p-ISSN 2521-4209
e-ISSN 2521-4217

جامعة التنمية البشرية
UNIVERSITY OF HUMAN DEVELOPMENT

UHD Journal of Science and Technology

A Scientific periodical issued by University of Human Developement

Vol.7 No.(2) December 2023

2023 2723

www.jst.uhd.edu.iq

Kurdistan Regional Government
University of Human Development

UHD Journal of Science and Technology

A periodic scientific journal issued by University of Human Development

Introduction

UHD Journal of Science and Technology (UHDJST) is a semi-annual journal published by the University of Human Development, Sulaymaniyah, Kurdistan Region, Iraq. UHDJST member of ROAD, e-ISSN: 2521-4217, p-ISSN: 2521-4209 and a member of Crossref, DOI: 10.21928/issn.2521-4217. UHDJST publishes original research in all areas of Science, Engineering, and Technology. UHDJST is a Peer-Reviewed Open Access journal with Creative Commons Attribution Non-Commercial No Derivatives License 4.0 (CC BY-NC-ND 4.0). UHDJST provides immediate, worldwide, barrier-free access to the full text of research articles without requiring a subscription to the journal, and has article processing charge (APC). UHDJST applies the highest standards to everything it does and adopts APA citation/referencing style. UHDJST Section Policy includes three types of publications: Articles, Review Articles, and Letters.

By publishing with us, your research will get the coverage and attention it deserves. Open access and continuous online publication mean your work will be published swiftly, ready to be accessed by anyone, anywhere, at any time. Article Level Metrics allow you to follow the conversations your work has started.

UHDJST publishes works from extensive fields including, but not limited to:

- Pure Science
- Applied Science
- Medicine
- Engineering
- Technology

Scope and Focus

UHD Journal of Science and Technology (UHDJST) publishes original research in all areas of Science and Engineering. UHDJST is a semi-annual journal published by the University of Human Development, Sulaymaniyah, Kurdistan Region, Iraq. We believe that if your research is scientifically valid and technically sound then it deserves to be published and made accessible to the research community. UHDJST aims to provide a service to the international scientific community enhancing swap space to share, promote and disseminate the academic scientific production from research applied to Science, Engineering, and Technology.

SEARCHING FOR PLAGIARISM

We use plagiarism detection: detection; According to Oxford online dictionary, Plagiarism means: *The practice of taking someone else's work or ideas and passing them off as one's own.*

Section Policies

No.	Title	Peer Reviewed	Indexed	Open Submission
1	Articles: This is the main type of publication that UHDJST will produce	☑	☑	☑
2	Review Articles: Critical, constructive analysis of the literature in a specific field through summary, classification, analysis, comparison.	☑	☑	☑
3	Letters: Short reports of original research focused on an outstanding finding whose importance means that it will be of interest to scientists in other fields.	☑	☑	☑

PEER REVIEW POLICIES

At UHDJST we are committed to prompt quality scientific work with local and global impacts. To maintain a high-quality publication, all submissions undergo a rigorous review process. Characteristics of the peer review process are as follows:

- The journal peer review process is a "double-blind peer review".
- Simultaneous submissions of the same manuscript to different journals will not be tolerated.
- Manuscripts with contents outside the scope will not be considered for review.
- Papers will be refereed by at least 2 experts as suggested by the editorial board.
- In addition, Editors will have the option of seeking additional reviews when needed. Authors will be informed when Editors decide further review is required.
- All publication decisions are made by the journal's Editors-in-Chief on the basis of the referees' reports. Authors of papers that are not accepted are notified promptly.
- All submitted manuscripts are treated as confidential documents. We expect our Board of Reviewing Editors, Associate Editors and reviewers to treat manuscripts as confidential material as well.
- Editors, Associate Editors, and reviewers involved in the review process should disclose conflicts of interest resulting from direct competitive, collaborative, or other relationships with any of the authors, and remove oneself from cases in which such conflicts preclude an objective evaluation. Privileged information or ideas that are obtained through peer review must not be used for competitive gain.
- Our peer review process is confidential and the identities of reviewers cannot be revealed.

Note: UHDJST is a member of CrossRef and CrossRef services, e.g., CrossCheck. All manuscripts submitted will be checked for plagiarism (copying text or results from other sources) and self-plagiarism (duplicating substantial parts of authors' own published work without giving the appropriate references) using the CrossCheck database. Plagiarism is not tolerated.

For more information about CrossCheck/iThenticate, please visit
http://www.crossref.org/crosscheck.html.

OPEN ACCESS POLICY

This journal provides immediate open access to its content on the principle that making research freely available to the public supports a greater global exchange of knowledge. Open Access (OA) stands for unrestricted access and unrestricted reuse which means making research publications freely available online. It access ensures that your work reaches the widest possible audience and that your fellow researchers can use and share it easily. The mission of the UHDJST is to improve the culture of scientific publications by supporting bright minds in science and public engagement.

UHDJST's open access articles are published under a Creative Commons Attribution CC-BY-NC-ND 4.0 license. This license lets you retain copyright and others may not use the material for commercial purposes. Commercial use is one primarily intended for commercial advantage or monetary compensation. If others remix, transform or build upon the material, they may not distribute the modified material. The main output of research, in general, is new ideas and knowledge, which the UHDJST peer-review policy allows publishing as high-quality, peer-reviewed research articles. The UHDJST believes that maximizing the distribution of these publications - by providing free, online access - is the most effective way of ensuring that the research we fund can be accessed, read and built upon. In turn, this will foster a richer research culture and cultivate good research ethics as well. The UHDJST, therefore, supports unrestricted access to the published materials on its main website as a fundamental part of its mission and a global academic community benefit to be encouraged wherever possible.

Specifically:

- The University of Human Development supports the principles and objectives of Open Access and Open Science
- UHDJST expects authors of research papers, and manuscripts to maximize the opportunities to make their results available for free access on its final peer-reviewed paper
- All manuscript will be made open access online soon after final stage peer-review finalized.
- This policy will be effective from 17th May 2017 and will be reviewed during the first year of operation.
- Open Access route is available at http://journals.uhd.edu.iq/index.php/uhdjst for publishing and archiving all accepted papers,
- Specific details of how authors of research articles are required to comply with this policy can be found in the Guide to Authors.

ARCHIVING

This journal utilizes the LOCKSS and CLOCKSS systems to create a distributed archiving system among participating libraries and permits those libraries to create permanent archives of the journal for purposes of preservation and restoration.

LOCKSS: Open Journal Systems supports the LOCKSS (Lots of Copies Keep Stuff Safe) system to ensure a secure and permanent archive for the journal. LOCKSS is open source software developed at Stanford University Library that enables libraries to preserve selected web journals by regularly polling registered journal websites for newly published content and archiving it. Each archive is continually validated against other library caches, and if the content is found to be corrupted or lost, the other caches or the journal is used to restore it.

CLOCKSS: Open Journal Systems also supports the CLOCKSS (Controlled Lots of Copies Keep Stuff Safe) system to ensure a secure and permanent archive for the journal. CLOCKSS is based upon the open-source LOCKSS software developed at Stanford University Library that enables libraries to preserve selected web journals by regularly polling registered journal websites for newly published content and archiving it. Each archive is continually validated against other library caches, and if the content is found to be corrupted or lost, the other caches or the journal is used to restore it.

PUBLICATION ETHICS

Publication Ethics and Publication Malpractice Statement

The publication of an article in the peer-reviewed journal UHDJST is to support the standard and respected knowledge transfer network. Our publication ethics and publication malpractice statement is mainly based on the Code of Conduct and Best-Practice Guidelines for Journal Editors (Committee on Publication Ethics, 2011) that includes;

- General duties and responsibilities of editors.
- Relations with readers.
- Relations with the authors.
- Relations with editors.
- Relations with editorial board members.
- Relations with journal owners and publishers.
- Editorial and peer review processes.
- Protecting individual data.
- Encouraging ethical research (e.g. research involving humans or animals).
- Dealing with possible misconduct.
- Ensuring the integrity of the academic record.
- Intellectual property.
- Encouraging debate.
- Complaints.
- Conflicts of interest.

ANIMAL RESEARCHES

- For research conducted on regulated animals (which includes all live vertebrates and/or higher invertebrates), appropriate approval must have been obtained according to either international or local laws and regulations. Before conducting the research, approval must have been obtained from the relevant body (in most cases an Institutional Review Board, or Ethics Committee). The authors must provide an ethics statement as part of their Methods section detailing full information as to their approval (including the name of the granting organization, and the approval reference numbers). If an approval reference number is not provided, written approval must be provided as a confidential supplemental information file. Research on non-human primates is subject to specific guidelines from the Weather all (2006) report (The Use of Non-Human Primates in Research).
- For research conducted on non-regulated animals, a statement should be made as to why ethical approval was not required.
- Experimental animals should have been handled according to the highest standards dictated by the author's institution.
- We strongly encourage all authors to comply with the '*Animal Research: Reporting In Vivo Experiments*' (ARRIVE) guidelines, developed by NC3Rs.
- Articles should be specific in descriptions of the organism(s) used in the study. The description should indicate strain names when known.

ARTICLE PROCESSING CHARGES

UHDJST is an Open Access Journal (OAJ) and has article processing charges (APCs). The published articles can be downloaded freely without a barrier of admission.

Address

University of Human Development, Sulaymaniyah-Kurdistan Region/Iraq
PO Box: Sulaymaniyah 6/0778

Contact

Principal Contact

Dr. Aso Darwesh

Editor-in-Chief

University of Human Development – Sulaymaniyah, Iraq

Email: jst@uhd.edu.iq

Support Contact

UHD Technical Support

Phone: +964 773 393 5959

Email: jst@uhd.edu.iq

Contents

ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Identification of Blood Protozoa Infestation Transmitted by Vector Tikes among Awassi Sheep Herds in Kifri City, Kurdistan Region of Iraq

Mahmood Ahmad Hossein*

Department of Animal Production, Collage of Agricultural Engineering Science, University of Garmian, Kalar, As-Sulaymaniyah, KRG, Iraq

ABSTRACT

Blood protozoan disease is a common disease among animals in the Kifri city, Kurdistan region of Iraq that this disease is mostly transmitted by ticks. Therefore, the present study aimed to investigate the level of blood protozoan and to identify vector ticks in the native breed sheep (Awassi sheep) in Kifri city. For this purpose, blood samples were taken from 150 sheep suspected suffering from protozoan infection according to their clinical symptoms. In the present study, we prepared blood slides from suspected sheep and stained with Giemsa staining, and then at the same time, hard ticks were collected from the sheep's body. Then, the protozoan type was diagnosed and the vector tick species were identified by microscopically. The obtained results were statistically analyzed by the chi-square test. The results showed that 35 (23.33%) of that samples were infected with *Babesia* protozoa as 25 samples (16.66%) were infected with *Babesia ovis*, seven samples (4.66%) with *Babesia mutasi*, and three samples (2%) with *B. ovis* and *B. mutasi*. No infestation with *Theileria* and *Anaplasma* species was found. *Rhipicephalus*, *Hyalomma*, *Dermacentor,* and *Haemaphysalis* ticks were isolated and identified from the studied sheep. The results showed that the presence of the *Rhipicephalus bursa* tick is significantly ($P < 0.05$) related to the existence of *Babesiosis* disease in sheep. This study concluded that most of the studied sheep in Kifri city are infected with *Babesia* protozoa, especially *B. ovis*.

Index Terms: *Babesia ovis*, *Babesia mutasi*, *Kifri*, *Rhipicephalus* bursa, Sheep

1. INTRODUCTION

The sheep population in Iraq in 2020 was about 7 million head [1]. Most of this population (99.9%) is owned by the private sector [2] and is distributed all over the Iraq. The native breeds include the Awassi, Arabi, Karadi, and Hamadni sheep. One of the important native species of sheep in Kifri region is the Awassi sheep, which is abundant in this region. The condition of herding in Kifri city and the presence of a large nomadic population in this area indicates that most of the sheep grazing is done in the pastures and the ranchers tried to make the most of it in the hot seasons. Because ticks spend a relatively short time of their life cycle on the host, and they spend a long time apart from the host on the surface of pastures. As the climate of the region becomes favorable for the growth and appearance of ticks during the period of livestock grazing in the pastures, various types of blood protozoa cause contamination and the sheep suffer from protozoan diseases, especially

Access this article online

DOI: 10.21928/uhdjst.v7n2y2023.pp1-5

E-ISSN: 2521-4217

P-ISSN: 2521-4209

Corresponding author's e-mail: Dr. Mahmood Ahmad Hossein, Assistant Professor, Department of Animal Production, College of Agricultural Engineering Science, University of Garmian, Kalar, As-Sulaymaniyah, KRG, Iraq. E-mail: mahmood.ahmad@garmian.edu.krd

Received: 28-11-2022 Accepted: 17-06-2023 Published: 08-08-2023

Babesiosis. Babesia ovis and *Babesia mutasi* are among the most common causes of *Babesiosis* in sheeps [3], [4]. *Babesia crassa* from Iraq, *Babesia foliata* from India, and *Babesia taylori* from Pakistan have been reported as non-pathogenic *Babesia* [5]. *B. mutasi* is found in Southern Europe, Southern Africa, the Middle East, Caucasus, Southeast Asia, Mediterranean coastal areas, and other regions with warm and moderate climates [6], [7]. Sheep and goats are considered the main hosts for them. *Haemaphysalis punctata, Rhipicephalus bursa, Rhipicephalus sanguineous,* and *Ixodes ricinus ticks* are vector parasites [8], [9]. Sheep and goats are the main hosts of *B. ovis*. This parasite is spread throughout the tropical and subtropical regions, as well as in southern Europe, the former Soviet Union, Eastern Europe, North Africa, the equatorial region, and western Asia [10], [11]. The vector of *Babesia ripe* is *Cephalus bursa* tick, which is a two-host tick [12]. The *Hyalomma anatolicum excavatum, I. ricinus, Rhipicephalus turanicus,* and *Rhipicephalus sanguineus* ticks were also reported as vectors of *B. ovis* [8]. *B. ovis* is the most important cause of Babesiosis in Europe [13]. *Theileria hirci* is the cause of malignant theileriosis in sheep and goats, and the ticks *C. bursa* and *Hyalomma anatomical* are its vectors. These protozoa are found in lymphocytes and red blood cells of small ruminants. *Theileria ovis* causes a mild disease in small ruminants and is transmitted by species of *C. bursa* tick. Based on the results of the studies, diagnosis of parasites is possible by preparing slides from blood and lymphatic glands [14].

The disease caused by *Anaplasma ovis* is called tropical anaplasmosis of small ruminants. The distribution of this parasite is related to the distribution of its most important carriers, including the *Rhipicephalus bursa* in the Mediterranean region and the *Rhip*icephalus *ortisi* in the tropical regions of Africa [6].

Other studies suggested that the distribution of *B. mutasi* was reported to be limited to the northwestern regions of Iraq [15]. Mosqueda *et al.* also believe that sheep *Babesiosis* caused by *B. ovis* is spread all over Iraq and is considered an acute disease in Iraqi sheep [16]. Survey of seroepidemiology of *B. ovis* in sheep in climatic regions of Iraq using indirect brilliant antibody test shows that 36% of sheep had a positive serum titer [17]. Considering the economic losses due to protozoan diseases, especially *Babesiosis* in sheep, paid for this. For this reason, the present study was conducted to investigate the contamination of blood protozoa and to identify the vector ticks in Awassi sheep in Kifri region.

