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ORIGINAL RESEARCH ARTICLE | UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Environmental Impacts of Shewashok Oil Field on Sheep and Cow Meat Using Vital Trace Elements as Contamination Bioindicators

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ABSTRACT

Ambient environment is built based on the interaction of living and non-living organism and chemical and physical compounds, and thus, oil field emissions, effluents, and its general waste can be a part of environmental condition of certain area. This study is to investigate the environmental impacts of oil field on sheep and cow meat around Shewashok oilfield. It has been performed at the Laboratories of the Department of Medical Microbiology, Koya University, by detecting and measuring heavy metals and vital trace elements as contamination indicators. 20 meat samples of domestic animals (cow and sheep) in both control and affected area were collected for the purpose of detecting the concentration of heavy metals in the animals. The samples dried and digested with concentrated HNO_3 and concentrated H_2O_2. The concentration of heavy metals of the sample digested domestic animal was determined using inductively coupled plasma–optical emission spectroscopy. This study shows that iron, cobalt, copper, zinc, arsenic, manganese, aluminum, mercury, and chromium were detected in all the meat samples. Overall, this study confirms that the cow and sheep meat are still safe to eat in both locations because only Al, Fe, and Hg were found danger in both sheep and cows' meat in comparison with allowed limits of the World Health Organization 2017, and all other trace elements are complying with the global standards.

Index Terms: Cows' and Sheep Meat, Environmental Pollution, Oil Field, Shewashok, Trace Elements

1. INTRODUCTION

The Shewashok oil field was discovered in 1930. The first well was drilled in 1960 and the second was drilled in 1978, but, due to political circumstances, oil was not extracted until 1994 where the production was 44,027 barrels/day in that year. Then production reached 140,000 barrels a day by 2016 [1]. A total of 31 wells are drilled, and currently, more wells are drilling, but the field has rarely been studied scientifically, especially regarding ecological aspects.

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Air, water, and food are the basic needs of most of the living organisms to survive. The quality of consumed water, air, and food may transfer to the consumer body organisms. With gas flaring in the oil field, toxic gases and particles are released into the atmosphere [2]. Quite possibly the particles contain heavy metals due to that they are driven from hydrocarbons and come from deep geological layer formations, obviously living organisms consume this contaminated air as the source of their respiration.

Furthermore, diet is the most critical pathway of transferring the trace elements to mammal's organisms and store in the tissues; therefore, laboratory testing of animal tissues can be

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a vital bioindicator for environmental pollution [3]-[5]. Some Nigerian studies showed that, during drilling, oil production, refining, and gas flaring, harmful elements can add to air, soil, and both surface and groundwater [6], [7]. If air, water, and soil quality is not acceptable by standards, then vegetation, plants, and fruit quality can alter [7]. In general, contamination of air, water, and soil can transfer to plants then to animals by ingestion and then to human. In the study area, a research showed that groundwater is already not complying with national and international standards [1]. However, air, soil, and agriculture crops have not been studied yet.

Not all the trace elements are heavy metal but all the heavy metals are trace elements and toxic out of their limits. Therefore, some of the trace elements are essential for life, although some of them can cause a high risk to the health [8], [9]. In general, the metals can be classified into three main groups: Potential toxic such as cadmium and mercury; probably essential such as manganese and silicon; and essential metals such as cobalt, copper, zinc, and iron [8]-[10]. The toxicity effects are referred to specific types of metals which are not beneficial to human health; contrary, it causes severe toxicological effect if body receives an amount out of safe limit [8]. It may not be easy to prevent intake of trace elements by human, as industries significantly develop on a sustained speed around the world, a large amount of metals streaming into the environment. Moreover, yet, most of the heavy metals are permanently circling in the environment because they are indecomposable materials and these can integrate with daily essentials such as food and water, and hence, they make their way into the human tissues through the food chain [8], [11].

Meat is considered as an essential source of human nutrition. The chemical composition of meat depends on the quality of animal feeding; this may potentially accumulate toxic minerals and represent one of the sources of critical heavy metals [8], [10]. The risk associated with the exposure to heavy metals present in food and food products has aroused widespread concern in human health [11]. However, improvement in food production and processing technology achieved, but food contamination with various environmental pollutants also increased, especially trace elements and heavy metals among them.

In the light what introduces above, the current study aims to evaluate some vital trace elements such as Al, As, Cu, Cr, Co, Fe, Hg, Mn, and Zn in raw meat of cow and sheep that produced in Iraqi Kurdistan, and it tries to understand their level of danger and toxicity to consumers. The samples were collected from two industrial sites, an area surrounding the Shewashok oil field and in the north of Erbil. It will compare both samplings together and then evaluate them by considering the WHO standards for heavy metals and trace elements.

1.1. Study Area

The samples were collected from north of Iraq in Erbil province Fig. 1. This region is with Mediterranean climates system, having cool, wet winter, and hot and dry summers with mild spring and autumn, and its annual average precipitation is 450 mm with some variation from the mountains to the plains [12].

Two locations were selected from the province for the sampling: Focused location which is Shewashok oil field (called study area group in this article) in the southeast of Erbil and the second location is in the north of Erbil which is the main arable area and livestock farming of the province. The animals are feeding with available rearing resources in the region that means that the meat quality is affected by the ambient environment condition.

2. MATERIALS AND METHODS

The study data collection, preparation, and analysis followed below stages.

2.1. Sample Collection

The materials used for the study included field and laboratory materials. The experimental work has been performed at the laboratories of the Department of Medical Microbiology, Koya University. The collected samples from slaughterhouse of Arbil city "control area" and Koya city "study area." 20 meat samples were collected from each cow and sheep of the study area to detect the concentration of trace elements. In parallel, 20 samples have been collected from each cow and sheep of the control area.

2.2. The Summary of the Samples Collected at Both the Locations

- Number of samples collected: 80 samples.
- Number of samples collected of the study area sheep and cows: A total of 40 samples "in another word, 20 samples of each."
- Number of samples collected of control sheep and cows: A total of 40 samples "in another word, 20 samples of each."
- Trace element analyzed: Iron, cobalt, copper, zinc, arsenic, manganese, aluminum, mercury, and chromium.

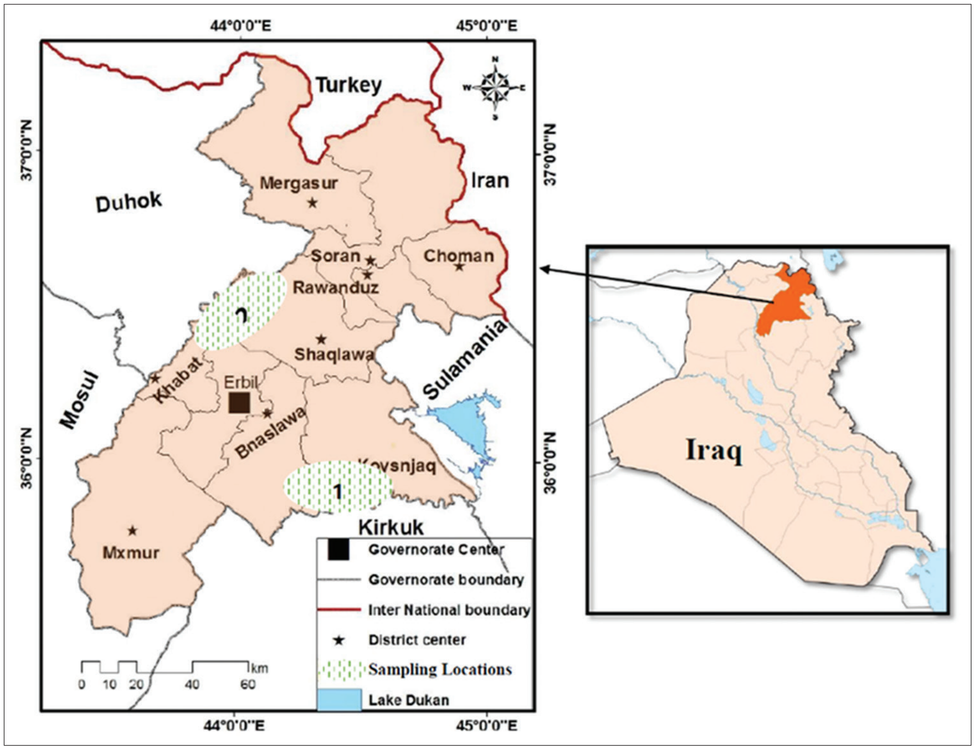

Fig. 1. Study area map with explain sampling locations.
Source: Kurdistan Region of Iraq, Ministry of Planning, Information Directorate and the preparation of maps, map of Erbil in 2016, scale (1: 250000).

2.3. Used Materials and Chemicals

2.3.1. Material

Cylinder, funnel, beaker filter paper watch glass, pipette, volumetric flask, conical flask, balance, bottle (250+500) ml hot plate, oven, centrifuge, hood, gloves, tissues, bio hand (alcohol to cleaning), plastic bags, blade operations, parafilm, bottle to save solution, falcon tube, cuter, and tongue depressor were used.

2.3.2. Chemical

Nitric acid, hydrogen peroxide, distilled water, deionized water, vacuum clever for cleaning materials, and inductively coupled plasma (ICP) were used as chemicals.

2.3.3. Digestion procedure to the determination of trace elements in the sample meat of sheep and cow animals by ICP–optical emission spectroscopy (OES)

The collected samples were decomposed by wet digestion method for the determination of various metals.

The collected samples were washed with distilled water to remove any contaminant particles. The samples were cut to small pieces using clean scalpel. Samples were dried in an oven at 100°C.

Weight 1 g of dried sample, using sensitive balance. Transfer the dried samples into 250 ml digestion beaker or flask. Digest the sample by adding 10 ml of concentrated HNO_3 and mix well. Heat the digestion mixture on a hot plate at 100 ± 10°C for 30 min, inside the fume chamber (Hood). Repeat the heating process once more with 10 mL of the acid. Cool down the mixtures to room temperature, and then, add 2 mL of concentrated H_2O_2. Heat the beaker or flask again carefully, until dryness. Leave to cool down, then dissolve the mixture in distilled or deionized water until obtaining a clear solution. Filter the sample solution through a cellulose filter paper into 25 ml digestion tubes. The filtrate was diluted to 25 mL with distilled or deionized water and heated the solution to dissolve the precipitate Transfer the samples into laboratory polyethylene bottles and store until analyzed. A blank digestion prepared in the same procedure for the control samples. Finally, analyze the elements in the sample solutions by ICP/ICP-OES. The final measurement volume of the sample solutions should be 5 ml [13]-[15].

2.3.4. ICP-OES

The well-known ICP–mass spectrometry technique has been used to test the samples at a modern scientific laboratory for heavy metals. Among the trace elements, only 17 critical heavy metals have been examined due to their negative impacts on living organisms [16].

2.4. Statistical Analysis

For the first section of this study discussion, data were expressed as mean ± standard error of mean ,and the Statistical Package for the Social Sciences (Version 20) software was used to analyze the results. Differences in mean values between two groups were analyzed by *t*-test. $P < 0.05$ was considered to be statistically significant.

2.5. Comparison of the Study Observations with the WHO Standards for Trace Elements

For the second section of this study discussion, only study area data (excluding control area in this section) were compared with the WHO 2017 guidelines for trace elements limits to find the level of contamination in our study according to the global scale.

3. RESULTS AND DISCUSSION

In recent years, much attention has been given to contamination of food products, among the animal meats. The level of trace elements in meat from different animals depends on some factors such as environmental conditions of the animal grazing location. The obtained results of the current study were divided into two sections to discuss; the first section is a comparison between study area which is Shewashok oil field and control area which is the north of Erbil, whereas the second section is a comparison between the study areas with the WHO standards.

3.1. First Section: Comparison of Study Area with Control Area

Table 1 shows that the difference between control and study groups of aluminum in sheep samples is 254.6 and 404.5 ppb, respectively, that means the study area is higher than control group by 1.5 times. Table 2 shows that the value of aluminum in cow sample of both control group and study area is 186.2 and 278.7 ppb, respectively, again the value of study area is higher than the control group by 1.4 times. Both locations have a similar value for aluminum, but in comparison with the WHO 2017 guidelines which are 200 ppb, both locations are higher than allowed limit that is due to the type of animal diet in both the groups [17].

Arsenic is also very toxic to animals, because it affects their body through gastrointestinal tract and the cardiovascular system. Symptoms of arsenic poisoning in animals include watery diarrhea, severe colic, dehydration, and cardiovascular collapse [13].

Table 1 presents that the value of arsenic in sheep samples of control area and study area is 8.005 ppb and 6.256 ppb, respectively, and Table 2 presents that the value in cow samples of control area and study area is 8.015 ppb and 7.478 ppb, respectively. Both sample sheep and cows of control group are higher than the study area and it is due to the contamination of pasture by industrial emissions [14]. Previous study shows a high concentration of arsenic in the meat of cattle and goats in Bieszczady mountains [18]. All samples of both locations in this study are within the allowed limit of the WHO which is10 ppb.

Tables 1 and 2 show that the result of chromium in both the locations had high differences between the control group and study area. The value of the control group of both sheep and cows' meat samples showed zero, but the study area location of the samples showed 0.752 and

TABLE 1: Trace element concentration in control and study groups of sheep meat

Elements	Control group (ppb)	study group (ppb)	*P* value
Al	254.6±48.51	404.5±126.3	0.275
Fe	1941±295.2	474.1±121.2	0.0001
Hg	26.12±0.434	26.91±0.484	0.229
Mn	159.5±31.21	179.7±28.88	0.638
Zn	1006±100.9	1080±128.8	0.654
As	8.005±0.789	7.478±1.010	0.683
Co	0.000±0.000	0.266±0.116	0.028
Cr	0.000±0.000	0.752±0.347	0.037
Cu	492.6±61.65	1038±253.8	0.043

Results expressed as mean±SE

TABLE 2: Trace element concentrations in control and study groups of cow meat

Elements	Control group (ppb)	study group (ppb)	*P* value
Al	186.2±31.59	278.7±41.19	0.08
Fe	1356±154.9	3720±534.3	0.0001
Hg	26.49±0.455	26.78±0.585	0.699
Mn	104.9±22.35	110.0±12.45	0.842
Zn	685.9±90.73	1688±264.4	0.001
As	8.015±0.812	6.256±0.950	0.171
Co	0.271±0.127	1.242±0.344	0.012
Cr	0.000±0.000	6.692±4.636	0.157
Cu	922.2±268.9	134.3±28.96	0.006

Results expressed as mean±SE

6.692 ppb, respectively, of sheep and cow sample; the high value of chromium in the study area is due to the release of chromium into the environment due to natural gas flaring during oil processing [19], [20]. This result was supported by the assessment of heavy metal pollution and contaminations in the cattle meat [13], [21]; however, the samples of both the locations had a lower value of chromium than allowed limit 50 ppb according to the WHO guideline.

For cobalt, Tables 1 and 2 show that the value between both locations in the sheep meat sample is 0.000 and 0.266 ppb, respectively, in control and study group, and for the cows' meat sample, the recorded value in control and study group is 0.271 and 1.242 ppb, respectively; the study area was higher than control area by approximately 4.6 times, it might due to soil contamination, also pasture lands is recognized as a source of Co, it can occur as a result of animal treading or soil splash on short pasture during heavy rain [22]. However, all samples of both the locations are within the allowed limit of the WHO which is 3 ppb.

Mercury is volatile liquid metal, found in rocks and soils, and also is present in air as a result of human activities as the use of mercury compounds in the production of fungicides, paints, cosmetics, papers pulp, etc. The highest concentrations were found in soils from urban locations; mercury may induce neurological changes and some diseases [23].

Table 1 shows that the sample of sheep meat had a high value of mercury contents of samples in the control and study area ranged between 26.12 ppb and 26.91 ppb, respectively, and also the sample of cows' meat like sheep meat had a high amount in both location control group (26.49 ppb) and study area (26.78 ppb). A previous study findings comply with this finding as mercury recorded high in beef meat from Algeria [14].

Zinc is another essential element in our diet, but the excess may be harmful, and the provisional tolerable weekly intake (PTWI) zinc for meat is 700 mg/week/person [21]. The minimum and maximum levels of Zn were detected in both the location of control group and study area of sheep samples which was recorded between 1006 and 1080 ppb respectively, and for the cows' sample, was recorded 685.9 and 1688 ppb, respectively, in both location of control group and study area, and none of the samples exceeded the recommended limit 3000 ppb according to the WHO guideline. Moreover, the difference between both positions of zinc metal is non-significant in sheep samples but for the cows' sample had a highly significant; however, the meat sample of cows and sheep in study area location showed a higher value when compared to control group because of the high intake of zinc by animals, due to several factors, first of all having excessive amounts of zinc in animal's food, pastures lands contaminated with smoke that polluted by zinc, surfaces painted with high-zinc paints where animals could lick them and finally food transport in galvanized containers that already containing zinc when manufactured [24], [25].

Iron deficiency causes anemia and meat is the source of this metal; however, when their intake is excessively elevated, the essential metal can produce toxic effects [26]. Table 1 shows that the iron value of control group and study area for sheep was 1941 and 474.1 ppb, respectively, and the amount of the control is more elevated than study group by 4 times, which recorded among the sheep meat samples [8].

Table 2 shows that the value of iron in cows' meat sample was 1356 and 3720 ppb, respectively, of the control group and study area, and both the locations are higher than allowed limit 300 ppb according to the WHO guideline. That is due to the type of feeding which contains dry plants that may be very rich with mentioned elements, or the consumed water is containing a high level of Fe.

Tables 1 and 2 show that the value of manganese element in cows' meat sample in control group and study area is 104.9 and 110 ppb, respectively, also in sheep meat sample, the amount of manganese of control and study area is 159.5 and 179.7 ppb, respectively, and the values of the study area is higher than the control group.

Although copper is essential for good health, the PTWI copper for fresh meat has been proposed as 14 mg/week/person [13]. However, very high intakes can cause health problems such as liver and kidney damage [25]. Determination of the Cu content in food is also an important subject concerning human consumption [27], [28].

Table 1 shows that the value of copper element of control group and study area for sheep is 492.6 and 1038 ppb, respectively, and the study area is higher than control area by 2.1 times. The results of the present study indicate that the values of copper in the study area were relatively high compared with the WHO guideline. That is, since this metals enter through feed material from burning zoon and transport excuse products, ultimately passage into the tissues and the excessive ingestion of copper by animals could occur in various situations such as grazing immediately after fertilization, pastures grown on soils containing high concentration of copper, supply of wheat treated with antifungal drugs containing copper, and pasture contaminated by smoke from foundries [21].

