	_	_	_	*	*	*	_	_
Understandability	_	*	_	_	_	_	_	_	_	_	_
Modifiability	_	*	_	_	_	_	_	_	_	_	_
Functionality	_	_	_	*	_	*	_	*	*	*	*
Supportability	_	_	_	*	_	_	_	_	_	_	_
Performance	_	_	_	*	_	_	_	_	_	_	_
Evolvability	_	_	_	_	_	_	_	_	_	_	*
Interoperability	*	_	_	_	_	_	_	_	_	_	_

The variables which are available in the model are set apart as "*," which means that this factor has been incorporated into the individual model, and the variables which are not present are set apart as "–" saying that these elements are not incorporated into the model. FR: Functional requirement, NFR: Non-functional requirement

According to Kumar *et al.* [47] proposed augmentation of the ISO/IEC 9126 quality model. In this quality model, we have included particularity as a sub-trademark under practicality, code reducibility as a sub- characteristic under effectiveness, multifaceted nature as a subfeature under ease of use, and reusability as a sub-characteristic under usefulness. The new model is given in Fig. 7. In this table, qualities and sub-attributes have likewise been allotted marks such as C2 (specific number 2) and SC32 (specific number 2 of distinctive number 3), which will be alluded in the following segments. It is important to show the significance of (ISO/IEC 9126) regarding qualities and sub-attributes, in the setting of AO technology.

SQuaRE comprises a group of principles under the general title of software product quality requirements and evaluation (Fig. 8 represents the association of these families or divisions [41], [48], [43]. The divisions inside the SQuaRE Model are as follows: ISO/IEC 2500n – Quality Management Division, ISO/IEC 2501n – Quality Model Division, ISO/IEC 2502n – Quality Measurement Division, ISO/IEC 2503n – Quality Requirements Division, and ISO/IEC 2504n – Quality Evaluation Division. In standard, ISO/IEC 25000-Guide to SQuaRE speaks to the umbrella archive of the SQuaRE arrangement; it gives a general outline and advisers for utilizing the SQuaRE series. This record contains the SQuaRE engineering, wording, planned clients, and associated parts of the arrangement. ISO/IEC 25000 presents the entire SQuaRE arrangement as an accumulation of value designing instruments. We are keen on the ISO/IEC 25030 (quality prerequisites) and the ISO/IEC 25010 (quality model, once in the past called ISO/IEC 9126-1), which will be displayed in what follows. In Fig. 2 – explains the architecture of the SQuaRE framework [41], [48], [43]. Adding more ISO/IEC 9126-1 and ISO/IEC 25010 it focus on software components is built to be agreeable with specific needs, required by its user. Their quality is resolved in the measure that these necessities are accomplished.

ISO/IEC 25010 is an update of ISO/IEC 9126-1 [49], with minor changes. According to the draft variant [41], it essentially keeps up similar definitions and structure of ISA/IEC (2001), anyway it offers eight attributes: A similar six characteristics of ISO/IEC (2001) or more interoperability and security, which were disposed of from the usefulness sub-attributes, for a sum of eight abnormal state characteristics. This decision reacts to the quality necessities particular of current software applications, for instance, web administration applications, where interoperability and security are building primary concerns. This work will consider ISO/IEC 9126-1 because it is formally received a standard.

The requirements, aspects, and software quality (REASQ) applied model, communicated in unified modeling language [50], encourages thinking on the fundamental ideas innate to a perspective situated quality prerequisites designing discipline. In the model, the product necessity, concern, and quality trademark components are the primary thoughts used to interrelate the wording of three ambits: The prerequisites building discipline.

4. CONCLUSION AND FUTURE WORK

Software users consider programming to be an apparatus to be utilized to help them in the manner they work together in their particular Structure. Quality is a structure of numerous attributes. Therefore, quality is usually caught in a model that portrays the characteristics and their connections. The models are helpful; they show what individuals believe is significant when talking about quality. Extraordinary associations utilize distinctive quality models dependent on the aspect-oriented software development (AOSD) worldview, and the product item quality detail. Using REASQ, a mapping is built up between the ISO/IEC guidelines and the developing AOSD discipline. Non-practical concerns and quality necessities are connected with at least one quality attribute of the standard quality model (potential cross-cutting concerns), which is a principal objective of AOSD [6], [51]). There is a general concurrence on the way that a perspective takes care of the issue of the crosscutting concerns (gave these are recognized), by typifying them in a particular structure, through an arrangement component [51]-[53]. The technique is possible from the get-go in the product improvement process through a structure table [54], while demonstrating the framework engineering, for example, to encourage the plan and execution stages.

Ghezzi *et al.* expressed that interior characteristics manage the structure of programming, which helps the product engineers to accomplish the external features just as essential attributes of programming, which are accuracy, flexibility, integrity, practicality, portability, reliability, reusability, and convenience [55], [43].

5. IDENTIFY TOOLS FOR QUALITY MEASUREMENTS FOR AOP

In the previous section, we have discussed various software quality models that support AOP. In Table 1, there is

a detail of the criteria of comparison and advantages and disadvantages of these software quality models the prerequisites.

Various ideas of programming quality qualities are evaluated and discussed in this paper. Too near investigation of different programming quality models utilized by different associations is being examined in this paper. A lot of effort is invested in the procedure quality improvement. At the point, when a task is embraced, the point is to convey the correct item at the ideal time with the exact functionalities. It is a typical situation that the one at the less than desirable end consistently wants/anticipates that the best should be conveyed to them. The onus lies on the engineers and testers to guarantee that they can meet the expectations for their customers. In this paper, we have examined different programming quality models given by various creators now and again and recognized that adaptability was inadequate in the current model. It is essential for the present framework to be able to oblige an expanding number of components to process developing volumes of work agilely, what is more, to be helpless for expansion. Henceforth, another sub-trademark versatility has been added under the viability of the AOSQ model. Each proposed model needs evaluation. We have been analysis most of the quality model for supporting measuring of AOP, some of them argue the standard metrics of OOP. We suggest proposing a framework for evaluating state metrics for AOP then moving on dynamic metric for a hybrid software application. In future, research will recommend a quality measurement framework and applied on static and dynamic parameters for AOP.

As it is described in Table 1, there is not software could give a total number of AO quality metrics. Many software used difference quality models to extract exact quality metrics. However, they have been succeeding in obtaining standard quality metrics but failed in hybrid application system or AO software.

The future work will be proposing a unique software product quality for hybrid software applications (OOP and AOP) to identify product quality metrics. The framework will help software engineering to measure AOP Metrics, which adapted ISO 9126 software quality model; this means that any hybrid system can measure with this new framework. The unique quality measurement framework of this research is the extension of quality model ISO 9126.

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REVIEW ARTICLE

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Protective Effect of *Eruca sativa* Leaves Extract on Sperm Abnormalities in Mice Exposed to *Hypericum triquetrifolium* Aqueous Crude Extract

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ABSTRACT

This study was carried out to evaluate the effect of *Eruca sativa* on the cytotoxic effect of *Hypericum triquetrifolium* on sperm abnormalities in albino mice. Leaves of *E. sativa* and aerial parts of *H. triquetrifolium* were dried in shade and grinded and their aqueous extracts were used for the treatments to study their effect on sperm morphology. Treated groups were injected with a single dose of 38 mg/kg body weight (BW) of *Hypericum* subcutaneously, while the *Eruca* groups were orally administered with 250 mg/kg BW twice/week for 2 weeks. After the exposure of *H. triquetrifolium*, the frequency of abnormal sperms showed a highly significant induction of sperm abnormalities; separated head from tail sperms, swollen head, hookless, defective head, and hook. However, the *Eruca* group showed no obvious abnormalities in sperm morphology, while in cotreatment with both *Eruca* and *Hypericum* (H/E) groups, there was an extremely significant decrease ($P < 0.0001$) in the abnormal sperms. In conclusion, it appeared that *E. sativa* could prevent or at least minimize the damages that *Hypericum* toxins would make on the sperm morphology significantly.

Index Terms: *Eruca sativa*, *Hypericum triquetrifolium*, Sperm morphology

1. INTRODUCTION

There has been a growing interest in the study of medicinal plants and their traditional use in different parts of the world over the past few decades as this can lead to new discoveries about plant agents. Therefore, traditional medicine remains as an integral part in the most Arabic countries and the flora of these countries with their use somehow is similar [1]. *Hypericum* species are herbaceous plants known to have medicinal properties and are widely used in phototherapy in many countries. The *Hypericum* genus is known to contain a wealth of secondary metabolites and many of which are biologically active. The main constituents are naphthodianthrones (hypericin, pseudohypericin, protohypericin, and protopseudohypericin), phloroglucinols (hyperforin, adhyperforin, hyperfirin, and adhyperfirin), and a broad range of flavonoids (hyperoside and rutin) [2]. It has been used in Traditional Arab Herbal Medicine to treat various inflammatory diseases and as sedative, astringent, antispasmodic, for intestine and bile disorders and poisonous antioxidant, antiviral, antimicrobial, and antinociceptive activities have also been reported in the literature for *Hypericum triquetrifolium* [3]. Along with the medicinal plants, Iraq also has a rich and diverse flora including a wide variety of plants with the potential to cause animal and human poisoning [2]. Animal-plant poisoning is usually accidental and occurs most often due to unfavorable conditions when pasture is poor in drought, overstocking, and trampling of grazing. Plant poisons consist of toxic compounds that can actually be fatal even in small doses while others may cause a

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reduction in performance as weight loss, weakness, diarrhea, or rapid pulse rate [3].

As previous studies have shown, *Hypericum* is one of the most common poisonous plants in Iraq and the genus has more than 400 species [3], but only sixteen is observed in Iraq, and the most abundant types are *H. triquetrifolium* and *Hypericum perforatum* [4].

H. triquetrifolium Turra are a perennial herbaceous plant and one of the Iraqi wild species of *Hypericaceae* distributed in the North and Northwest of the country, the local Arabic name of the species is Roja and the Kurdish name is Swrnatik [5]. It contains a mixture of poisonous pigments referred to as hypericin that is able to cause many deleterious effects in livestock including hyperthermia and acute photodermatitis when consumed by grazing animals [2]. Animals that are most likely to be poisoned are sheep, goats, horses, cattle, and swine. Symptoms that result of poisoning are first to appear in unpigmented or lightly pigmented areas of skin that damaged and may become necrotic, and never recover and regrowth of hair in those areas are uncommon [6]. Then, lactating animals suffering from decline or shutoff milk completely, even in severe case animals loss appetites and die from starvation and dehydration [7].

Many researchers conducted to review the effect of *H. perforatum* and compared its toxicity to *H. triquetrifolium* in each rabbit and sheep [8]-[10]. However, an investigation accomplished in 2010 in Iraq/Kurdistan, studied the cytotoxic and genotoxic effect of *H. triquetrifolium* tested on male albino mice to come up the result with that, indeed in a particular dose, *Hypericum* is noxious to both sperm cells and chromosomes that influence sperm morphology and chromosomal aberrations [11]. A similar study performed in 2012 in Iraq/Kurdistan, using different doses and duration revealing the same result of cytotoxicity and genotoxicity of *H. triquetrifolium* on albino mice [12].

However, there is no study shows an effect of a medicinal plant in animals that have been exposed to *H. triquetrifolium* as a common toxic plant on sperm morphology; thus, this study is aimed to achieve exactly that goal to compare both results before and after the treating with both plants, toxic, and medicinal.

Eruca sativa known as Jarjir, Rocket, or Arugula plant belongs to the Brassicaceae family, is a minor oil crop and medicinal plant in several parts of Middle East since ancient it has been used in traditional medications as remedies for different diseases [13]. Hence, phytochemical composition and corresponding biological activities are crucial to apprehending the therapeutic potential of medicinal plants. Numerous studies infer that pharmacological action of any medicinal plants is attributed to the presence of secondary metabolites; these generally consist of the phenolic compounds, alkaloids, tannins, saponins, carbohydrates, glycosides, flavonoids, steroids, etc. Among the others, phenolic compounds are the universally discovered phytochemicals for the sake of therapeutic potential in a different medicinal plant [14]. All of these secondary metabolites and particularly phenolic compounds have been reported as scavengers of free radicals and also have been considered as good therapeutic candidates for free radical related pathologies as it has been reported that *E. sativa* seed extracts are potent antioxidants, exhibit diuretic effects, and provide renal protection [14]. The previous phytochemical studies of *E. sativa* showed that leaves and seeds contain glucosinolates. Three new quercetins have been isolated and identified from *E. sativa* leaves [15]. However, there is not sufficient information in the form of scientific analysis about detailed phytochemical composition of *E. sativa* and their respective bioactivities [16]. On the other hand, many studies revealed the intense aphrodisiac effect of Jarjir since ancient Roman times [17], [18], in a way that the seed oil enhance increasing fertility and sexual activity through dilation of seminiferous tubules, proliferation of spermatogenic cells, increasing mitotic activity, number of sperms, epididymis weight, elevating level of testosterone, and hyperplasia of interstitial Leydig cells have also been noticed [19]. In addition, Barillari *et al.* [20] proposed that the presence of saponin and alkaloid extract is responsible for increasing sperm activity.