2. MATERIALS AND METHODS

This study was conducted in the summer of 2020 in the villages of Kifri City, Kalar, Kurdistan region of Iraq. Sampling carried out on 150 Awassi sheep (39 male and 111 female sheeps) that were suspected of protozoan infestation and had the disease symptoms. General clinical examinations were performed on the sheep introduced by the owner. Sampling was collected only from the sheep that had symptoms of illness such as depression, anorexia, high fever (40–41°C) or had jaundice, and urine nails and also had respiratory symptoms such as tachypnea and tachycardia. After sampling, one slide was prepared from each sample. The slides were dried in the air and sent to the laboratory. In the laboratory, the slides were stained with Giemsa's stain and then examined. If objects were observed in the desired slide, the parasites were measured in microns with a calibrated optical micrometer. To collect the tick sample, the target sheep was laid on the ground. Then, first, the area below and around the tail were visually inspected, and in the second step, in the side, chest, around the chest, back of the legs, and ears, respectively. The ticks were collected by the angle they were attached to the host so that their oral appendages remain intact. Then, they were transferred to the sampling container containing 10% formalin and the containers were labeled. During sampling, animal characteristics such as the area, the date of sampling, the animal owner, the number of samples and clinical symptoms, the presence or absence of jaundice, and blood from the animal's urine were recorded in the sampling handbook. In this study, *Babesia* and Ticks species were identified morphologically based on the guidelines of William *et al.* [18] and Zajac and Conboy [19]. The data of the present study were analyzed using SAS software.

3. RESULTS

The results of the present study showed that 35 (23.33%) the samples were infected with *Babesia* protozoa and that 25 samples (16.66%) were infected with *B. ovis*, seven samples (4.66%) with *B. mutasi*, three samples (2%) with *B. ovis,* and *B. mutasi* (Fig. 1). In this study, the samples infected with *Babesia theileria* and *Babesia anaplasma* were not found. Based on the results of our findings, *B. mutasi* is pear-shaped, 2.5–4 microns long and two microns wide, and *B. ovis* is mostly round and has 1–1.5-micron red blood cells on the sides. There is a hole in the center of the parasite, and thus, it takes the shape of a ring. Pear-shaped bodies are relatively rare and are seen as pairs with open angles in the margin of red blood cells (Figs. 2 and 3).

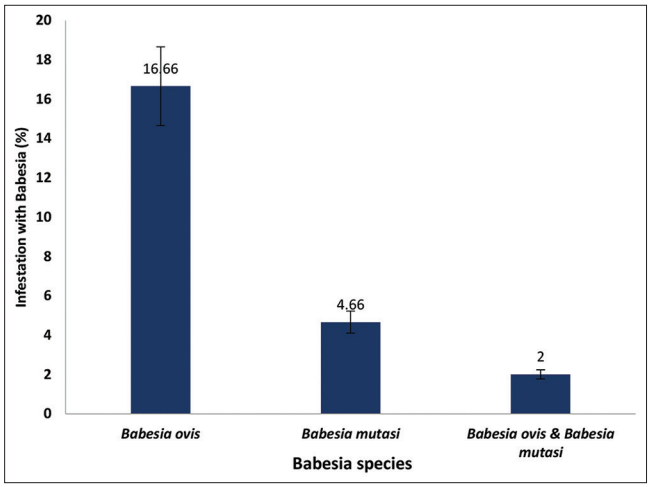


Fig. 1. The rate of infection of Babesia protozoa among native sheep in Kifri city.

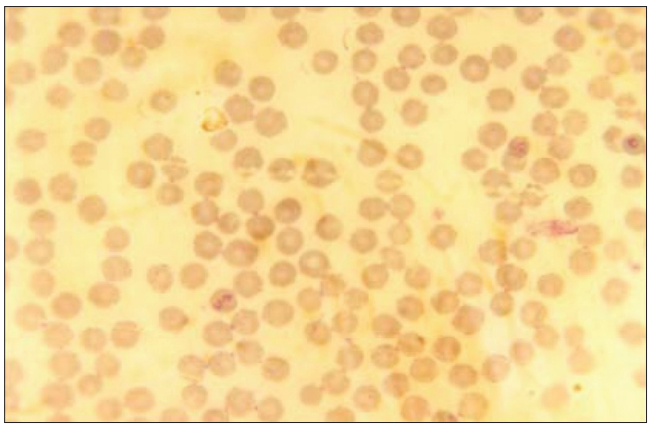


Fig. 2. The blood film of sheep stained with Giemsa contains the trophozoite of *Babesia mutasi* (×100).

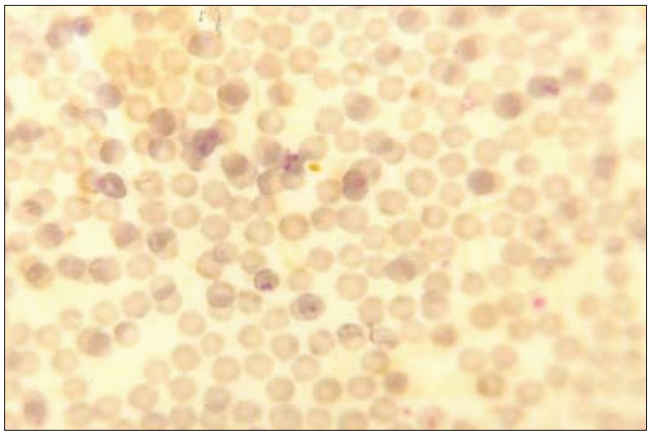


Fig. 3. The blood film of sheep stained with Giemsa contains the trophozoite of *Babesia ovis* (×100).

Out of 150 samples infected with *Babesia* protozoa, 39 samples were from male sheep (26%), and 111 samples were from female sheep (74%) (Table 1). Out of 39 samples of male sheep infected by *Babesia* protozoa, seven samples (4.66%) were infected with *B. ovis*. Out of 111 samples of female sheep infected by *Babesia* protozoa, 24 samples (68.58%) were infected with *B. ovis*, one sample (2.58%) with *B. mutasi*, and three samples (8.57%) with *B. ovis* and *B. mutasi* (Table 1).

Out of 150 samples of infected sheep in this study, 96 samples of sheep were infected with ticks, and a total of 204 ticks were isolated from them. Out of this number, 130 *Rhipicephalus* ticks (63.72%) were found among hard ticks, and the highest percentage of sheep infection with ticks in Kifri city is attributed to *Rhipicephalus* ticks. In addition to *Rhipicephalus* tick, other species of ticks were detected on the infected sheep that their infection percentages are as follows: *Hyalomma* tick 51 samples (25%), *Dermacentor* tick 13 samples (6.37%), and *Haemaphysalis* tick 10 samples (4.9%) (Fig. 4). Out of 130 samples of Rhipicephalus ticks, 112 samples of R. bursa, 17 samples of R. sanguineus, and one sample of R. turanicus were identified. Thirteen samples of *Dermacentor* tick belonged to the species *Dermacentor marginatus* and ten samples of *Haemaphysalis* tick belonged to the species *Haemaphysalis punctata*. Out of 51 *Hyalomma* ticks, 26 samples were *Hyalomma asiaticum asiaticum*, 17 samples were *H. anatolicum anatolicum*, seven samples were *Hyalomma marginatum* and one sample was *Hyalomma atatolicum exquatum*. The mean of intensity of ticks on each head of the sheep in Kifri city was 1.36 ticks, and the mean of intensity of ticks on each head of the sheep infested with *Babesia* protozoa was 2.7 ticks.

4. DISCUSSION

B. ovis is highly pathogenic, especially in sheep and causes a severe infection that is characterized by fever, anemia, icterus, and hemoglobinuria with mortality rates ranging from 30% to 50% in the susceptible host during field infections [20], [21]. Due to its severe effect on the homeotic system, it has caused significant losses among small ruminants, especially sheep in Kifri city. Therefore, the present study aimed to investigate the infestation of blood protozoa and to identify the vector ticks in Awassi sheep in Kifri region. The results of the present study showed that the sheep in Kifri region are mostly infected with *B. ovis* species (16.66%), and the highest percentage of infection with external hard ticks is

Table 1: Distribution of absolute and relative frequency of sheep infected with *Babesia protozoa,* separated by species of sheep and *Babesia species*

The number of samples (male and female animal)	Babesia species	Infected male sheep		Infected female sheep	
		Number	%	Number	%
150	*Babesia ovis*	7	4.66	24	68.58
	Babesia mutasi	-	-	1	2.58
	Babesia ovis and *Babesia mutasi*	-	-	3	8.57

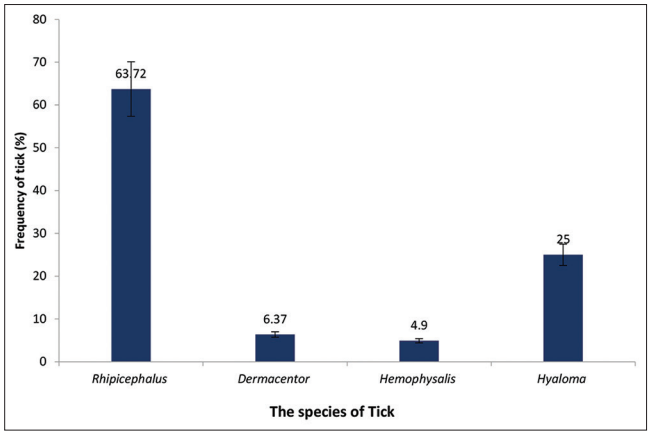


Fig. 4. Frequency of hard ticks identified from infected sheep in the present study.

related to *Rhipicephalus* (63.72%). The results of the present study indicate the predominance of *B. ovis* species in sheep infected with *Babesia* protozoa in the Kifri area. These results are consistent with the results of Tousli and Rahbari [22], which reported that 41.6% of sheep in the Kurdistan region of Iran were infected with *B. ovis*. Infestation with *B. ovis* is severe in some areas. The infection of sheep in Greece with *B. ovis* was reported to be 52% [23]. Furthermore, 72% of sheep in the Samson region of Turkey were infected with *B. ovis* [24]. As mentioned, the results obtained from this research are consistent with the results reported from Iran and Turkey, and the dominant species of this protozoan in these regions is *B. ovis*. One of the main reasons for this issue is the neighborhood of these areas. Due to the closeness of these areas, there are a lot of transfers and sales of sheep between ranchers. Paying attention to the fact that the information obtained from this research, from a statistical point of view, is mostly qualitative data. Hence, if we calculate the probability of disease transmission by all the hard ticks found in the area in comparison with the disease transmission by the statistical population of *Rhipicephalus* species by the chi-square test, there is a significant difference between the transmission of *Babesiosis* disease by the *Rhipicephalus* tick compared to its transmission by all other ixodidae ticks (*Dermacentor, Haemaphysalis*, and *Hyalomma* ticks) in the region ($P < 0.05$). Considering that the transmission of *Babesia* disease by ticks has been proven, it can be assumed that the sheep that are infected with *Babesia* and are tick-free; there is a possibility that the tick was separated from the host after feeding. Furthermore, in cases where the animal shows the symptoms of the disease, but the protozoa have not been isolated from its blood, such a case cannot be a negative reason for *Babesiosis* disease in this sheep. This probably indicates the presence of a small number of *Babesia* protozoa inside the sheep erythrocytes, which makes their identification difficult at this stage. In this case, it is better to repeat the sampling with a longer time interval.

There are different opinions about the severity and pathogenicity of the *Babesia* species. The reason for these reports is probably the long-term contamination of livestock in the region and finally the creation of relative immunity against some strains of protozoa. Therefore, there are strains with less intensity than any of the species of B. mutasi and *B. ovis* in different regions. However, in case of double infestation (*B. mutasi* and *B. ovis*), the disease will appear in a more severe form Iqbal *et al.* [17]. The investigations carried out at the time of sampling as well as the results obtained in the present study showed that the seasonal abundance of ticks on sheep starts from the end of January and reaches its peak in the middle of March. It seems that due to the warm weather in the Kifri region, the activity time of ticks is shorter and the maximum infection with *Babesia* in sheep is in February. In totally, babesiosis in sheep specially caused by *B. ovis* can be considered as an emerging disease in Kifri city.

5. CONCLUSION

Our finding showed that the common blood protozoan that causes sheep infection is *B. ovis* in the Kifri area. Furthermore, the predominant tick among infected sheep in the study area is Rhipicephalus tick, and the infection rate of the sheep with the tick was higher than *Babesiosis* species in Kifri area.

6. ACKNOWLEDGMENT

The authors would like to deeply thank the all ranchers who allowed us to gather specimens from their husbandry and equally grateful to the authorities of the Head of Veterinary Lab of Garmian University who allow us free access to laboratory facilities which led to the performing of the current research.

REFERENCES

[1] FAO. "*Quarterly Bulletin of Statistics*". Vol. 1. FAO, Rome, Italy, 2020, p. 234.

[2] Ministry of Planning, "Means and prospects and Sheep and Goat development in Iraq", 2022, p. 124.

[3] Q. Liu, Y. Q. Zhou and D. N. Zhou. "Semi-nested PCR detection of *Babesia orientalis* in its natural hosts *Rhipicephalus haemaphysaloides* and buffalo". *Veterinary Parasitology*, vol. 143, pp. 260-266, 2007.

[4] J. Y. Kim, S. H. Cho, H. N. Joo, M. S. R. Cho, M. Tsuji, I. J. Park, G. T. Chung, J. W. Ju, H. I. Cheun, H. W. Lee, Y. H. Lee and T. S. Kim. "First case of human Babesiosis in Korea: Detection and characterization of a novel type of Babesia sp. (KO1) similar to ovine *Babesia*". *Journal of Clinical Microbiology*, vol. 45, pp. 2084-2087, 2015.

[5] S. Naz, A. Maqbool, S. Ahmed, K. Ashraf, N. Ahmed, K. Saeed, M. Latif, J. Iqbal, Z. Ali, K. Shafi and I. A. Nagra. "Prevalence of theileriosis in small ruminants Lahore-Pakistan". *Journal of Veterinary and Animal Science*, vol. 2, pp. 16-20, 2012.

[6] K. Altay, M. Aktas and N. Dumanli. "Detection of *Babesia ovis* by PCR in *Rhipicephalus* bursa collected from naturally infested sheep and goats". *Research in Veterinary Science*, v*ol.* 85, pp. 116-119, 2007.

[7] A. Cakmack, A. Inci and Z. Kararer. "Seroprevalence of *Babesia ovis* in sheep and goats on Cankiri region". *Acta Parasitologica Turcica*, vol. 22, pp. 73-76, 2020.

[8] E. J. L. Soulsby. "*Helminth, Arthropoda and Protozoa of Domesticated Animals*". Vol. 14. Bailler Tindall, London, 1982, pp. 456-471.

[9] B. Fivaz, T. Petney and I. Horak. "*Tick Vector Biology Medicine and Veterinary Aspects*". Vol. 45. Springer-Verlag, Berlin Heidelberg, 2020, p. 28.