This result is compatible with other studies in countries such as Sweden, as high values of copper were found in the cattle meat [28], [29]. Moreover, about copper, Moreover, Table 2 shows that copper values of the control group and study area is 922.2 and 134.3 ppb respectively for cow's meat. Cows' meat from the control group had a higher value of Cu concentration compared with the study group. In this study, records of both animals and locations are within allowed limit 1000 ppb of WHO 2017.

In general, both areas are quite similar for cows and sheep because the values are close, which may be result of similarity of the geographic feature and exist no effective physical barrier between both locations.

3.2. Section Two: Comparing Study Area with the WHO 2017 Standards

Most of the elements are within the WHO standards such as Mn, Zn, As, Co, and Cr in both cows' and sheep meat, and only Cu is just above the WHO limit by 38 ppb in sheep meat samples; however, it is within the standard in cow samples (Table 3). Al and Fe both are exceeding the WHO guideline, Al by 204.5 and Fe by 174.1 ppb in sheep samples and Al 78.7 ppb and Fe 3420 ppb in cow samples. Furthermore, Hg is out of the WHO accepted range but with a high significant difference between the samples and the standard value, which is more than 4 times higher than the standard (Table 3).

This simple comparison notes that most of the elements are within the WHO standards such as Mn, Zn, As, Co, and Cr, which means that they have no health risks on consumers [30], [31]. Cu which is an essential trace element for a human body is just above the WHO limit only in sheep meat samples, but it probably not causing a tremendous health risk as the exceedance is negligible. Cu can increase in animal body if the consumed vegetable leafs have contaminated with Cu [8].

Both Al and Fe are effective exceeding the WHO guideline, as discussed in the first section high value of Al is due to the type of both animals' diet in the study area [17]. Fe is higher than the WHO standards in both animal meat samples, but it is very high in cows' meat samples as showed above. Both excessive and deficiency of Fe intake can lead to health disorder [32]. Fe is a naturally occurring element, but extreme high value as read in cow samples may be due to human intervention through the quality of air, water, or food that consumed by the animals, but there is no study regarding of air, water, or vegetation quality of the study area.

TABLE 3: Comparison of study area with the WHO 2017 standards

Elements	WHO (ppb)	Study group (sheep) (ppb)	Study group (cow) (ppb)
Al	200	404.5	278.7
Fe	100-300	474.1	3720
Hg	1-6	26.91	26.78
Mn	100-400	179.7	110.0
Zn	3000	1080	1688
As	10	7.478	6.256
Co	3	0.266	1.242
Cr	50	0.752	6.692
Cu	1000	1038	134.3

This table is made based on Tables 1 and 2 and the WHO standards for heavy metals 2017

Furthermore, Hg which is a toxic elements [8], [9] is out of the WHO accepted range but with a high significant distance between the samples and the standard value. A previous study confirms this finding as mercury recorded high in beef meat in North Algeria [14]. However, Hg is a naturally accruing element, but a high value in the body can have a detrimental effect on health of the consumers [33], such as damaging nervous system, liver, and eyes, and infant may be deformed; other symptoms of mercury toxicity are a headache, fatigue, anxiety, lethargy, and loss of appetite.

4. CONCLUSION

The present findings indicated that these trace elements such as iron, cobalt, copper, zinc, arsenic, manganese, aluminum, mercury, and chromium were detected in all the samples. Only, Hg, Al, and Fe, in both sheep and cows' meat, presented high values for both groups in comparison with allowed limits of the WHO 2017. However, overall, this study confirms that the cow and sheep meat still safe to eat in the study area because only Al, Fe, and Hg were found danger, but all other elements are complying with the global standards.

5. ACKNOWLEDGMENT

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ORIGINAL RESEARCH ARTICLE | UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Happiness Measurement through Classroom Based on Face Tracking

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ABSTRACT

Increasing the happiness during class room cause exciting the students to improve their ability of learning. This research focused on the evaluation of the learning process through classroom before and after applying the proposed method. One of the big challenges during classroom lesson, the students after a short period of time (about 10-15 min) at the starting of the class, stop learning and remain absolutely out of understanding. Our goal is to revitalize the classroom environment so that you are always attentive to the lecture. The proposed approach aims to track and detect the emotional facial expression and transient from emotional facial expression to raise the happy expression to reach the classroom happiness. Image processing issue is an important part of this approach in which based on face recognition and tracking, then evaluates the students' happiness according to the proposed mode that located in the class. This approach is implemented using Raspberry Pi device, high-resolution camera, and high definition screen. The implemented approach allowing you to continue of face tracking and rising the happiness parameters. Raising the happiness scale, leading to improve the ability of students in understanding the lecture. This approach is implemented to cover both software and hardware, so, it is acceptable to work in real time. The main contribution of this work is to raise the happiness of students to increase their understanding during the lecture.

Index Terms: Classroom Lecture, Direct Teaching, Electronic Learning, Happiness Measurement, Rising Happiness

1. INTRODUCTION

Two thousand and five hundred years ago, the philosophy of happiness was started. The issue of happiness was found with Confucius, Socrates, Buddha, and Aristotle. These thinkers were defining some aspects of happiness and who to find the happiness? These great thinkers have almost the same ideas about the happiness that leading to nice future of modern sciences [1], [2].

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Past 10 years, there is significant increase in psychological science of happiness. This leading to wide range of works and projects concentrated in this field. Some of these works dealing with scientific impacts and factors those affecting the level of happiness. The direct and excited application of raising the human happiness was shown in clinical psychology [3]-[5].

Many factors are affecting the level of happiness such as social relationship, financial, employment, culture and living environment, media, and networks. In general, human will be happy according to (Fig. 1) [6]-[9]:

- Fun (Pleasure).
- Commitment (Engagement).
- Social relationships.
- Sense (Meaning).
- Achievements (Accomplishments).

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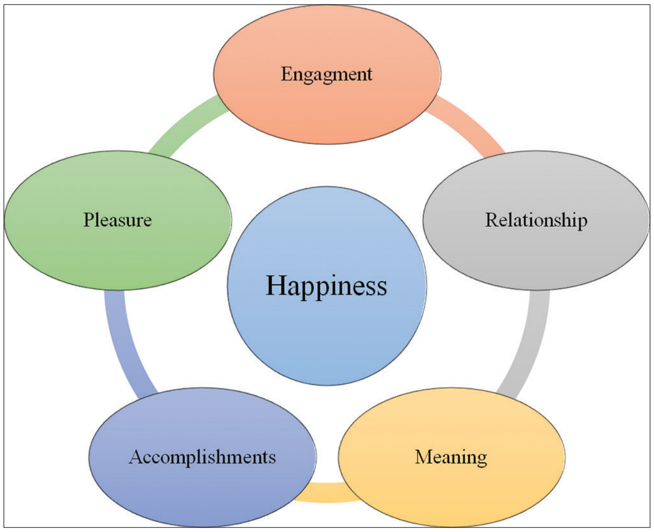

Fig. 1. Happiness of people.

2. RELATED WORK

Many journal and conference papers are published regarding the field of happiness. These papers are treated the happiness filed in many aspects such as health, education, business, and industry. Below some of these papers:

Sekulova and van den Bergh proposed an empirical study that explored the key factors that determine the satisfaction of life in Barcelona. They examined a sample of 840 people and check how changes in income, including reductions in income, related to the current economic situation in Spain, affect subjective well-being. The declines in income from a year ago have a negative effect on happiness when they are specified in logarithmic and positive terms as a fictitious variable. The divergences of the obtained results were discussed and several explanations were presented. However, both effects are temporary and do not stay more than a year, probably for reasons of adaptation and for a downward adjustment of baseline consumption and income levels [10].

Romo-González *et al.* (2014) developed a psychoeducational intervention by integrating professional learning with happiness and well-being by teaching healthy lifestyles to the students of Veracruzana University. The positive effects of psychoeducational on the work environment of the students were considered important. They described the effects of psychoeducational on students' academic programs and their duration overtime. In addition, they explained their effects in rising of a positive education. The result indicated positive effects on applying psychoeducational on student happiness. In addition, applying psychoeducational improved the student performance [11].

Booth (2015) explored how nursing students describe the elements of their nursing education through the social networking platform of Twitter. The websites about courses, classes, and nursing courses were compiled in October 2011 and analyzed. A total of 498 tweets were collected during a collective 6-day period and 189 tweets were coded into five thematic presentations. Nursing students analyzed various elements related to their nursing education, including events and situations that they perceived as positive exciting. Messages about stress and discomfort were also mentioned as an important issue expressed by nursing students when describing their studies [12].

Vinichuk and Dolgova (2016) examined the image of happiness in children with different levels of creativity. The results of the survey leading to clarify the differences in attitude toward happiness expressed in images drawn by preschool children. Very creative children interpret happiness as an emotional phenomenon; in addition, the result indicated that the image of happiness is built with social interaction and a focus on others. Non-creative children associate happiness with the satisfaction of their material needs; in addition, the result indicated that the image of happiness is impersonal, concrete and does not focus on others [13].

Salavera *et al.* (2017) purposed an approach to describe the coping strategies adopted by adolescents in different stressful situations that occur in their daily lives, as well as their perception of happiness. This approach was applied on the first- and fourth-stage students of compulsory secondary education whom attended different high schools; then, these data are analyzed and evaluated. The study sample consisted of 1402 students (711 men and 691 women) from 11 to 18 years old. The results showed differences between the genders and years of schooling in the strategies adopted to deal with stress. In addition, the happiness decreases with age. Coping strategies that treat others and unproductive coping strategies have influenced happiness, in contrast to productive coping strategies [14].

Kamthan *et al.* (2018) conducted a study among 115 second-stage medical students at Subharti Medical College. The Oxford Happiness Questionnaire model was implemented to collect the data, which was distributed to the second-stage students at that college during the study sessions. The data were analyzed using Chi-square test and descriptive statistics. The distribution of happiness in relation to the basic characteristics showed that 60.8% of the selected medical students were in a happy group. The happiness of male students reaches to 52% while female students reach to 48% [15].

3. CLASSROOM SCENARIO

Classroom competition depends on many aspects and manages by many factors [16], [17]. The teacher and the student are the two important issues in the educational process (considering the surrounding environment) [18], [19]. After few minutes of the scientific lesson, this should be stopped to restore the process of understanding [20], [21]. Human competence is defined as competition in which two or more people participate, where generally the winner will be only one or a few participants and others do not win [8], [22]. Some of us have excellent experiences with students' competition, while others think it is not pleasant [23], [24]. Adults reproduce the ideas of competence as students and then apply these ideas to teach the trainers (students and children) [25], [26].

Some aspects are considered in determining the benefits of competition in the classroom [27].

- Good results of competition will have more dangerous effects during competition in classroom for symbolic results.
- The competition has a beneficial effect in short life. The duration of the contest increases their sense of importance and decreases the feeling of intensity and pleasure, both unusual effects.
- The competency manager should focus on the product process. If victory is the point, students take a single gesture regardless of attitude.

4. HAPPINESS EXPRESSIONS

Happiness is an important factor through education and it may take seriously, and below some of the important issue regarding this factor [9], [28].

- First, happiness in education concentrates on the teacher, students, classroom, and the teaching context. The formal educational methods deal with the whole person then offers other opportunities and experiences [29].
- Second, happiness in education engages with informal education, dialogical forms of educating and community learning [30].
- Third, happiness in education covers large areas of national and state curricula and seeking out approaches and subjects that do not alienate [31].
- Fourth, happiness in education requires the possibility of easy to use and access to needed materials and information so that those who are troubled have a means to come an understanding of themselves and their situation [32].

5. FEATURE ANALYSIS

Face expressions are an important factor to determine the human situation (happy or sad face) [33]. Hence, it is important to study the facial features to analysis the human situation that is the key factors in this subject [34]. In general, human happiness based on facial expression analysis is an effective method which is an important method to recognize the human attitude [35]. Several methods, tools, and techniques are explained and these methods are regarding to a certain criteria [36]. Thus, there is powerful guide for the standard facial expressions of seven emotions: Fear, joy, anger, sadness, contempt, disgust, and surprise [37], [38].

Science of people has a wide range of applications and it is an important part of our life [39]. Face and facile recognition are the most important indicators of human emotions [40]. Emotions are leading to face reading that allowing other people to glimpse into our minds as they read face in the light of changes in key face features such as eyes, eyebrows, eyelids, nose, and lips [41]. To understand the human face and the non-verbal human behavior, it is important to go deep in microexpressions reading [42]. Human microexpression deals with the details of facial expression [43]. In general, there are seven universal human microexpressions based on face expression: Disgust, sadness, anger, fear, happiness, surprise, and contempt [44]. These microexpressions depend on the face details and these microexpressions occur as fast as 40-60 ms [45].

Happiness based on microexpressions depends on many factors as shown in Fig. 2 [46], [47]:

- Lips detection and exactly the corners of the lips are drawn back and up.
- Teeth expose detection in which mouth may or may not be parted.
- Wrinkle runs detection that runs from outer nose to outer lip.
- Cheeks detection which is raised.
- Lower lid detection that may show wrinkles or be tense.
- Crow's feet detection that located near the outside of the eyes.

6. METHODOLOGY

When man advances in age, the attributes and characteristics of the human face change overtime, where wrinkles appear to lead to confusion in the science of discrimination. As a fact, there is a big difference of emotional facial expressions according to human age groups. To solve these things, we decided to apply this approach on a certain group with near or similar age group. The adaptation of this approach based on the ability of understanding and recognizing the emotional effects. Expressions of human face based on the reflected reaction are divided into seven issues. These expressions deal with many human face aspects such as happiness through classroom. The duration of the normal class lecture may be 50-90 min. Hence, it is important to motivate and excite students each 5 or 10 min through interactive face recognition approach of emotional facial expressions.

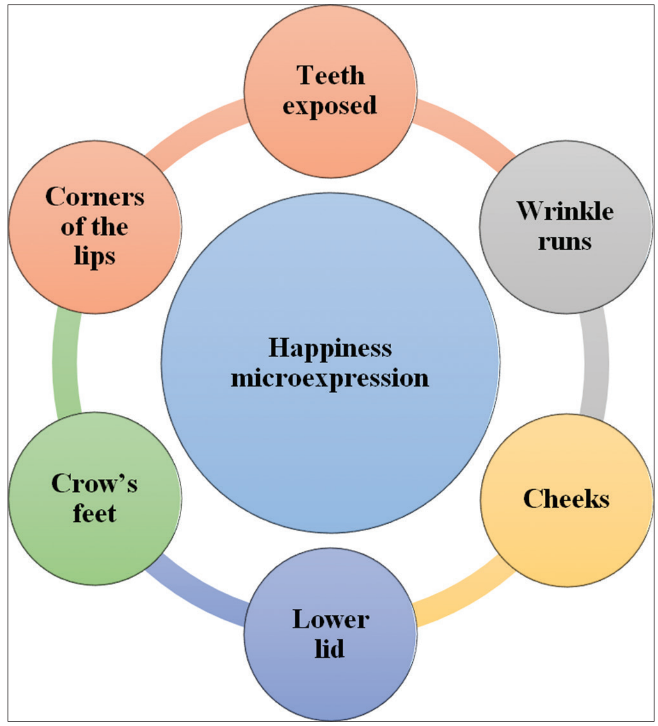

Fig. 2. Happiness microexpression factors.

6.1. Formation of Happiness

Formation of happiness deals with excitation of human face to reflect their emotional attitude as a main part of happiness that can be applied in the following steps (Fig. 3):

- Happiness description.
- Happiness definition.
- Happiness doing.
- Happiness building.

This approach aims to transit from one step to other steps, means from description, definition, doing, and building of happiness.

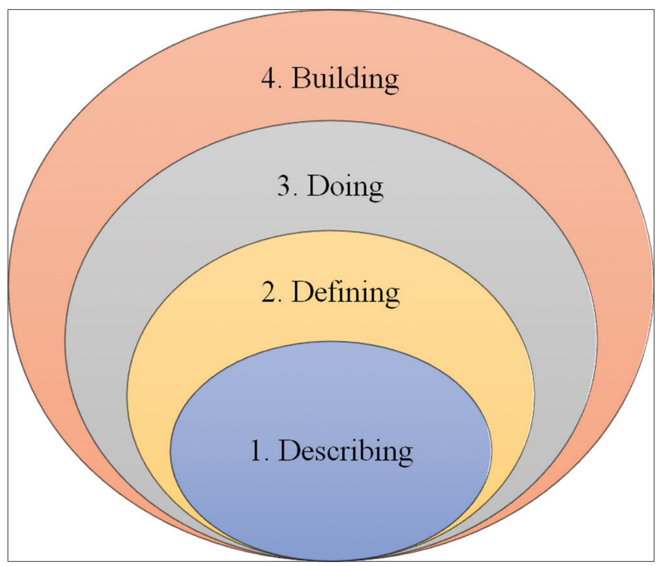

Fig. 3. Steps of happiness.

The implementation of this approach is based on reflecting the capture image into color models, in which the color intensity indicates the darkness and lightness of the indicated color. In addition, three types of colors red, green, and blue are used in this approach. These three main colors are divided into three subdivisions, so we have nine color values that indicated nine levels of happiness as shown in Fig. 4.

Student faces are detected via the implemented system using certain threshold to separate the face from the background based on skin color difference then tracking these faces to generate the decreasing and increasing of happiness level. Face recognition is an important part in this approach to detect the attitude of human faces to get continuous face tracking. These steps leading to initiate the action to start rising the happiness through classroom are shown in Fig. 5.

6.1. Hardware Implementation

Educator and learner are the main two aspects of the educational environment through classroom. One of the important aspect in educational environment is How to improve the information received by the learner. Happiness is an important part of education and it requires the possibility of easy access. Flexibility and easy to use are two main issues that must be considered in this approach. Both hardware and software are required in the implementation of this approach. The hardware part of the system is divided into five parts:

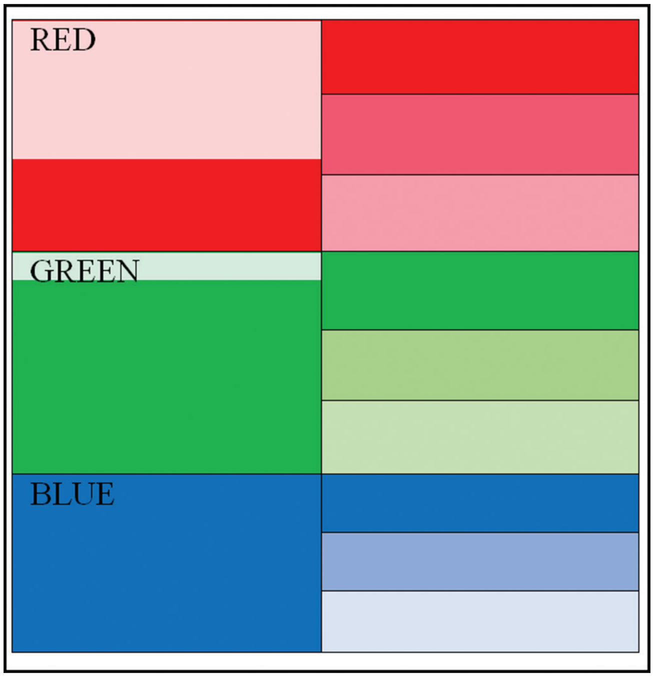

Fig. 4. Happiness divisions and colors.