2. MATERIALS AND METHODS

The aerial parts of *H. triquetrifolium* were harvested by hand at Moghagh/Piramagrwn/Sulaimanya during the early stage of flowering time in June since the plant shows its most toxicity at this stage while *E. sativa* was obtained from a local market in Sulaimanya. The same procedure was used for both plants, as they aqueous extracted. The plants were air-dried indoors at room temperature for about 1 week, then ground to obtain a powder using an electric grinder. The powder suspended in distilled water for about 24 h at the rate 50 g/400 ml, and then the solution was filtered twice using Whatman Filter Paper. The final crude extract was dried using an oven at 42°C temperature for about 12 h to obtain powder crude extract, then kept in dark bottles at 4°C until preparing the treatment doses [10].

2.1. Solution Preparation

The powder of the plants crude extracts was used for preparing the solution as follows:

- −35 mg/kg body weight (BW) of *H. triquetrifolium* were mixed with 1 ml of distilled water shaking until dissolving the powder completely and injected subcutaneously to the mice
- −250 mg/kg BW of *E. sativa* powder was mixed with 1 ml of distilled water that administered orally using gavage needle.

2.2. Experimental Design

Twenty-five albino male mice were divided into five groups designated as C, T1, T2, T3, and T4. Each group consisted of 5 mice and subjected to the following treatments:

Control: Mice were treated with 1 ml of distilled water.

- T1: Mice were treated with a single dose of 1 ml *Hypericum* extract subcutaneously at the dose 38 mg/kg BW
- T2: Mice were orally treated with 1 ml *Eruca* extract using gavage needle at the dose 250 mg/kg BW twice a week for 2 weeks
- T3: Mice were treated with a single dose of 1 ml *Hypericum* extract then injected with 1 ml of *Eruca* by oral administration twice a week for 2 weeks
- T4: Mice were treated with 1 ml of *Eruca*
- Then, injected with 1 ml of *Hypericum*.

2.3. Collection and Preparation of Sperms

After sacrificing the animals with cervical dislocation, the sperm morphology of the treated mice was examined 2 weeks after the first treatment. Vas deference of each mouse of the five groups was removed from the testes and put into a small Petri dish filled with normal saline. Using a scissor and disposable blades, vas deference was cut from the testes and sperm were transferred (semen extracted) on to a clean slide, preparing a smear for each. The smear was stained with hematoxylin for 15 min and washed, then stained with eosin and washed again. At the final step, the slides left to dry, then the results were read, counting about 100 sperm from each slide/animal (500 sperm for each treatment) to determine sperm morphology abnormalities [11].

2.4. Statistical Analysis

The values of the investigated parameters were analyzed using a statistic program GraphPad (Prism 2019). The experimental results were expressed as mean ± standard error of the mean. Groups were compared by analysis of variance using one-way, two-way ANOVA, and Dunnett's test for multiple comparisons test. $P < 0.05$ was regarded as statistically significant.

3. RESULTS AND DISCUSSION

Table 1 summarized the results of sperm morphology observations among treated groups and the control group. The data obtained from 100 sperm/replication (500 sperm/group) in semen samples collected from vas deferens of each mouse. The data show that there is a significant difference between control and *Hypericum* treated group (T1). The most frequent aberrant shapes were sperm without a head, sperm without a tail, swollen head, hookless, defective head, and defective hook. While in the *Eruca* treated groups (T2), there was no significant difference in the aberrant types comparing to control group. However, in the creating groups, (groups treated with both *Eruca* and *Hypericum*), in compare with T1 (*Hypericum* treated group) and the results exhibited that all forms of sperm abnormalities were significantly lowered in T3 and T4 comparing to T1, and the total number of normal sperm increased significantly. While T3 and T4 comparing to each other were not significantly different, mentioning that the (*Hypericum-Eruca*) treated groups (T3 and T4), differed in the subsequent of the treatments, wherein T3 the injection started with *Hypericum* and ended with *Eruca* while in T4 the reverse was applied; hence, the results showed no significant difference in none of the parameters comparing to one another. Fig. 1 showed the aberrations resulted in this study.

The whole process of developing spermatogonia to haploid spermatids takes around 35 days in mice [13], [14] through a complex process is known as spermatogenesis. Three crucial events are the major steps of this process: (i) Mitosis which is the multiplication of spermatogonia; (ii) reducing chromosome number from diploid to haploid by meiosis and begins with the entry of Type B spermatogonia into the prophase of the first meiotic division. These cells now called primary spermatocytes, divide to form secondary spermatocytes and next to form round spermatids; and (iii) the successful transformation of the round spermatid into the complex structure of the spermatozoon is called spermiogenesis.

Each of these steps represents a key element in the spermatogenic process, defects in any of them can fail in the entire process and lead to the production of defective spermatozoa or reduction in sperm production [17]. As previous researchers have confirmed its genotoxic effect on sperms and the male reproductive system in general, *Hypericum* toxicity attributed to the active principles

TABLE 1: Cytogenetic effect of *Eruca sativa* and *Hypericum triquetrifolium* with their interaction on sperm

Treatments	Aberrant							
	Normal sperm	Sperm without tail	Sperm without head	Defective head	Hookless	Defective hook	Swollen head	Two-tail
Control	87.00±3.162^{a}	3.200±0.4899^{a}	1.600±0.4000^{a}	0.2000±0.2000^{a}	0.4000±0.2449^{a}	0.200±0.200^{a}	0.4000±0.2449^{a}	0.00±0.00^{a}
Hypericum (T1)	57.00±1.449^{b}	5.200±0.8602^{a}	9.400±2.293^{b}	4.800±0.7348^{b}	4.400±1.122^{b}	2.600±0.6782^{b}	4.800±1.393^{b}	0.6000±0.4000^{a}
Eruca (T2)	90.80±1.241^{a}	3.600±0.6000^{a}	3.2000±0.5477^{a}	1.200±0.3742^{a}	1.000±0.4472^{a}	0.00±0.00^{a}	0.2000±0.2000^{a}	0.000±0.000^{a}
H/E (T3)	92.80±1.497^{a}	4.800±1.068^{a}	0.8000±0.5831^{a}	1.000±0.4472^{a}	0.4000±0.2449^{a}	0.000±0.000^{a}	0.2000±0.2000^{a}	0.000±0.000^{a}
E/H (T4)	93.60±0.509^{a}	2.600±0.5099^{a}	0.6000±0.4000^{a}	0.4000±0.2449^{a}	0.6000±0.2449^{a}	0.600±0.400^{a}	0.000±0.000^{a}	0.000±0.000^{a}

Using Dunnett test analysis, we compared the morphological abnormalities that have been observed by microscopic examinations among the treatment groups. E: *Eruca*, H: *Hypericum*, letters, [a and b] Represent significant difference value ($P<0.05$), same letter: No significant difference, different letter: Significant difference

(hypericin, hyperforin, quercetin, and flavonoids) [18]. This study attempted to repair or reduce its effect on germ cells. It is believed that any abnormalities in sperm morphology may be due to a change in the genetic component and these are classified as defects in the head, midpiece, and tail.

The results in this study agreed with Mohammed and Kheravii [19] as they stated that the frequency of abnormal mice sperms examined for 35 days injected with *H. triquetrifolium* but using different doses revealed a significant induction of sperm abnormalities in all concentrations of plant extract comparing with untreated animals. The most frequent types of sperm abnormalities of the treated groups were irregular head defect, pseudodroplet defect, bent midpiece defect, and corkscrew midpiece defect.

Mohammed and Mohammed [19] illustrated that the mixture of the compounds found in the aqueous extract of *Hypericum* caused cytotoxicity and induced different cytogenic effects in both somatic and germ cells of male albino mice. Similar to this conclusion, Mohammed and Ali [21] have also verified that at dose 17 mg/kg BW, the total abnormal spermatozoa has increased compared with the control group, indicating that the most frequent aberrant occurrence was bent midpiece and coiled tail as sperm morphology was always an indicator of toxicity and mutagenicity in mammals [21].

The results in this study revealed that *Eruca* has reduced the toxicological effects of *Hypericum* on sperm morphology in a marvelous way as it's obvious in T3 and T4 groups, this is in agreement with many researches as [22] reported that exposed rats to cadmium chloride treated with *E. sativa* seeds extracts, improved the hormonal profile concentrations, serum testosterone, follicle-stimulating hormone, and luteinizing hormone (LH) and number of Leydig cells by increasing them parallel with alleviating the testicular toxicity induced by cadmium chloride [22]. They accredited the result to its antioxidant and free radicals scavenging activity [20] of many phytochemical compounds including glucosinolate and flavonoids [23] against oxidative damage induced by Cd and thereby improving the pituitary- testes axis and fertility [24], [12].

E. sativa seeds extract exhibited an evidence for a stimulatory effects on reproductive gonadal system through androgenic activities through increasing the number of Leydig cells could be due to the free radical scavenging ability through excluding the Fe^{3+} [15] or may be due to an increasing the number and/or the sensitivity of receptors

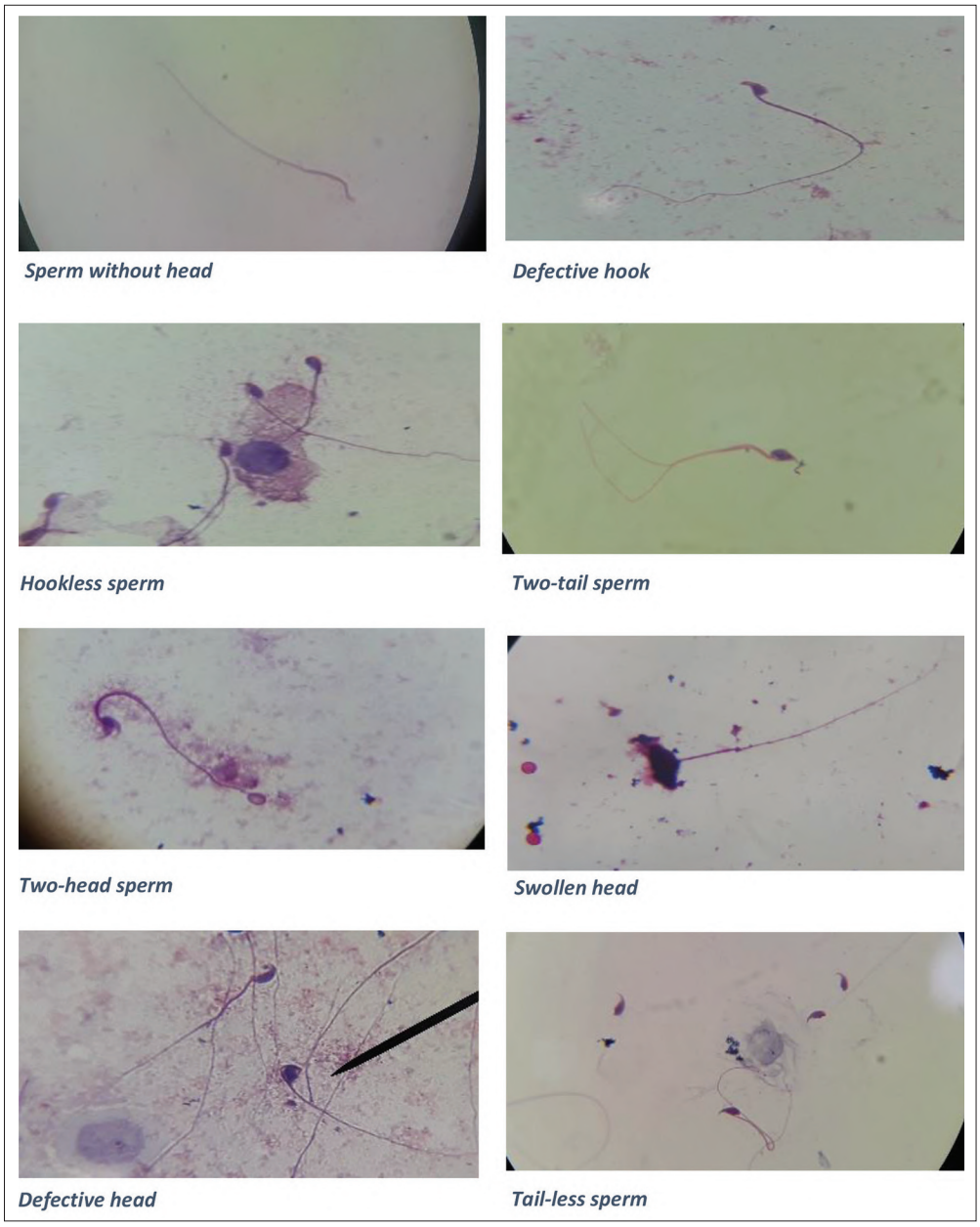

Fig. 1. Sperm abnormality types, depending on their morphology (×1000).

of the Leydig cells to LH which led to increase testosterone biosynthesis [16].