[10] B. A. Allsopp, H. A. Baylis, M. T. Allsopp, T. Cavalier-Smith, R. P. Bishop, D. M. Carrington, B. Sohanpal and P. Spooner. "Discrimination between six species of *Theileria* using oligonucleotide probes which detect small subunit ribosomal RNA sequences". *Parasitology*, vol. 107, pp. 157-165, 1993.

[11] S. Durrani, Z. Khan, R. M. Khattak, M. Andleeb, M. Ali, H. Hameed, A. Taqddas, M. Faryal, S. Kiran, M. Riaz, R. S. Shiek, M. Ali, F. Iqbal and M. Andleeb. "A comparison of the presence of *Theileria ovis* by PCR amplification of their SSU rRNA gene in small ruminants from two provinces of Pakistan". *Asian Pacific Journal of Tropical Disease*, vol. 2, pp. 43-47, 2012.

[12] A. Inci, A. Ica, A. Yildirim and O. Duzlu. "Identification of *Babesia* and *Theileria* species in small ruminants in Central Anatolia (Turkey) via reverse line blotting". *Turkish Journal of Veterinary and Animal Sciences*, vol. 34, pp. 205-210, 2010.

[13] K. T. Freiedhoff. "Tick-borne disease of sheep and goats caused by *Babesia*, *Theileria* or *Anaplasma* spp". *Parassitologia*, vol. 39, pp. 99-109, 1997.

[14] D. Nagore, J. García-Sanmartín, A. L. García-Pírez and R. A. Juste and A. Hurtado. "Identification, genetic diversity and prevalence of *Theileria* and *Babesia* species in a sheep population from Northern Spain". *International Journal for Parasitology*, vol. 34, pp. 1059-1067, 2004.

[15] A. Rafiai. "Veterinary and comparative entomology". *Current Medicinal Chemistry*, vol. 19, pp. 1504-1518, 2012.

[16] J. Mosqueda, A. Olvera-Ramirez, G. Aguilar-Tipacamu and G. J. Canto. "Current advances in detection and treatment of Babesiosis". *Current Medicinal Chemistry*, vol. 19, pp. 1504-1518, 2012.

[17] F. Iqbal, M. Ali, M. Fatima, S. Shahnawaz, S. Zulifqar, R. Fatima, R. S. Shaikh, A. S. Shaikh, M. Aktas and M. Ali. "A study on prevalence and determination of the risk factors of infection with *Babesia ovis* in small ruminants from Southern Punjab (Pakistan) by PCR amplification". *Parasite*, vol. 18, pp. 229-234, 2011.

[18] L. William, N. Nicholson, N. Richard and M. Brown. In: "*Medical and Veterinary Entomology*". 3rd ed. Georgia Southern University, Statesboro, GA, United States, 2019, pp. 51-65.

[19] A. M. Zajac and G. A. Conboy. "*Veterinary Clinical Parasitology*". Vol. 7. Blackwell Publishing Ltd., UK, 2000, pp. 172-175.

[20] S. Kage, G. S. Mamatha, J. N. Lakkundi and B. P. Shivashankar. "Detection of incidence of *Babesia* spp. in sheep and goats by parasitological diagnostic techniques". *Journal of Parasitic Diseases*, vol. 43, pp. 452-457, 2019.

[21] Z. S. Dehkordi, S. Zakeri, S. Nabian, A. Bahonar, F. Ghasemi and F. Noorollahi. "Molecular and biomorphometrical identification of ovine Babesiosis in Iran". *Iranian Journal of Parasitology*, vol. 5, pp. 21-30, 2010.

[22] M. Tousli and S. Rahbari. "Investigation of seroepidemiology in sheep in different regions of Iran". *Veterinary Journal*, vol. 53, pp. 57-65, 1998.

[23] B. Papadopoulos, N. M. Perie and G. Uilenberg. "Piroplasms of domestic animals in the Macdonia region of Greece. 1. Serological cross-reactions". *Veterinary Parasitology*, vol. 63, pp. 41-56, 1995.

[24] A. Clmak, S. Dincer and Z. Karer. "Studies on the serological diagnosis of *Babesia ovis* infection in Samsun area". *Ankara Üniversitesi Veteriner Fakültesi Dergisi*, vol. 38, pp. 242-251, 2018.

REVIEW ARTICLE

UHD JOURNAL OF SCIENCE AND TECHNOLOGY

A Review of Computer Vision–Based Traffic Controlling and Monitoring

Kamaran H. Manguri[1,2], Aree A. Mohammed[3]

[1]Department of Technical Information Systems Engineering, Erbil Technical Engineering College, Erbil Polytechnic University, Erbil, Iraq, [2]Department of Computer Science, College of Basic Education, University of Raparin, Ranya 46012, Iraq, [3]Department of Computer Science, College of Science, University of Sulaimani, Sulaymaniyah, Iraq

ABSTRACT

Due to the rapid increase of the population in the world, traffic signal controlling and monitoring has become an important issue to be solved with regard to the direct relation between the number of populations and the cars' usage. In this regard, an intelligent traffic signaling with a rapid urbanization is required to prevent the traffic congestions, cost reduction, minimization in travel time, and CO2 emissions to atmosphere. This paper provides a comprehensive review of computer vision techniques for autonomic traffic control and monitoring. Moreover, recent published articles in four related topics including density estimation investigation, traffic sign detection and recognition, accident detection, and emergency vehicle detection are investigated. The conducted survey shows that there is no fair comparison and performance evaluation due to the large number of involved parameters in the abovementioned four topics which can control the traffic signal controlling system such as (computation time, dataset availability, and an accuracy).

Index Terms: Traffic signaling system, Intelligent traffic, Computer vision, Traffic congestion, Traffic monitoring, Review.

1. INTRODUCTION

Number of cars has significantly increased nowadays, [1], [2] consequently, traffic congestion problem has been arise around the world [3]. Subsequently, vehicle clashing and crashing and dramatic increase of CO2 emission per year [4] are threatening sustainable mobility of future [5]. Furthermore, traffic control needs man power to be controlled [6]. The traffic control devices are time dependent and designed to flow the traffic in all directions. On top of that, sometimes during turning the lights from green to red causes traffic deadlock in a direction without having a noticeable flow in the other direction [7].

Access this article online

DOI: 10.21928/uhdjst.v7n2y2023.pp6-15

E-ISSN: 2521-4217

P-ISSN: 2521-4209

Congestions caused by traffic signals could negatively impact on economy in terms of transportation due to fuel [8], time expenditure [9], and air pollution [10]. Moreover, injuring even sometimes death caused by accidents happened in deadlock traffics [8], on the other hand, reducing congestion may have economic, environmental, and social benefits.

In general, to make the optimization problem manageable, several assumptions have to be made. The main problem that arises is that these assumptions deviate and sometimes do so significantly from the real world. Meanwhile, many factors have effects on drivers in real world traffics such as on driver's preference interactions with vulnerable road users (e.g., pedestrians, cyclists, etc.), weather and road conditions [11].

On the other hand, computer vision has an important role in managing and controlling traffic signals with great success [6], [12]. The best way to control traffic flow in big and busy cities is to utilize intelligent traffic signal [6], the system has ability to approximately evaluate density estimation,

Corresponding author's e-mail: kamaran@uor.edu.krd

Received: 20-12-2022 Accepted: 26-04-2023 Published: 10-08-2023

traffic signals detection and recognition, emergency and police car detection, and accident detection. Even though a better infrastructure can improve the traffic flow [13]. Usually in quiet intersections, the traffic is controlled by human or system controls [6]. In most congestions, cameras have been put for purposes other than traffic control, such as security, vehicle detection, and arrangement [14]. These cameras can be utilized for the reason of analyzing traffic scenes simply by employing specific hardware. The main advantage is that there is no need for replacing the CCTVs. The main objective of this survey is to fill the research gap that exists in the field of traffic signal controlling and monitoring.

The importance of this survey is to propose some technique based on computer vision for reducing the road congestion and keeping the environment green and public health. In this study, different approaches based on computer vision for traffic signaling controls are reviewed. For this purpose, the literatures over the period January 2015–January 2022 are surveyed. The structure of this review is as follows: Section I provides an introduction to the traffic and its problems. Background of traffic management addressed in Section II. In Section III, a literature review is provided for the existing solution of the intelligent traffic signaling. Section IV provides a discussion of review of the existing solutions. Finally, conclusion remarks are presented in last section.

2. REVIEW STRATEGY

This review is aimed in analyzing the recent literature for the vision-based methods for traffic controlling and managing, which have been published from January 2015 to January 2022 in terms of journal papers and conference proceedings. The reviewed papers were chosen after an extensive manual search of databases including IEEE Xplore, Springer, Elsevier, and Google Scholar. Keywords used to explore the databases are shown in Table 1. In addition, vision or image processing keywords are selected as the main keywords in the title of papers. Moreover, one of the sub search keywords has been used with main keyword to find the studies in the above mentioned period.

3. URBAN TRAFFIC LIGHT SYSTEM

Usually, each traffic light contains three color lights precisely, green, yellow, and red lights. They are put in the four parallel and perpendicular directions [15]. Fig. 1 shows a common intersection that formed by two perpendicular and parallel lanes.

Globally, the meaning of the lights for the drivers is as follows, green light means that the current lane has right to move forward meanwhile all other three directions are red which means they are not allowed to flow [11]. Besides, models of controlling traffic signaling and monitoring using computer vision required CCTV camera to acquisition images from the live traffic intersection. The simulation of traffic controlling in the cross road is shown in Fig. 2 [16].

4. LITERATURE REVIEW

To improve traffic signaling control and monitoring, scientists and researchers proposed many methods based on machine vision. Computer vision-based architecture of traffic signaling controlling and monitoring includes image acquisition, preprocessing and applying advance computer vision techniques density estimation, traffic sign detection and recognition, accident detection, and emergency vehicle detection. In this review, papers are randomly selected according to proposed methods in the recent years (between January 2015 and January 2022) for controlling and monitoring traffic signals.

4.1. Density Estimation

Density estimation is a key aspect for automatic traffic signaling control and reducing congestion in the intersection areas. Different approaches by reviewers to estimate traffic density are detailed below:

Table 1: Search parameters of the literature review

Date range	Database	Main Keywords (OR)	AND/Sub Search Key-words
January 2015–January 2022	IEEE Xplore Springer Elsevier Google Scholar	Vision Image Processing Machine Learning Deep Learning	Traffic Controlling Traffic Density Traffic Congestion Crowd Detection Accident Accident Detection Accident Identification Emergency Vehicle Traffic Sign

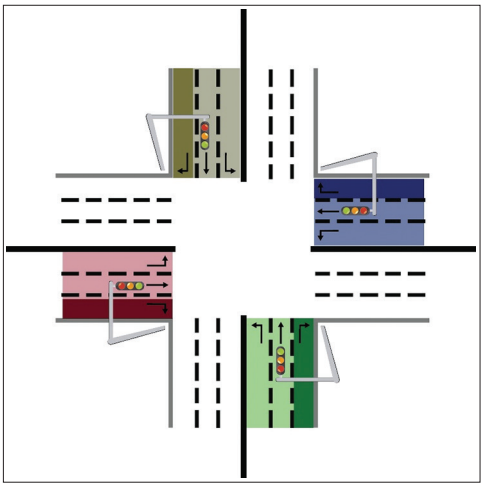


Fig. 1. Four road lanes intersection.

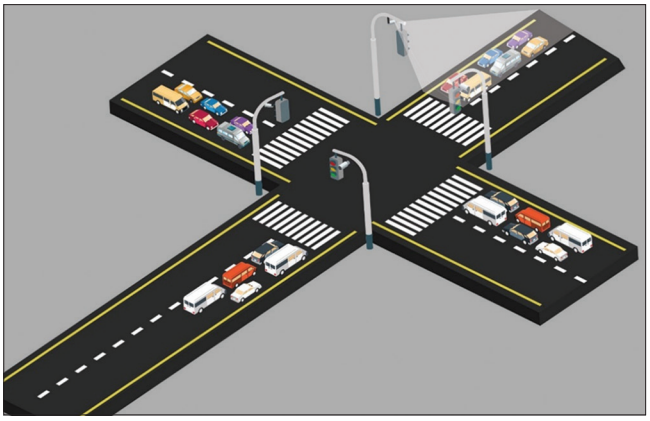


Fig. 2. Vision-based crossroad model.

Garg *et al.* [17] presented the approach for estimating traffic density based on vision which forms the fundamental building block of traffic monitoring systems. Due to the low accuracy of vehicle counting and tracking of existing techniques, the sensitivity to light changes, occlusions, congestions, etc. are made. Moreover, the authors addressed another problem of existing holistic-based methods by difficulty of implementation in real-time because the high computational complexity is required. To handle this issue, density is calculated using block processing approach for busy road segments. The proposed method involves two steps including marking of region of interest (ROI), generating block of interest, and background construction in the first step. Recurring process has been applied in the second step which involves background update, occupied block detection, shadow block elimination, and traffic density estimation. Finally, the proposed methods are evaluated and tested using the TrafficDB dataset.

In Biswas *et al.* [1] density estimated based counting cars, Background Subtraction (BS) method and OverFeat framework are implemented. The accuracy of the proposed system is evaluated by manual counting of cars. Furthermore, the comparative study was conducted before and after outperforming OverFeat framework. Average accuracy reached 96.55% after applied OverFeat Framework from 67.69% average accuracy for placemeter and 63.14% average accuracy for BS, respectively. Furthermore, this study confirmed that the OverFeat Framework has another application area. The advantages and shortcomings of the BS and six individual obtained traffic videos have used for analyzing OverFeat Framework with regarding different perspectives such as camera angles, weather conditions, and daily time.

Biswas *et al.* [3] implemented single shot detection (SSD) and MobileNet-SSD for estimating traffic density. For this purpose, 59 individual traffic cameras used for analyzing the SSD and MobileNet-SSD framework advantages and shortcomings. Moreover, two algorithms are compared with manually estimated density. The SSD framework demonstrates significant potential in the field of traffic density estimation. According to their experiment, the significant accuracy of detection achieved, numerically speaking the precisions were 92.97% and 79.30% for SSD and MobileNet-SSD, respectively.

Bui *et al.* [18] developed a method for analyzing traffic flow, advanced computer vision technologies have been used to extract traffic information. For finding traffic density estimation in intersections data acquired from video surveillance. Moreover, YOLO and DeepSORT techniques turned for the detection, tracking, and counting of vehicles have enveloped to estimate the road traffic density. To evaluated the proposed method, data collected in a real-world traffic through CCTV during 1 day.

A new technique for estimating traffic density utilizing a macroscopic approach has been developed by Kurniawan *et al.* [19]. The proposed method contains two parts including background construction and a traffic density estimation algorithm. The background construction obtained from detected non-moved vehicles in the front or behind vehicles. Moreover, background of the image founded using the edge detection technique. Density estimated by founding the ration between the number of ROI containing object and the total number of ROI.

Eamthanakul *et al.* [20] proposed a method-based image processing techniques for congestion detection. The

technique contains three parts: (1) Image background substation used for separating vehicles from the background, (2) Morphological techniques applied for removing the image noises, and (3) traffic density calculated from the obtained image from CCTV. Finally, the results of the process are sent to transport plan database.