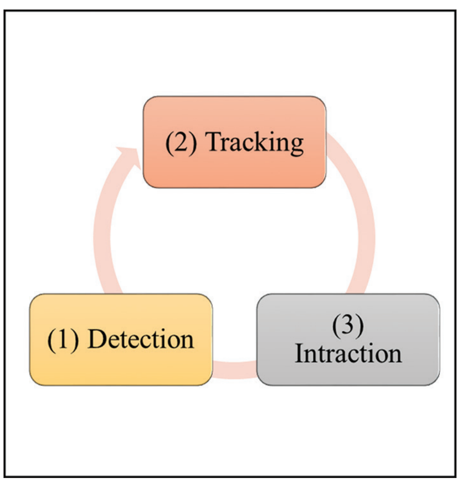

Fig. 5. Increasing of happiness.

Digital camera, input interface, processor, output interface, and LCD as shown in Fig. 6.

- Digital camera: Including high-resolution digital camera that fixed in front of students in the classroom.
- Input interface: Including the interface device that converting the received data to the processor.
- Processor (Raspberry Pi): This processor is connected through two interfaces one for the input and other for the output.
- Output interface: Including the interface device that converting the received data to the LCD.
- LCD: High-resolution LCD screen with a special size (about 50") fixed above the whiteboard in the classroom.

6.3. Raspberry Pi

Raspberry Pi introduced and released in the UK, in 2012, that was the first generation (Raspberry Pi I) [48]. The second generation (Raspberry Pi II) released in 2015 with increasing RAM [48]. The third generation (Raspberry Pi III) has more advantage that applied WiFi and Bluetooth [49]. The Raspberry Pi is an embedded microcomputer system that designed in the Laboratory of Cambridge University [49]. These microcomputers devices are used to teach of information technology at schools [50]. The Raspberry Pi uses 700 MHz processor [50] and has 512 MB RAM on model B+ whereas 256 MB RAM on model A [51]. Raspberry Pi is an open-source system that leading to wide range of applications. Raspberry Pi has the ability to work in real time that can be managed at this environment such as capturing and tracking according to the implemented system. Furthermore, Raspberry Pi has a flexible platform that helps in simulation of many applications in our life [51].

The hardware circuit diagram of the implemented system is applied using Raspberry Pi. In this system, you can control and interact with the students at real-time work. The main aspect of this system is the merging between hardware and software to be work on flexible environment and fast processing.

6.4. Implemented Software

Emotional face expressions are very important part of the happiness, so this work concentrated on recognition of emotional face expressions. Fig. 7 shows the block diagram of the implemented software procedure that can be covered in the following steps:

- Acquisition and detection of face and lips: Including acquisition the human face then detect the image face using certain threshold based on skin color difference, then compare the area of emotional face expression of human face and lips to detect the differences in gray scale.
- Recognition of face and lips: including recognizing the detected face and lips then extract the important features based on discrete wavelet transform.
- Tracking of face and lips: Including tracking and monitoring face and lips by a certain colored rectangular based on the orientation of histogram levels.
- Interaction with faces: Including interaction between the face displayed on the screen and the original human person to excite them.
- Measuring of happiness: Including divides this section into many measures depends on the implemented criteria,

then, these measures mapped into levels according to the related colors.

- Levels of colors: The main colors are divided into red (R), green (G), and blue (B), then, each level is divided into three sublevels.

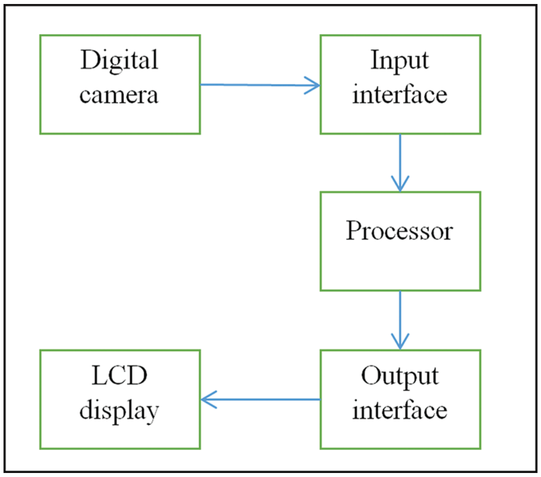

Fig. 6. Hardware implemented system.

7. RESULTS AND ANALYSIS

Classroom environment is a complex environment and it is difficult to resizing and measuring the happiness value. Many methods and tests are applied to recognize the happiness value during classroom environment. The final decision concentrated on the effective characteristics of faces and emotions to be the main influence in this area. Many factors of teeth exposed can be merged to express some kind of happiness. The happiness level is divided into three parts according to their values; low (blue), middle (green), and high (red). If most of the student does not care what happens, this leading to low level (blue color). If stimulating students at an intermediate level, this will refresh their memory and they will be within the middle level of happiness (green color). Then, if students are shouting and disturb the overall lecture so may they are out of control, this leading to the high level (red color). This research was concentrated on stage four undergraduate students at the Computer Science Department at Anbar University as shown in Fig. 8.

The main idea is concentrated on the tracking faces based on digital smart controlled camera. The procedure is started

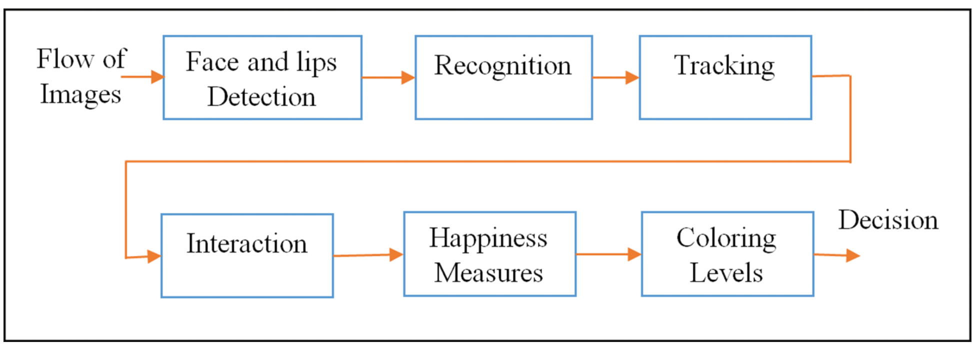

Fig. 7. Emotional facial expressions approach

Fig. 8. Sad emotion classroom.

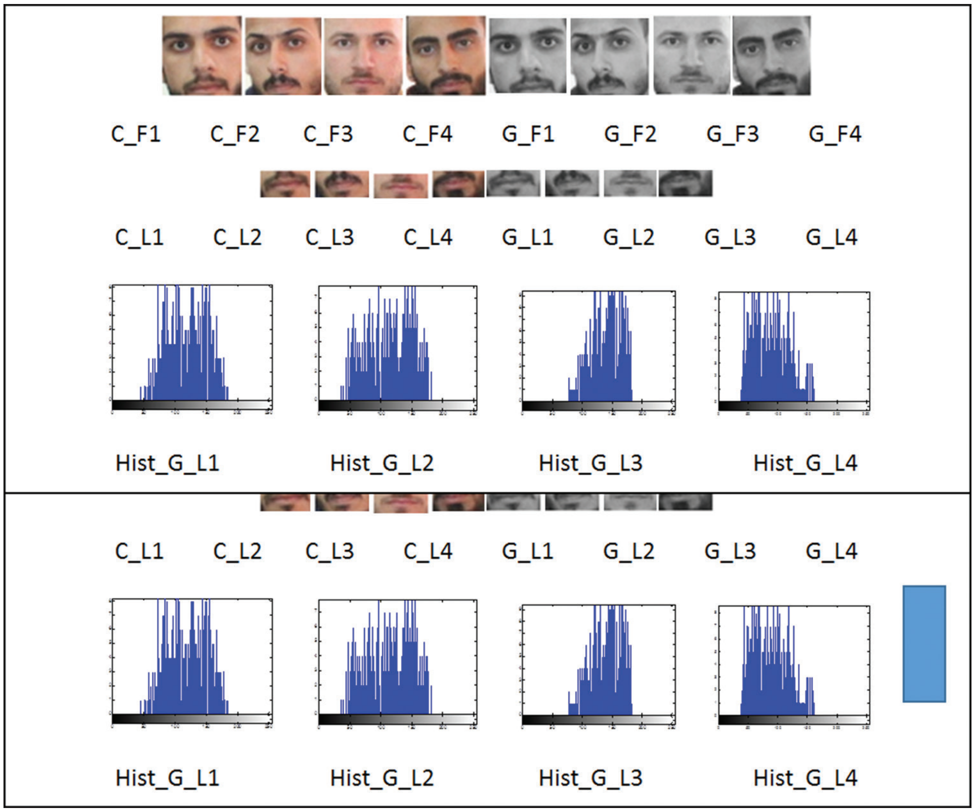

Fig. 9. Tracking of student faces (sad or not happy).

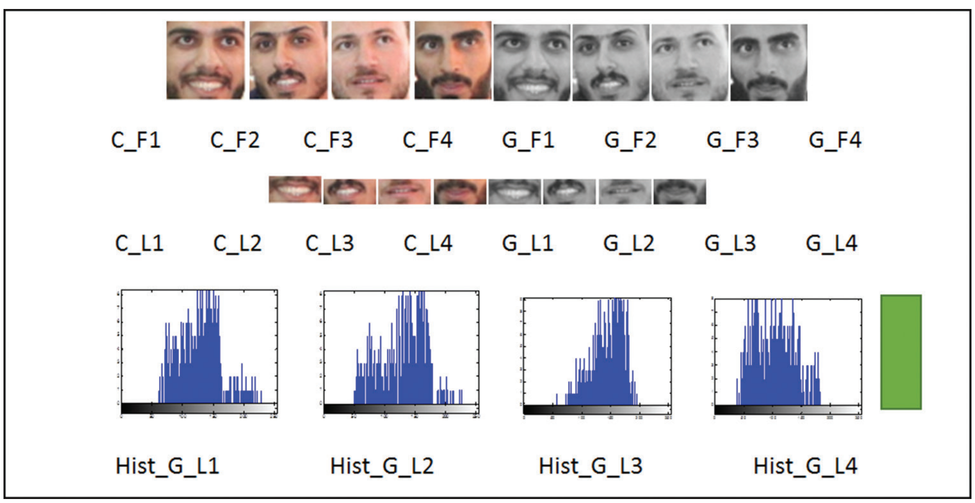

Fig. 10. Tracking of student faces (mid happy).

according to detect active faces then tracking these faces continually that can be the good indication of the happiness. The implemented procedure proposed faces and lips image of sizes 46*46 and 16*31 pixels, respectively. This process based on skin color variation. The happiness values of students are measured through certain criteria mentioned in this method based on emotional movement of faces and lips. Figs. 8 and 9 demonstrate the faces of students and the analysis, respectively. These show the tracking of faces and lips in which it is clear these students at the beginning of the lecture they are totally at sad emotion, so the scale of happiness is appointed on blue color based on the scale color levels. Many factors are applied

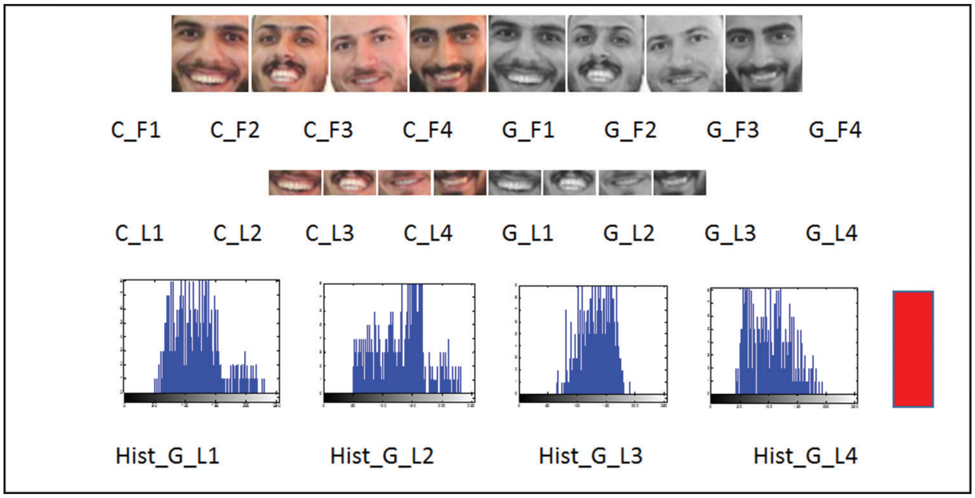

Fig. 11. Tracking of student faces (full happy).

here to demonstrate the happiness value. Some abbreviations are used here to identify different types of images. C_F1 represents the color first face image, G_F1 represents the gray first face image, and so on. C_L1 represents the color first libs image, G_L1 represents the gray first libs image, and so on.

The proposed system depends on monitoring of face images and tracking the changes happen in that face. Hence, the implemented indicator start rising as some movement happened in the class, and then, at the same time, the level of happiness will rise. The happiness is increased gradually regarding to smile of some students in the class, so the scale reaches the green color. Looking carefully on Fig. 10, you can see the histogram is displaced into right side in which indicated the high level of happiness.

Significant value of happiness was obtained from Fig. 11, in which it is clear from their emotion of faces that most of them are in smile mode. In addition, the histogram is shifted with about 10% to the right side regarding to the number of pixels in each gray scale, this means to the very high values so the scale appointed on red color. Hence, consequently, the student may be so loudly that disturbs the class, and it needs to control the classroom.

8. CONCLUSIONS

Rising of happiness in classroom is an important issue of teaching and learning in real life and there is a direct privacy between students and lecturers. According to classroom situation, the learners or students may decay in receiving of knowledge after a short time such as 10 or 15 min. At that situation, it is important to excite them to be able to receive the knowledge. This is the main issue that affected the educational process to pull students to the actual lesson. Pulling the attention of students to the lecture is a big challenge in classroom. Hence, many methods are used to realize this issue. These methods are focusing on teaching methods and procedure to implement the lecture. Classroom environment reflects the activities between students and lecturers, so, at the beginning of the lecture, students give their attention to the lecturer and what he displays on the board or data show, then after short time they will be on the other world outside of the lesson. The aim of the lecturer is to excite students to go back to the lesson and raise the proportion of happiness.

The implemented approach is concentrated on applying of image processing in classroom environment to excite students and increase their happiness. The implemented system divided into two parts: Hardware and software. Hardware part includes digital camera, Raspberry Pi, and digital screen. Raspberry Pi is suggested to work in real time. Software part includes image processing and analyzing the results to evaluate the happiness level. This system activates students to collaborate through the lecture that increases the happiness level. This system based on analysis of face microexpression (that stay with 40 ms) to run the overall program at real time. The color scale design is an attractive method that raising the happiness through students. The examined approach based on the histogram that deals with number of pixels in each gray scale (gray level). The threshold value is based on the averaging of gray levels to generate the face emotion. The threshold value is based on the averaging of gray levels to generate the face emotion. These levels indicated the changing in the gray intensity (color levels) to compare that with the happiness scale.

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ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Signature Recognition based on Discrete Wavelet Transform

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ABSTRACT

Personal identification is an actively developing area of research. Human signature is a vital biometric attribute which can be used to authenticate human identity. There are many approaches to recognize signature with a lot of researches. The aim of this research is to introduce an efficient approach for signature recognition. This approach starts with the process the acquired signatures and stores these signatures in the database to be ready for verification. The collection of signature data based on collecting samples of 10 people and 10 signatures for each person through traditional ink stamp method. These signatures are digitized to be ready for processing. Many steps are applied to the acquired images to perform the pre-processing stage. The proposed approach based on discrete wavelet transforms to extract significant features from each signature image. Pre-processing is applied at the beginning of this approach to avoid any unwanted noise. This approach consists of many steps: Data acquisition, pre-processing, signature registration, and feature extraction. High recognition rate results (100%) are obtained through applying this approach.

Index Terms: Biometrics System, Off-line Signature Recognition, Feature Extraction, Discrete Wavelet Transform

1. INTRODUCTION

Biometrics can be represented by physiological or behavioral characteristics for identification purposes. Physiological biometrics includes data derived directly from the measurement of any part of the human body, such as fingerprints, iris, retina, or facial shape [1]. Among the various behavioral characteristics that can be measured, the signature is recognized as one of the most reliable, unique, undeniable, and stable characteristics for human identification. Behavioral biometrics, in turn, analyses the data, which records the way a person behaves, such as the way of speaking or the dynamics of the signature [2].

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Signature recognition is one of the most important methods among the ways in which to authorize transactions and manifest the human identity compared with alternative strategies of electronic identification such as fingerprint scanning and retinal vascular pattern screening [3]. It's easier for folks to migrate from mistreatment the favored pen-and-paper signature to at least one wherever the written signature is captured and verified electronically, information about the way the human hand creates the signature such as hand speed and pressure measurements, acquired from special peripheral units, is needed [4].

Signature of someone is a vital biometric characteristic of a person's being and is employed for biometric authorization for many years [5]. While monetary establishments and different business organizations primarily specialize in the visual look of our signature, this leading to an accurate verification functions [6].

Signature recognition and verification system are widely applied for legal and common human identification using

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recognition and verification. The advantage of signature verification has a very high user acceptance in public because people are used the sign in their daily life [7].

Signature handwriting is a unique identity of every person, and cannot be lost, stolen or broken, also does not have user name and password in the case of forgetting password [8]. Wide range of applications is targeted within the field of electronic banking systems, electronic commerce, mobile applications, and security applications of significant installations [9,10].

1.1. Signatures Recognition Systems

Handwritten signatures are simply divided into two categories:

1.1.1. Online system

The data are obtained using an electronic tablet and other electronic devices. They require a pen and a tablet connected to a computer to enter the dynamic information of the signature. The online approach will acquire additional data concerning the signature which has the dynamic properties of signature. Extract signature data concerned with many aspects: The writing speed, pressure points, strokes, and acceleration [11].