These findings cooperate with the researches of Mona and Nehal [25] and [26] that concluded the capability of *E. sativa* to improve healthy sperm characteristics and fertility. The increase of abnormal sperm morphology and decrease in viability may serve as a useful indicator of potential damage to the sperm by intubation of H_2O_2 [25] or may be due to impaired of Leydig's cell functions that can lead to enhances alteration of testosterone synthesis [12], [27]. Thus, in the present study, an improvement in male spermatogenesis in the cotreatment group has been documented, we suggest that *Eruca* protects and reduces the cytotoxic effects of *Hypericum*.

4. CONCLUSION

we concluded that Eruca could lower most of the sperm abnormalities significantly, and highly prevent the action of the Hypericum's toxins.

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ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Effect of Cationic Surfactants on Properties of Zinc Oxide Nanoparticles Synthesized through Sol-gel Technique

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ABSTRACT

Zinc oxide (ZnO) is an important metal oxide which participates in lots of applications, including gas sensors, catalysis, and optoelectronic devices. For nanostructured materials, agglomeration is problematic in the chemical production processes. In surfactant-free chemical reactions, aggregation occurs immediately as particles are generated. Therefore, the synthesis of controllable size nanoparticles is of great fundamental and technological interest. In the present study, the effect of cationic surfactants such as cetyltrimethylammonium bromide and benzalkonium chloride concentrations, on the optical properties, size, and morphology of ZnO nanoparticles synthesized through sol-gel method were studied. The characterizing tools were X-ray diffraction, Fourier transform infrared (FTIR) spectroscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), and ultraviolet-visible (UV-Vis-near-infrared) spectrophotometer. X-ray diffractogram confirmed the hexagonal (wurtzite structure) of ZnO. FTIR analyzed the presence of functional groups. The shape and size of the ZnO nanostructures were revealed by SEM and TEM. The band gap energy of the prepared ZnO samples was determined by UV-Vis spectrophotometer.

Index Terms: Benzalkonium Chloride, Cationic Surfactants, Cetyltrimethyl Ammonium Bromide, Nanostructures, Sol-gel Method, Zinc Oxide

1. INTRODUCTION

Zinc oxide (ZnO) is an interesting material as it is a semiconductor that has a large exciton binding energy of 60 MeV with a wide band gap of 3.4 eV at room temperature. The study of synthesis and growth of ZnO due to its size-dependent optical absorption is always a valuable tool. In fact, in an accessible size range experimentally, ZnO can show quantum confinement effects, unlike many oxides. Therefore, to quantum size ZnO particles, the best method to be used in cases like this is the sol-gel preparation method [1]. Not to mention ZnO has a low-temperature process in addition to cost savings, high carrier mobility, and transparency [1]. In the production and use of many chemical and pharmaceutical products, the most problematic matter is agglomeration. This aggregation immediately occurs when particles are generated in surfactant-free chemical reactions. To prevent aggregation, we have to embark from conventional colloid science in which particles are coated with foreign capping agents and/or the surface charges are tailored to separate them through electrostatic repulsions [2]. Because of its great fundamental and technological interest, it is always favorable to synthesize the ultrafine and controllable size particles with nanocrystalline structures [3].

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Most surfactants have a hydrophilic (water-loving) head and a long hydrophobic (water-hating or oil-loving) tail, as shown in Figs. 1 and 2. We often describe surfactants is being amphiphilic molecules – they love everything [4]. Due to their capability to control crystal growth and to provide solubility, surfactants are widely used during the preparation of crystalline metal oxide in the nanoscale, which by organizing the small oxide crystallites into a controlled structure, they can maintain regular pores and low angle Bragg reflection [5]. Previous studies showed that cationic surfactants generally affect the morphology, size, and optical properties of metal oxides by controlling the particle's growth. Cetyltrimethylammonium bromide (CTAB) is a common surfactant used in nanoparticle synthesis. One of CTAB's uses is to direct the growth and stabilize the shape of nanoparticles [6]. Although the study on benzalkonium chloride (BAK) effect on metal oxide properties is still unknown but it has similar uses to other cationic surfactants [7]. However, the variety in the molecular structure of the surfactants was taken into consideration to choose BAK that consists of a head group and a double ring bi-tailed structure.

Several physical and chemical methods could be taken under consideration to synthesize ZnO nanostructures. Chemical vapor deposition (CVD), metal-organic CVD, and molecular beam epitaxy, pyrolysis, vapor-liquid-solid growth, and vapor-solid processes such as thermal reduction, are considered physical methods. At the same time, to have a very large scale production, there are chemical methods that are very simple yet effective such as precipitation, sol-gel, and solvothermal processes. Unlike general methods, these methods do not require high temperatures and sophisticated instruments [8]. In this work, the purpose is to synthesize a controllable grain size of particles, to approach that goal, the sol-gel method is the most convenient process, especially when we adjust these experimental conditions such as concentration, temperature, pH, and reaction time. Besides, its simplicity, this method is reproducible and cost affective, as well as its the reliability of stoichiometry control, which makes it a thoroughly suitable process for industrial production of ZnO [9].

2. EXPERIMENTAL

2.1. Apparatus

The tools that have been used in this experiment are silica crucible, measuring cylinder, electronic balance, filter tunnel, spatula, plastic wash bottle, beaker, Petri dish, desiccators, beaker (100–500 mL), volumetric flask (100–250 mL), plastic tubes, magnetic stir bar, hotplates, filter paper, forceps, gloves, containers, Pyrex glasses substrate, furnace, oven, and the centrifuge instrument.

2.2. Preparation of ZnO Nanoparticles without and with (CTAB) and (BAK) Individually

ZnO nanocrystals were prepared by adding 100.0 mL of 0.5 mol/l NaOH solution dropwise slowly into 250.0 mL of 0.1 mol/l $Zn(Ac)_2$ solution under vigorous stirring and closed vessel to produce the $Zn(OH)_2$ precipitate, then an appropriate amount of NH_4HCO_3 (0.8 g) powder was added. After stirring for 30 min, a semitransparent zinc carbonate hydroxide colloid was obtained. After 30 min, the colloid was centrifuged and

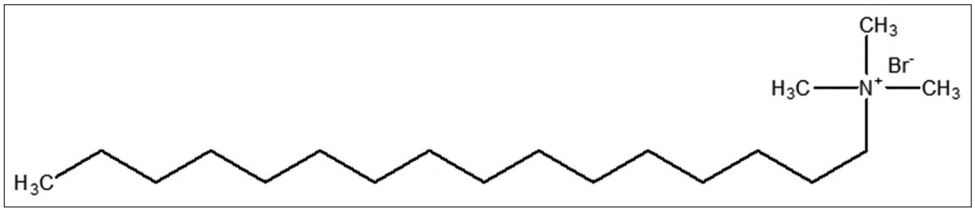

Fig. 1. Chemical structure of cetyltrimethylammonium bromide surfactant $CH_3(CH_2)_{15}N(CH_3)3+Br^-$ [4].

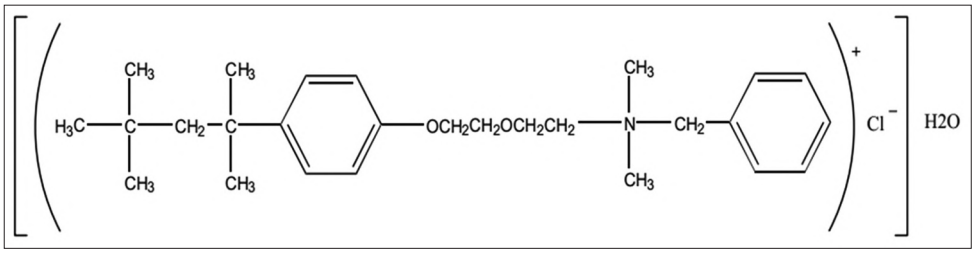

Fig. 2. Structure of benzalkonium chloride [7].

dried at 80°C. Thus, the precursor of a small crystallite of $Zn_5(CO_3)_2(OH)_6$ with white color was formed then calcinated at 450°C for 2 h. Finally, the product was dried at 70°C to obtain the white-colored sample of ZnO nanoparticle.

In the case of CTAB, after adding NH_4HCO_3 powder then CTAB (5×10^{-4} M below, 9×10^{-4} M at, 15×10^{-4} M above) critical micelle concentration (CMC) was added individually. After stirring for 30 min, a semitransparent zinc carbonate hydroxide, CTAB colloid was obtained. After 30 min, the colloid was centrifuged and dried at 80°C. Thus, the precursor of a small crystallite of $Zn_5(CO_3)_2(OH)_6$: CTAB with white color was formed. The precursor was then calcinated at 450°C for 2 h to obtain the sample. Finally, the product was dried at 70°C to obtain the white-colored sample of ZnO.

On the other hand, this time instead of CTAB, BAK (1×10^{-5} M below, 5×10^{-5} M at, 15×10^{-5} M above), and CMC were added one at a time. After stirring for 30 min, a semitransparent zinc carbonate hydroxide, BAK colloid was obtained. After 30 min, the colloid was centrifuged and dried at 80°C. Thus, the precursor of a small crystallite of $Zn_5(CO_3)_2(OH)_6$: BAK with white color was formed. The precursor was then calcinated at 550°C for 5 h to obtain the sample. Finally, the product was dried at 70°C to obtain the white-colored sample of ZnO [10].

2.3. Determination of CMC of CTAB Surfactant

CMC value determination of the CTAB surfactant was done using the conductivity method. Experiment was taken place at 298 K using thermostated water bath [10]-[13]. A CMC of the surfactant solutions was prepared using distilled water. These solutions were left for 15–20 min before being added to the ZnO synthesis precursor solution and measurements. The electrical conductivity was measured using conductivity meter, model ECCON1103K made from Singapore.

3. RESULTS AND DISCUSSION

3.1. CMC of CTAB

Fig. 3 shows that the CMC of CTAB was determined by plotting conductivity values against the concentration of surfactant solutions. The CMC value is obtained from the interception of two conductivity lines [11], the result was found to be 0.9 mM this result is near to that given in the literature data 0.89 mM [12]. The difference might be caused by taking the reading of conductivity meter before the conductivity meter could display a constant value. The CMC value of BAK was taken from literature data and it was 0.04 mM [13].

3.2. Analysis of Fourier Transformed Infrared (FTIR)

Fig. 4a shows the FTIR spectrum of prepared ZnO nanoparticles without CTAB. Furthermore, Fig. 4b-d shows the FTIR spectra of prepared ZnO nanoparticles in the presence of CTAB (below CMC, at CMC, and after CMC), respectively, while Fig. 5 shows the FTIR spectra of prepared ZnO nanoparticles in the presence of BAK (below CMC, at CMC, and after CMC), respectively. The broad absorption band centered above 3000 cm^{-1} is attributable to the band O–H stretching vibrations of water molecules on ZnO, and the band near 1630 cm^{-1} is assigned to the bond in H–O–H bending vibrations mode were also presented due to the adsorption of humidity in the air when FT-IR sample disks were prepared in an open air.