4.2. Traffic Sign Detection and Recognition

Traffic sign recognition plays a key role in driver assistance systems and intelligent autonomous vehicles. Furthermore, it can be helpful for automatic traffic signals which leads to prevent pass across the intersections in the case of read signals.

Novel approaches proposed in Berkaya *et al.* [21] for traffic sign detection and recognition. A new method developed to detect traffic sign under the name of circle detection algorithm. In addition, RGB-based color thresholding technique was proposed by Berkaya *et al.* [21]. Moreover, three algorithms have been used to recognize traffic signs including histogram of oriented gradients (HOG), local binary patterns and Gabor features are employed within a support vector machine (SVM) classification framework. The performance of the proposed methods for both detection and recognition evaluated on German Traffic Sign Detection Benchmark (GTSDB) dataset. Based on the obtained results from experiments, the proposed system better than the reported literatures and can be used in a real-time operation.

Yang *et al.* [22] presented a method for traffic sign detection and recognition, the method includes three steps. Thresholding of HSI color space components used to segment image in the first step. Applying the blobs extracted to the first step for detecting traffic signs in the second step. The contribution of their method in the first step, machine learning algorithms not used classify shapes instead of this invariant geometric moments have been used. Second, inspired by the existing features, new method has been proposed for the recognition. The HOG features have been extended to the HSI color space and combined with the local self-similarity (LSS) features to get the descriptor. As a classifier, random forest and SVM classifiers have been tested together with the new descriptor. GTSDB and the Swedish Traffic Signs (STS) data sets have been used to test the proposed system. Finally, the results of the presented technique compared with existing techniques.

Salti *et al.* [23] combined solid image analysis and pattern recognition techniques for detecting traffic sign in mobile mapping data. The system designed base on interest regions extracting which makes a significant with other existing systems that sliding window detection have been used. Furthermore, with having challenging conditions such as varying illumination, partial occlusions, and large scale variations, the proposed system good performance demonstrated. Three variant category traffic signs aimed to detect including mandatory, prohibitory and danger traffic signs, according to the experimental setup of the recent GTSDB competition. With having a very good performance of the proposed method in the online competition, the proposed method challenging dataset mobile mapping of Italian signs the pipeline has been evaluated and showed its successfully be deployed in real-world mobile mapping data.

In Du *et al.* [24] designed the robust and fast performance classifier-based detector. They addressed two algorithms for detection and classification. First, aggregate channel features based on three types of features, which including the color feature, the gradient magnitude, and gradient histograms proposed. Second, boosted trees classifier multiscale and multiphase detector have been proposed based on Real AdaBoost algorithm. The obtained results from experiments of this study show high average-recall and speed which is evaluated on Daimler, LISA, and LaRA datasets.

Real-time traffic signs' detection and recognition are necessary for smart vehicles to make them more intelligent. To deal with this this issue. Shao *et al.* [25] are proposed a new approach that includes two steps; in the first one acquitted images from the road scene converted to grayscale images. Then simplified Gabor wavelets (SGW) filter has been applied to the optimized parameters of grayscale images. Furthermore, traffic sings bounded by edge detection which helps preparing the obtained result to the next process. In the second, the ROI extracted using the maximally stable extremal regions algorithm and the superclass of traffic signs are classified by SVM. To classify their subclasses, the traffic signs convolution neural networks (CNN) with input by simplified Gabor feature maps, where the parameters were the same as the detection stage is used. Finally, the proposed method tested on GTSDB and CTSD datasets and the results obtained from the experiments show that the method is fast and accurate by 6.3 frames per second and 99.43%, respectively.

Berkaya *et al.* [21] presented new ideas to provide colorful graphics to improve traffic in terms of object recognition and problem detection. Two digital image processing methods, namely, Circle Detection Algorithm and RGB which based on the simplest image segmenting method have been improved to develop the ability of traffic sign

detection. The classification framework, namely, SVM has been formed through assembling three main attributes including Gabor features HOG, and local binary patterns in the smart system. The presented technique is validated by German Traffic Sign Detection and Recognition Benchmark datasets, correspondingly. According to the practical results, their technique is by far more efficient than the quoted approaches in this paper; the results are also aligned with the real time operation.

A new approach for detecting and recognizing traffic signs proposed in Ellahyani *et al.* [26] which includes three main steps. Thresholding of HIS has been used to segment the image based on components of color spaces in the first step. It followed by applying blobs by the result of extracted from the former step. Then, the traffic signs recognition performed for the detected signs in the last step. Moreover, in their study, two different approaches used to classify signs. Instead of machine learning algorithms, invariant geometric moments used to classify shapes in the first step. Second, inspired by the existing features, new ones have been proposed for the recognition. HSI color space taken from the HOG features and combined with the LSS features to get the descriptor while used in the proposed algorithm. Then, last test has been done based machine learning algorithms which are random forest and SVM classifier. Finally, the performance of proposed method evaluated and tested on German Traffic Sign Recognition Benchmark (GTSRB), GTSDB, and STS datasets.

Convolutional Neural Networks (CNN) machine learning algorithm is applicable for object recognition by having power full recognition rate and less time required for execution. In Shustanov and Yakimov [27] implemented traffic sign recognition using CNN. Furthermore, several architectures of CNN compared together. Meanwhile, Tensor Flow library is used for training and massively parallel architecture for multithreaded programming CUDA. The entire procedure for traffic sign detection and recognition is executed in real time on a mobile GPU. Finally, their method efficiency evaluated on GTSRB dataset and it is obtained very good result by 99.94% for classification images.

4.3. Accident Detection

A main aspect of traffic monitoring is the identification and tracking of vehicles. Monitoring vehicles helps to report and detect in the situation of the traffic junctions. One of the main aspects of traffic monitoring is the identification and tracking of vehicles. In this section, accident prediction and detection approaches are faced.

Tian *et al.* [28] developed a Cooperative Vehicle Infrastructure Systems (CVIS) and proposed machine based-vision that can be used to detect car accident automatically. The study includes two phases; CAD-CVIS database has been created to improve the accuracy of accident detection in the first phase. CAD-CVIS dataset with regarding different traffic situations consists of various types of accidents, weather conditions and accident location. In the second phase, to detect accident deep neural network model YOLO-CA based on CAD-CVIS and deep learning algorithms developed. Moreover, to improve the performance of the model for detection small objects Multiscale Feature Fusion and loss function with dynamic weights utilized. The results showed the proposed method faster than the previous methods, it can detect car accident in milliseconds with a very good average precision by 90.02%. Finally, the proposed methods compared with existing methods, and the results determined accuracy improved and real-time over other models.

A neoteric framework proposed for detecting accident in Ijjina *et al.* [29]. For accurate object detection, Mask R-CNN capitalized in the proposed framework by an efficient centroid-based object tracking algorithm for surveillance footage. The basic idea is to determine an accident after overlapping vehicles together are speed and trajectory anomalies in a vehicle after an overlap with other vehicles. This framework was found to be dominant and paves the way to the development of general-purpose vehicular accident detection algorithms in real-time. The framework tested and evaluated by the proposed dataset with the different weather condition.

In Saini *et al.* [30], a vehicle tracking technique based on image processing is developed without applying background subtraction for extracting the ROI. Instead, a hybrid of feature detection and region matching approach is suggested in their study, which is helpful for estimating the trajectory of vehicles over consequent frames. Later, as the vehicle path through an intersection, the tracked direction is monitored for the occurrence of any specific event. It is found that the proposed method has capability to detect an accident between two vehicles.

Wenqi *et al.* [31] proposed the TAP-CNN model for predicting accident based on CNN in the highways. Traffic state and CNN model are described by some accident factors such as traffic flow, weather, and light to build a state matrix. In addition, the way of increasing TAP-CNN model accuracy for predicting traffic accident different iterations are analyzed. Accident data collected for inflected learning and evaluation of the model. Finally, the experimental results show that the proposed model

named TAP-CNN is more effective than the traditional neural network model for producing traffic accidents.

Dogru and Subasi [32] presented an intelligent system for accident detection in which vehicles exchange their microscopic vehicle variables with each other. Based on the vehicle speed and coordinates, data collected from vehicular ad-hoc networks (VANETs) simulated model in the proposed system and then, it sends traffic alerts to the drivers. Furthermore, it shows how to use machine learning methods to detect accidents on freeways in ITS. Two parameterizes help to analyze and detect accident easy which are position and velocity values of every vehicle. In addition, OOB data set has been used to test the proposed method. Finally, the results show that the RF is better than ANN and SVM algorithms by with 91.56%, 88.71, and 90.02% accuracy, respectively.

Vision-based algorithms have been used in Yu *et al.* [33] to detect traffic accident including an ST-IHT algorithm for improving the robustness and sparsity of spatiotemporal features and weighted extreme learning machine detector for distinguishing between traffic accident and normal traffic. Furthermore, a two-point search technique is proposed to find a candidate value adaptively for Lipschitz coefficients to improve the tuning precision. For testing and evaluating the proposed method 30 traffic videos collected from YouTube website. Finally, the results show that the proposed method performance for detecting a traffic accident outperforms other existing methods.

Accelerometer is a widely employed method that used to detect a crash. In this research work [34], after calibration of accelerometer value of acceleration is use to detect an accident. Due to the limitation of accelerometer accuracy and providing the efficient accident detection, CNN machine learning algorithm is tuned. For detecting an accident, image classification technique is used; however, CNN takes a lot of time, data, and computing power to train. Transfer learning methods have been innovatively applied to alleviate these problems and for the accident detection application, which involves retraining the already trained network. For this purpose, Inception-v3 classifier that developed by Google for image was incorporated. Finally, the proposed method efficiency compared with the traditional accelerometer-based techniques for detecting accident by 84.5% of accuracy for transfer learning algorithm.

4.4. Emergency Vehicles Detection

The success of law enforcement and public safety relies directly on the time needed for first responders to arrive at the emergency scene. Emergency cars include ambulance, firefighter, and police car. Many methods are proposed to detect emergency cars and some of them as example are reviewed in this section.

In Borisagar *et al.* [35], two methods of computer vision are used to detect and localize the emergency vehicle. The used methods including object detection and instance segmentation. The proposed method implementation includes Faster RCNN for object detection and Mask RCNN for instance segmentation. The results show that the proposed method is accurate, most importantly, and suitable for emergency vehicle detection in disordered traffic conditions are deliberated. In addition, a custom dataset used for detecting emergency vehicles which contains 400 images and labeled using the label me tool.

Roy and Rahman [36] are proposed a model for detecting emergency cars from CCTV footage such as ambulance and fire-fighter on a heavy traffic road. In this model, priority given to these cars and clearing the emergency lane to pass the traffic intersection. For traffic police, sometimes deciding opening the specific lane for emergency vehicles is difficult or even impossible. Deep CNN and COCO dataset have been used for automated emergency car detection. The result of presented method for detecting and identifying all kinds' emergency vehicles generally is reasonable.

E. P. Jonnadula and P. M. Khilar [37] are presented a hybrid architecture for detecting emergency vehicles by combining features of image processing and computer vision. Also, search space decreased by using region of interest.

Prediction of ambulance helps to decrease the number casualty on the real traffic in case of having emergency situation on the road. To cover this problem, Lin *et al.* [38] presented a novel approach-based machine learning techniques and features are extracted using the multi-nature which can extract ambulance characteristics on demand. Furthermore, they experimentally evaluate the performance of next-day demand prediction across several state-of-the-art machine learning techniques and ambulance demand prediction methods, using real-world ambulatory and demographical datasets obtained from Singapore. Finally, various machine learning techniques used for different natures and SCDF-Engineered-Socio dataset have been used to show the proposed method accuracy.

The existing traffic light system is a lack of information in emergencies such as ambulances, firefighters, and police when a car is in. Suhaimy *et al.* [39] developed an embedded

Table 2: Proposed methods in literature reviews

Type of traffic management	Reference (s)	Algorithm (s)	Dataset (s)	Accuracy %	Contribution (s)
Density Estimation	[17]	Block Variance	The TrafficDB	93.70	Traffic density estimation with the low computational cost
	[1]	Background Subtraction, over feat framework, and place meter	ImageNet	96.55	Defining ROI by over feat framework
	[3]	Detection (SSD) and MobileNet-SSD	Data collected from cameras with different places	92.97 (SSD), 79.30 (MobileNet-SSD)	New path opened for real time traffic density estimation
	[18]	YOLO and DeepSORT	Collected data from CCTV	87,88 (Day, Congestion) 93,88 (Day, Normal) 82,1 (Night, Normal)	Detecting, tracking and counting vehicles
	[19]	ROI and edge detection	-	N/A	New technique developed for estimating traffic density
	[20]	Background subtraction and morphological techniques	-	N/A	Traffic density estimated
	[40]	CNN	UCSD	99.01	Traffic density estimation model proposed based CNN and computer vision
Traffic Sign Detection and Recognition Approaches	[22]	HSI, HOG, LSS, and SVM	GTSDB, CTSD	98.24 (GTSDB), 98.77 (CTSD)	Developed Circle detection algorithm and an RGB-based color thresholding technique
	[21]	HOG, LSS, Random Forest, and SVM	GTSDB	97.04	In the first step, machine learning algorithms not used classify shapes instead of this invariant geometric moments have been used. Second, method has been proposed for the recognition
	[23]	ROI, HOG, SVM, and Context Aware Filter	GTSDB	99.43 (Prohibitory) 95.01 (Mandatory) 97.22 (Danger)	Online detecting mandatory, prohibitory and danger traffic signs
	[24]	Aggregate Channel Features and Boosted Trees Classifier	Daimler, LISA and LaRA	84.314 (Daimler), 90.33 (LISA), 92.048 (LaRA)	Proposed the high average-recall and speed method
	[26]	HOG, LSS, and SVM	GTSRB, GTSDB and TST	97.43	Shapes classified byusing invariant geometric moments
	[25]	SGW and SVM	GTSDB and CTSD	99.43	Speed of detection and classification improved which is more than 6 frames per second
	[27]	CNN	GTSRB	99.94	CNN process described
	[41]	Proposed model named CapsNet	TL_Dataset		The proposed CapsNet is employed for traffic sign recognition.
Accident Detection	[28]	Deep neural network model YOLO-CA	CAD-CVIS	90.02	CAD-CVIS dataset created and the proposed method more fast and accurate
	[29]	Mask R-CNN	Proposed	71	Developing vehicular accident detection algorithms in real-time
	[30]	Hybrid of feature detection and Region matching	Real world dataset	N/A	Accident detection between two vehicles
	[31]	CNN	Accident data collected	78.5	Accident predicted using CNN
	[32]	ANN, SVM, and Random Forests (RF)	OOB data set	91.56 (RF), 88.71 (ANN), 90.02 (SVM)	The proposed method can provide estimated geographical location of the possible accident

(Contd...)