1.1.2. Offline system

Images of the signatures written on a paper are obtained using a scanner or camera, and then this signature takes as an input image to the system. The purpose of verifying the offline signature is to determine whether a signature is of a particular signer based on the scanned image of the signature and some images of the original signatures of the signer [12].

These wide applications give rise to a computerized signature verification system. However, in several systems, solely image of a signature is obtainable; therefore, the verification of offline signature appears additional aspects compared with the online signature verification system. The most significant issue is that a signature of an individual could vary in keeping with his/her mood, health, etc., in that even the real signer might not copy his/her signature as it is. In many cases, it seems somewhat difficult to distinguish between genuine signature and forgery signature [13].

1.2. Levels of Forgeries

Forgeries generally, based on making, forging, or fixing nearly any document, with the intent to different kinds of forgeries are classified into the subsequent categories [14]:

1.2.1. Random forgery

This type formed without any knowledge of the signer's name or signature shape. The name of the victim is used by the signer in his vogue to form a forgery signature called the easy forgery or random forgery. This forgery accounts for the bulk of the forgery cases though they are terribly straight forward to sight even by the eye [15].

1.2.2. Unskilled forgery

The person who made the signature with their vogue regarding that he has not any data of the orthography and knowledge. This will be through with observant the signature closely for the associate degree within enough time [16].

1.2.3. Skilled forgery

Undoubtedly, the foremost tough of all forgeries is formed by skilled cheaters or persons who have expertise in signature repetition. To detect this, one may either trace or imitate the signature by arduous manner. Various types of forgeries and related original signatures are shown in Fig. 1 [17].

1.3. Signature Characteristics

The signature should be treated as an image, because a person can use any symbol, letter, group of letters, etc., like signature. Therefore, it is possible not to separate the written letters, or maybe you cannot understand what is written. Therefore, the applied system for the analysis of signatures must use image processing ideas. Most likely, the signature of a signer may vary for each sign based on many factors. However, there must be a unique feature to identify the signature so that it can be used as biometrics. Below some of the essential features [18]:

- Invariant: It ought to be permanent over a protracted amount of time.
- Singular: It should be distinctive to each person.
- Inimitable: It should be inimitable by alternative suggests that.
- Reducible and comparable: It ought to be capable to be acceptable to a format that is simple to handle and digitally such as others.

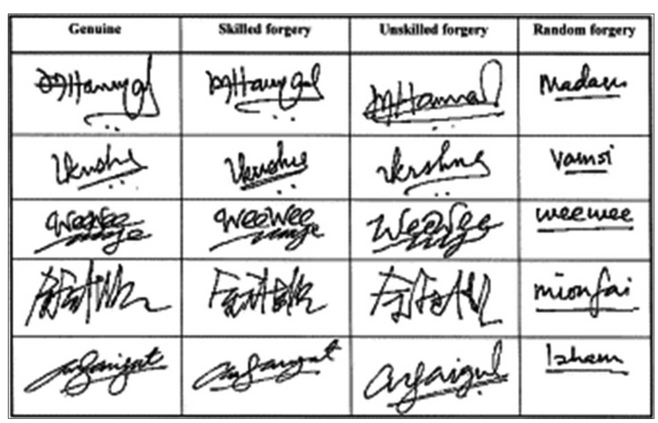

Fig. 1. Types of forgery.

As signature conjointly belongs to at least one of the parameters that satisfy the characteristics; therefore, it is going to be used as a signal of person identification.

1.4. Literature Review

There are many methods that used for signature recognition; this section explains some of these methods:

Bharadi and Kekre (2010) showed a comprehensive review of handwriting recognition systems and special attention is paid to the analysis of static signature recognition systems (SRSs). They discussed a set of conventional features based on offline SRS, as well as cluster-based global characteristics. This system is multi-algorithmic; such systems combine the benefits of individual feature sets and improve recognition rates. The system reported a precision of 95.08%, which is higher than the individual performance measures [19].

Tomar and Singh (2011) proposed a method to compare the performance of energy density methods; the directional characteristic method and the proposed directional method with the energy method, based on the time required for training, accuracy, acceptance, and rejection ratios. The obtained results showed that if the samples available for training are limited, then the method of directional characteristics is better than the density of the energy method but the merging of the directional characteristics with the energy method, leading to the best method. While the time required for training is a bit longer for this proposed method, accuracy and false acceptance rate (FAR) are satisfactory, and this additional time may be bearable. The obtained results indicated that False Rejection Ratio (FRR) varies randomly for all cases. In addition, this research gives the reason for future studies [20].

Radmehr *et al.* (2012) demonstrated that signature recognition poses a problem of recognition of difficult model. This research introduced a new SRS based on the transformation of Radon, shape dimension (fractal dimension), and support vector machine (SVM). Signature verification competition (SVC) database was used to evaluate the performance of this method. The results of the simulation indicate that the planned technique is promising in recognition of signatures. In addition, the performance of the SVM classification has been evaluated with different cores. This research presented an effective algorithm, and it may be valid in a large signature database where many signature styles are taken into account. Other attractive perspectives and challenges for future research are based on two aspects: How to extract more efficient features and how to combine an SVM-based classifier with other signature recognition methods [21].

Kanawade and Katariya (2013) explained that a person's signature is an important biometric attribute of a human being that can be used to authenticate human identity. However, human signatures can be treated as an image and recognized by artificial vision. They examined the problem of personal authentication through the recognition of signatures. Online and offline methods have been described in this work. The method of signature verification indicated that pre-processing and future extraction limits the advantage of being extremely acceptable to potential customers over the rest of the biometric solutions. This research indicated that verification and recognition of the offline identity are provided each time the signature is captured and delivered to the user in an image format. The signatures that are verified can support the parameters extracted from the signature using many image processing techniques. This research presented a case study of the signature verification method for offline signature verification [22].

Hiary *et al.* (2013) implemented an Arabic and Persian offline signature verification system. This technique is divided mainly into four stages: Pre-processing, recording of images, extraction of features and finally, verification of signatures. Pre-processing operations were performed to reduce processing time and increase accuracy. Then applied discrete wavelet transform (DWT) to extract the characteristics of the signature image and used logical operations with mathematical formulas to verify the signatures. The experimental results have shown reasonable improvements in many recent works. This approach reduces the number of levels of DWT levels and the amount of training required, with a low percentage of FAR of 1.56% and a false rejection rate of 10.9% and a low average error rate of 6.23%. Future plans include improving this technique to increase the accuracy of verification and testing techniques with different forms and types of signatures [23].

Kanawade and Katariya (2013) explained a method to verify the handwritten signature in offline mode. This approach proposed a new technique of recognition and verification of signatures in offline mode based on global characteristics, mask, signature grid, and SVM. It is better to try counterfeiting using the online signature verification method. The concept of offline signature verification can be extended to other biometric identification systems, such as handwriting. Combined signature features with other biometric aspects such as speech and facial recognition; it provides better results than any individual system [24].

Bhattacharya *et al.* (2013) implemented a signature authentication machine to provide a security system of simple, safe, and fast biometric behavior. Based on some mathematical coordinates, this methodology is faster than the different forms. Color technique is applied to make it safer. The interface of this application is extremely simple, which makes it easy to use and easy user-friendly. The implemented system has some limitations: It can only identify static changes in a signature and cannot identify any dynamic change in a signature. This signature authentication system works only for offline mode, and the results were tested only offline. The proposed system for recognizing and verifying offline signatures is implemented through pixel matching technique (PMT). PMT is used to verify the signature of the user with the signature stored in the database. The performance of the proposed method was compared with the existing back propagation artificial neural network and SVM [25].

Doroz *et al*. (2014) proposed an efficient method of verification of handwritten signatures. This method creates complex functionalities for each signature that describe this signature. These characteristics are based on the analysis of the dependencies between the dynamic characteristics recorded by the tablets. These complex features are used to create vectors that describe the signature. The elements of these vectors are calculated using the measures indicated in this research. The similarity between the signatures was evaluated by determining the similarity of the vectors in the comparative signatures. The obtained results showed a high effectiveness of the verification using the proposed method where the precision obtained was 96.67% [26].

Malik and Arora (2015) talked about two types of signature verification system are present offline (static) and online (dynamic). The biometrics has an important advantage over traditional authentication techniques due to the fact that biometric characteristics of the individual are not easily acceptable for convert, are unique of every person, and cannot be lost, stolen, or broken. The signature is acquired as an image; this image shows a personal style of human handwriting. A signature verification system sometimes focuses on the detection of one or more type of forged signatures. The purpose of this work is to design and develop an offline handwritten signature verification system that will differentiate between the original signature and closer forge signature depending on some special features [27].

Al-Ani and Al-Saidi (2011) studied how to improve handwritten Arabic signature recognition. They this work proposed SRS used for many applications and have played an important role in these applications. This work presented a simple and efficient signature recognition approach based on the discrete Fourier transform used to extract features. Many people are registered through a built-in signature database. The results obtained indicated that a good and effective recognition rate was recognized, as the results showed, it provides value almost greater than zero [28].

Hafemann *et al*. (2015) proposed a method for offline signature verification. Although the categorization of authentic signatures and qualified counterfeits remains a difficult task, the error rates have decreased significantly in recent years, mainly due to the progress of deep learning applied to the task used for the verification of Persian firms of convolutional neural network (CNN). Analyzing the recent contributions to the field, they can notice that they concentrate in the following categories: Obtaining better features, improving classification with a limited number of samples, augmenting the datasets, and building model ensembles. As a suggestion for future work, this research can be continued to explore higher feature representations and introducing methods to improve classification with a limited number of samples [29].

Hedjaz *et al*. (2018) proposed an offline signature recognition method using binary features. It is clear; the offline signatures recognition is mainly important for the authentication of administrative and official documents that required greater precision. The characteristics are extracted using two descriptors: Binary statistical image and local binary models. To evaluate the reliability of the method, experiments were conducted using MCYT-75 and GPDS-100 databases. Using a nearest k-neighbor classifier, the recognition performance reaches a high 97.3% and 96.1% for the MCYT-75 and GPDS-100 databases, respectively. During the verification of the signature, the accuracy of the classification measured with the same error index equal error rate (EER) reached, respectively, 4.2% and 4.8% in the GPDS-100 and the GPDS-160. In addition, the EER for the MCYT-75 database reached 7.78% [30].

1.5. Statement of the Problem

Many researches are published regarding signature recognition issue but many of these researched suffered from many aspects. This paper presents an offline SRS. DWT is suggested to extract common features and different change of the original image and signal of signature. We expected an efficient result in signature recognition that supports the verification step.

2. METHODOLOGY

This section can be divided into two parts: Data collection and implemented algorithm.

2.1. Data Collection

The offline signature images are acquired from traditional papers. This requires a high specific signature image that can be achieved through high-resolution scanner. In general, the first step of an offline signature verification system is to extract these signatures from traditional papers using a scanner. In this research, signatures are collected using either black or blue ink on a white A4 paper. Each A4 paper is divided into 10 parts to cover 10 signatures per page. A group of 100 persons are used to collect 10 signatures from each person, which resulting 1000 signature samples as shown in Fig. 2.

2.2. Implemented Approach

The offline signature approach for verification and recognition is divided into many steps as shown in Fig. 3:

1. Data acquisition: This step including converting signature images into digital image using a scanner device.
2. Pre-processing: This step including removing unwanted noise from signature images where that negatively influences the accuracy of verification and recognition.
3. Signature registration: In which the signature is scaled into an appropriate form to realize the higher and correct result.
4. Feature extraction: In which extract common features based on DWT.
5. Signature verification: In which compare the input with the original image and the result to show the accuracy of the system.

3. RESULTS AND DISCUSSION

To explain the obtained results regarding the implemented approach, we will pass the steps of this approach gradually.

Fig. 2. Sample of signatures.

3.1. Pre-processing

Pre-processing step plays an important role in signature recognition to overcome any raised problem. The purpose of this step is to make standard signatures that are ready for the feature extraction process. In this research, the pre-processing step is achieved through the following operations.

3.1.1. Noise removal

Minimizing of noise is an important operation that affects the overall signature recognition process because the signature image may contain unwanted information. In this research, the implemented noise removal operation is performing through filtering that not affects the details of signature image information. The median filter is an adequate filter that resolves the problems of noise reduction. Both signature images before and after applying media filter are shown in Figs. 4 and 5, respectively.

3.1.2. Image filtering and binarization

The true color image red green blue (RGB) is converted into grayscale intensity image through eliminating the hue and saturation information while retaining the luminance element. A grayscale image could be an information matrix whose values represent intensities within some range wherever every part of the matrix corresponds to at least one image pixel.

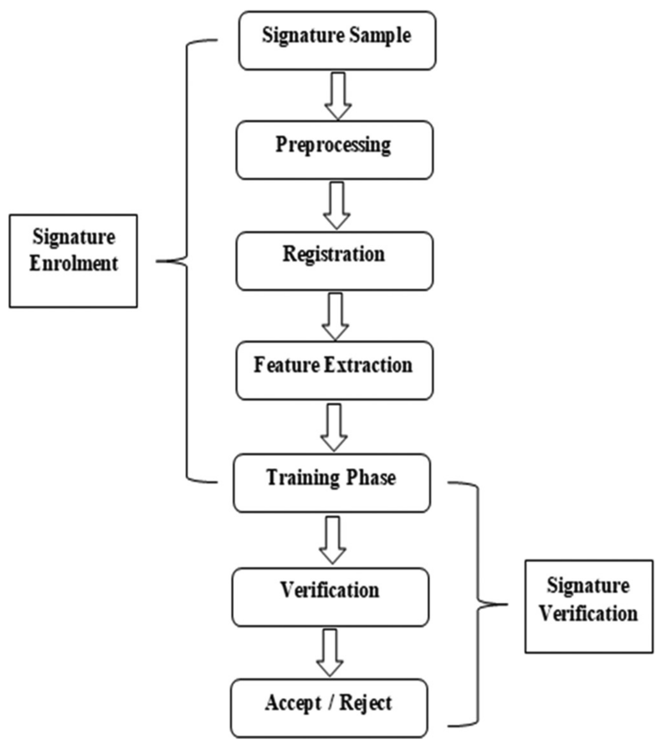

Fig. 3. Signature verification and recognition system.

The process of signature image filtering and binarization is shown in Figs. 6 and 7, respectively.

3.1.3. Width normalization

Signature dimensions could have intrapersonal and interpersonal variations. That the image width is adjusted to a default value and also the heights can be modified considering constant height-to-width ratio, as a result, the width dimension is adjusted to 100. Signature image before and after normalization is shown in Figs. 8 and 9, respectively.

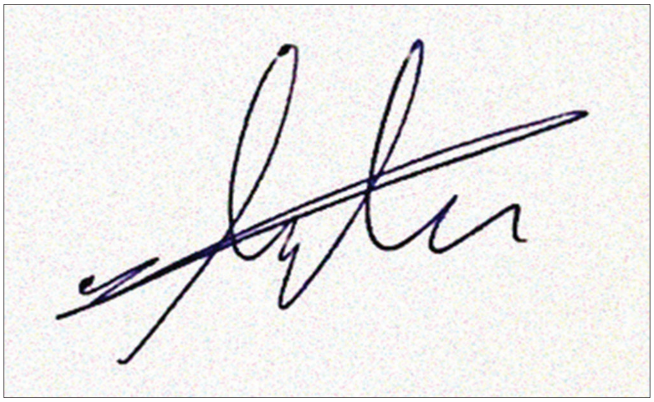

Fig. 4. Signature image before noise removal.

Fig. 5. Signature image after noise removal.

Fig. 6. Signature image before binarization.

Fig. 7. Signature image after binarization.

Fig. 8. Signature image before normalization.

Fig. 9. Signature image after normalization.

3.1.4. Thinning

The goal of the thinning operation is to eliminate the thickness variations of a pen by creating the line of one pixel of thickness that leading to accurate recognition rate. Furthermore, signatures are thinned so as to reduce the computations needed by the graph matching algorithm. Figs. 10 and 11 represent signature images before and after thinning.

3.2. Registration

The registration step contains two main operations; scaling and shifting. In scaling, the signature is re-scaled into the suitable type to realize the higher and accurate result. After that, shifting operation is applied to determine the center of the signature. These operations are mentioned below [5].

3.2.1. Scaling

This step resizing all the signature images for all persons. Alternative techniques performed this resizing supported the maximum height and width for all samples in the database. This leading to unnecessary, superfluous stretching of signatures and may cause errors in verification. To avoid this problem, the implemented technique uses the maximum height and width for signatures of the same person rather than unifying over all dataset where Figs. 12 and 13 show the signature images before and after scaling.

3.2.2. Shifting

In this step, the scaled signature image is aligned to the center of gravity of each person's signatures. Figs. 14 and 15 show the signature images before and after applying to the align process.

3.3. Feature Extraction

Feature extraction is an important step to enhance the signature image characteristics that are necessary to apply the comparison operation. DWT is to extract the perfect features before the verification step. The advantage of using vectors is the fact that they always have the same length, which does not depend on the size of the signature.

Fig. 10. Signature image before thinning.

Fig. 11. Signature image after thinning.

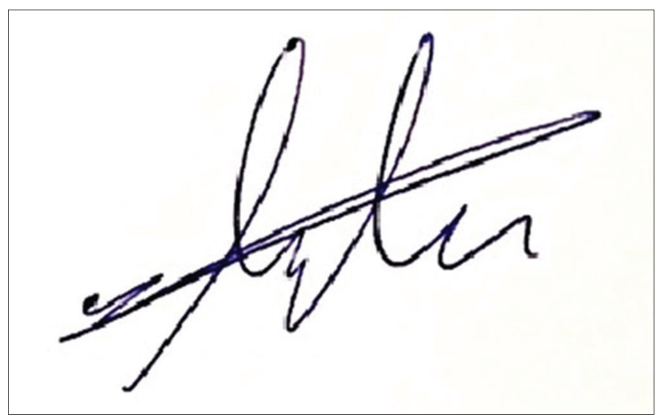

Fig. 12. Signature image before scaling.

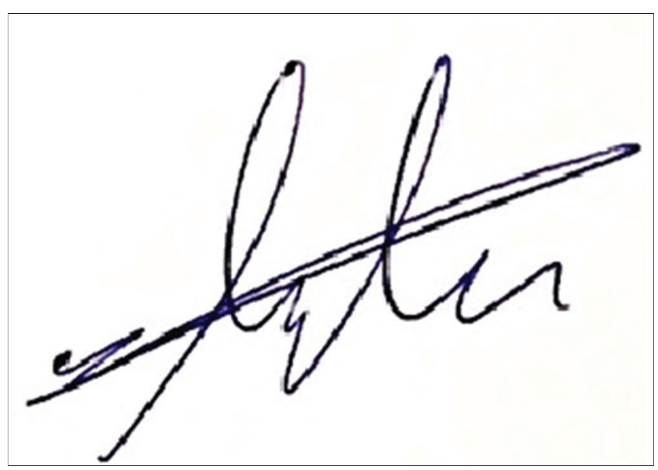

Fig. 13. Signature image after scaling.