The spectrums near 1450 cm^{-1} indicate the existence of C-O. The broad absorption band in the region 1030–1384 cm^{-1} is assigned to C–H long-chain methyl, probably this is due to impurities like CTAB remnants. The existence of extra spectrums in Fig. 4b-d could indicate the unsuccessful removal of surfactant due to the calcination low temperature, which was 450°C and for 2 h. However, for ZnO samples with BAK surfactant, the calcination temperature was raised to 550°C for 5 h. The difference in the calcination temperatures and the time could explain the difference between the figures, and because of using two different surfactants, Fig. 4b-d of ZnO samples with CTAB surfactant is generally blue-shifted which means a decrease in wavelength [14] while Fig. 5 of ZnO samples with BAK surfactant is not blue shifted.

3.3. Analysis of Scanning Electron Microscopy (SEM)

The morphology of the prepared ZnO samples was determined by SEM analysis, as shown in Figs. 6-12,

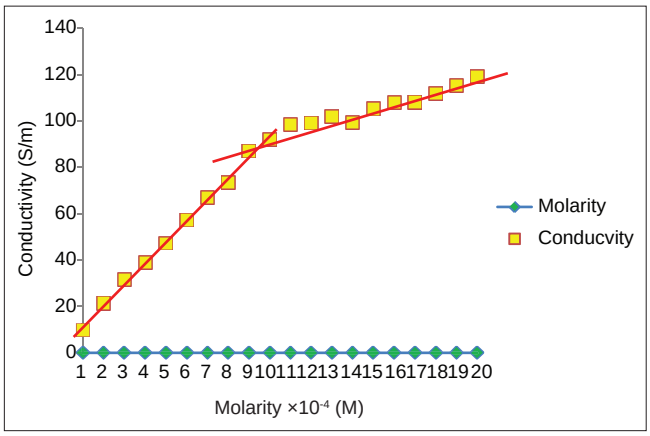

Fig. 3. Plot of conductivity against cetyltrimethylammonium bromide concentration, the temperature is at 298 K.

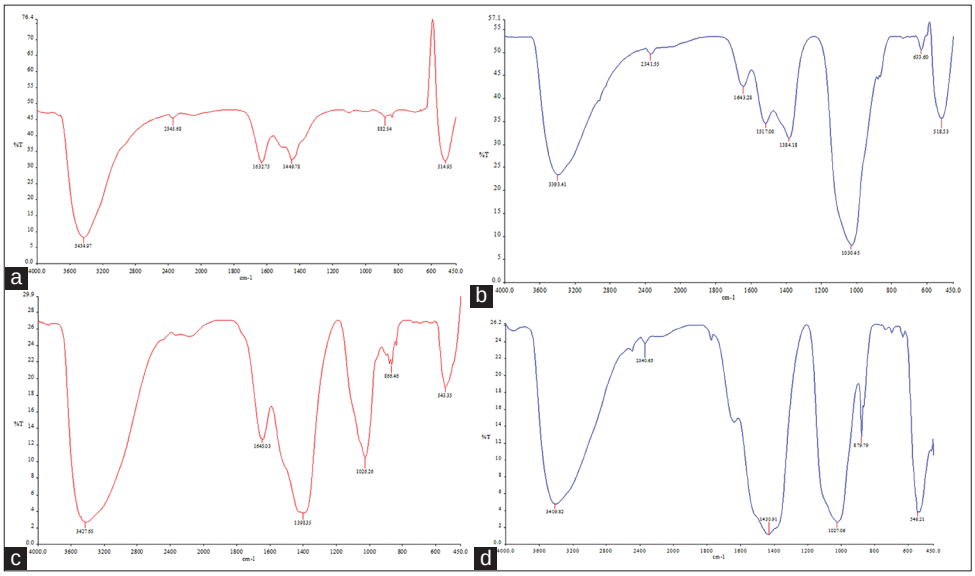

Fig. 4. Combined Fourier transform infrared spectrums of zinc oxide nanoparticles without and with cetyltrimethylammonium bromide (CTAB) surfactant. (a). Without surfactant, (b) with CTAB below critical micelle concentration (CMC), (c) with CTAB at CMC, (d) with CTAB above CMC.

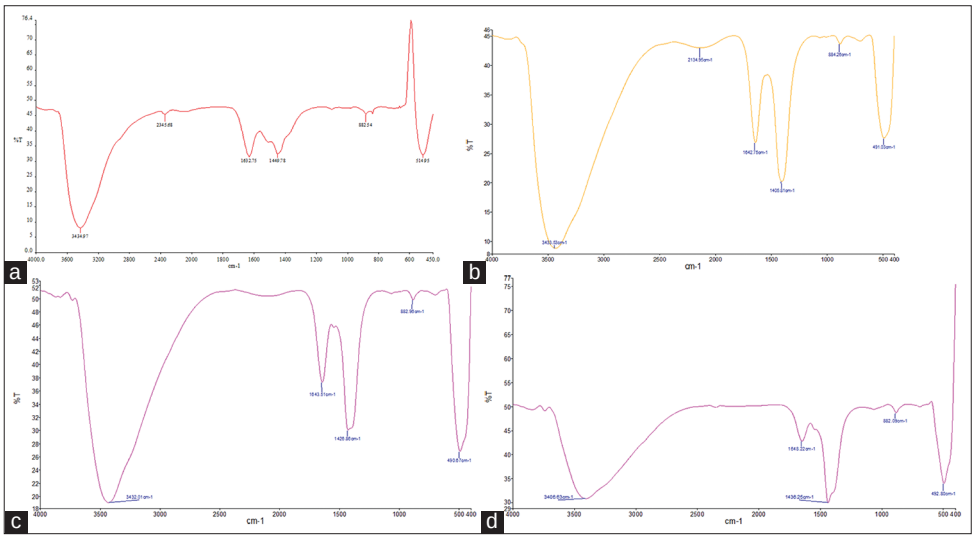

Fig. 5. Combined Fourier transform infrared spectra of zinc oxide nanoparticles without and with benzalkonium chloride (BAK) surfactant. (a). Without surfactant, (b) with BAK below critical micelle concentration (CMC), (c) with BAK at CMC, (d) with BAK above CMC.

ZnO samples with CTAB are calcined at 450°C for 2 h; demonstrate uniform but not the best morphology, due to impurities that have been investigated by FTIR results. ZnO samples with BAK are calcined at 550°C for 5 h, do not reveal uniform morphology. The structure of BAK is bulky and bi-tailed which is insoluble; the particles tend to agglomerate, which caused the increase in the particle size [15]. The particle sizes of ZnO sample were taken by line intersecting method; the result revealed that the prepared ZnO sample without CTAB and BAK in Fig. 4 was in the range of 80–85 nm which was larger than the prepared samples in the presence of CTAB (Figs. 7-9) and smaller than the prepared samples in the presence of BAK (Figs. 10-12), respectively. Among the other samples, the particle size of ZnO with CTAB at CMC, as shown in Fig. 8, was in the range of 55–60 nm. Both surfactants have a long chain of carbon included compound, in CTAB carbon may surround the zinc (Zn) particle or located between them, resulting in reduction of particle size and minimize the agglomeration of particles.

Although SEM is not an accurate technique to determine the particle size, using line intersecting method according

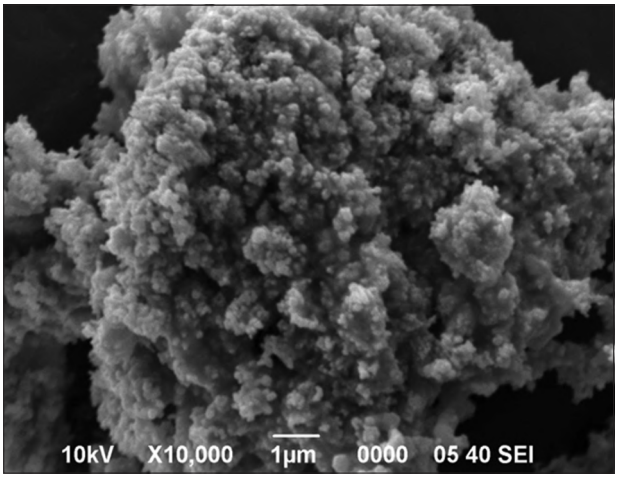

Fig. 6. Scanning electron microscopy image of zinc oxide nanoparticles without surfactant.

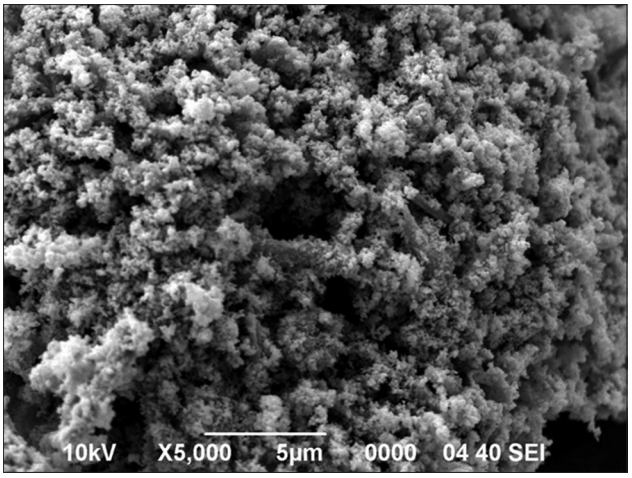

Fig. 8. Scanning electron microscopy image of zinc oxide nanoparticles with cetyltrimethylammonium bromide at critical micelle concentration.

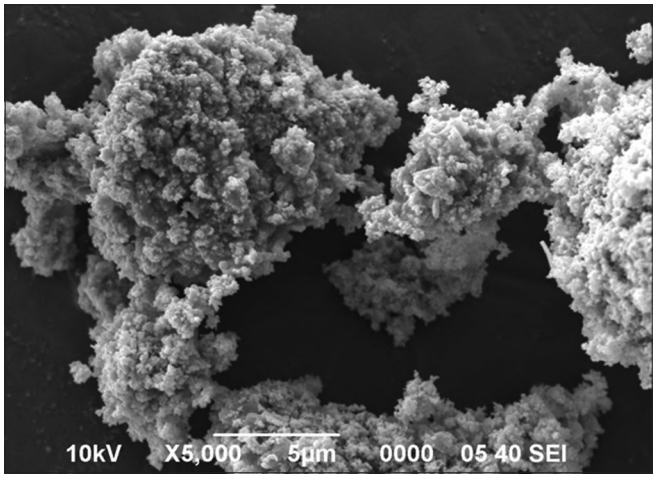

Fig. 7. Scanning electron microscopy image of zinc oxide nanoparticles with cetyltrimethylammonium bromide below critical micelle concentration.

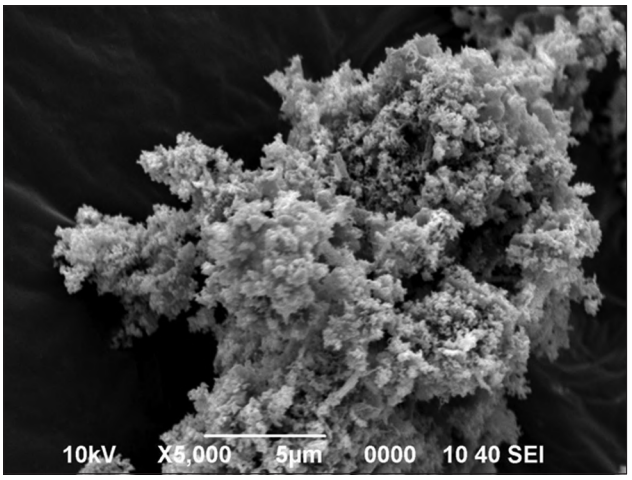

Fig. 9. Scanning electron microscopy image of zinc oxide nanoparticles with cetyltrimethylammonium bromide above critical micelle concentration.

to particle size distributions of ZnO nanoparticles based on SEM images, ZnO particles without surfactant reveal an average size of 86 nm, as shown in Fig. 13. The average size of samples with CTAB below CMC point is 84 nm. From both figures, it can be concluded that there is not a considerable change. Nevertheless, ZnO samples at CMC point demonstrate a smaller average size of 73 nm. The average size of samples with CTAB above CMC point is 80 nm, as shown in Figs. 14-16.