Table 2: *(Continued)*

Type of traffic management	Reference (s)	Algorithm (s)	Dataset (s)	Accuracy %	Contribution (s)
	[33]	ST-IHT, Spatio-Temporal Features and W-ELM	Collected dataset	87.4±0.3 (SVM), 94.3±0.2 (ELM), 95.5±0.3 (W-ELM)	(i) Robust Fractures extraction proposed based on OF-DSIFT and ST-IHT (ii) detect imbalance between traffic accident and normal traffic
	[42]	YOLOv4	video sequences collected from YouTube	N/A	presents a new efficient framework for accident detection
Emergency Vehicles Detection	[35]	Faster RCNN and Mask RCNN	Custom dataset	81 (Object Detection), 92 (Instance Segmentation)	The computational and accuracy for emergency vehicle detection are suitable
	[36]	Deep convolutional neural network	COCO	97.97	Detecting and identifying all kinds emergency cars
	[37]	YOLO + ResNet	COCO	N/A	Hybrid architecture presented for detection of emergency vehicles in a real time
	[38]	SVR, MLP, RBFN, and LightGBM	SCDF-Engineered-Socio	N/A	Varying degrees to the model training in LightGBM
	[39]	MFCC-SVM	-	97	Effectively distinguish audio events from audio signals

SSD: Single Shot Detection, CNN: Convolution neural networks, HOG: Histogram of oriented gradients, LSS: Local self-similarity, SVM: Support vector machine, GTSDB: German Traffic Sign Detection Benchmark, and GTSRB: German Traffic Sign Recognition Benchmark

Table 3: Used datasets

Type of Traffic Management	Used in References	Dataset (s)	Type	No. of Images
Density estimation	[17]	The TrafficDB	Image	-
	[1]	ImageNet	Image	3.2 million
	[3], [18]	Data collected from cameras with different places		-
	[40]	UCSD	Video	-
Traffic sign detection and recognition approaches	[21], [22], [23], [25], [26]	GTSDB	Image	50, 000
	[24]	Daimler	Image	5,000
	[24]	LISA	Video	-
	[24]	LaRA	Video	-
	[26], [27]	GTSRB	Image	900
	[41]	TL_Dataset	Image	46,000
Accident detection	[28]	CAD-CVIS	Video	-
	[29], [30], [31], [33], [42]	Proposed, real, and collected data		-
	[42]	YOLOv4		
Emergency vehicles detection	[35], [43]	Custom dataset		-
	[36], [37]	COCO		328,000

GTSDB: German Traffic Sign Detection Benchmark, GTSRB: German Traffic Sign Recognition Benchmark

machine learning application, including acquisition of data, features extraction, different algorithms exploration, tuning, and deploying the model to a good output model in a simulation application. Specifically, a classifier of ambulance siren sound into "Ambulance Arrive" and "No Ambulance Arrive" has been developed, which is the traffic light system could be used to track an ambulance's arrival in an emergency. This paper suggests an approach based on Mel-frequency spectral Coefficients-SVM (MFCC-SVM) on MATLAB R2017b tools.

5. DISCUSSION

According to the results of this review, several attempts have been made to develop intelligent traffic controlling vision-based methods. Some challenges can be seen when researchers try to develop vision based automatic traffic signals. One of the challenges is that there is no available framework to cover all traffic problems because huge amount of data and computational time are required. Another challenge is the power consumption to get real traffic data to testing their proposed methods in the different weather conditions. The

third challenge is the lack of standardized dataset for testing and training methods. The results show that there is no any comprehensive dataset for traffic controlling and monitoring. For example, in density estimation, most of the researchers have created their own datasets while in traffic sign detection and recognition; they have used some publicly available datasets such as (GTSDB and GTSRB). On the otherhand, both the accident and emergency vehicle detection methods have only collected and prepared (customized) real data which captured by CCTV cameras. Finally, current systems while studied in the literature provide a low-cost solution for traffic applications in the expense of the system accuracy and they are applicable.

5.1. Survey of Technique's Summary

According to the literature survey, researchers have proposed and developed many approaches for controlling and monitoring signal system based on computer vision algorithms. In Table 2, presenting methods for each survey topics associated with a summary of their (methods, datasets, and contributions). The reason that why the performance of the reviewed methods is not evaluated is a non-availability of a common datasets.

5.2. Datasets

For testing and evaluating the proposed methods, researchers worked on the public datasets and on their collected datasets. The used datasets are described in Table 3.

6. CONCLUSION

In recent years, reducing road congestion has become a key challenge because of the threatening rise in the number of vehicles on the roads. In this review, the existing studies on autonomic traffic controlling and monitoring are reviewed in the computer vision community. Furthermore, computer vision is considered as the areas with the most studies are for the future technologies. The intelligent traffic systems perceive the density estimation investigate, traffic sign detection and recognition, accident detection, and emergency vehicle detection. Furthermore, name of the used datasets in the reviewed papers are presented. The main gap that founded in this review is a non-availability of dataset for traffic controlling and monitoring. Finally, intelligent traffic systems can play a key role in reducing congestion in the intersection areas and traffic flow management. The conducted survey indicates the accuracy finding of each method as described in Table 2. This research work could be having a potential impact for further researches in the same field of study. Various challenges such as (weather conditions, lighting, and traffic patterns) can be considered with all techniques based on computer vision and machine learning methods. Consequently, these conditions will improve our survey in the future work.

REFERENCES

[1] D. Biswas, H. Su, C. Wang, J. Blankenship and A. J. S. Stevanovic. "An automatic car counting system using OverFeat framework," *Sensors*, vol. 17, no. 7, p. 1535, 2017.

[2] N. K. Jain, R. K. Saini and P. Mittal. "A review on traffic monitoring system techniques," in *Soft Computing: Theories and Applications*, Singapore, Springer Singapore, pp. 569-577, 2019.

[3] D. Biswas, H. Su, C. Wang, A. Stevanovic and W. Wang. "An automatic traffic density estimation using Single Shot Detection (SSD) and MobileNet-SSD," *Physics and Chemistry of the Earth, Parts A/B/C*, vol. 110, pp. 176-184, 2019.

[4] M. C. Coelho, T. L. Farias and N. M. Rouphail. "Impact of speed control traffic signals on pollutant emissions," *Transportation Research Part D: Transport and Environment*, vol. 10, no. 4, pp. 323-340, 2005.

[5] Q. Guo, L. Li and X. Ban. "Urban traffic signal control with connected and automated vehicles: A survey," *Transportation Research Part C: Emerging Technologies*, vol. 101, pp. 313-334, 2019.

[6] S. K. Kumaran, S. Mohapatra, D. P. Dogra, P. P. Roy and B. G. Kim. "Computer vision-guided intelligent traffic signaling for isolated intersections," *Expert Systems with Applications*, vol. 134, pp. 267-278, 2019.

[7] M. H. Malhi, M. H. Aslam, F. Saeed, O. Javed and M. Fraz. "Vision based intelligent traffic management system," in *2011 Frontiers of Information Technology*. IEEE, New Jersey, pp. 137-141, 2011.

[8] C. J. Lakshmi and S. Kalpana. "Intelligent traffic signaling system," in *2017 International Conference on Inventive Communication and Computational Technologies* (*ICICCT*), pp. 247-251, 2017.

[9] P. Jing, H. Huang and L. J. I. Chen. "An adaptive traffic signal control in a connected vehicle environment: A systematic review," *Information*, vol. 8, no. 3, p. 101, 2017.

[10] S. S. S. M. Qadri, M. A. Gökçe and E. Öner. "State-of-art review of traffic signal control methods: challenges and opportunities," *European Transport Research Review*, vol. 12, no. 1, p. 55, 2020.

[11] B. Ghazal, K. ElKhatib, K. Chahine and M. Kherfan. "Smart Traffic Light Control System," In: 2016 3rd International Conference on Electrical, Electronics, Computer Engineering and Their Applications (EECEA), IEEE, United States, 2016, pp. 140-145.

[12] H. Jeon, J. Lee and K. J. Sohn. "Artificial intelligence for traffic signal control based solely on video images," *IEEE Acces*, vol. 22, no. 5, pp. 433-445, 2018.

[13] Y. Wang, X. Yang, H. Liang and Y. Liu. "A review of the self-adaptive traffic signal control system based on future traffic environment," *Journal of Advanced Transportation*, vol. 2018, 1096123, 2018.

[14] S. D. Khan and H. Ullah. "A survey of advances in vision-based vehicle re-identification," *Computer Vision and Image Understanding*, vol. 182, pp. 50-63, 2019.

[15] Y. S. Huang and T. H. Chung. "Modeling and analysis of urban traffic light control systems," *Journal of the Chinese Institute of Engineers*, vol. 32, no. 1, pp. 85-95, 2009.

[16] K. H. K. Manguri. "*Traffic Signaling Control at Highway*

Intersectıons Usıng Morphologıcal Image Processıng Technıque," Türkiye, Hasan Kalyoncu Üniversitesi, 2016.

[17] K. Garg, S. K. Lam, T. Srikanthan and V. Agarwal. "Real-time road traffic density estimation using block variance," in *2016 IEEE Winter Conference on Applications of Computer Vision* (*WACV*), New Jersey, IEEE pp. 1-9, 2016.

[18] K. H. N. Bui, H. Yi, H. Jung and J. Cho. "Video-based traffic flow analysis for turning volume estimation at signalized intersections," in *Intelligent Information and Database Systems*, Cham, Springer International Publishing, pp. 152-162, 2020.

[19] F. Kurniawan, H. Sajati, O. Dinaryanto. "Image processing technique for traffic density estimation," *International Journal of Engineering and Technology*, vol. 9, no. 2, pp. 1496-1503, 2017.

[20] B. Eamthanakul, M. Ketcham and N. Chumuang. "The traffic congestion investigating system by image processing from cctv camera," in *2017 International Conference on Digital Arts, Media and Technology (ICDAMT)*, New Jersey, IEEE, pp. 240-245, 2017.

[21] S. K. Berkaya, H. Gunduz, O. Ozsen, C. Akinlar and S. Gunal. "On circular traffic sign detection and recognition," *Expert Systems with Applications*, vol. 48, pp. 67-75, 2016.

[22] Y. Yang, H. Luo, H. Xu and F. Wu. "Towards real-time traffic sign detection and classification," *IEEE Transactions on Intelligent Transportation Systems*, vol. 17, no. 7, pp. 2022-2031, 2016.

[23] S. Salti, A. Petrelli, F. Tombari, N. Fioraio and L. Di Stefano. "Traffic sign detection via interest region extraction," *Pattern Recognition*, vol. 48, no. 4, pp. 1039-1049, 2015.

[24] X. Du, Y. Li, Y. Guo and H. Xiong. "Vision-Based Traffic Light Detection for Intelligent Vehicles," in *2017 4th International Conference on Information Science and Control Engineering (ICISCE)*, pp. 1323-1326, 2017.

[25] F. Shao, X. Wang, F. Meng, T. Rui, D. Wang and J. J. S. Tang. "Real-time traffic sign detection and recognition method based on simplified Gabor wavelets and CNNs," *Sensors*, vol. 18, no. 10, p. 3192, 2018.

[26] A. Ellahyani, M. E. Ansari and I. E. Jaafari. "Traffic sign detection and recognition based on random forests," *Applied Soft Computing*, vol. 46, pp. 805-815, 2016.

[27] A. Shustanov and P. Yakimov. "CNN design for real-time traffic sign recognition," *Procedia Engineering*, vol. 201, pp. 718-725, 2017.

[28] D. Tian, C. Zhang, X. Duan and X. Wang. "An automatic car accident detection method based on cooperative vehicle infrastructure systems," *IEEE Access*, vol. 7, pp. 127453-127463, 2019.

[29] E. P. Ijjina, D. Chand, S. Gupta and K. Goutham. "Computer Vision-based Accident Detection in Traffic Surveillance," in *2019 10th International Conference on Computing, Communication and Networking Technologies (ICCCNT)*, pp. 1-6, 2019.

[30] A. Saini, S. Suregaonkar, N. Gupta, V. Karar and S. Poddar. "Region and feature matching based vehicle tracking for accident detection," in *2017 Tenth International Conference on Contemporary Computing* (*IC3*), pp. 1-6, 2017.

[31] L. Wenqi, L. Dongyu and Y. Menghua. "A model of traffic accident prediction based on convolutional neural network," in *2017 2nd IEEE International Conference on Intelligent Transportation Engineering* (*ICITE*), pp. 198-202, 2017.

[32] N. Dogru and A. Subasi. "Traffic accident detection using random forest classifier," in *2018 15th Learning and Technology Conference* (*L&T*), pp. 40-45, 2018.

[33] Y. Yu, M. Xu and J. Gu, "Vision-based traffic accident detection using sparse spatio-temporal features and weighted extreme learning machine," *IET Intelligent Transport Systems*, vol. 13, no. 9, pp. 1417-1428, 2019.

[34] P. Borisagar, Y. Agrawal and R. Parekh. "Efficient vehicle accident detection system using tensorflow and transfer learning," in *2018 International Conference on Networking, Embedded and Wireless Systems* (*ICNEWS*), pp. 1-6, 2018.

[35] S. Kaushik, A. Raman and K. V. S. R. Rao. "Leveraging computer vision for emergency vehicle detection-implementation and analysis," in *2020 11th International Conference on Computing, Communication and Networking Technologies* (*ICCCNT*), pp. 1-6, 2020.

[36] S. Roy and M. S. Rahman. "Emergency vehicle detection on heavy traffic road from CCTV footage using deep convolutional neural network," in *2019 International Conference on Electrical, Computer and Communication Engineering* (*ECCE*), pp. 1-6, 2019.

[37] E. P. Jonnadula and P. M. Khilar. "A New Hybrid Architecture for Real-Time Detection of Emergency Vehicles." In: Computer Vision and Image Processing. Springer, Singapore, 2020, pp. 413-422.

[38] A. X. Lin, A. F. W. Ho, K. H. Cheong, Z. Li, W. Cai, M. L. Chee, Y. Y. Ng, X. Xiao and M. E. H. Ong. "Leveraging machine learning techniques and engineering of multi-nature features for national daily regional ambulance demand prediction," *International Journal of Environmental Research and Public Health*, vol. 17, no. 11, p. 4179, 2020.

[39] M. A. Suhaimy, I. S. A. Halim, S. L. M. Hassan and A. Saparon. "Classification of ambulance siren sound with MFCC-SVM," in *AIP Conference Proceedings*, United States, AIP Publishing LLC vol. 2306, no. 1, p. 020032, 2020.

[40] L. A. T. Nguyen and T. X. Ha. "A novel approach of traffic density estimation using CNNs and computer vision," *European Journal of Electrical Engineering and Computer Science*, vol. 5, no. 4, pp. 80-84, 2021.

[41] X. Liu and W. Q. Yan. "Traffic-light sign recognition using Capsule network," *Multimedia Tools and Applications*, vol. 80, no. 10, pp. 15161-15171, 2021.

[42] H. Ghahremannezhad, H. Shi and C. Liu. "Real-time accident detection in traffic surveillance using deep learning," in *2022 IEEE International Conference on Imaging Systems and Techniques* (*IST*), pp. 1-6, 2022.

ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Analyzing the Performance of Bitcoin to Gold Prices, the Telecommunications Market, the Stock Price Index, and Insurance Companies' Performance from (March 1, 2021–September 4, 2023)

Hawre Latif Majeed[1], Diary Jalal Ali[1], Twana Latif Mohammed[2]

[1]Assistant Lecture, Accounting Department, Kurdistan Technical Institute, Kurdistan Region (KRG), Iraq, [2]Assistant Lecture, Information Technology Department, Kurdistan Technical Institute, Kurdistan Region (KRG), Iraq

ABSTRACT

Managing cryptocurrencies by financial intermediaries offer numerous benefits to global financial markets and the economy. Among all cryptocurrencies, Bitcoin stands out with the highest market capitalization and a weak correlation to other assets, making it an attractive option for portfolio diversification and risk management. This research aims to examine the impact of Bitcoin on the NASDAQ gold price (GC), the telecommunications market (IXUT), and insurance company performance (IXIS) through the analysis of secondary data from March 1, 2021, to September 4, 2023. The data were obtained from https://www.investing.com; statistical software E views applied various econometric methods to the data. The results suggest a positive correlation between Bitcoin and the other variables, indicating that Bitcoin can significantly expand investment opportunities and drive economic growth. This study highlights the importance of considering cryptocurrencies, especially Bitcoin, as a viable option for investment diversification and risk management in financial markets.

Index Terms: Cryptocurrencies, Bitcoin, Gold price, Telecommunications, Stock price, Insurance.

1. INTRODUCTION

As the globe experiences rapid technological advancement, the financial industry has capitalized on these developments. As a byproduct of technological progress, cryptocurrencies are a valuable contribution to financial markets and the global economy. Bitcoin has the highest market capitalization among all cryptocurrencies, estimated at $930 billion on December 28, 2021 [1]. The exchange or trading of Bitcoin and other cryptocurrencies has attracted the interest of investors in global financial markets. Likewise, market research analysts have become interested in cryptocurrencies and their interactions with financial market indicators. Although the impact of Bitcoin on Gold prices, the telecommunications market, the stock market index, and the performance of insurance companies is lower, the insurance industry is uniquely positioned to benefit from blockchain technology [2].

The financial sector has made extensive use of technological advancements in recent years. Due to technological progress, cryptocurrency is a valuable contribution to

Access this article online

DOI: 10.21928/uhdjst.v7n2y2023.pp16-31

E-ISSN: 2521-4217
P-ISSN: 2521-4209

Corresponding author's e-mail: Twana Latif Mohammed, Assistant Lecture, Information Technology Department, Kurdistan Technical Institute, Kurdistan Region (KRG), Iraq. email: twana.mohammed@kti.edu.iq

Received: 27-04-2023 Accepted: 26-06-2023 Published: 20-08-2023

financial markets and the global economy. The exchange or trading of Bitcoin and other cryptocurrencies has become prevalent in global financial markets, attracting practitioners. Economic analysts are interested in cryptocurrencies and the interactions between cryptocurrencies and financial market indicators. Cryptocurrencies, in 2009, BitCoin developed cryptographically secure digital currency [3]. The 2008–2009 global financial crisis and the 2010–2013 European sovereign debt crisis made Bitcoin popular among practitioners and economic agents.

Bitcoin-accepting businesses have also grown. Despite government limitations, a terrible reputation, and several hacks, Bitcoin's popularity has grown. By providing indemnification or encouraging savings, the insurance business is vital to any economy. Its premium pooling makes it a prominent institutional investor. Insurance companies serve customers. It is also a financial entity that invests insured money for profits, helping economic and social advancement. Bitcoin is attracting investors despite its young origin. International investors now sell precious metals and buy Bitcoin. BitShares, Dash, Ethereum, LiteCoin, Mixin, Moreno, PeerCoin, and Zcash, have emerged due to BitCoin's popularity [3]. Most virtual currencies use blockchain technology like Bitcoin and aim to equal or improve its features.

Cryptocurrencies need cointegration and convergence tests for numerous reasons. Gold and cryptocurrency values are interconnected because they cointegrate. Since cryptocurrency and gold have a long-term relationship, linking them is a good idea. Convergence between cryptocurrency and gold prices suggests that low-priced cryptocurrencies will rise more quickly [4]. Most countries' economic progress and global developments have internationalized and regulated the insurance business. Most countries have understood insurance's economic and social value and fostered, developed, and encouraged the technical advances that have accelerated development, including the insurance sector. Dash aims to speed up transaction processing and protect anonymity, whereas LiteCoin conserves central processing unit power for mining.

Gold miners' stocks, ETFs, and actual gold can be invested today. Thus, explaining why gold was an inevitably valued hedge while it was used in the monetary system and why it remained a hedge afterward is beneficial. Gold is traditionally used to buffer portfolios against volatile markets and investor anxiety [5]. Since its introduction, Bitcoin's high returns have made gold less appealing to investors. Investors have preferred Bitcoin over gold in the recent decade due to its 100-fold higher return. Despite Bitcoin's greater short-term volatility than gold's, its long-term price evolution is anticipated to follow gold's [6]. As the globe digitizes, traditional currencies and physical money are becoming less popular.

Bitcoin prices rose from under US$1000 in 2014 to over US$17,000 in 2018.2 Dash prices rose from below US$2 in 2014 to above US$400 in 2018 [7]. Gold prices were between US$1050 and US$1400 throughout the same period. Forecasting, economic modeling, and policymaking can benefit from cryptocurrency and gold price convergence. This research examines how Bitcoin affects the telecommunications industry, stock price index, insurance company performance, and convergence assumptions between cryptocurrency and gold prices. From a univariate perspective, we first evaluate the fractional order of integration in the stochastic characteristics of gold and cryptocurrency prices.

1.1. Problem of the Study

This research seeks to determine if Bitcoin impacts gold prices, telecommunications, stock prices, and insurance company performance and if Bitcoin can be predicted using economic data. Thus, the question is how Bitcoin relates to other variables or if there is any link. Since Granger causality shows that one event can influence another, understanding its direction might improve market comprehension. Finding a correlation between the two may allow investors and economists to predict bitcoin prices using gold's past pricing.

1.2. Aims of the Study

This study aims to examine the effects of Bitcoin on the performance of insurance companies, the telecommunications market, the stock price index, and gold prices. Based on how these variables interact and behave, by developing the following hypothesis:

1. Hypothesis (H1): Bitcoin has no significant effect on gold price.
2. Hypothesis (H2): Bitcoin has no significant effect on telecommunications stock index price.
3. Hypothesis (H3): Bitcoin has no significant effect on insurance companies.

2. LITERATURE REVIEW

This section discusses the overview literature. A comprehensive literature review was conducted using a systematic approach to ensure objectivity and methodological rigor in locating

and evaluating relevant academic literature regarding the correlation between gold prices, the telecommunications market, the stock price index, and insurance companies performance. Several studies have explored this relationship from various angles, providing valuable insights into the subject matter. Bams, Blanchard, Honarvar, and Lehnert (2017) examined how gold prices affect insurance company stock performance, stressing economic fundamentals and investor mood. Studied how the telecommunications market affects stock price indexes, stressing market dynamics and regulatory strategies [23].

Boonkrong, Arjrith, and Sangsawad (2020) examined the relationship between gold prices and the telecoms market, revealing potential spillover effects. The literature review synthesizes these and other related studies to identify significant factors, mechanisms, and theoretical frameworks. Advanced filters and the "peer-reviewed journals" option ensured high-quality research. Despite the paper's novelty in the academic world, a typical method was used to choose relevant papers based on their publication dates, focusing on current studies to include the newest scientific achievements [24].

2.1. Bitcoin

Bitcoin accounts for 36.33% of the market capitalization of cryptocurrencies, down from 80% in June 2016. Thus, Bitcoin-specific studies exist. Bitcoin is a decentralized digital currency created in 2009 by an unknown person using Satoshi Nakamoto's pseudonym. It is based on a peer-to-peer network, where transactions take place directly between users without the need for intermediaries such as banks or other financial institutions. Bitcoin has gained increasing popularity over the years, and its use has spread across different industries, including finance, e-commerce, and even healthcare. This literature review examines the current state of research on Bitcoin, its impact on various industries, and its prospects.

One of the key features of Bitcoin is its decentralized nature. Bitcoin transactions are verified by a network of users, who use complex algorithms to confirm and record transactions on a public ledger known as the blockchain. This feature has made Bitcoin attractive to many users, particularly those concerned about traditional financial institutions' role in controlling their money. Several studies have examined the impact of Bitcoin on the financial industry, and many have suggested that Bitcoin has the potential to disrupt traditional banking systems.

For instance, Ali *et al.* [8] found that Bitcoin could reduce the costs associated with traditional payment systems, particularly cross-border payments. The study noted that traditional payment systems involve a complex network of intermediaries, which can result in high fees and slow processing times. Conversely, Bitcoin allows for fast and cheap cross-border payments, which could benefit individuals and businesses in developing countries.

Another area where Bitcoin has shown potential is e-commerce. Several studies have examined the use of Bitcoin in online marketplaces, such as the dark web. One study by Böhme *et al.* [9] found that Bitcoin was the dominant currency used in illegal online marketplaces, particularly for purchasing drugs and other illicit goods. However, the study also noted that Bitcoin was used for legitimate transactions, particularly in countries with unreliable traditional payment systems.

Despite its potential, Bitcoin has also faced several challenges. One of the biggest challenges has been its association with illegal activities, particularly money laundering and terrorism financing. Several studies have examined the extent to which Bitcoin is used for illegal activities, and many have suggested that the currency is more anonymous than some may believe – tracing Bitcoin transactions to real-world identities as possible, mainly when the transactions involve exchanges between Bitcoin and traditional currencies.

Another challenge facing Bitcoin is its volatility. The price of Bitcoin has fluctuated significantly over the years, with several high-profile crashes and booms. This volatility has made Bitcoin less attractive to many investors, particularly risk-averse investors. Several studies have examined the factors that influence the price of Bitcoin, and many have suggested that a combination of supply and demand factors and speculative activity drives it.

Despite these challenges, many experts believe that Bitcoin has a bright future. Several studies have examined the potential of Bitcoin to revolutionize various industries, including healthcare. For instance, in a study by Elahi and Hasan (2018), Bitcoin could facilitate secure and efficient medical record-keeping, particularly in countries with weak health systems. Other studies have examined the potential of Bitcoin to facilitate charitable giving and crowdfunding.

2.2. Gold

Gold has been a significant part of human culture and society for thousands of years. It has been used for various purposes, including jewelry, currency, and investments. Gold has always been associated with wealth, power, and

prestige, and its value has remained high throughout history. This literature review explores the historical significance, geological properties, mining and extraction techniques, and the uses and applications of gold.

Historical significance: Gold has been valued and treasured by civilizations for thousands of years. It has been used for jewelry, religious artifacts, and currency. The ancient Egyptians believed that gold was the flesh of the gods, and it was used in constructing temples and tombs. The Aztecs and Incas also valued gold and used it for jewelry and religious artifacts. In Europe, gold was used as currency, and during the gold rush in the 19th century, it was used as a means of payment for goods and services. Gold continues to be highly valued today, and it is often used as a store of value and as a haven asset during times of economic uncertainty [10].

2.2.1. Geological properties

Gold is a chemical element with the symbol Au, one of the least reactive chemical elements. It is a soft, dense, yellow metal with a high luster. Gold is highly malleable and ductile, meaning it can be easily shaped and formed into various shapes and sizes. It is also a good conductor of electricity and does not corrode or tarnish. Gold is primarily found in the Earth's crust and is often associated with other minerals, such as silver, copper, and zinc. Gold deposits are typically found in three main types of geological settings: veins, placers, and disseminated deposits [11].

2.2.2. Mining and extraction techniques

Gold mining and extraction techniques have evolved. In ancient times, gold was extracted by panning, where gold-bearing sand or gravel was placed in a shallow pan and swirled around to separate the gold from the other minerals. Today, gold is typically extracted from large deposits using various techniques, including open-pit mining, underground mining, and placer mining. Open-pit mining involves the removal of large amounts of soil and rock to access the gold-bearing ore [12]. Underground mining uses tunnels to access the ore, while placer mining involves water to separate the gold from the other minerals.

2.2.3. Uses and applications

Gold has a wide range of uses and applications. It is primarily used for jewelry, decorative purposes, and various industrial applications, including electronics, medical devices, and aerospace technology. Gold is also used as a value store and haven asset during economic uncertainty [13]. In addition, gold is used to produce coins and bullion, which are often purchased as investments.

2.3. Telecommunications Companies

Telecommunications companies have been integral to the modern world's communication infrastructure for decades. These companies provide the necessary tools and infrastructure to enable people to communicate and exchange data across vast distances. Telecommunications companies have played a critical role in facilitating the digital transformation of modern society. This literature review aims to provide an overview of the current state of the telecommunications industry and highlight some of the critical challenges and opportunities facing telecommunications companies [14].

The telecommunications industry has undergone significant changes in recent years, driven by technological advancements, consumer behavior, and increased competition. The industry has seen the rise of new players, such as over-the-top (OTT) providers, which have disrupted traditional business models. OTT providers offer messaging, voice calls, and video streaming over the Internet, often bypassing traditional telecommunications networks. This has forced telecommunications companies to adapt to new business models, such as offering bundled services, developing new value-added services, and focusing on customer experience.

One of the critical challenges facing telecommunications companies is the need to invest continually in new infrastructure to keep up with the increasing demand for data and connectivity. Telecommunications companies must invest in new networks and technologies to remain competitive with the rise of new technologies such as 5G, the Internet of Things, and artificial intelligence (AI). At the same time, they must balance this investment against the need to maintain profitability and shareholder returns [14].

Telecommunications companies face increasing regulatory scrutiny, particularly concerning net neutrality and data privacy. Governments around the world are implementing regulations to protect consumers' privacy and ensure that telecommunication companies provide fair and open access to the Internet. In addition, the increased focus on data privacy has led to increased demand for secure communications solutions, which has created new business opportunities for telecommunications companies.

The telecommunications industry is also experiencing a shift toward digital transformation. Companies increasingly invest in cloud computing, AI, and big data analytics technologies to improve operations and offer new services. These technologies enable telecommunications companies

to improve network efficiency, offer personalized services, and enhance the customer experience.

Despite these challenges, telecommunications companies are well-positioned to benefit from the increasing demand for connectivity and the digital transformation of modern society. Companies that can successfully adapt to new business models and invest in new technologies will be well-positioned to capture new opportunities and maintain market share. The telecommunications industry is expected to grow in the coming years, driven by increasing demand for connectivity, the adoption of new technologies, and the ongoing shift toward digital transformation [15].

2.4. Insurance

Insurance is an agreement between an individual or an organization and an insurer, which promises compensation or protection against a specific loss in exchange for regular payments, known as premiums. The concept of insurance has been around for centuries, with records of various types of insurance being used as far back as ancient China and Babylon. Insurance is essential in managing risk, especially for individuals and businesses that face significant financial loss in an unexpected event.

Insurance companies are organizations that provide insurance products and services to customers. They collect premiums from policyholders and use the funds to pay for claims made by customers who experience losses covered by their policies. Insurance companies play a key role in society, as they provide a safety net for individuals and businesses, allowing them to recover from unexpected losses.

Insurance companies, including life insurance, health insurance, property and casualty insurance, and auto insurance, among others, offer various types of insurance. Each type of insurance serves a specific purpose and has unique features and benefits. For instance, life insurance provides financial protection to the policyholder's beneficiaries in the event of their death, while health insurance covers medical expenses incurred by the insured.

Another study by Bashaija [16] investigated the impact of insurance on the financial performance of small and medium-sized enterprises (SMEs) in India. The study found that SMEs that had insurance coverage had better financial performance than those without insurance. The authors attributed this to the fact that insurance provided SMEs with financial protection against unexpected losses, allowing them to focus on business operations and growth.