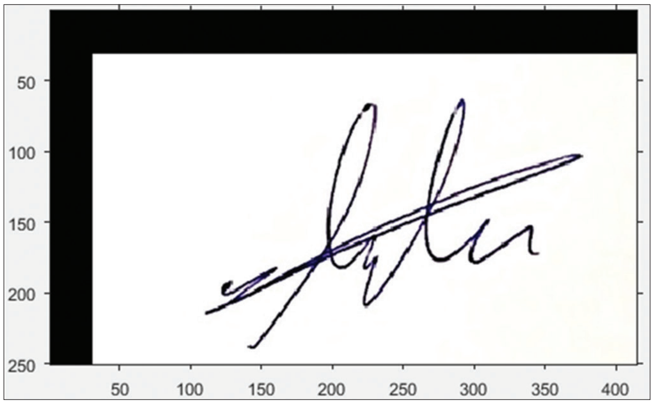

Fig. 14. Signature image before alignment.

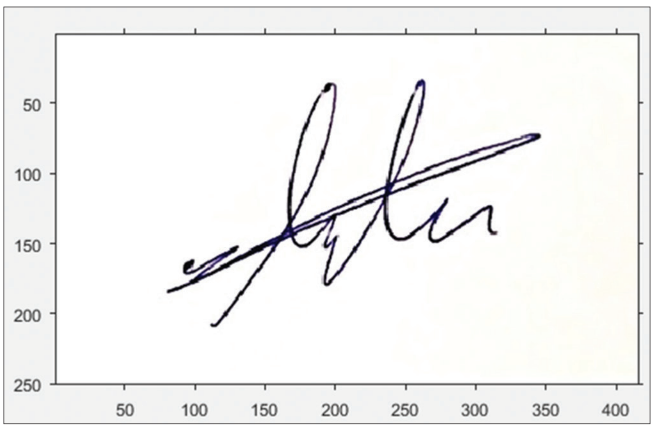

Fig. 15. Signature image after alignment.

DWT produces multi-scale image decomposition using filtering and sub-sampling that leading to the shape of the decomposition image where terribly effectively revealing knowledge redundancy in many scales.

Since signature images are two-dimensional (2D) signals, so it is better to increase the theme to 2D space by applying the transformed row and column-wise, respectively. According to 2D DWT, four sub bands are generated for each level of DWT. One low-pass sub-band containing the coarse approximation of the source image referred to as low-low (LL) sub-band, and three high-pass sub-bands that exploit image details across totally different directions, high-low for horizontally, low-high for vertical, and high-high (HH) for diagonal details, as shown in Fig. 16.

Applying DWT, each sample of the signature image is decomposed into four images, the primary image represents the LL band values, whereas the other three images represent the HH in vertical, diagonal, and horizontal directions,

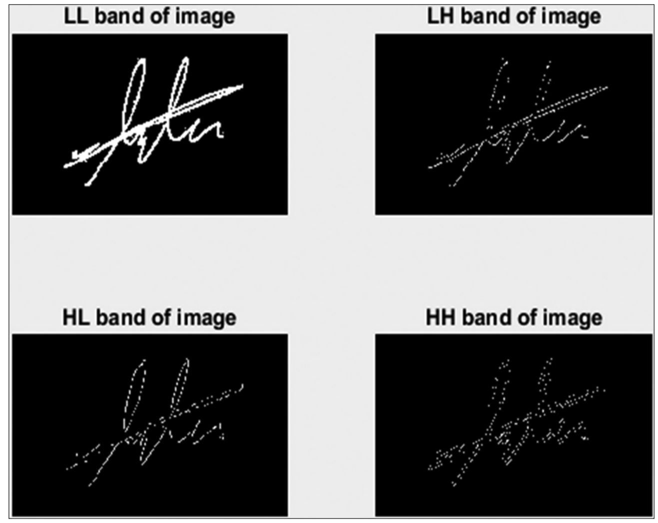

Fig. 16. Discrete wavelet transform bands: Low-low, low-high, high-low, and high-high.

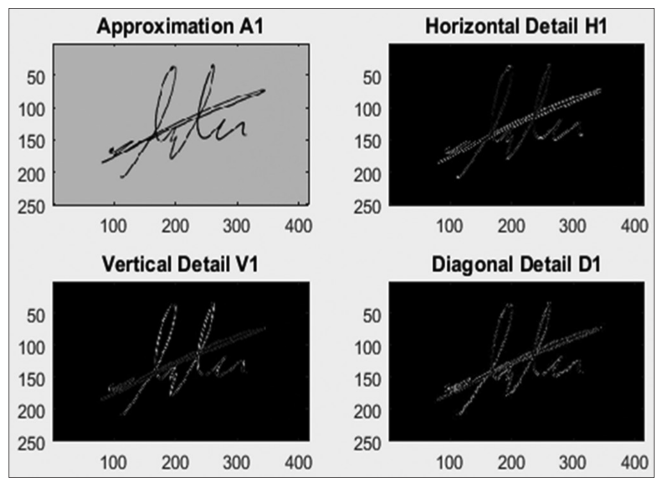

Fig. 17. Discrete wavelet transform, (A1) approximation results, (V1) vertical, (H1) horizontal, and (D1) diagonal high pass results.

respectively, as shown in Fig. 17. DWT is especially used to extract the features from the signature image. The proposed technique uses high pass images to extract the mandatory data for signature verification.

The DWT of a signal is calculated by passing it through a series of filters. First the samples are passed through a low-pass filter with impulse response resulting in a convolution of the two:

$$y[n]=(x*g)[n]=\sum_{k=-\infty}^{\infty} x[k]g[n-k] \quad (1)$$

The signal is additionally rotten at the same time using a high-pass filter. The outputs are given the brief coefficients (from

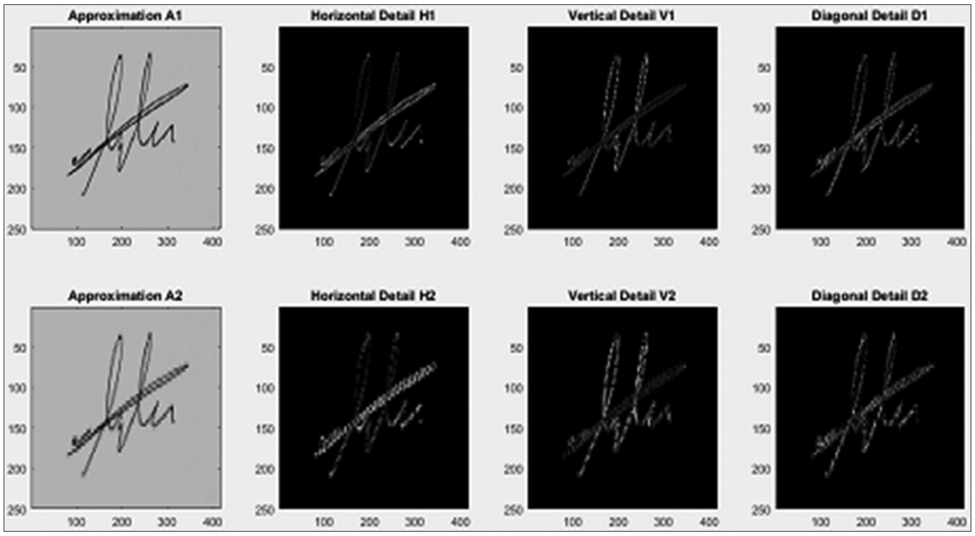

Fig. 18. Different between two levels of discrete wavelet transform.

Fig. 19. Original image and 2-level reconstruct the image.

the high-pass filter) and approximation coefficients (from the low-pass). It is necessary that the two filters are associated with one another and that they are called a construction mirror filter.

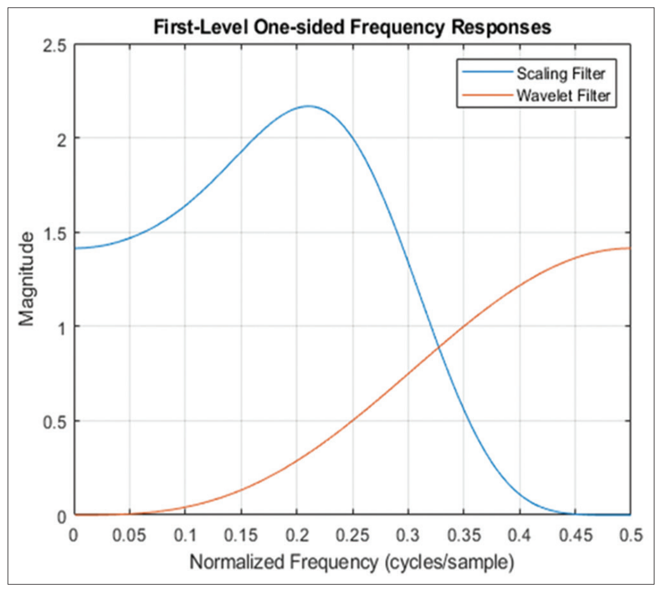

Fig. 20. First-level one-side signal filtering and scaling.

Each sample is changed during the decomposition first level and decomposition second level, the primary image represents the low pass values, whereas the opposite three images represent the first level high pass in vertical, diagonal, and horizontal directions, and the second level of primary image represents the low pass values whereas the opposite three images represent the second level high pass in vertical, diagonal, and horizontal directions. Fig. 18 illustrates the differences between the two levels of the same sample.

Fig. 19 represents two levels reconstructed signature image compared with the original image.

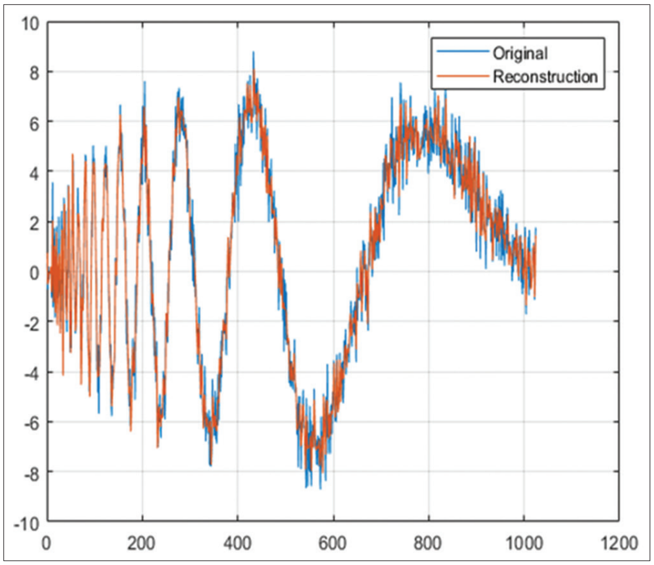

Fig. 21. Original signal compared with reconstruct signal.

Fig. 20 shows the obtained first-level one side DWT of a noisy Doppler signal using the wavelet (high pass) and compared that with the scaling (low pass) filter.

Fig. 21 shows the reconstructed of the smoothed version of the signal using the approximation coefficients compared with the original signal, in which a high similarity is obtained.

4. CONCLUSIONS

Signature recognition is one of the most widely accepted personal attributes for human biometric identification. In this paper, we proposed and discussed offline signature recognition based on DWT. The proposed approach is mainly divided into three steps: Pre-processing, image registration, and feature extraction. Pre-processing operations were performed to extend the accuracy and reduce processing time. This approach is performed using many levels of DWT to extract effective features from the signature image. An efficient recognition rate reached to 100% is obtained through implementing the proposed approach.

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ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Node Detection and Tracking in Smart Cities Based on Internet of Things and Machine Learning

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ABSTRACT

It is essential to know that using technologies in an ethical manner will facilitate human life. Hence, internet of things (IoT) which has been used widely due to developments in information and verbal exchange technologies, with some of its most famous applications are used in the fields of identification, transmission, and health care. In those fields, IoT technologies are used to collect data, recognizing the problem, and proposing a solution for it. Exploiting Global Positioning System (GPS) systems seem to solve the development of node location detection systems. However, concerning a specific target, the accuracy and exactitude of GPS are not enough to satisfy the need for specific location-aware applications. Node detection and tracking system aim is to find an autonomous target using radio frequency identification, IoT tag, GPS location, and k-nearest neighbors (KNN) for detecting the actual zone of the target. We also want to find and predict the best pathway that the node needs to go or want to go through, even to create a system for collecting all the information about nodes and saving it in the cloud and then use it for different purposes. Finding and detection the actual zone of our users are done using KNN algorithm. We use 3NN because that model gets a better result in our dataset, for transmission depending on the users' problem. We are using a new equation to find weights that are integrated with Dijkstra's algorithm. The equation is to calculate the weight between any two nodes using traffic information and image processing for finding a load of the road by counting the number of vehicles inside the image that is collected from our readers. Dijkstra's algorithm is used to find the best path between source and destination using weights between nodes. We tested this algorithm on 11,095 samples on a machine with the following properties; central processing unit (CPU): Core i7 – 4600M at 2.90 GHz (4 CPUs), RAM: 10 GB DDR3, and VGA: Intel HD Graphic 4600–2GB. A set of 7745 nodes used as a training set and 3350 as test sets. The accurate prediction was 3324 nodes, and the false ones were 26 nodes. The accuracy of 3NN algorithm with this configuration is 99.224%, in 11.605 s. After this step, detecting nodes' zone takes only 0.012 s. Using our proposed system, we can detect the actual zone of any user that needs help and track any node that we want. For example, an ambulance in the city and also find the best path for the ambulance or police to travel in from source to destination this idea is used in healthcare but can be used in many other fields such as security, military and information, and communication technologies.

Index Terms: Detection, Global Positioning System, Internet of Things, K-Nearest Neighbors, Location, Node Tracking, Radiofrequency Identification

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1. INTRODUCTION

Internet of Things (IoT) as a system of reticulate computing devices, mechanical and digital machines, objects, animals or those who have area units with given distinctive identifiers (Unique Identification) and therefore the ability to transfer

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knowledge over a network while not requiring human-to-human or human-to-computer interaction, become more popular in the future and may control everything [1]. The IoT is recognized collectively of the foremost important areas of future technology and is gaining vast attention from a large varies of industries. The true worth of the IoT for enterprises will be fully accomplished once connected area unit devices are able to communicate with each other [2].

In IoT, we need the THING which is made up of a processor, sensors, and a communication module. This THING when it connects to the internet, it becomes IoT.

In this research, we present a new method for location detection using IoT. The idea is to use radio frequency identification (RFID) tags and machine learning algorithms to find the location of a mobile node and predict the best path to reach the destination.

RFID allows automatic identification and records capture, the use of radio waves, a tag, and a reader, the tag can store further Information than traditional barcodes. The tag incorporates records within the form of the electronic product code. In an international RFID-based object identification machine, three sorts of tags may be used for identification [3].

Passive RFID tags depend on radio frequency strength transferred from the reader to the tag to provide electricity to the tag; now, they may not be battery-powered. This type is used in supply chains, passports, digital tolls, and item-degree tracking [4].

1.1. Active Tags

Lively RFID tags have their own battery supply and can instigate communication with a reader. Active Tag can include outside sensors to monitor temperature, stress, chemical compounds, and other situations. Energetic RFID tags are used in manufacturing, health facility laboratories, and faraway-sensing asset management [4].

Semi-passive RFID tags use batteries to energize the microchip while speaking, while drawing power from the reader. Lively and semi-passive RFID tags are more expensive than passive tags [5].

Passive tags are the most widely used, as they are smaller and less high-priced to enforce. Passive tags have to be "powered up" by the RFID reader before then they can transmit information. Unlike passive tags, active RFID tags have an onboard power supply (e.g., a battery), thereby enabling them to communicate information at all times.

If we want to implement the system in a real city, we must use an active tag and a ultrahigh frequency (UHF) RFID reader because the reading distance is defined primarily based on the size and energy of the antenna. We have the diverse frequency ranges which include low frequency, high frequency (HF), and UHF; with their range covering from few centimeters to 100 m [6]. Hence, by the use of those hardware's we can locate and identify our nodes in any road that we want.

Our proposed system is implemented by creating a small model that contains RFID reader, tag, and Arduino to detect and collect information about nodes or tags. We use passive tags, and a HF RFID reader that uses 13.56 MHz with a reading range between 5 cm and 1 m, to transfer information we create a closed network using 2.4G nRF24L01 Wireless Module w/power amplifier (PA) and low noise amplifiers (LNA) module, it uses the 2.4 GHz band and it can operate with baud rates from 250 kbps up to 2 Mbps. If used in open space its range can reach up to 1000 m (Fig. 1).

1.2. Features

1. Voltage: 3–3.6 V (recommended 3.3V) V
2. Maximum output power: +20 dBm
3. Emission mode current (peak): 115 mA
4. Receive mode current (peak): 45 mA
5. Power-down mode current: 4.2 uA
6. Sensitivity 2 Mbps mode in received: −92 dBm
7. Sensitivity 1 Mbps mode in received: −95 dBm
8. Sensitivity 250 kbps mode in received: −104 dBm
9. PA gain: 20 Db LNA gain: 10 Db
10. LNA Noise Fig. 2. 6Db
11. Antenna Gain (peak): 2 Dbi
12. 2 MB rate (Open area): 520 m
13. 1 MB rate (Open area): 750 m
14. 250 Kb rate (Open area): 1000 m.

The module can use 125 different channels, which means that it has the possibility to have a network of 125 independently working modems in one place [7]. Each channel can have up to six addresses, or each unit can communicate with up to 6 other units at the same time for both transmission and receiving, so nRF24L01 can send and receive data and communicate with each other while connected in the network.

1.3. K-nearest Neighbors (KNN) Algorithm

KNN is a simple supervised learning algorithm [8] that stores all available cases and classifies new cases based on a similarity measure (e.g., distance functions). KNN has already been used in statistical estimation and pattern recognition since the beginning of the 1970s as a non-parametric technique [9].

In KNN a case is classified by a majority vote of its neighbors, with the case being assigned to the class most common among its KNN measured by a distance function. If $K = 3$, then the case is simply assigned to the class of its nearest neighbors.

$$\text{Euclidean distance} = \sqrt{\sum_{i=1}^{k}(xi - yi)^2} \quad (1)$$

We use Euclidean distance, and it should also be noted that the Euclidean distance measures are only valid for continuous variables [10].