However, the results for ZnO samples with BAK revealed a bigger average size of 125 nm for ZnO with BAK below CMC point, 145 nm for ZnO with BAK at CMC point, and 212 nm for ZnO with BAK above CMC point. These samples are not nanosized, as shown in Figs. 17-19. The actual reason is due to BAK's bulky structure which contains 25 carbon atoms in the tail that cause the agglomeration, as a result of this led to an increase in the size of the particles [15].

3.4. Analysis of Ultraviolet-Visible-Near-Infrared Spectroscopy

Figs. 20-26 illustrates the $(\alpha h\upsilon)^2$ versus $h\upsilon$ plot used for the estimation of the band gap of ZnO nanoparticles calcined at 550°C by extrapolating the graph to X-axis so as to calculate the band gap of the samples. The band gap is found to be 3.26 eV, 3.31 eV, 3.49 eV, 3.39 eV, 3.27 eV, 3.24 eV, and 3.21 eV for the samples prepared without surfactant and with both surfactants CTAB and BAK

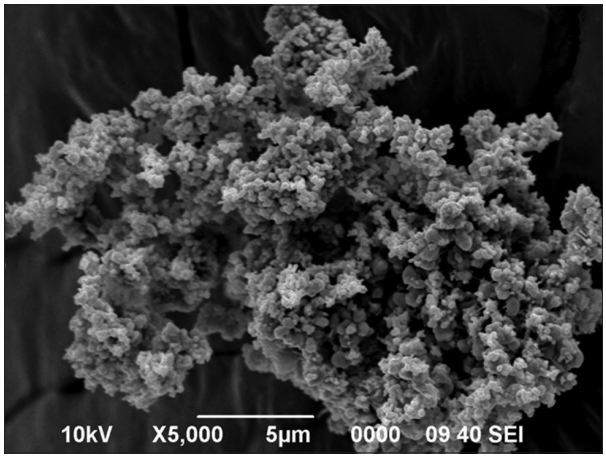

Fig. 10. Scanning electron microscopy image of zinc oxide nanoparticles with benzalkonium chloride below critical micelle concentration.

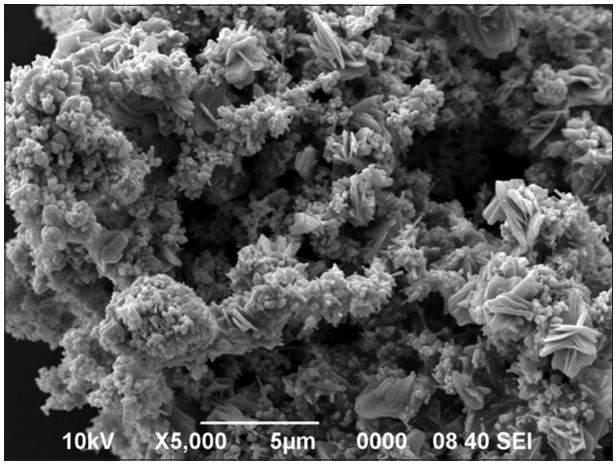

Fig. 11. Scanning electron microscopy image of zinc oxide nanoparticles with benzalkonium chloride at critical micelle concentration.

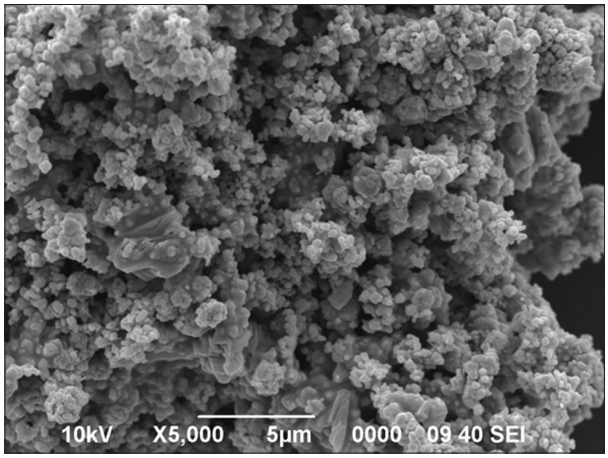

Fig. 12. Scanning electron microscopy image of zinc oxide nanoparticles with benzalkonium chloride above critical micelle concentration.

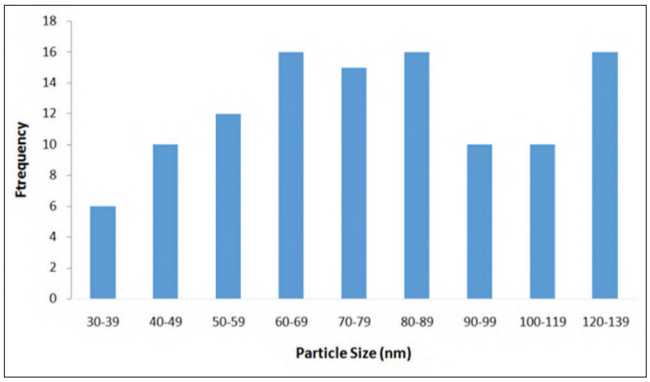

Fig. 13. Particle size distributions of zinc oxide nanoparticles without surfactant.

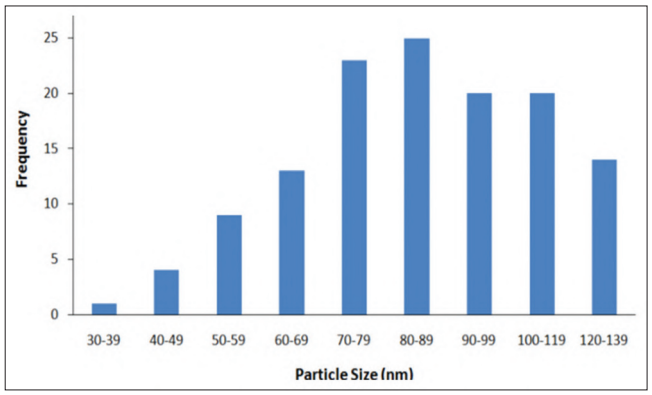

Fig. 14. Particle size distributions of zinc oxide nanoparticles with cetyltrimethylammonium bromide below critical micelle concentration.

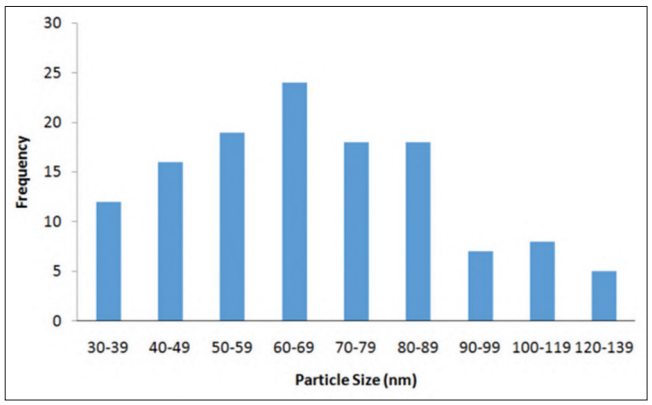

Fig. 15. Particle size distributions of zinc oxide nanoparticles with cetyltrimethylammonium bromide at critical micelle concentration.

individually at different concentration (below, at, and after), respectively. The band gap increases in the presence of CTAB particularly at CMC point due to quantum size effects, as the size of a particle decrease, till it reaches a nanoscale, the decrease in confining dimension makes the energy levels discrete and this increases or widens

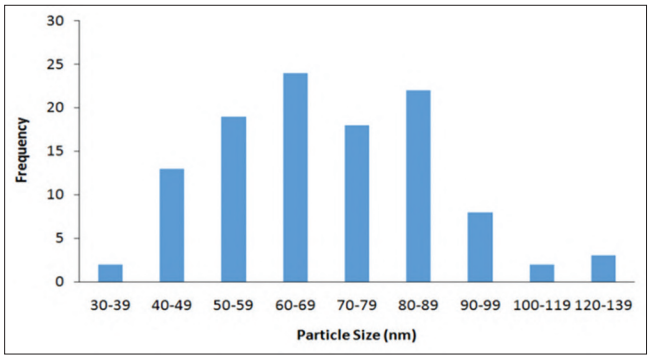

Fig. 16. Particle size distributions of zinc oxide nanoparticles with cetyltrimethylammonium bromide above critical micelle concentration.

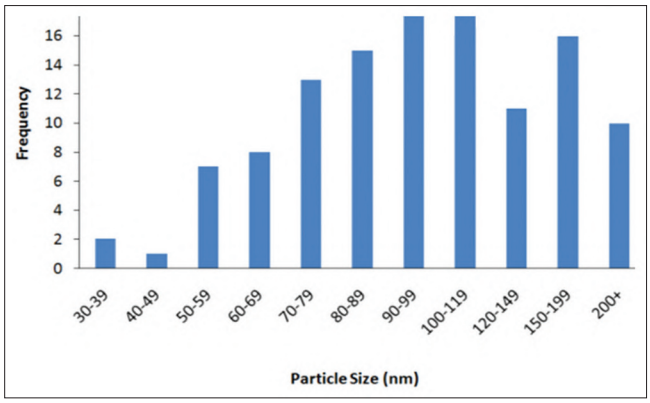

Fig. 17. Particle size distributions of zinc oxide nanoparticles with benzalkonium chloride below critical micelle concentration.

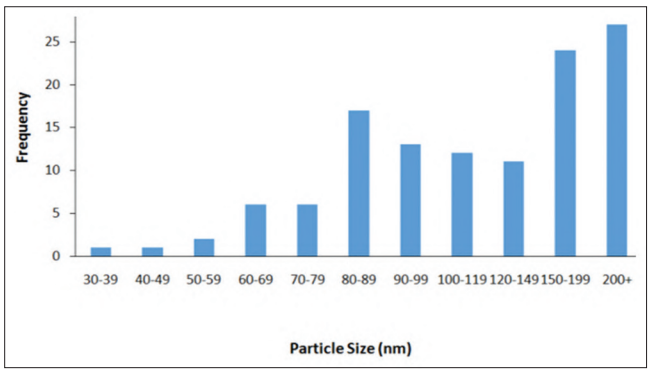

Fig. 18. Particle size distributions of zinc oxide nanoparticles with benzalkonium chloride at critical micelle concentration.

up the band gap and ultimately the band gap energy also increases [16], and decreases in the presence of BAK surfactant because of its bulky structure which contains 25 carbon atoms in the tails that cause the agglomeration. Although the results show two curves, which means impurities presence.

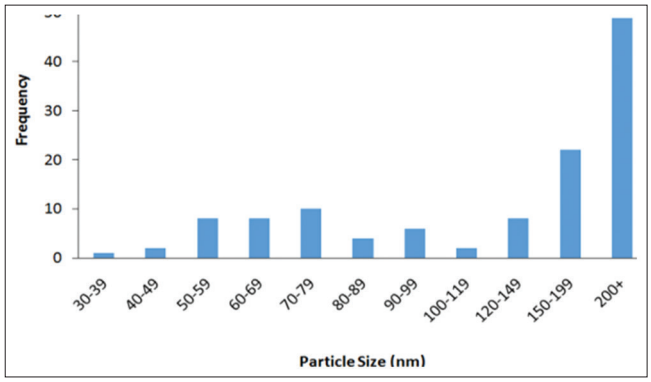

Fig. 19. Particle size distributions of zinc oxide nanoparticles with benzalkonium chloride above critical micelle concentration.

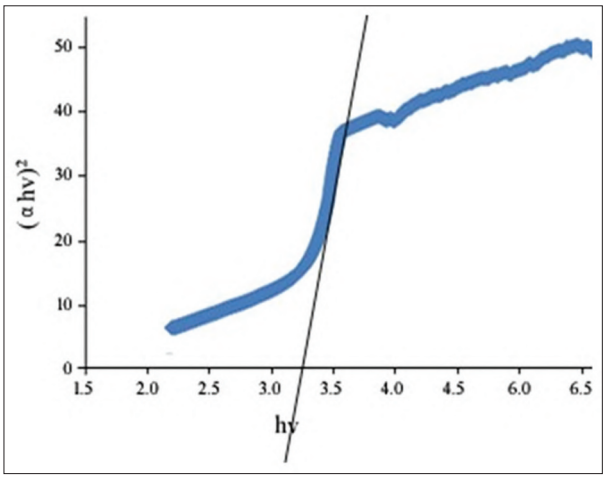

Fig. 20. Band gap energy for zinc oxide nanoparticles without surfactant.