The role of insurance companies in managing risk has also been extensively studied. Demirgüç-Kunt and Huizinga [17] the study examined the impact of insurance on financial stability. The study found that insurance companies play a crucial role in promoting financial stability by providing a buffer against unexpected losses, thereby reducing the risk of systemic financial crises.

In addition, the impact of insurance companies on the economy has been investigated. A study by Hamadu and Mojekwu [18] examined the insurance industry's contribution to economic growth in the United States. The study found that the insurance industry contributes significantly to economic growth, as it provides financial protection and risk management services to individuals and businesses, thereby promoting investment, innovation, and entrepreneurship.

2.4.1. The impact of bitcoin on the gold price

The rise of digital currencies has become a significant topic of interest among investors and academics. The most popular cryptocurrency has grown and is now widely used as a medium of exchange and store of value. Despite the increased adoption of digital currencies, gold remains a valuable asset class for investors. The relationship between Bitcoin and gold has been debated among researchers. This literature review aims to examine the impact of Bitcoin on the price of gold.

2.4.2. Bitcoin and gold: A comparison

Bitcoin and gold have several similarities and differences that affect their prices. Gold has been a store of value for centuries and is viewed as a safe-haven asset during economic uncertainty. Gold prices are affected by macroeconomic factors such as inflation, interest rates, and geopolitical events. In contrast, Bitcoin is a relatively new digital currency that has gained popularity due to its decentralization, security, and limited supply. Bitcoin prices are affected by technological advancements, regulatory changes, and investor sentiment.

Several studies have examined the relationship between Bitcoin and gold prices. Some researchers have argued that Bitcoin is a substitute for gold and can be used as a hedge against inflation and economic uncertainty. Others have argued that Bitcoin and gold have different characteristics and should not be considered substitutes.

Several studies have examined the impact of Bitcoin on gold prices. In a study by Bouri *et al.* [19], the authors used a VAR-GARCH model to examine the relationship between Bitcoin and gold prices. The results showed a positive relationship

between Bitcoin and gold prices in the short run, but the relationship becomes negative in the long run. The authors argued that Bitcoin and gold are not substitutes and that the long-term negative relationship is due to differences in the characteristics of the two assets.

In contrast, a study by Bouri *et al.* [19] found evidence that Bitcoin is a hedge against gold during economic uncertainty. The authors used a VAR model to examine the relationship between Bitcoin, gold, and the stock market. The results showed that Bitcoin is a hedge against gold during times of financial stress but not during normal market conditions. The authors argued that Bitcoin could be used as a safe-haven asset in addition to gold.

In a more recent study, Sökmen and Gürsoy [20] examined the impact of Bitcoin on gold prices using a cointegration model. The authors found evidence of a long-run equilibrium relationship between Bitcoin and gold prices, suggesting that the two assets are substitutes. The authors argued that Bitcoin is an attractive investment for investors who prefer digital currencies over physical assets like gold.

2.5. Impact of Bitcoin on Telecommunications Companies

Bitcoin, a decentralized digital currency, has gained significant attention since its inception in 2009. Its impact has been felt across various industries, including the telecommunications industry. This literature review aims to explore the impact of Bitcoin on telecommunications companies.

Bitcoin is a cryptocurrency that operates on a decentralized network without a central authority or intermediary. Transactions on the Bitcoin network are recorded on a public ledger known as the blockchain, which allows for secure and transparent transactions. Bitcoin has been touted as a potential disruptor of traditional financial systems, with its decentralized nature allowing for faster, cheaper, and more secure transactions [21].

The telecommunications industry is one of the industries impacted by the rise of Bitcoin. Telecommunications companies provide the infrastructure and technology for communication and data transfer. With the rise of Bitcoin, telecommunications companies have had to adapt to changes in consumer behavior and demand.

One of how Bitcoin has impacted telecommunications companies is through blockchain technology. Blockchain technology is the underlying technology behind Bitcoin, and it has the potential to revolutionize the telecommunications industry. Blockchain technology can be used to create secure, transparent, and tamper-proof communication networks, improving telecommunications networks' security and reliability.

Telecommunications companies have also had to adapt to consumer behavior and demand changes. With the rise of Bitcoin, consumers are increasingly using digital currencies to pay for goods and services. This has led to a shift in consumer demand for telecommunications companies to provide services that cater to the needs of Bitcoin users. For example, telecommunications companies have had to adapt to provide secure and reliable Bitcoin wallets and payment processing systems [21].

Furthermore, the rise of Bitcoin has also led to the emergence of new business models in the telecommunications industry. For example, some telecommunications companies have started to offer Bitcoin-based services, such as micropayments, remittances, and international transfers. These services are often cheaper and faster than traditional banking services, making them an attractive option for consumers.

However, the impact of Bitcoin on telecommunications companies is only partially positive. Bitcoin has various risks, including fraud, money laundering, and cybercrime. Telecommunications companies have had to invest in cybersecurity measures to protect their networks and customers from these risks. Furthermore, the regulatory landscape for Bitcoin still needs to be determined, which makes it difficult for telecommunications companies to navigate the legal and regulatory requirements associated with providing Bitcoin-based services.

2.6. Impact of Bitcoin on Insurance Companies

The impacts of Bitcoin on insurance companies. It will examine how insurance companies use Bitcoin, the challenges they face, and the benefits they are experiencing.

One of the main ways insurance companies use Bitcoin is as a form of payment. Bitcoin allows for fast and secure transactions, which helps speed up the claims process. This is particularly useful for international claims, where traditional payment methods can be slow and costly. In addition, Bitcoin transactions can be processed 24/7, meaning claims can be paid out quickly, even outside traditional business hours [22].

Another way that insurance companies are using Bitcoin is as an asset to insure. Bitcoin is an emerging asset class, and some insurance companies are starting to offer coverage for it.

This can be particularly useful for companies that hold large amounts of Bitcoin, as it can help to protect them against theft or loss. For example, in 2019, insurance giant Lloyd's of London began offering coverage for cryptocurrency theft.

However, there are also challenges associated with using Bitcoin in the insurance industry. One of the main challenges is the volatility of Bitcoin's value. Bitcoin is a highly volatile asset, and its value can fluctuate rapidly. This makes it difficult for insurance companies to price policies accurately and to set appropriate coverage limits. In addition, the regulatory environment surrounding Bitcoin is still evolving, making it difficult for insurance companies to comply with regulations.

Despite these challenges, there are also benefits associated with using Bitcoin in the insurance industry. One of the main benefits is the potential for cost savings. Bitcoin transactions are generally cheaper than traditional payment methods, which can reduce insurance companies costs. In addition, using Bitcoin can help to streamline the claims process, which can help to reduce administrative costs.

3. RESEARCH FRAMEWORK

This section describes the variables of the study, their sources, and the relationships between independent and dependent variables. https://www.investing.com provided the data. Statistical software E views applied various econometric methods to the data. Finally, $P = 0.05$ rejects the null hypothesis and accepts the alternative. If the variable's *P*-value exceeds 0.05, neither hypothesis is supported. The following paragraphs provide a concise explanation of these tools to identify the impact of Bitcoin on gold prices, the telecommunications market, the stock price index, and the insurance company's performance. Thus, Bitcoin impact was substituted by the insurance companies' performance (IXIS) and telecommunications stock index price (IXUT), whereas gold price (GC). Their findings conclude that independent variables are considerably affected by depending on variables.

3.1. Model of the Study

Bitcoin is accepted as independent and insurance, telecommunications, and gold price as dependent variables.

3.2. Augmented Dickey–Fuller (ADF) Test

The first step in using econometric methods is to assess the data's stationarity, as most economical series are non-stationary and have a unit root at the primary level. This is significant because the presence of a unit root can induce bias in the outcomes of statistical tests such as the Granger causality test and the VAR model, lowering their accuracy. Non-stationary series analysis can potentially produce deceptive statistical results. The series' first difference can be changed into a stationary form to solve this. The Augmented Dickey–Fuller (ADF) test is employed in this study to assess the stationarity of time series data.

- The null hypothesis (H0) states that the series is non-stationary or has a unit root.
- The alternative hypothesis (H1) proposes that the series lacks a unit root and is stationary.

3.3. Johansen Cointegration Test

The Johansen (1988) cointegration test establishes long-term relationships between variables.

The null hypothesis (H0) shows no long-term association between Bitcoin and variables.

Alternative hypothesis (H1) suggests a long-term association between Bitcoin and factors.

3.4. Granger Causality Test

The Granger causality test determines whether two variables have a unidirectional, bidirectional, or non-existent causal link. Test significance is 5%.

The null hypothesis (H0) asserts that Bitcoin has no Granger causality with the variables. Alternatively, H1 implies no Granger causation between Bitcoin and the variables. *P*-value determines null hypothesis acceptance or rejection. The null hypothesis is rejected if *P*-value is less than the significance level and accepted if it is more extensive.

3.5. Vector Error Correction

If the results confirm the cointegration of the variables under investigation, this demonstrates their long-term relationship. The vector error correction model (VECM) investigates this relationship. In this section, the results and data analysis are presented and discussed.

3.6. Stationarity of Data

The ADF and Phillips-Perron (P-P) tests are employed to determine the stationarity of the series. The series is initially discovered to be non-stationary at the primary level. To make the data stationary, the first series differences are calculated. If *P*-values from the ADF and P-P tests are more significant than 0.05, then the following is true:

- The null hypothesis is adopted at a 5% level of significance.
- The statistics associated with the stationarity of the data series are presented in the table below.

3.7. Model Selection

The Akaike information criterion (AIC) used the model selection method to choose the best model. A total of 500 models were evaluated, and the selected model is an autoregressive distributed lag (ARDL) (1, 0, 1, 0) model. This indicates that the lag order for the dependent variable (BTC) is one, with no lags for the other independent variables.

3.7.1. Coefficients and statistical significance

BTC (-1): The lagged value of BTC (one period ago) has a coefficient of 0.917958. This suggests that a one-unit increase in BTC yesterday is associated with an approximately 0.917958-unit increase in BTC today. GC: The coefficient for the variable GC is 1.484124, but it is not statistically significant ($P = 0.7447$). Therefore, the inclusion of GC in the model is a relatively insignificant impact on BTC (Please see Table 3).

3.7.2. IXIS

The coefficient for the variable IXIS is 110.0404, which is statistically significant (*P*-value = 0.0005). This suggests that a one-unit increase in IXIS is associated with a 110.0404 unit increase in BTC. IXIS (-1): The lagged value of IXIS (one period ago) has a coefficient of -96.63934, and it is statistically significant (*P*-value = 0.0019). This implies that a one-unit increase in IXIS yesterday is associated with a decrease of approximately 96.63934 units in BTC today (Please see Table 3).

3.7.3. IXUT

The coefficient for the variable IXUT is 0.213805, but it is not statistically significant (*P*-value = 0.7117). Therefore, the inclusion of IXUT in the model does not significantly impact BTC. C: The constant term has a coefficient of −8104.335, but it is not statistically significant (*P*-value = 0.3722). Therefore, the intercept is not significantly different from zero.

3.7.4. The goodness of fit

R^2: The model's coefficient of determination (R^2) is 0.934858, which indicates that approximately 93.49% of the variation in BTC can be explained by the independent variables in the model (Please see Table 4).

Adjusted R^2: The adjusted R^2 is 0.931950, which considers the degrees of freedom and penalizes including irrelevant variables. S.E. of regression: The standard error of the regression is 3642.267, which measures the average distance between the observed values of BTC and the predicted values from the model. Prop (F-statistic): The probability associated with the F-statistic is 0.000000, indicating that the overall model is statistically significant. F-statistic: The F-statistic is 321.4634, and its associated *P*-value is 0.000000, indicating that the overall model is statistically significant.

Note: *P*-values in the results do not account for model selection. Therefore, caution should be exercised when interpreting the individual variable significance based solely on *P*-values provided.

Based on the provided information, the econometric function can be represented as follows:

$$BTC = 0.917958 * BTC(-1) + 1.484124 * GC + 110.0404 * IXIS + (-96.63934) * IXIS(-1) + 0.213805 * IXUT - 8104.335 + \varepsilon$$

The coefficients for each variable are given as 0.917958, 1.484124, 110.0404, −96.63934, 0.213805, and −8104.335.

This equation represents an ARDL model, where BTC is regressed on its lagged value, along with other variables such as GC, IXIS, and IXUT. The model selection method used was the AIC, and the selected model was ARDL (1, 0, 1, 0).

3.7.5. Test statistic and critical values

The ADF test statistic is −1.505250. This value is compared to critical values to determine the statistical significance. At the 1% level, the critical value is −3.486551. At the 5% level, the critical value is −2.886074. At the 10% level, the critical value is −2.579931. The test statistic is less negative than the critical values at all significance levels, suggesting that we do not reject the null hypothesis.

3.7.6. Coefficients and statistical significance

BTC (-1): The lagged value of BTC (one period ago) has a coefficient of −0.038019. This coefficient is not statistically significant (*P*-value = 0.1350). Therefore, the lagged BTC does not significantly impact the different BTC.

C: The constant term has a coefficient of 1449.238, but it is not statistically significant (*P*-value = 0.1394). Therefore, a constant term in the differenced BTC equation is not significant.

3.7.7. The goodness of Fit

R^2: The coefficient of determination (R^2) for the differenced BTC equation is 0.019158, indicating that approximately

1.92% of the variation in the differenced BTC can be explained by the lagged BTC and the constant term. Adjusted R^2: The adjusted R^2 is 0.010703, which considers the degrees of freedom and penalizes including irrelevant variables. F-statistic: The F-statistic is 2.265778, and its associated *P*-value is 0.134978, which suggests that the overall model is not statistical.

3.7.8. Significant

Other information: Mean dependent var: The average value of the differenced BTC in the sample is 82.18729. S.D. Dependent var: The standard deviation of the differenced BTC is 3836.238. Sum squared resid: The sum of squared residuals is 1.69E+09, which measures the model's overall fit.

3.7.9. Suggest no autocorrelation

Prob (F-statistic): The probability associated with the F-statistic is 0.134978, indicating that the overall model is not statistically significant.

Note: Based on the results, there is insufficient evidence to reject the null hypothesis that BTC has a unit root, suggesting that BTC is non-stationary.

Bitcoin (-1): The lagged value of Bitcoin (one period ago) has a coefficient of 0.917958. This suggests that a one-unit increase in Bitcoin yesterday is associated with an approximately 0.917958 unit increase in BTC today. GC: The coefficient for the variable GC is 1.484124, but it is not statistically significant (*P*-value = 0.7447). Therefore, the inclusion of GC in the model is relatively minor in Bitcoin. The coefficient for the variable insurance companies' performance. It is 110.0404 and statistically significant (*P*-value = 0.0005). This suggests that a one-unit increase in insurance companies' performance is associated with a 110.0404 unit increase in Bitcoin-insurance companies' performance. (-1): The lagged value of IXIS (one period ago) has a coefficient of −96.63934, and it is statistically significant (*P*-value = 0.0019). This implies a one-unit increase in insurance companies' performance. Yesterday is associated with a decrease of approximately 96.63934 units in Bitcoin today. The coefficient for the variable telecommunications stock index price. It is 0.213805 but not statistically significant (*P*-value = 0.7117). The coefficient for the variable telecommunications stock index price. The model has little impact on Bitcoin. C: The constant term has a coefficient of −8104.335, but it is not statistically significant (*P*-value = 0.3722). Therefore, the intercept is not significantly different from zero.