The value of K is crucial; the large value gives more precision because it reduces the noise even though there is no guarantee. Choosing the optimal value for K is best done by first inspecting the data. Cross-validation is another way to retrospectively determine a good K value using an independent dataset to validate the K value, historically, the optimal K for most datasets has been between 3 and 7 [11]. In our case, we use 3NN because that model gets a better result in our dataset for detecting the actual zone of any user that needs help after a significant test that we have implied on the algorithm.

Fig. 1. 2.4 G nRF24L01 wireless module w/power amplifier long-range transceiver.

2. APPLICATION DOMAIN

There are varies application domains which can be compacted by the emergence of IoTs. We categorize the applications into few domains, as in healthcare, Information and Communication Technologies, Transportation, Government, Public Safety and Military, smart home and sensible building, mobile technology, and smart business [12].

In this paper, our focus is on using node detection and tracking based on IoT for domains of health care and track monitoring.

2.1. Health Care

In some cases, patients do not even have enough time to get to a hospital. One of the most obvious and popular applications of health care is sending an ambulance to transfer the patients to a hospital for treatment, so what is the best process for find the patient's location at the briefest time and how we can track an ambulance in a city [13]. The idea is to find the patient's location and guide the ambulance to take the shortest and/or fastest way.

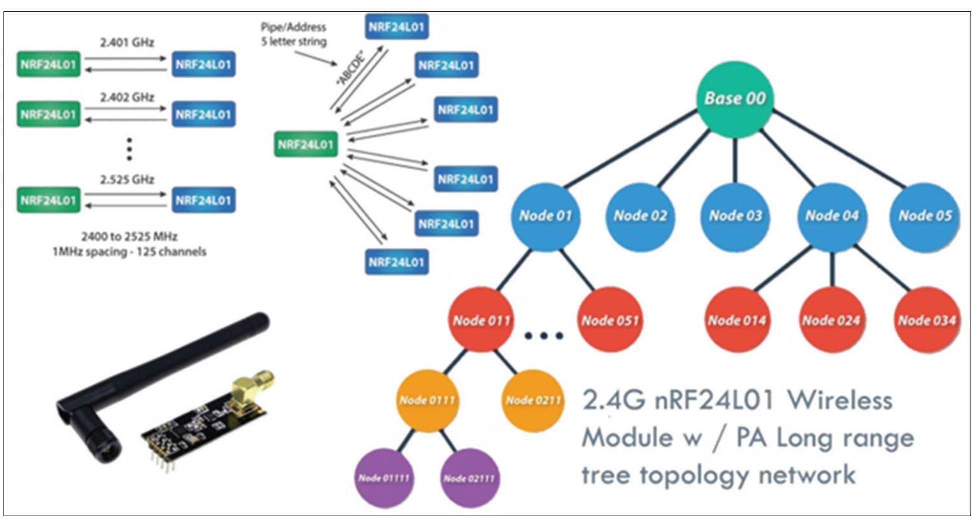

Fig. 2. nrf24l01 tree topology network [7].

2.2. Tracking and Monitoring

Real-time monitoring through connected devices can save lives, with real-time monitoring of the condition in place by means of a smart device connected to a system or smartphone app; connected devices can collect information and other required data and use a communication technique to transfer the collected information to a data center [14].

The IoT device in an ambulance can collect and transfer data: Like blood pressure, oxygen and blood sugar levels, weight, and electrocardiograms [15].

2.3. End-to-end Connectivity and Affordability

IoT enables interoperability, machine-to-machine communication, information exchange, and data movement that make service delivery effective [16].

2.4. Data Assortment and Analysis

Vast amount of data that an IoT device sends in a very short time due to their real-time application is hard to store and manage if the access to the system is unavailable. Even for field providers to acquire data originating from multiple devices and sources and analyze it manually is a tough bet [17].

3. PROBLEM STATEMENT AND AIM OF USING NODE DETECTION AND TRACKING

Node tracking is used in many fields such as transportation [18] and military security [19]. Among the techniques used in this field, we focused on IoT using RFID technology for its simplicity and its performance in this field.

In this research, we use IoT and machine learning algorithms to detect nodes in a closed network. Then, find the actual zone of any node in a smart city.

After that, we suggest the best pathway to any destination depending on distance, speed, time, and traffic. Finally, we predict the path of any IoT node using machine learning techniques.

4. METHODOLOGY

At the beginning, we should determine the location; in our case, its Iraq-Sulaymaniyah Governorate. Then, data collection about this area must be collected (Fig. 3).

We divided this city into 42 zones (Fig. 4) depending on the police stations, classified areas, main roads, and hospitals. Then, we group zones and decrease them into 27 zones (Fig. 5). To simplify and improve our dataset.

At this step, we work only on 27 zones, due to the mentioned reason above, for each zone, we collect 100–500 samples depending on the size of the area. The idea of choosing this region is for it has most of the hospitals and police stations inside it, availability of more accurate data comparing to other zones, and it is the most active part of Sulaymaniyah in terms of traffic and connected roads (Fig. 6).

After determining our zones, for each sample in any zone, we get longitude, latitude, zone code, nearest hospital, and police station that is responsible for that zone and the nearest Fire Stations is an important attribute we collect for each zone, so for training set and testing set we need all attributes mentioned above. We use Google earth for samples collection. Our system implemented by java and some data structure algorithm is used for getting better performance.

4.1. First Step

First Step must provide the dataset to the system for training and testing to get a result and finding the actual zone of each node that the system can recognize.

4.2. Second Step

Number of instances in our dataset is 11,095 samples for 27 zones, we use 70% of our samples for training and 30% for testing (Fig. 7) and depending on these samples and using machine learning our system can find the actual zone for each of the users because Sulaymaniyah Governorate at least has 10 billion coordinates which is a large number amount of data. We take only 11,095 coordinates, and we can give the same results. We use two cross-validated methods for sampling, Hold-out and bootstrap sampling, but Hold-out has better accuracy than bootstrap in our work.

4.3. Third Step

We use KNN to find actual zone (Euclidian distance) is used to calculate the distance between two points.

4.4. Fourth Step

After building a model, we must test it in the real world, for that reason using two approaches we can test our system, one of them is IoT tag and RFID reader by detecting node and sending tag information and their location to our system for finding the zone and other attributes. Or for the second mechanism the user send information to the system through a mobile application using SMS that contain critical information for finding that the user and their information are valid to

Fig. 3. Iraq-Sulaymaniyah governorate.

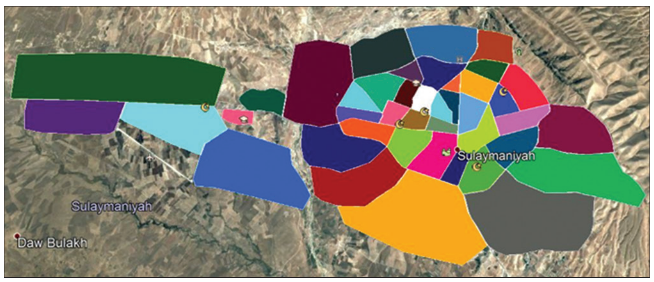

Fig. 4. Sulaymaniyah 42 zones.

Fig. 5. Case study inside city.

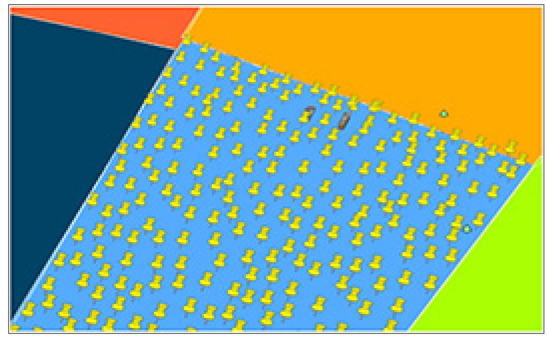

Fig. 6. Training sample.

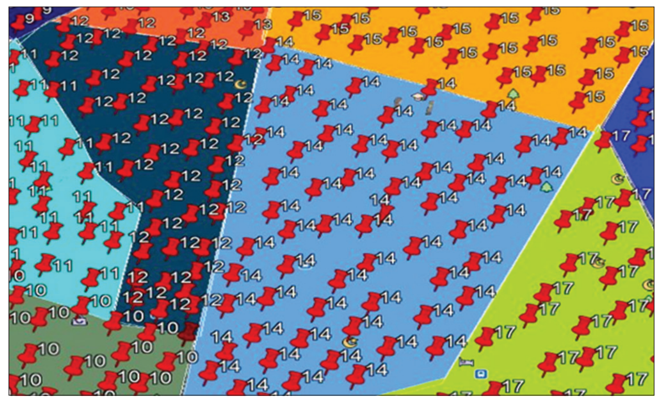

Fig. 7. Testing sample.

our system or not, the information that the user send contain longitude, latitude, phone number, and type of the help that s/he needs like the need for an ambulance or police or Firefighter. After determining the problem, we go to the next step.

4.5. Fifth Step

For sending an ambulance or police or Firefighter to the user, our system must find the best and shortest path to those users that need help. we create a closed network node detection in our city, so using the user information system the algorithm can detect the source and the destination targets, then calculate all possible ways from source to destination depending on these factors: Distance, speed, Traffic in that path and roads load because we already know that in some roads may have a lot of traffic in some periods such as in the morning and evening (start and end of a workday).

In our proposed system, we created a new algorithm for finding weights between nodes, and we can say that it is an improvement in finding weights between two readers or nodes in smart cities. Using (equation no. 2), we can calculate and find weights between any two nodes depending on (distance, speed, traffic, and some other parameters) and give that weight to Dijkstra's algorithm [20] to find the best path between source and destination.

$$T = \frac{D}{S} + \left(Tr * Te * N * Z\right) + C \qquad (2)$$

Where:

T = Time $_{\text{weight in (s)}}$

D = Distance$_{\text{ab (m)}}$

S = Speed$_{\text{ab (m/s)}}$

T_r = Traffic $\begin{cases} 0 \\ 1 \end{cases}$

T_e = Traffic time

N = No. side

C = Car count in image

T_c = Traveled car in Traffic ~ 30

$$Z = \frac{C}{Tc} \begin{cases} 1 \;; 0 \le Z > 1 \\ \left\lfloor \frac{C}{Tc} \right\rfloor \ge 1 \;; floor\ function \end{cases}$$

In the algorithm above, we have (*C* = Car count in image), when it comes to deep learning-based object detection algorithm, there are three primary object detectors you'll encounter:

- Regions-convolutional neural network (R-CNN) and their variants, including the original R-CNN, Fast R- CNN, and Faster R-CNN
- Single Shot Detector
- YOLO.

We use YOLO v3 [21] in our algorithm, in particular, YOLO trained on the Common Objects in Context (COCO) dataset [22]. The COCO dataset consists of 80 labels we use only those that are related to vehicles.

We are implementing YOLO v3 by two powerful languages python and java in our algorithm we created a specific java file that can send parameters and run the python file and return the number of detected vehicles inside the images and send it to our algorithm (Fig. 8).

Number of images is equal to the number of RFID readers in that path; this process is repeated every 1 min because we need updated data from an updated image from any node.

We already know that the problem of image processing is memory consumption, we separated the work into two parts; the process of counting the number of vehicles in an image is separated from another process such as finding the actual zone and detecting the best path each of them run on a separate machine. A web service is used to communicate between them.

4.6. The Dijkstra's Algorithm [20]

4.6.1. Step 1: Initialization

- Assign the zero weights value to node s, and label it as permanent (The state of node *s* is [0, *P*]).
- Assign to every node a weights value of ∞ and label them as temporary (The state of every other node is [∞, *t*]).
- Designate the node *s* as the current node.

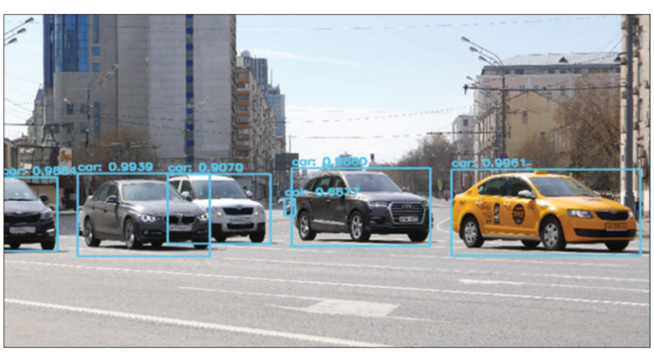

Fig. 8. Vehicle detection in image using YOLO [21].

4.6.2. Step 2: Weights value update and current node designation update let i be the index of the current node

1. Find the set J of nodes with temporary labels that can be reached from the current node i by a link (i, j). Update the weights values of these nodes. For each j ∈ J, the weights value d_j of node j is updated as follows new $d_j = \min\{d_j, d_i + c_{ij}\}$ where c_{ij} is the cost of link (i, j), as given in the network problem.
2. Determine a node j that has the smallest weights value dj among all nodes j ∈ J, find j* such that min j∈J $d_j = d_j$*
3. Change the label of node j* to permanent and designate this node as the current node.

4.6.3. Step 3: Termination criterion

If all nodes that can be reached from node s have been permanently labeled, then stop – we are done. If we cannot reach any temporary labeled node from the current node, then all the temporary labels become permanent – we are done. Otherwise, go to Step 2 [7].

Using the above algorithm, the system can find the best path from source to destination.

5. RESULTS

We use 3NN because it gives better results, as explained in Table 1. We divide our 11,095 samples into two-part training and testing by two famous sampling techniques in cross-validate sampling hold-out and bootstrap in the table below you can see the result of accuracy to find the actual zone of detected node.

In each sample, we have a lot of attributes, but the important ones are longitude and latitude. Using KNN we calculate and find the 3, 5, and 7 nearest neighbors of each sample after that we find the means absolute error for all tests, as shown

TABLE 1: KNN results for both hold-out and Bootstrap

Result: 70% of samples for trine and 30% for test			
Type of sampling	3 NN accuracy	5 NN accuracy	7 NN accuracy
Hold-out	99.22388%	99.07462%	98.98507%
Bootstrap	98.70793%	98.73798%	98.97836%

KNN: K-nearest neighbors

in Table 1 we have best accuracy (99.22388%) in hold-out at 3NN, the mean absolute error is 0.00776 which shows that our dataset and our implemented algorithm have a good result.

When a node has been detected, we calculate the zone based on their nearest neighbors as described in the third step. After that, we determine the destination (fourth step) then suggest the best path (Fig. 9). We describe the closed network area inside our city, the entire RFID reader's node connected to each other. Each reader has a specific number, location, pathway that is connect to other nodes that node has traffic or not, nearest (hospital, police stations, and Firefighter), so if any reader detects the specific node, alert the system by sending some packet through our Wi-Fi network for notifying it that the node is here now, and system must choose the best path for it to travel to its destination in the first example the result is the best case because we do not have any traffic (Fig. 9).

In the second example, we have traffic between those two nodes (Fig. 10).

At any point in the city, we can collect new information and set new order when the node is recognized by a RFID reader so the system can detect a new path if eventually, some accident happens such as traffic accident or cartography like fire at some building. Hence, the system finds the best path depending on all attributes that we have mentioned before.

Hence, our work can be updated at any time so that the reader detects the tag and calculates the new information for tracking and detecting the path that the node must travel.

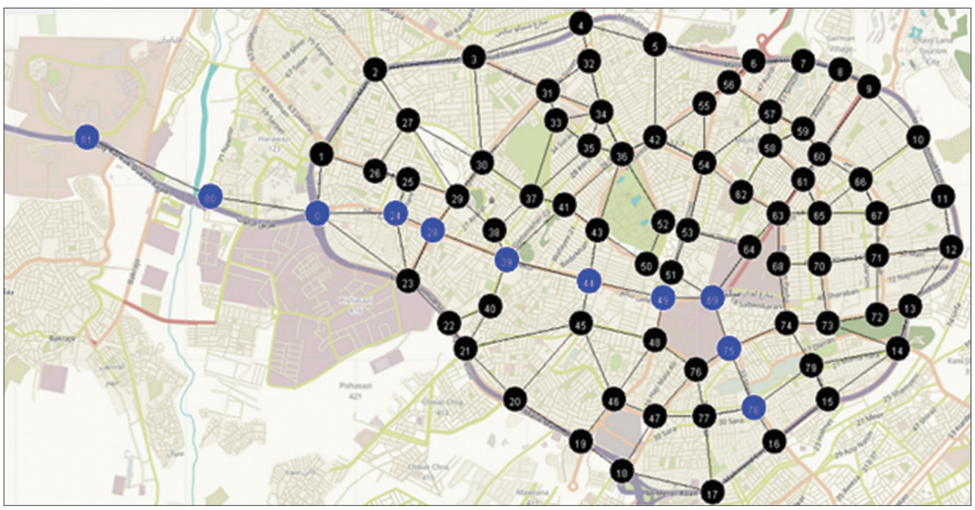

Fig. 9. Best case path detection.

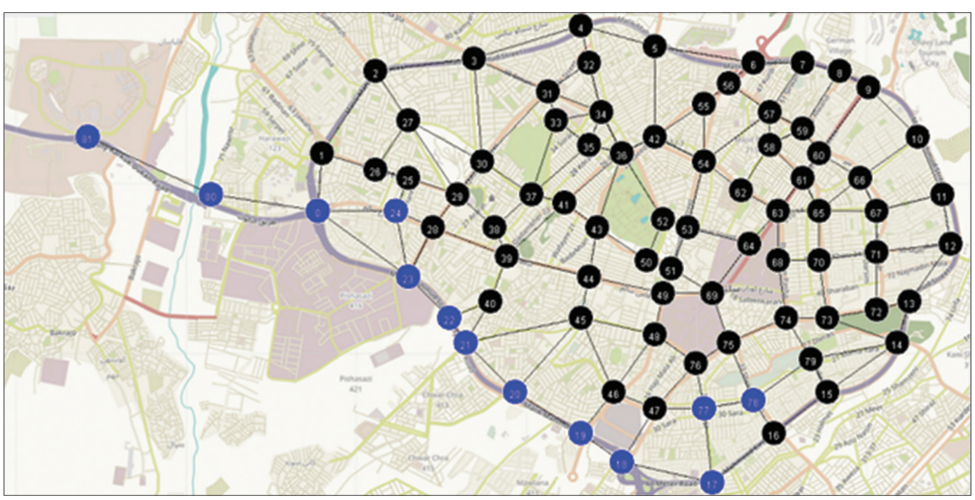

Fig. 10. Path detection depending on all attributes.

Fig. 11. Path detection flowchart.