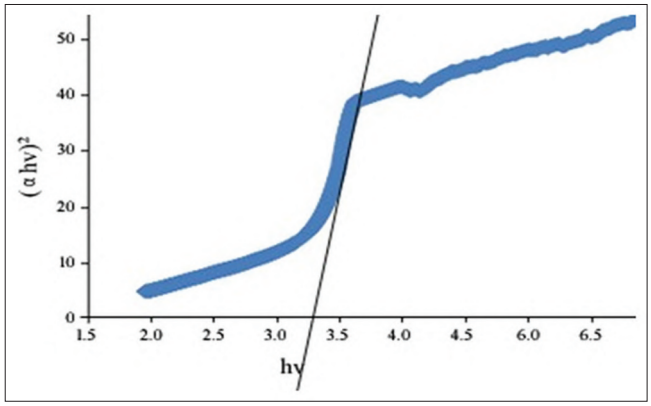

Fig. 21. Band gap energy for zinc oxide nanoparticles with cetyltrimethylammonium bromide below critical micelle concentration.

The following table (Table 1) reveals a comparison of band gap energy for each sample:

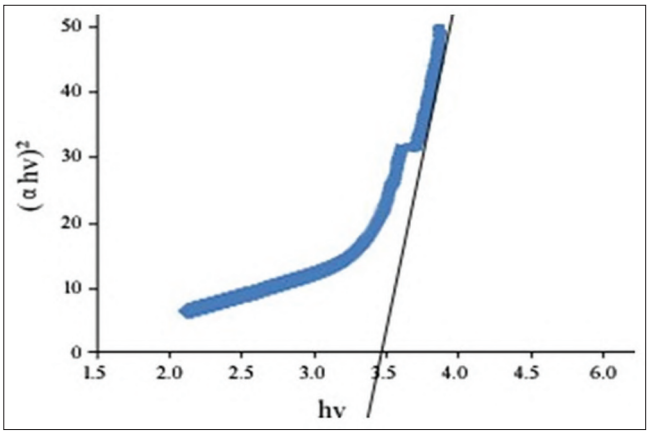

Fig. 22. Band gap energy for zinc oxide nanoparticles with cetyltrimethylammonium bromide at critical micelle concentration.

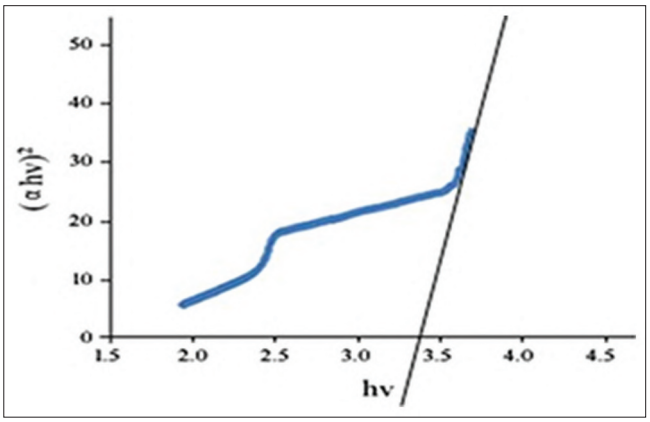

Fig. 23. Band gap energy for zinc oxide nanoparticles with cetyltrimethylammonium bromide above critical micelle concentration.

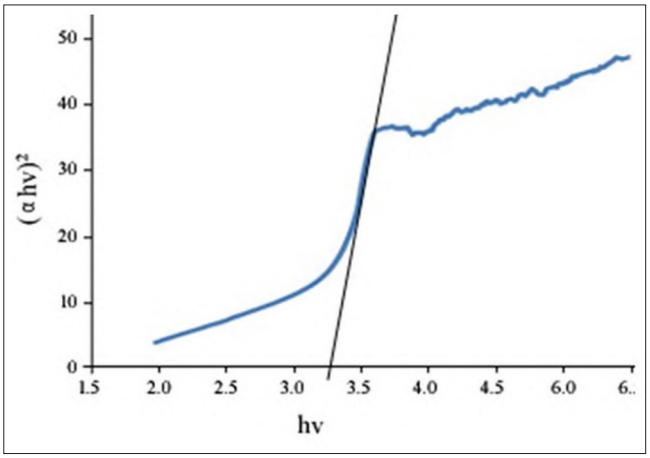

Fig. 24. Band gap energy for zinc oxide nanoparticles with benzalkonium chloride below critical micelle concentration.

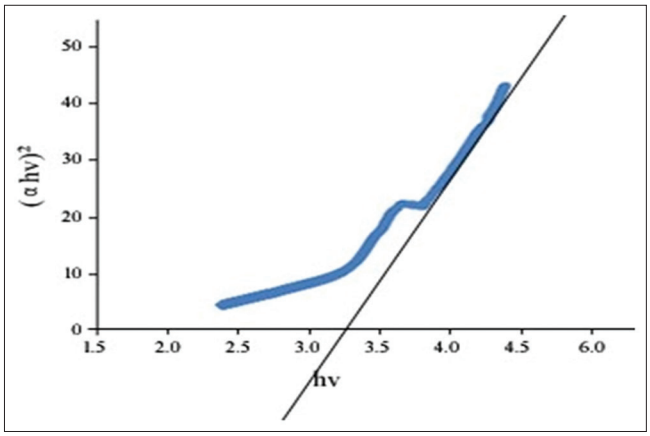

Fig. 25. Band gap energy for zinc oxide nanoparticles with benzalkonium chloride at critical micelle concentration.

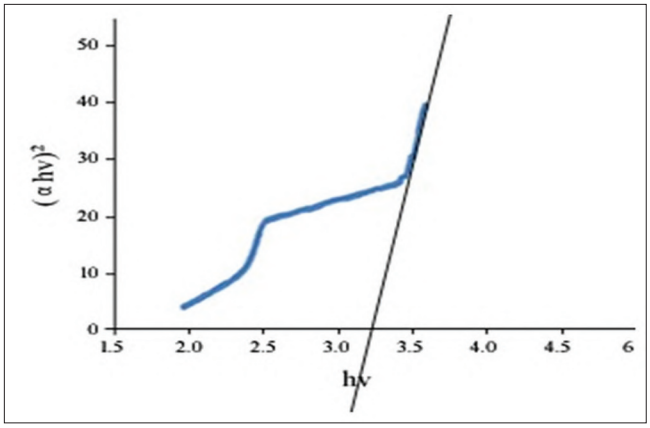

Fig. 26. Band gap energy for zinc oxide nanoparticles with benzalkonium chloride above critical micelle concentration.

TABLE 1: Band gap energy for each sample

Status	Band gap for ZnO: CTAB (eV)	Band gap for ZnO: BAK (eV)
Below CMC	3.31	3.27
At CMC	3.49	3.24
Above CMC	3.39	3.21

CTAB: Cetyltrimethylammonium bromide, ZnO: Zinc oxide, BAK: Benzalkonium chloride, CMC: Critical micelle concentration

3.5. Analysis of X-Ray Diffractometer (X-Ray Diffraction [XRD])

Fig. 27 shows the XRD patterns of the ZnO nanoparticles calcined at 450°C for 2 h. A study of standard data JCPDS 76-0704 confirms that all the synthesized materials are hexagonal ZnO phase (wurtzite structure). The indexed spectrums of ZnO samples with CTAB at CMC, as shown in Fig. 28, have a high intensity and narrow width, which indicates that the products are well crystallized.

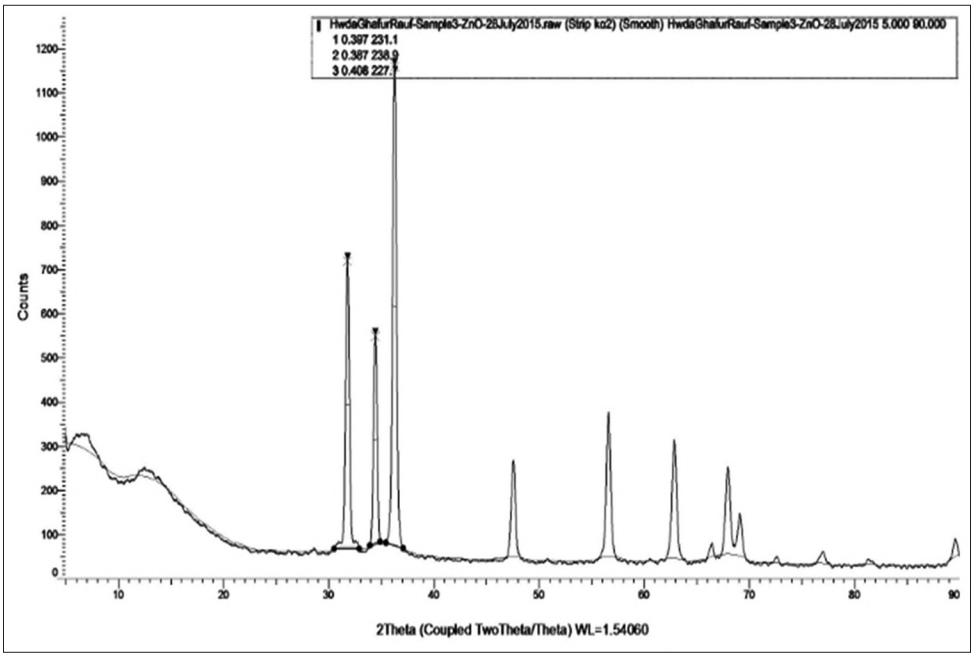

Fig. 27. XRD diffractogram of zinc oxide nanoparticles without surfactant.

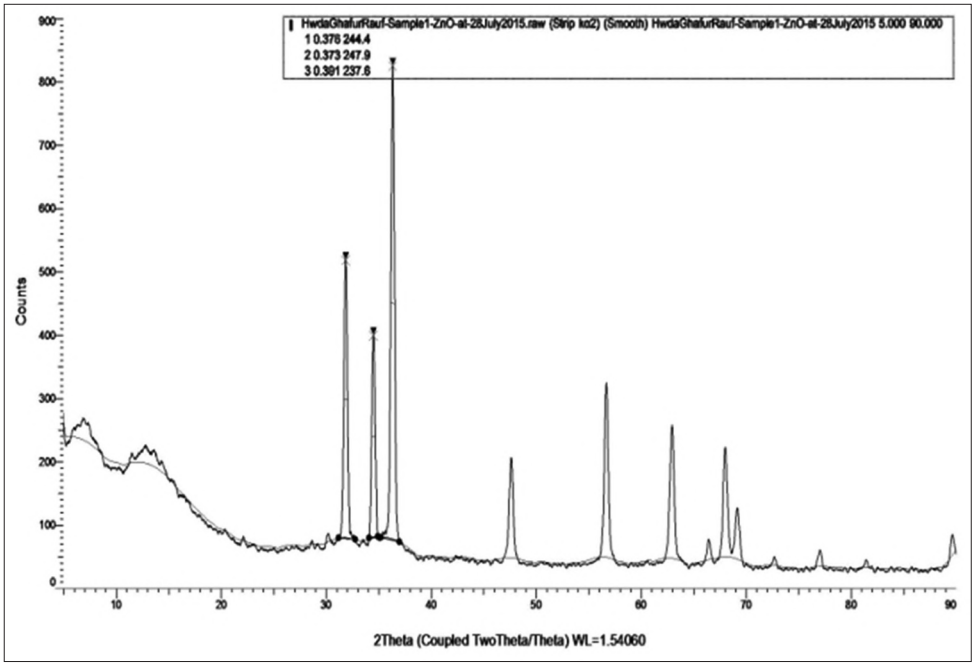

Fig. 28. XRD diffractogram of zinc oxide nanoparticles with cetyltrimethylammonium bromide at critical micelle concentration.

The XRD pattern for the ZnO nanoparticle prepared without surfactant calcined at 450°C for 2 h is shown in Fig. 27. The three highest spectrums were assigned as (100), (002), and (101) matched planes for 2Θ values of 31.769, 34.422, and 36.254°, respectively. The calculated average size of the most intense three diffraction spectrums was 76.9 nm. However, Fig. 29 is the XRD pattern for the ZnO nanoparticle prepared in the presence of CTAB below CMC calcined at 450°C for 2 h, recorded similarity matching with ZnO nanoparticles prepared without surfactant based on reference (JCPDS 76-0704). To estimate the average crystallite sizes of the prepared ZnO nanoparticle, Debye–Scherrer equation was used for the

(100), (002), and (101) planes corresponding to three exhibited broadened diffraction spectrums, and the average particle size was 74.1 nm (Fig. 29). This shows that the crystalline size becomes slightly smaller with increasing CTAB concentration.