Seeing the flowchart above (Fig. 11) describes all steps from source to destination for finding the best path. At any reader that detects a specified node, those steps above are done and send new instruction to the node. Like ambulance, police, and firefighters to travel and also they can send the notification before each interconnection of roads and ask the system to determine the path for it and send an instruction to them.

All the detection and information collected from readers and the system are automatically saved in an encrypted manner in a database on the server.

6. CONCLUSION

The character of IOT has changed the entire world. This has been finished through the help of introducing IoT devices, smartphones, and character automated collaborators within the health area, security, learning, traveling, and transmission. The framework we propose is fit for following self-governing node inside a closed network area depends on RFID innovation. In the end, using this system, we can detect any node at any position in our city and find the actual zone for it and choose the best path from the source node to the destination node depending on the type for transmission, for example, if the problem is to provide health care, the system detects the best path from the source to the nearest hospital or if the problem is to provide police services, detect the best path to the nearest police or a fire station. It calls the nearest firefighters station. We have tested our algorithms on a prototype implemented on a surface of 1×1 m^2; the results obtained are excellent. Our goal is to implement the proposed system in a real city and validate the algorithm on real data. Using this system and dataset can help other researchers work in other areas that can help cities use technologies to improve their lives.

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ORIGINAL RESEARCH ARTICLE | UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Using Regression Kriging to Analyze Groundwater According to Depth and Capacity of Wells

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ABSTRACT

Groundwater is valuable because it is needed as fresh water for agricultural, domestic, ecological, and industrial purposes. However, due to population growth and economic development, the groundwater environment is becoming more and more important and extensive. The study contributes to current knowledge on the groundwater wells prediction by statistical analysis under-researched. Such as, it seems that the preponderance of empirical research does not use map prediction with groundwater wells in the relevant literature, especially in our region. Instead, such studies focus on several simple statistical analysis such as statistical modeling package. Accordingly, the researcher tried to use the modern mechanism such as regression kriging (RK), which is predicted the groundwater wells through maps of Sulaimani Governorate. Hence, the objective of the study is to analyze and predicting groundwater for the year 2018 based on the depth and capacity of wells using the modern style of analyzing and predicting, which is RK method. RK is a geostatistical approach that exploits both the spatial variation in the sampled variable itself and environmental information collected from covariate maps for the target predictor. It is possible to predict groundwater quality maps for areas at Sulaimani Governorate in Kurdistan Regions Iraq. Sample data concerning the depth and capacity of groundwater wells were collected on Groundwater Directorate in Sulaimani City. The most important result of the study in the RK was the depth and capacity prediction map. The samples from the high depth of wells are located in the South of Sulaimani Governorate, while the north and middle areas of Sulaimani Governorate have got low depths of wells. Although the samples from the high capacity are located in the South of Sulaimani Governorate, in the north and middle the capacity of wells have decreased. The classes (230–482 m) of depth are the more area, while the classes (29–158 G/s) of capacity are the almost area in the study.

Index Terms: Groundwater Analysis, Interpolation, Regression Kriging

1. INTRODUCTION

Groundwater is a valuable freshwater resource and constitutes about two-third of the fresh water reserves of the world [1]. Buchanan (1983) estimated that the groundwater volume is 2000 times higher than the volume of waters in all the world's rivers and 30 times more than the volume contained in all the fresh water of the world lakes. The almost is 5.0 L × 1024 L in the world of groundwater reservoir [2]. Groundwater is used in many fields for industrial, domestic, and agricultural purposes. However, due to the population growth and economic development, the groundwater environment is becoming more and more important and extensive [3], and the heavy groundwater extraction has caused many problems such as groundwater level drop, saltwater intrusion, and ground surface depression, which need to be improved. Therefore, the identification, assessment, and remediation

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of groundwater problems have become quite a crucial and useful topic in the current time. For the above reasons, the analysis of groundwater requires implementing scientific and academic methods, from which one of the verified models is the RK that is used for this purpose [2]. Regression-kriging (RK) is a spatial prediction technique that combines regression of the dependent variable on auxiliary variables with kriging of the regression residuals. It is mathematically a consideration of interpolation method variously called universal kriging and kriging with external drift, where auxiliary predictors are used to solve the kriging weights directly [4]. RK is an application of the best linear unbiased predictor for spatial data, which is the best linear interpolator assuming the universal model of spatial variation [5]. RK is used in many fields, such as soil mapping, geological mapping, climatology, meteorology, species distribution modeling, and some other similar fields [6]. Regression kriging (RK) is one of the most widely used methods, which uses hybrid techniques and combines ordinary kriging with regression using ancillary information. Since the correlation between primary and secondary variables is significant [7], so, the aim of this study is to analyze and predicting groundwater depending on depth and capacity of wells in Sulaimani Governorate; using RK.

1.1. Objective of the Study

The main objective of this research is to analyze and predict groundwater wells at the un-sampled locations in Sulaimani Governorate according to depth and capacity of existing groundwater wells using RK and to assess the accuracy of these predictions.

2. MATERIALS AND METHODS

2.1. Interpolation

Spatial interpolation deals with predicting values of the locations that have got unknown values. Measured values can be used to interpolate, or predict the values at locations which were not sampled. In general, there are two accepted approaches to spatial interpolation. The first method uses deterministic techniques in which only information from the observation point is used. Examples of direct interpolation techniques are such as inverse distance weighting or trend surface estimation. The other method depends on regression of addition information, or covariates, gathered about the target variable (such as regression analysis combined with kriging). These are geostatistical interpolation techniques, better suited to count for spatial variation, and capable of quantifying the interpolation errors. Hengl *et al.* (2007) advocate the combination of these two into so-called hybrid interpolation. This is known as RK [8]. In another paper, Hengl *et al.* (2004) explain a structure for RK, which forms the basis for the research in this study [7]. Limitation of RK is the greater complexity than other more straightforward techniques like ordinary kriging, which in some cases might lead to worse results [9].

2.2. RK

The most basic form of kriging is called ordinary kriging. When we add the relationship between the target and covariate variables at the sampled locations and apply this to predicting values using kriging at unsampled locations, we get RK. In this way, the spatial process is decomposed into a mean and residual process. Thus, the first step of RK analysis is to build a regression model using the explanatory grid maps [8]. The kriging residuals are found using the residuals of the regression model as input for the kriging process. Adding up the mean and residual components finally results in the RK prediction [8]. RK is a combination of the traditional multiple linear regression (MLR) and kriging, which means that an unvisited location s_0 is estimated by summing the predicted drift and residuals. This procedure has been found preferable for solving the linear model coefficients [10] and has been applied in several studies. The residuals generated from MLR were kriged and then added to the predicted drift, obtaining the RK prediction. The models are expressed as:

$$\hat{Z}_{ML.R}(s_0) = \sum_{k=0}^{P} \hat{\beta}_k \cdot x_k(s_0) \quad (1)$$

$$\hat{Z}_{RK}(s_0) = \hat{Z}_{ML.R}(s_0) + \sum_{i=1}^{n} w_i(s_0) \cdot e(s_i); x_0(s_0) = 1 \quad (2)$$

When $\hat{Z}_{ML.R}$ (s_0) is the predicted value of the target variable z at location s_0 using MLR model, $\hat{Z}_{RK}$ (s_0) is the predicted value of the target variable at location s_0 using RK model, $\hat{\beta}_k$ is the regression coefficiency for the k^{th} explanatory variable X_k, p is the total number of explanatory variables, w_i (s_0) are weights determined by the covariance function and e (s_i) are the regression residuals. In a simple form, this can be written as:

$$z(s) = m(s) + \varepsilon'(s) \quad (3)$$

When $z(s)$ is the value of a phenomenon at location s, $m(s)$ is the mean component at s, and ε' (s) stands for the residual component including the spatial noise. The mean component is also known as the regression component.

The process of refining the prediction in two steps (trend estimation and kriging) is shown in Fig. 1, where the result of the mean component, only regression $\hat{m}_{(s)}$, is visible as a dashed line, and the sum of trend + kriging is the curving thick line $\hat{z}_{(s)}$. This should approach the actual distribution better than either just a trend surface or a simple interpolation. The linear modeling of the relationship between the dependent and explanatory variables is quite empirical. The model selection determines which covariable is important, and which one is not. It is not necessary to know all these relations, as long as there is a significant correlation. Once the covariates have been selected, their explanatory strength is determined using (stepwise) MLR analysis. For each covariate this, leads to a coefficient value, describing its predictive strength, and whether this is a positive or negative relationship. With the combination of values for all covariate maps, a trend surface is constructed. This regression prediction is, in fact, the calculation for each target cell from each input cell from all covariates times the coefficient value. The amount of correlation is expressed by R^2 in the regression equation. To enable this, the covariate data first need to be processed by overlaying the sample locations with the covariate data layers. In this way, a matrix of covariate values for each sample point is constructed. This matrix may still hold several "NA" or missing values due to the fact that some maps do not have coverage, while some others do. An example of this is the absence of information on the organic matter in urban areas. Since the linear models cannot be constructed properly when some covariate data are missing, these sample points are discarded altogether. The resulting data matrix is therefore complete for all remaining measurement data points. The second step in which the covariate data are needed is the model prediction phase of the mean surface values. First, a prediction mask is made, which is the selection of grid cells for which covariate data are available and only contains the coordinates of valid cells. Next, the regression mean values are calculated by predicting the regression model for every grid cell in the prediction mask. In the residual kriging phase, this prediction grid is used again as a mask for the kriging prediction [7].

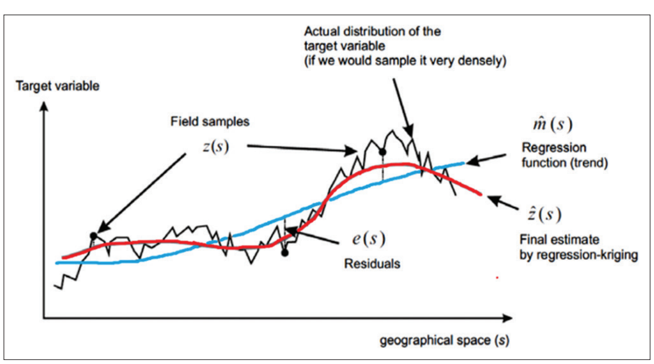

Fig. 1. A schematic representation of regression kriging using a cross-section [8].

2.3. Variogram and Semivariogram

Semivariogram analysis is used for the descriptive analysis. The spatial structure of the data is investigated using semivariogram. This structure is also used for predictive applications, in which the semivariogram is used to fit a theoretical model, parameterized, and also used to predict a regionalized variable at other unmeasured points. Estimating the mean function $X(s)T\beta$ and the covariance structure of $\varepsilon(s)$ for each s in the area of interest is the first step in both the analysis of the spatial variation and the prediction. Semivariogram is commonly used as a measure of spatial dependency. The estimated semivariogram explains a description of how the data is correlated with the distance. The factor 1/2 that $\Upsilon(h)$ indicates is a semivariogram, and $2\Upsilon(h)$ is the variogram. Thus, the semivariogram function measures half the average squared difference between pairs of data values separated by a given distance, h, which is known as the lag [11], [5]. The experimental variogram is a plot of the semivariance against the distance between sampling points. The variogram is the fitted line that best describes the function connecting the dots from the experimental variogram [12]. Assuming that the process is stationary, the semivariogram is defined in equation (4):

$$\gamma(h) = \frac{1}{2N_h} \sum_{N(h)} [z(s_i) - z(s_j)]^2 \tag{4}$$

Here, $N(h)$ is the set of all pairwise Euclidean distances $i–j = h$, N_h is the number of distinct pairs in $N(h)$. $Z(s_i)$ and $z(s_j)$ are the values at spatial location i and j, respectively, and $\Upsilon(h)$ is the estimated semivariogram value at distance h.

The semivariogram has three important parameters: The nugget, sill, and range. The nugget is a scale of sub-grid variation or measurement error, and it is indicated by the intercept graphically. The sill is the semivariant value as the lag (h) goes to infinity, and it is equal to the total variance of the data set. The range is a scalar which controls the degree of correlation between data points (i.e., the distance at which the semivariogram reaches its sill). As shown in Fig. 2, it is then necessary to select a type of theoretical semivariogram model based on that estimate.

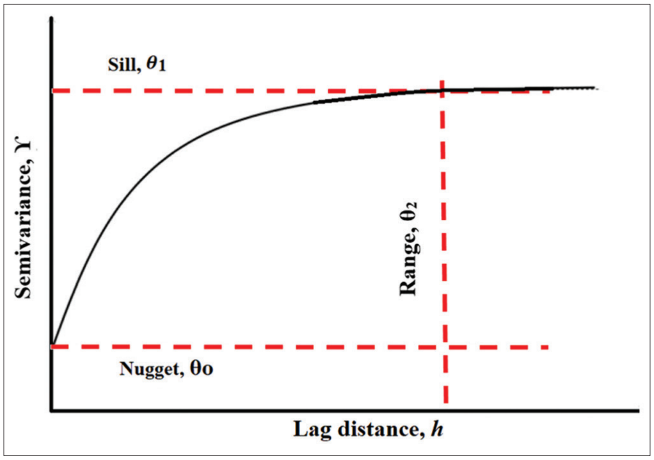

Fig. 2. Illustration of semivariogram parameters.

Commonly used theoretical semivariogram shapes increase monotonically as a function of distance, by comparing the plot of empirical semivariogram with various theoretical models that can choose the semivariogram model. Three are some parametric semivariogram models for testing, such as: Exponential, gaussian, and spherical. These models are given by the following equations:

Exponential: $$\gamma(h) = \theta_0 + \theta_1 \left\{ 1 - exp\left(-\frac{3h}{\theta_2} \right) \right\}, \quad (5)$$

Gaussian: $$\gamma(h) = \theta_0 + \theta_1 \left\{ 1 - exp\left(-3\left(\frac{h}{\theta_2} \right)^2 \right) \right\}, \text{ and} \quad (6)$$

Spherical: $$\gamma(h) = \begin{cases} \theta_0 + \theta_1 \left\{ 1 - exp\left(\frac{3h}{2\theta_2} - \frac{1}{2}\left(\frac{h}{\theta_2} \right)^3 \right) \right\}, 0 \le h \le \theta_2 \\ \theta_0 + \theta_1, h > \theta_2 \end{cases} \quad (7)$$

When h is a spatial lag, θ_0 is the nugget, θ_1 is the spatial variance (also referred to as the sill), and θ_2 is the spatial range. The nugget, sill, and range parameters of the theoretical semivariogram model can fit the empirical semivariogram ϒ(h) by minimizing the nonlinear function. When fitting a semivariogram model, if we consider the empirical semivariogram values and try to fit a model to them as a function of the lag distance h, the ordinary least squares' function is as given by $\sum_h \left[\hat{\gamma}(h) - \gamma(h:\theta) \right]^2$, where ϒ($h$: θ) denotes the theoretical semivariogram model and $\theta = (\theta_0, \theta_1, \theta_2)$ is a vector of parameters. RK computes the parameters θ and β separately. The parameters β in the mean function are estimated by the least squares method. Then, it computes the residuals, and their parameters in the semivariogram are estimated by various estimation methods, such as least squares or a likelihood function. Prediction of RK at a new location s_0 can be performed separately using a regression model to predict the mean function, a kriging model of prediction residuals and then adding them back together as in Equation (8):

$$Z(s_0) = \sum_{k=0}^{n} \beta_k X_k(s_0) + \sum_{i=0}^{n} \lambda_i(s_0)\varepsilon(s_i) \quad (8)$$

Here, $s_i = (x_i, y_i)$ is the known location of the i_{th} sample, x_i and y_i are the coordinates, β_k is the estimated regression model coefficient, λ_i represents the weight applied to the i^{th} sample (determined by the variogram analysis), $\varepsilon(s_i)$ represents the regression residuals, and $X_1(s_0)\ldots X_n(s_0)$ are the values of the explanatory variables at a new location s_0. The weight λ_i is chosen such that the prediction error variance is minimized, yielding weights that depend on the semivariogram [13]. More details about the kriging weight λ_i follow immediately [14].

The main objective is to predict $Z(s)$ at a location known as s_0, given the observations $\{Z(s_1), Z(s_2),\ldots, Z(s_3)\}'$. For simplicity we assume $E\{Z(s)\} = 0$ for alls. We briefly outline the derivation of the widely used kriging predictor. Let the predictor be in the form of $\hat{Z}(s_0) = \lambda' Z(s)$, where $\lambda = \{\lambda_1, \lambda_2,\ldots, \lambda_n\}'$. The objective is to find weights λ, which is a minimum.

$$Q(s_0) = E\left[\lambda' Z(s) - Z(s_0)\right]^2 \quad (9)$$

By minimizing $Q(s_0)$ with respect to λ, it can be shown that;

$$\hat{Z}(s_0) = \sigma'(s_0, s)\sum^{-1} Z(s) \quad (10)$$

When $\sigma'(s_0, s) = E(Z(s_0)\ Z(s))$, and $\sum = E[Z(s)\ Z\ (s)]$ are the covariance matrix. The minimum of $Q(s_0)$ is min $Q(s_0) = \sigma^2 - \sigma'(s_0, s)\sum^{-1} Z(s)$. Note that, $Q(s_0)$ can be rewritten in terms of the variogram by applying;

$$\sigma(s_0, s) = \sigma^2 1 - \frac{1}{2}\Gamma(s_0, s) \quad (11)$$

When $\Gamma(s_0, s)$ is the corresponding matrix of variograms. We can thus rewrite $Q(s_0)$ given in Equation (9) as;

$$Q(s_0) = -\frac{1}{2}\lambda'\Gamma\lambda + \lambda'\Gamma(s_0, s) \quad (12)$$

$Q(s_0)$ is now minimized with respect to λ, subject to the constraint $\lambda' 1 = 1$ (accounting for the unbiasedness of the predictor $\hat{Z}(s_0)$) [11].

2.4. Advantages of RK

Geostatistical techniques such as multiple regression, inverse distance weight, simple kriging, and ordinary kriging uses either the concept of regression analysis with auxiliary variables or kriging for prediction of target variable, whereas RK is a mixed interpolation technique; it uses both the concepts of regression analysis with auxiliary variables and kriging (variogram analysis of the residuals) in the prediction of target variable. It considers both the situations, i.e., long-term variation (trend) as well as local variations. This property of RK makes it superior (more accurate prediction) over the above-mentioned techniques [15]. Among the Hybrid interpolation techniques, RK has an advantage that there is no danger of instability as in the kriging with the external drift [9]. Moreover, the RK procedure explicitly separates the estimated trend from the residuals and easily combined with the general additive modeling and regression trees [16,17].

2.5. Cross-Validation of RK Results

To assess which spatial prediction method provides the most accurate interpolation method, cross-validation is used to compare the estimated values with their true values. Cross-validation is accomplished by removing each data point and then using the remaining measurements to estimate the data value. This procedure is repeated for all observations in the dataset. The true values are subtracted from the estimated values. The residuals resulting from this procedure are then evaluated to assess the performance of the methods. One particular method is called k-fold cross-validation, where *"k"* stands for the number of folds one wants to apply. Each fold is a set of data kept apart from the analysis, repeated for the number of folds. A special type of k-fold cross validation is where the repetition of analyses (*k*) is equal to the number of data. This is called *"leave one out"* cross-validation, for the analysis is repeated once for every sample in the dataset, omitting the sample value itself. Resulting is a prediction for every observation, made using the same variogram model settings as for the normal RK prediction. The degree in which the cross-validation predictions resemble the observations is then a measure for the goodness of the prediction method. This can be calculated using the mean squared normalized error or "z score" [18]. To aid further in the assessment of prediction results, additional parameters can be calculated from the cross-validation output, *such as* the mean prediction error (MPE), root mean square prediction error (RMSPE), and average kriging standard error (AKSE).

$$MPE = \frac{1}{N}\sum_{x=1}^{N}\left(Z_{(x)} - Z'_{(x)}\right) \quad (13)$$

$$RMSPE = \sqrt{\frac{1}{N}\sum_{x=1}^{N}\left[\left(Z_{(x)} - Z'_{(x)}\right)\right]^2} \quad (14)$$

When N stands for the number of pairs of observed and predicted values, $Z(x)$ is the observed value at location x, and $z'(x)$ is the predicted value by ordinary kriging at location z.

$$AKSE = \sqrt{\frac{1}{N}\sum_{x=1}^{N}\left[\sigma(x)\right]^2} \quad (15)$$

Here, x is a location, and $\sigma(x)$ is the prediction standard error for location x. MPE indicates whether a prediction is biased and should be close to zero. RMSPE and AKSE are measures of precision and have to be more or less equal. The cv-procedure only accounts for the kriging part, since the input *is* the residuals from the linear modeling phase [4].

3. DATA ANALYSIS AND RESULTS

3.1. Data Description

Data were obtained from a (groundwater directorate/well license department) in Sulaimani, Kurdistan-Region. 451 observations (wells) were used in the study, only records containing valid x, y – locations are used in the statistical modeling process. One check is to print all measurement locations to check whether they are located within the defined regions. If not, they are removed. The RK method is suitable for predicting the groundwater wells, due to nature of data (there are coordinates for each wells). For kriging purposes, duplicate x,y-locations need to be checked, to prevent singularity issues, as shown by Yang *et al.* [4]. Duplicated locations share the same coordinates (based on one decimal digit), making it impossible to apply interpolation. Therefore, the choice is made to delete each second record that has duplicated coordinates. The research area is limited to the Sulaimani Governorate of the Kurdistan region, only depth and capacity of wells are available at the individual point locations. Therefore, this research is targeted at depth and capacity of wells. The data were presented in Fig. 3. The dataset used for the analysis contains six variables and deals with properties of well for the year 2018, which are (depth, capacity, state well level, dynamic well level, latitude-X, and longitude-Y).

3.2. Experimental Variogram

Once the regression prediction has been performed, the variogram for the resulting residuals from the sample data can be modeled, as shown in Fig. 4.

The model of depth with partial sill C_0 = 5328, nugget = 371.95, and range = 0.078 was used for the residual variogram. The result has indicated that with an increase in distance, the semivariance value increases. Semivariograms are used to fit the residuals of the recharge estimates to enable the residuals then to be spatially interpolated by kriging. Fig. 4 shows simple kriging of the modeled residuals using the same locations from the first prediction surface; the kriging is provided over the surface to obtain the results, which are not interpolated over geological boundaries, which are not necessary to have any spatial correlation with the residuals. These semivariograms explain the nugget that is high in each group. When the nugget value is high, it indicates low spatial correlation in the residuals and has an effect that interpolation is not trying to match each point value of the residuals. Although the range shows the extent of the spatial correlation of recharge residuals, it ensures that the residuals' spatial surface is only using the local information.

The model for capacity of wells has partial sill C_0 = 3805.4, nugget = 11222.3, and range = 0.429. The result has indicated that with an increase in distance, the semivariance value increases. Fig. 5 shows simple kriging of the modeled residuals using the same locations from the first prediction surface for the capacity of wells. From the semivariograms, the nugget also is high in each group, which indicates low spatial correlation in the residuals. The range shows the extent of the spatial correlation of recharge residuals and ensures that the residuals' spatial surface is only using the local information.

From Fig. 6, the variance has some artifacts. It can be expected that values close to the locations, where point samples were taken, have lower variances. However, the blue colored regions in the depth of wells appear very strange here, especially when other sparsely sampled

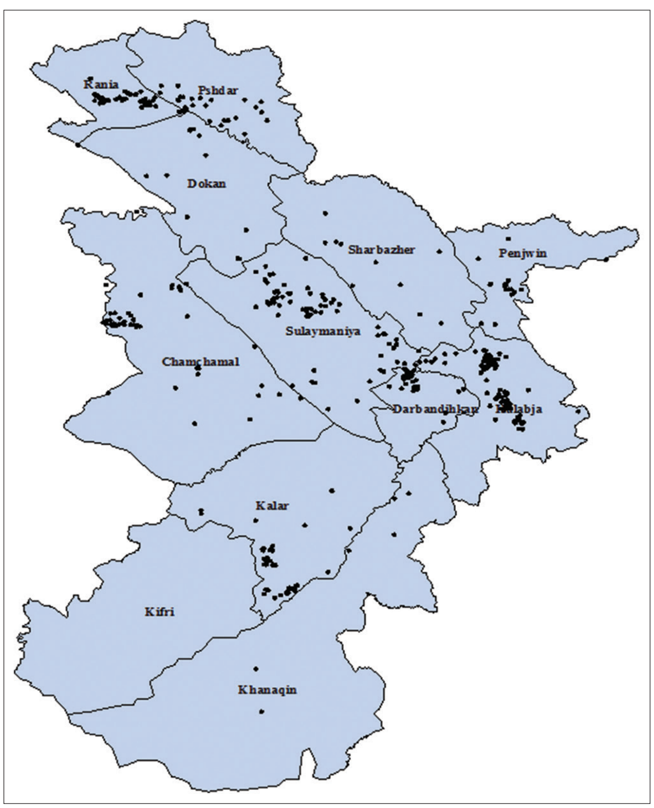

Fig. 3. Sample distribution.

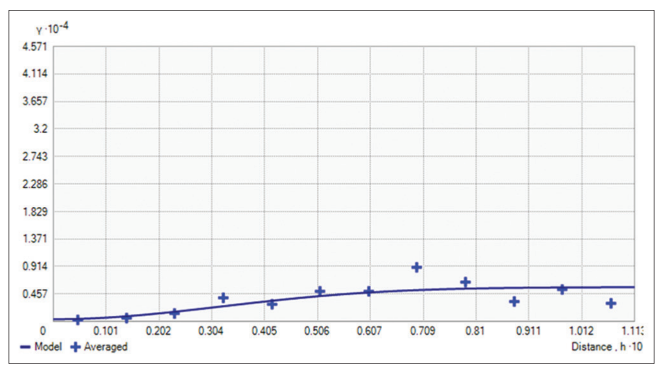

Fig. 4. Variogram for the depth of the wells.

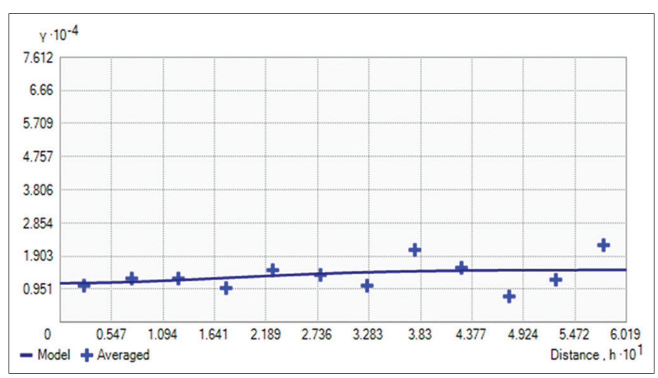

Fig. 5. Variogram for the capacity of wells.

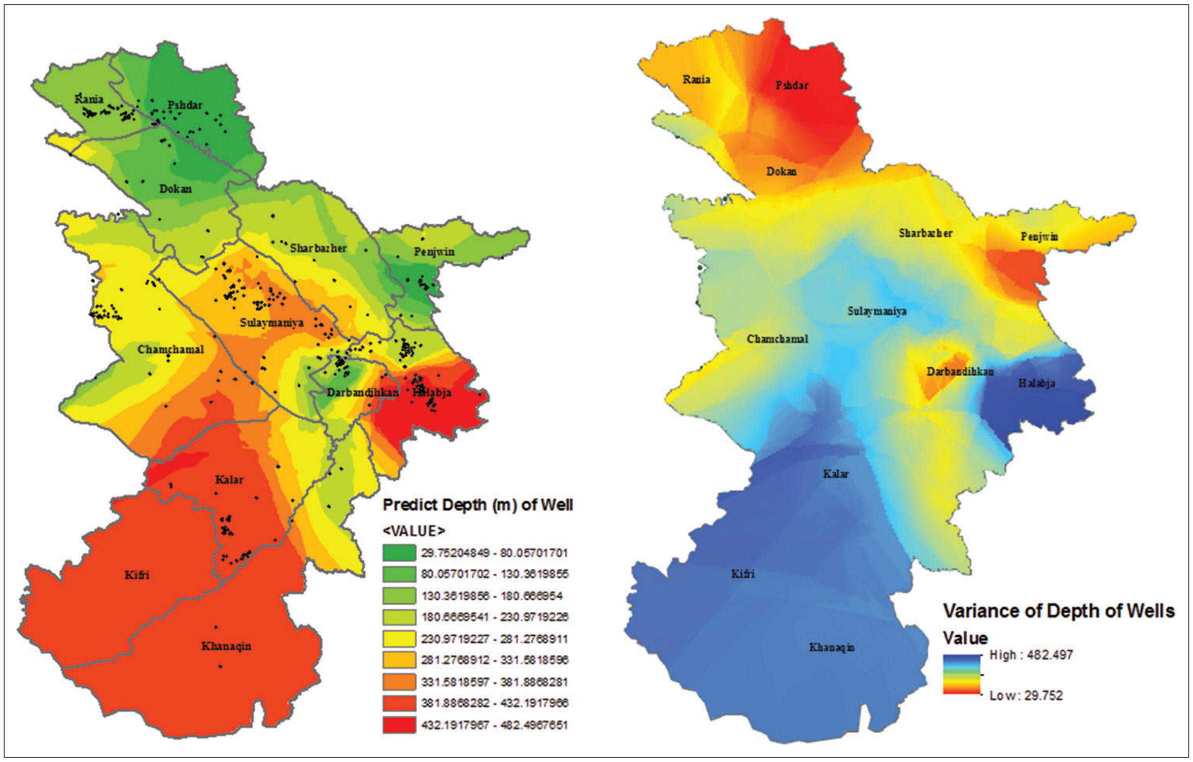

Fig. 6. Regression kriging results (left) and variance (right) of the residuals from the depth of wells' model.

regions do not have this blue color, but yellow and orange colors, indicating a lower variance value. The kriging variance is produced together with the kriging operation and is shown in the left part of Fig. 6. Although in the prediction map, the blue areas correspond somewhat to higher predictions for depth wells (red, 432–482 m Fig. 6 - left), this is not reversely so for the other regions. There are some points located at the blue area, each having a high depth of wells (ranged between 432 and 482 m). In the blue area, this phenomenon is enlarged, showing the scale at which the variance is increasing in the depth of wells, just around a cluster of sample points at the blue area. It is observed from the predicted depth of wells that the values are higher in the Kalar, Kifri, and Khanaqin (lower portion of the study area), followed by Sulaimani Governorate, while low values are found in the upper of Sulaimani Governorate (upper portion of the study area). This fact can be seen from the RK variance (Fig. 6 - left). Higher variance values (482) for the depth of wells are found in the plain areas whereas the mountainous areas have relatively lower values (29.7).

Fig. 7 explains the variance. It can be expected that values have lower variances, close to the locations, where point samples were taken. Although the blue colored regions in the capacity of wells' appear have very high variance value, yellow and orange colors are indicating a lower variance value. The kriging variance is produced together with the kriging operation and is shown in the left part of Fig. 7. Although in the prediction map, the blue areas correspond with higher predictions for capacity wells (372–415 G/m Fig. 7 - right). There are some points located at the blue area, each having high capacity of wells (range 372–415 G/m). In the blue area, this phenomenon is enlarged, showing the scale at which the variance is increasing in the capacity of wells. It is observed from the predicted capacity of wells that the values are higher in Kalar, Kifri, and Khanaqin, followed by Sulaimani Governorate, while low values are found in the upper of Sulaimani Governorate. This fact can be seen from the RK variance (Fig. 7 - left). Higher variance values (415) are found in the plain areas, whereas the mountainous areas have relatively lower values (29.8).

3.3. Cross-validation of Kriging

Cross-validation was used to obtain the goodness of fit for the model. In addition, for each cross-validation result, the MPE, or mean prediction error, was calculated. The MPE-value should be close to zero. RMSPE (root mean square

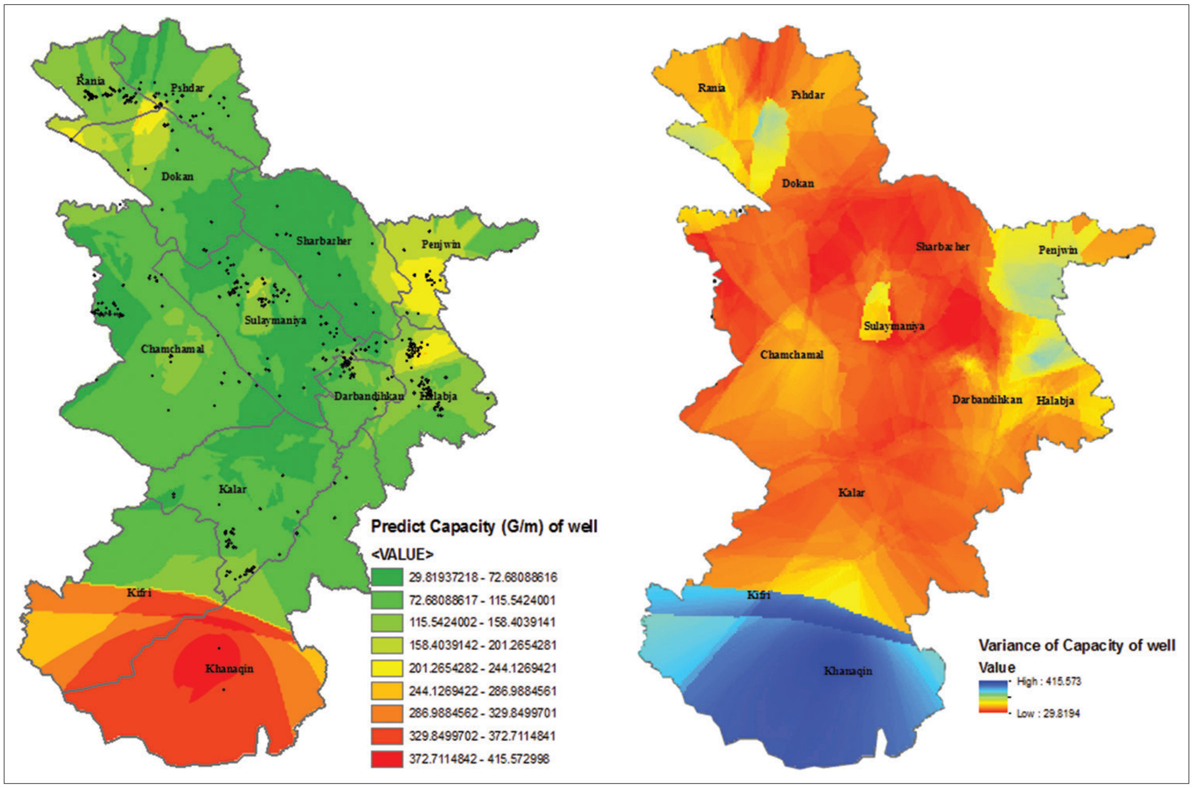

Fig. 7. Regression kriging results (left) and variance (right) of the residuals from the capacity of wells' model.

TABLE 1: Cross-validation results

Measurements	Depth of wells	Capacity of wells
MPE	0.019	0.021
RMSPE	0.844	0.720
AKSE	0.661	1.316

MPE: Mean prediction error, RMSPE: Root mean square prediction error, AKSE: Average kriging standard error

prediction error) and AKSE are given as well. The latter two error values should be close to each other, indicating prediction stability. The validation points were collected from all data in the study area so as to have an unbiased estimated accuracy. In this study, MPE, RMSPE, and AKSE are the three statistical parameters used for validation. The smaller the RMSPE, means the closer the predicted values to the observed values. Similarly, the MPE gives the mean of residuals and the unbiased prediction gives a value of zero. The results of the validation analysis are summarized in Table 1.

The MPE is quite low in both depth and capacity of wells and is a low bias value of 0.019 and 0.021, respectively. The value of MPE is a result of a slight over-estimation of predicted depth and capacity of wells in the model. The RMSPE value is only 0.844 and 1.31, indicating the closeness of predicted value with the observed value. The results indicate the utility of *RK* in spatially predicting depth and capacity of wells even in the varying landscape.

4. RESULTS AND CONCLUSIONS

The results of the study show that the cross-validation measurement of the models was achieved. Looking at the quantitative results from the cross-validation, there are no obvious indications that the kriging model prediction is worse in the models of depth and capacity of wells. One important result of the study is the region model predictions in the dataset with sample values. The samples from the high depth of wells are almost absent in north and middle of Sulaimani Governorate, while in the south they are present, although the capacity of wells gave the same result depth of the wells. The samples from the high capacity of wells are almost absent in the north and middle of Sulaimani Governorate, while in the south they are present. In the map results after the kriging in Figs. 4 and 5, the areas within class (230–482m) of depth are almost, this result was close to the master thesis from Iraq – Sulaimani University by Renas Abubaker

Ahmed, 2014, in which resulted that the depth of wells was between 20 m and more the 170 m for the same areas, which was used multivariate adaptive regression spline model to predicting groundwater wells [19], while the areas within class (29–158 G/s) of capacity are almost in the study, also it was close to Miss. Rena's results, which is reported that the capacity of wells between 10 and 140 gallon [19].

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