The XRD pattern for the ZnO nanoparticle prepared in the presence of CTAB at CMC calcined at 450°C for 2 h, as shown in Fig. 27, recorded the similarity matching with ZnO nanoparticles prepared without surfactant based on reference (JCPDS 76-0704) but there was a difference in the spectrum broadening, the diffraction spectrums became broader, which indicates the consistent of smaller particle sizes. They were assigned as (100), (002), and (101) for the three highest spectrums matched planes for 2Θ values of 31.769, 34.422, and 36.254°, respectively. The calculated average size of the most intense three diffraction spectrums was 68.0 nm. This shows that the crystalline size became smaller in the presence of CTAB at CMC concentration compared to the one below CMC. The reason is due to a large amount of surfactant monomers at CMC just before agglomeration and creating micelles. Moreover, the particles tend to agglomerate with the increase in CTAB surfactant concentration. Therefore, the amount of surfactant added was crucial in synthesizing ZnO with disperses particles. The surfactants create their own interface and form micelles at CMC [17]. Under the same conditions, micelle formation occurs in the bulk phase and surfactant-coated nanoparticles formed start to decrease by increasing surfactant concentration beyond the CMC point [18].

The XRD pattern of the ZnO nanoparticle prepared with BAK surfactant below CMC calcined at 550°C for 5 h is shown in Fig. 30. The three highest spectrums were assigned as (100), (002), and (101) matched planes for 2Θ values of 31.769, 34.422, and 36.254º, respectively. The structure of synthesized material is hexagonal ZnO (Wurtzite structure) according to standard data JCPDS 76-0704. The calculated average size of the most intense three diffraction spectrums was 116.4 nm. Moreover, the structure was hexagonal as the others. On the other hand, Fig. 31 shows the XRD pattern of the ZnO nanoparticle prepared with BAK surfactant at CMC calcined at 550°C for 5 h. The three highest spectrums were assigned as (100), (002), and (101) matched planes for 2Θ values of 31.769, 34.422, and 36.254º, respectively. The calculated average size of the most intense three diffraction spectrums was 130.0 nm.

The XRD pattern for the ZnO nanoparticle prepared with BAK surfactant above CMC calcined at 550°C for 5 h is shown in Fig. 32. The three highest spectrums were assigned as (100), (002), and (101) matched planes for 2Θ values of 31.769, 34.422, and 36.254°, respectively. The calculated average size of the most intense three diffraction spectrums was 240.0 nm. As its obvious the particle size of ZnO samples in the presence of BAK increased due to the bulky and bi-tailed structure of BAK which causes agglomeration. The tail of BAK contains 25 carbon atoms, which causes agglomeration and leads to increase in particle size [15].

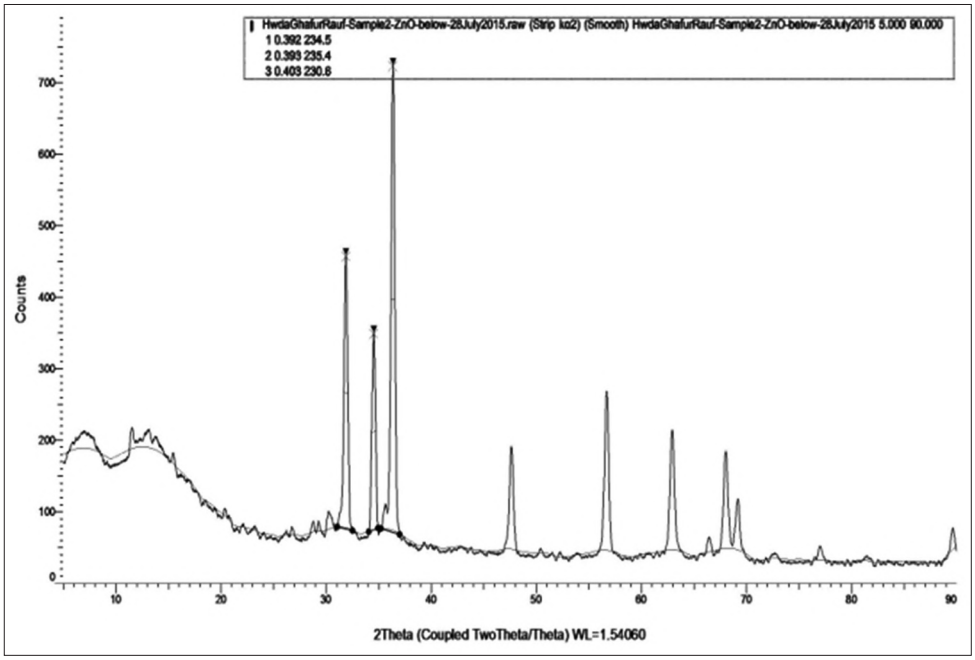

Fig. 29. XRD diffractogram of zinc oxide nanoparticles with cetyltrimethylammonium bromide below critical micelle concentration.

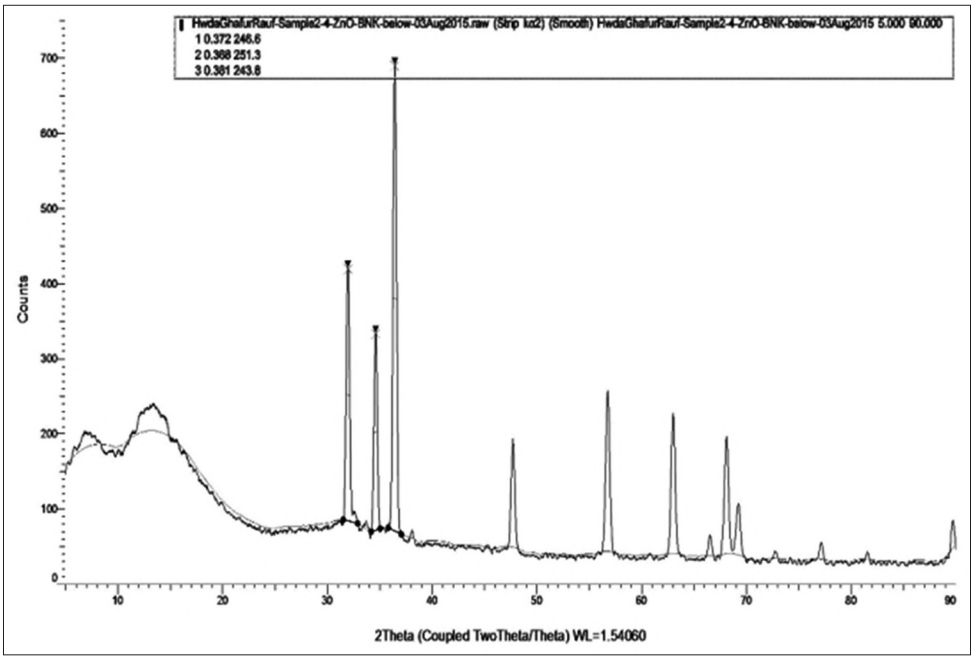

Fig. 30. XRD diffractogram of zinc oxide nanoparticles with benzalkonium chloride below critical micelle concentration.

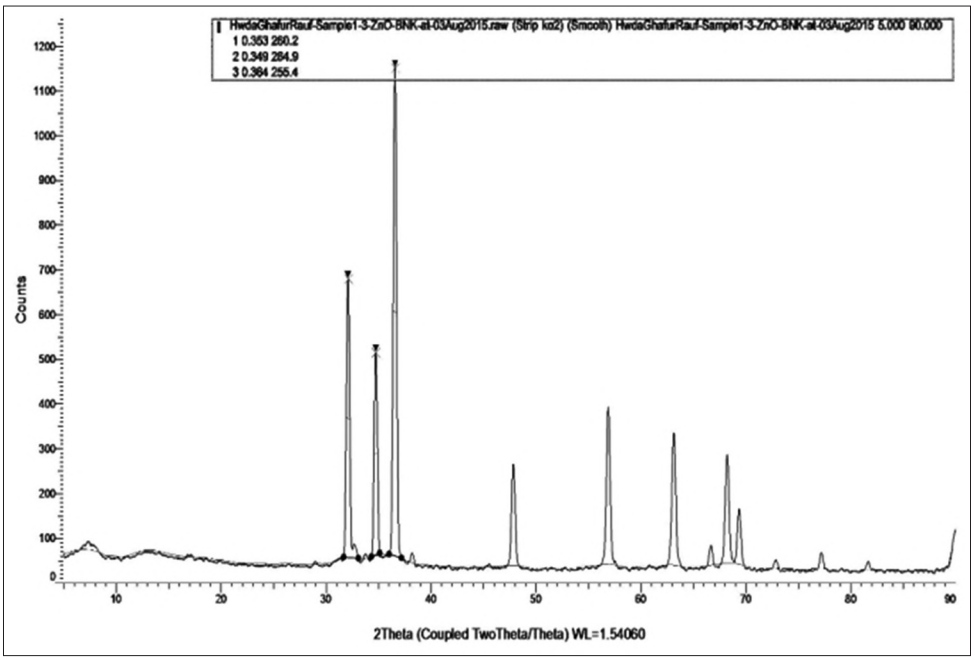

Fig. 31. XRD diffractogram of zinc oxide nanoparticles with benzalkonium chloride at critical micelle concentration.

3.6. Analysis of Transmission Electron Microscopy (TEM)

TEM was used to determine the average particle size by Digital Micrograph software. The results that obtained by TEM image and TEM particle size distribution of ZnO sample without surfactant were 66 nm and 60 nm for ZnO with CTAB below CMC, 51 nm for ZnO with CTAB at CMC, 100 nm for ZnO with BAK below CMC, and 140 nm for ZnO with BAK at CMC, as shown in Figs. 33-42, respectively. As it is been mentioned in the previous investigations, the particle size of ZnO samples in the presence of BAK increased due to the bulky and

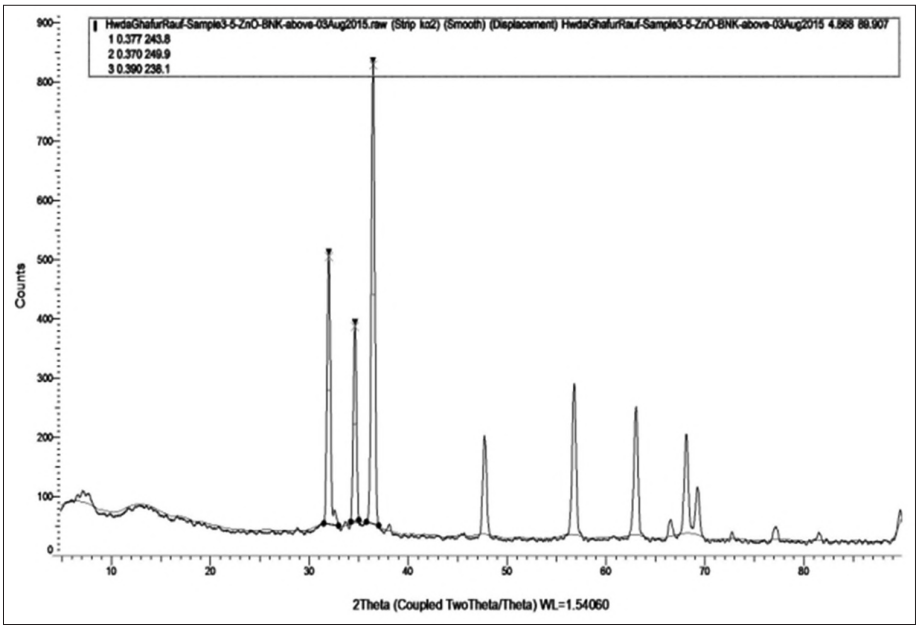

Fig. 32. XRD diffractogram of zinc oxide nanoparticles with benzalkonium chloride above critical micelle concentration.

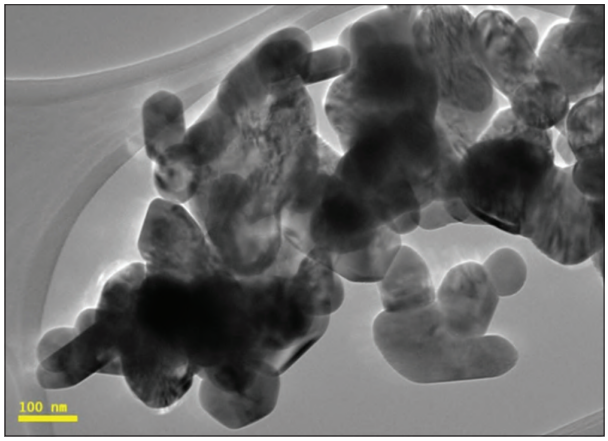

Fig. 33. Transmission electron microscopy image of zinc oxide nanoparticles without surfactant.

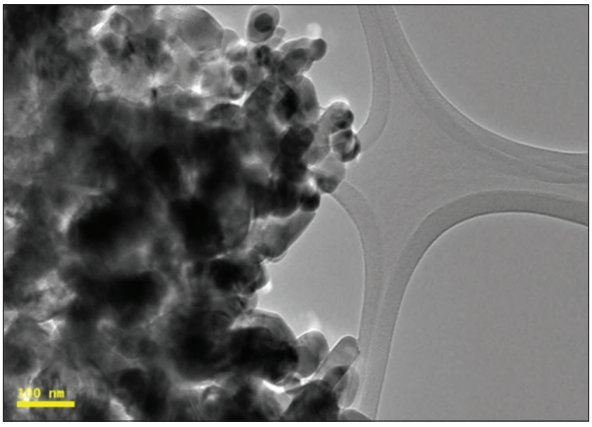

Fig. 35. Transmission electron microscopy image of zinc oxide nanoparticles with cetyltrimethylammonium bromide below critical micelle concentration.

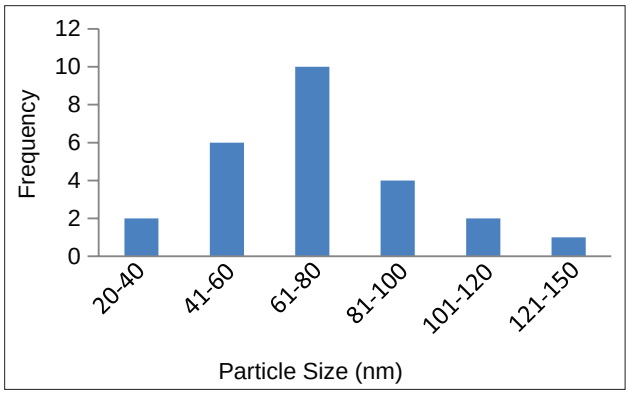

Fig. 34. Particle size distributions of zinc oxide without surfactant based on transmission electron microscopy.

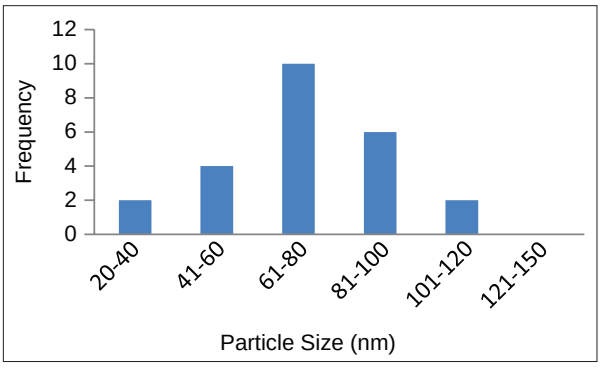

Fig. 36. Particle size distributions of zinc oxide with cetyltrimethylammonium bromide below critical micelle concentration based on transmission electron microscopy.

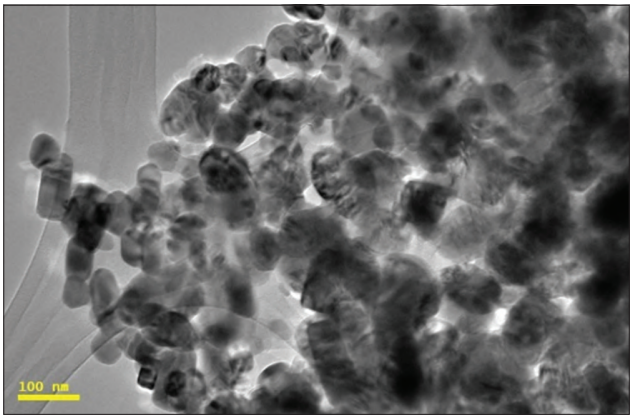

Fig. 37. Transmission electron microscopy image of zinc oxide nanoparticles with cetyltrimethylammonium bromide at critical micelle concentration.

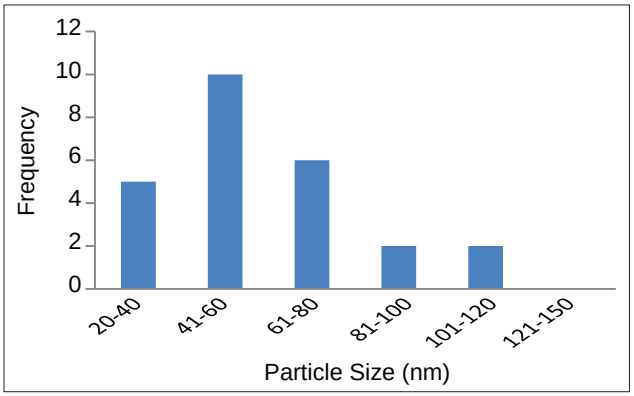

Fig. 38. Particle size distributions of zinc oxide with cetyltrimethylammonium bromide at critical micelle concentration.

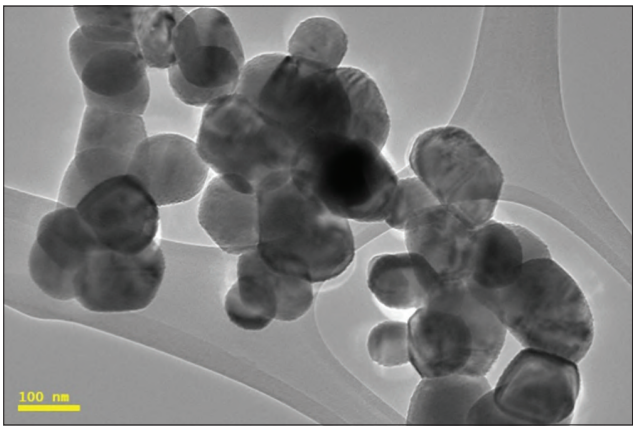

Fig. 39. Transmission electron microscopy image of zinc oxide nanoparticles with benzalkonium chloride below critical micelle concentration.

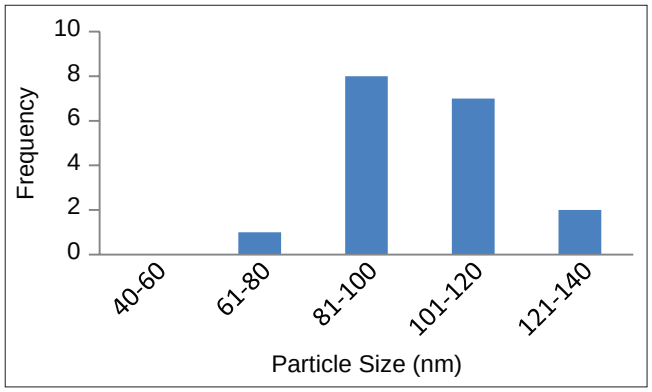

Fig. 40. Particle size distributions of zinc oxide with benzalkonium chloride below critical micelle concentration.

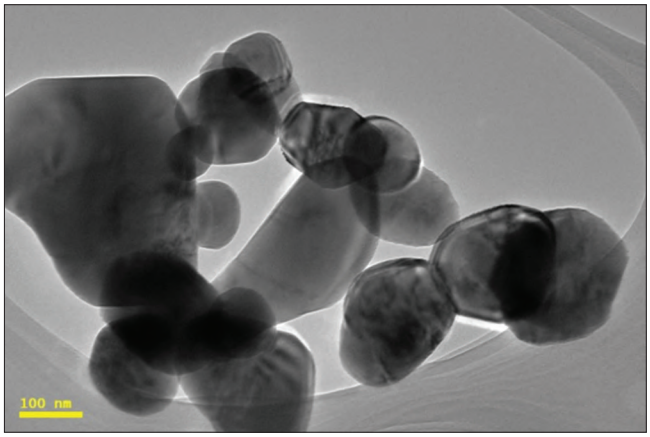

Fig. 41. Transmission electron microscopy image of zinc oxide nanoparticles with benzalkonium chloride at critical micelle concentration.

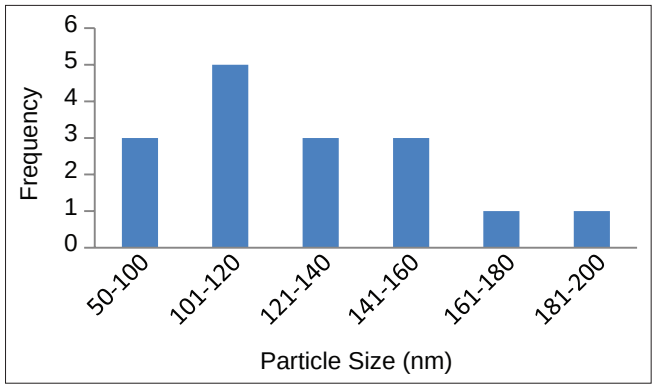

Fig. 42. Particle size distributions of zinc oxide with benzalkonium chloride at critical micelle concentration.

bi-tailed structure of BAK. The tail of BAK contains 25 carbon atoms, which causes agglomeration and lead to an increase in the particle size [15].

Among the samples, ZnO with CTAB at CMC has the smaller average particle size and starting to increase above CMC because the particles tend to agglomerate with the increase

TABLE 2: Calculated particle sizes for each sample from XRD, TEM, and SEM in different conditions

Status	Temperature (°C)	Average particle size from XRD (nm)	Average particle size from TEM (nm)	Average particle size from SEM (nm)
ZnO without surfactant	500	76.9	66	87
ZnO with CTAB below CMC	500	74.1	60	84
ZnO with CTAB at CMC	500	68	51	73
ZnO with CTAB above CMC	500	-	-	80
ZnO with BAK below CMC	500	116.4	100	125
ZnO with BAK at CMC	500	130	140	145
ZnO with BAK above CMC	500	240	-	212

ZnO: Zinc oxide, CTAB: Cetyltrimethylammonium bromide, BAK: Benzalkonium chloride, SEM: Scanning electron microscopy, TEM: Transmission electron microscopy, CMC: Critical micelle concentration

in CTAB surfactant concentration. The surfactants create their own interface and form micelles at CMC. Therefore, the amount of surfactant added was crucial in synthesizing ZnO with disperses particles.

The calculated particle sizes for each sample from XRD, TEM, and SEM are depicted in Table 2.

4. CONCLUSION

Among the prepared samples in the presence of CTAB at CMC, the prepared ZnO nanoparticles show uniform morphology, demonstrate a smaller size compared to the others, and the size increases with increasing CTAB concentration (after CMC), as the particles tend to agglomerate by increasing CTAB surfactant concentration. Moreover, with the addition of BAK surfactant, the particle size of all the samples starts to increase due to the carbon number in the structure of BAK which is for both tails is 25, which means surfactant activity becomes minimal and insoluble. Thus, solubility and practical surfactant properties are somewhat related. While the number of carbon atoms in the tail for CTAB is 17 at such level, a surfactant has good but limited solubility in water [15].

If the concentration of the surfactant was larger than the CMC, the surfactant formed micelles. When micelles are fully formed, the latter is not effective in dispersing the particles compared to monomers, which leads to an increase in particle size [19]. Agglomerations of particles occur in the micelle formation of surfactant, which results in larger particle size when the ratio of surfactant increases [19]. The indexed spectrums of ZnO with CTAB at CMC in the XRD spectrums have a high intensity and narrow width, which indicates that the products are well crystallized. Large band gap energy and highly blue-shifted absorption edge confirm that the synthesized ZnO nanoparticles in the presence of CTAB at CMC exhibit a strong quantum confinement effect [20].

5. ACKNOWLEDGMENTS

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6. AUTHORS' CONTRIBUTIONS

Hwda Rauf was responsible for data collection and analysis and for preparing the manuscript draft. Hamid Rasheedi worked on the concept of the given study and on the final manuscript review. Both authors read and approved the final manuscript.

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