ADF test statistic −1.505250 0.5276 Test critical values: 1% level −3.486551 5% level −2.886074 10% level −2.579931

*MacKinnon (1996) one-sided *P*-values. ADF test equation method: Least squares. Variable Coefficient standard error t-statistic prob.

BTC (-1) −0.038019 0.025258 −1.505250 0.1350 C 1449.238 973.7503 1.488306 0.1394

R^2 0.019158 Mean dependent var 82.18729 Adjusted R^2 0.010703 S.D. dependent var 3836.238 F-statistic 2.265778 Durbin-Watson stat 1.803764 Prob(F-statistic) 0.134978

BTC (-1): The variable BTC with a lag of one period has a coefficient of −0.038019. This suggests that a one-unit increase in BTC in the previous period is associated with a decrease of approximately 0.038019 units in the current period. The standard error for this coefficient is 0.025258, the t-statistic is −1.505250, and the corresponding p-value is 0.1350.

C: The constant term in the model has a coefficient of 1449.238. This represents the intercept or baseline value of the dependent variable (BTC) when all other variables in the model are zero. The standard error for this coefficient is 973.7503, the t-statistic is 1.488306, and the corresponding p-value is 0.1394.

The results are from unrestricted cointegration rank tests (trace and max-eigenvalue) performed to determine the presence of cointegration among the variables. Here is an interpretation of the critical components of the results: Unrestricted Cointegration Rank Test (Trace):

Hypothesized No. of CE(s): The number of common trends assumed in the null hypothesis. The tests are conducted for different assumed numbers of common trends. Eigenvalue: The eigenvalues associated with the assumed number of common trends.

Statistic: The test statistic for the trace test. Critical Value: The critical values correspond to the assumed number of common trends at the specified significance level.

Prob.**: p-value calculated based on the MacKinnon-Haug-Michelis (1999) method. The trace test compares the sum of the eigenvalues to the critical values to determine the number of cointegrating equations (common trends). The null hypothesis is that there are no cointegrating equations.

3.7.10. Based on the trace test results

No cointegration: The test statistic for the case of no cointegration (0 common trends) is 36.81853, which is lower than the critical value at the 0.05 level (47.85613). Therefore, we do not reject the null hypothesis of no cointegration at the 0.05 level.

3.7.11. Unrestricted cointegration rank test (Max-eigenvalue)

- Hypothesized No. of CE(s): The number of common trends assumed in the null hypothesis.
- Eigenvalue: The eigenvalues associated with the assumed number of common trends. Statistic: The test statistic for the max-eigenvalue test.
- Critical value: The critical values corresponding to the assumed number of common trends at the specified significance level.
- Prob.**: *P*-value calculated based on the MacKinnon-Haug-Michelis (1999) method.

The max-eigenvalue test examines the largest eigenvalue to determine the number of cointegrating equations. The null hypothesis is that no more than a certain number of cointegrating equations exist.

3.7.12. Based on the max-eigenvalue test results

No cointegration: The test statistic for the case of no cointegration (0 common trends) is 19.27991, which is lower than the critical value at the 0.05 level (27.58434). Therefore, we do not reject the null hypothesis of no cointegration at the 0.05 level. The trace and max-eigenvalue tests indicate no cointegration at the 0.05 level. This suggests that there is no long-term relationship among the variables being tested (Please see Table 4).

The Granger causality test is used to examine the causal relationship between variables. In this case, the test is conducted between BTC, GC, IXIS, and IXUT variables. Here is an interpretation of the critical components of the results:

Null Hypothesis: Indicates the null hypothesis being tested for Granger causality. Obs: The number of observations used in the test. F-Statistic: The F-statistic calculated for the Granger causality test. Prob: The p-value associated with the F-statistic.

3.7.13. Interpretation of the results

1. GC does not Granger cause BTC:
   - F-Statistic: 0.30848
   - Prob: 0.7352. *P*-value (0.7352) is higher than the significance level (e.g., 0.05), indicating no evidence to reject the null hypothesis. This suggests that GC does not Granger cause BTC.
2. BTC does not Granger Cause GC:
   - F-Statistic: 0.25926
   - Prob: 0.7721. Similarly, *P*-value (0.7721) is higher than the significance level, indicating no evidence to reject the null hypothesis. Therefore, BTC does not Granger cause GC.
3. IXIS does not Granger Cause BTC:
   - F-Statistic: 0.86716
   - Prob: 0.4229 *P*-value (0.4229) is higher than the significance level, indicating that there is no evidence to reject the null hypothesis. Therefore, IXIS does not Granger cause BTC.
4. BTC does not Granger Cause IXIS:
   - F-Statistic: 0.85998
   - Prob: 0.4259 *P*-value (0.4259) is higher than the significance level, suggesting that there is no evidence to reject the null hypothesis. Hence, BTC does not Granger cause IXIS.

The remaining results follow a similar pattern for the Granger causality tests between telecommunications stock index price and BTC, insurance companies' performance and gold price, telecommunications stock index price and gold price, telecommunications stock index price and insurance companies' performance, and insurance companies' performance and telecommunications stock index price. In each case, p-value is higher than the significance level, indicating a lack of evidence to reject the null hypothesis.

In summary, based on these Granger causality test results, no significant evidence suggests a causal relationship between the variables tested in either direction (Fig. 1).

The following tables offer the estimations of the influences of the models for three relations. To test the link between Bitcoin measured by the insurance companies' performance (IXIS) and telecommunications stock index price (IXUT), whereas gold price (GC), correlation, and multiple regression analyses were conducted. Table 1, which shows summary model results, indicates our model with the two forecasters. The model is a linear regression model with BTC (Bitcoin) as the dependent variable and three predictors: IXIS (Insurance companies' performance), IXUT (Telecommunications stock index price), and GC (Gold price). The model's R^2 value is 0.588, indicating that the three predictors can explain 58.8% of the variance in BTC. The adjusted R^2 value is 0.563,

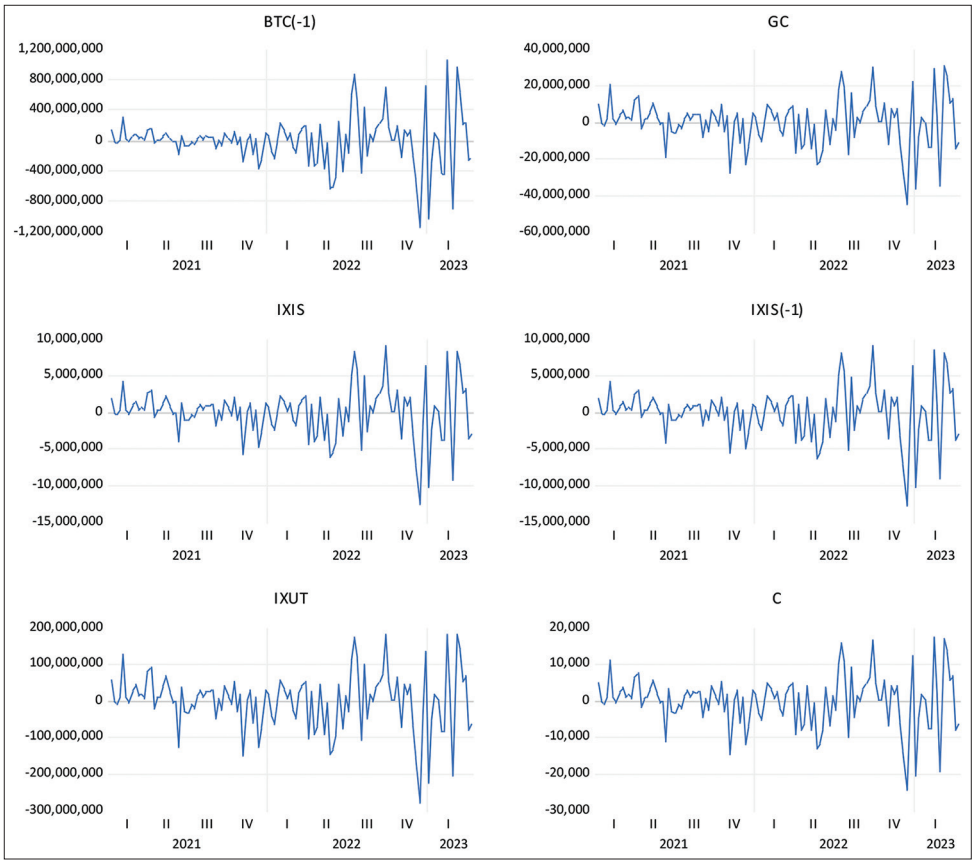
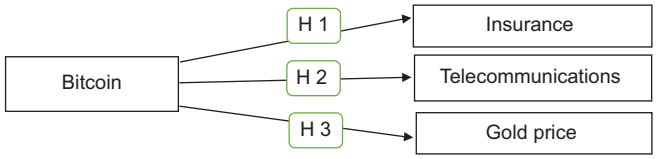


Fig. 1. Gradients of the objective function.

Table 1: Model of the study



tiModel description:
Where:
BTC=Bitcoin
IXIS=Insurance companies' performance.
IXUT=Telecommunications stock index price.
GC=Gold price.
μ=The error term.

which considers the number of predictors in the model. The standard error of the estimate is 3896.04060, which represents the average distance that the actual BTC values deviate from the predicted values.

Multiple regression analysis was conducted to examine the relationship between Bitcoin (BTC) as the dependent variable and three predictors: Insurance companies' performance (IXIS), telecommunications stock index price (IXUT), and gold price (GC). The summary model results are presented in Table 2.

The R^2 value of 0.93 indicates that approximately 93% of the variance in BTC can be explained by the three predictors included in the model. This suggests that the predictors collectively account for a significant portion of the variability in Bitcoin prices.

To further elaborate on the results, it would be helpful to provide more specific information from Table 1, such as the coefficients associated with each predictor variable and their corresponding p-values or confidence intervals. In addition, discussing the statistical significance of the coefficients and their interpretation of the research question would provide a more comprehensive understanding of the model's findings. The significance and interpretation of the coefficients can be further expanded to provide a deeper understanding of the relationships. For instance, the positive coefficient associated with the gold price (GC) suggests a positive correlation

between the price of gold and the price of Bitcoin. One possible explanation for this relationship is that gold and Bitcoin are considered alternative investment assets or stores of value. As investors seek to hedge against inflation or economic uncertainties, they may allocate funds to gold and Bitcoin, simultaneously driving up their prices.

Similarly, the positive coefficient for the telecommunications stock index price (IXUT) implies a positive association between the performance of the telecommunications sector and the price of Bitcoin. This relationship could be attributed to the increasing adoption and integration of cryptocurrencies within the telecommunications industry. As the telecommunications sector advances technologically and embraces cryptocurrencies, it may contribute to the growth and acceptance of Bitcoin, thereby positively impacting its price.

Table 2: Stationarity statistics at first difference

Dependent variable: BTC Method: ARDL Dependent lags: (4 max. lags): GC IXIS IXUT				
Variables	**Coefficient**	**Standard error**	**t-statistic**	**Prob.***
BTC(-1)	0.917958	0.039009	23.53190	0.0000
GC	1.484124	4.545807	0.326482	0.7447
IXIS	110.0404	30.44721	3.614136	0.0005
IXIS(-1)	−96.63934	30.37787	−3.181241	0.0019
IXUT	0.213805	0.576962	0.370570	0.7117

*Prob (F-statistic)=0.000000
R^2=0.934858
Adjusted R^2=0.931950

On the other hand, the negative coefficient associated with the insurance companies' performance (IXIS) indicates an inverse relationship between the performance of insurance companies and the price of Bitcoin. One possible explanation is that as the performance of insurance companies improves, investors may perceive them as more stable and secure investment options compared to the relatively volatile and speculative nature of Bitcoin. Consequently, increased confidence in traditional financial institutions, such as insurance companies, may lead to decreased demand for Bitcoin and a subsequent decrease in its price.

It is important to note that the constant term, representing the value of the dependent variable when all predictor variables are equal to zero, predicts a negative value for Bitcoin. However, since the constant term is not statistically significant, its impact on the overall Bitcoin price prediction may not be substantial. Therefore, the focus should primarily be on the coefficients of the predictor variables, as they provide more meaningful insights into the relationships being examined.

By delving into the underlying mechanisms and offering plausible explanations for the observed relationships, a more thorough understanding of the dynamics between the variables can be achieved, thereby strengthening the overall analysis.

Table 3: ADF test statistic

Null hypothesis: BTC has a unit root				
Exogenous: Constant				
			t-Statistic	**Prob.***
Augmented Dickey–Fuller test statistic			−1.505250	0.5276
Test critical values:	1% level		−3.486551	
	5% level		−2.886074	
	10% level		−2.579931	
*MacKinnon (1996) one-sided *P*-values				
Augmented Dickey–Fuller Test Equation				
Method: Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
BTC(-1)	−0.038019	0.025258	−1.505250	0.1350
C	1449.238	973.7503	1.488306	0.1394
R^2	0.019158	Mean dependent var		82.18729
Adjusted R^2	0.010703	S.D. dependent var		3836.238
F-statistic	2.265778	Durbin-Watson stat		1.803764
Prob (F-statistic)	0.134978			

The results are from an ADF test performed on the variable BTC to test for the presence of a unit root. Here is an interpretation of the key components of the results:
Null Hypothesis: The null hypothesis being tested is that BTC has a unit root, indicating that it is non-stationary

Table 4: Long-term relationship among variables

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized	**Eigenvalue**	**Trace**	**0.05**	**Prob.****
No. of CE (s)		**Statistic**	**Critical Value**	**Critical Value**
None	0.153128	36.81853	47.85613	0.3561
At most 1	0.077052	17.53862	29.79707	0.6002
At most 2	0.060441	8.237412	15.49471	0.4404
At most 3	0.008630	1.005381	3.841465	0.3160

Trace test indicates no cointegration at the 0.05 level
*Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) *P*-values

Unrestricted Cointegration Rank Test (Max-eigenvalue)				
Hypothesized	**Eigenvalue**	**Max-Eigen**	**0.05***	**Prob.****
No. of CE (s)		**Statistic**	**Critical Value**	**Critical Value**
None	0.153128	19.27991	27.58434	0.3932
At most 1	0.077052	9.301208	21.13162	0.8074
At most 2	0.060441	7.232031	14.26460	0.4621
At most 3	0.008630	1.005381	3.841465	0.3160

Max-eigenvalue test indicates no cointegration at the 0.05 level
*Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) *P*-values

Table 5: Results of pairwise Granger causality test

Sample: March 1, 2021–September 4, 2023			
Lags: 2			
Null hypothesis	**Obs**	**F-Statistic**	**Prob.**
GC does not Granger cause BTC	117	0.30848	0.7352
BTC does not Granger cause GC		0.25926	0.7721
IXIS does not Granger cause BTC	117	0.86716	0.4229
BTC does not Granger cause IXIS		0.85998	0.4259
IXUT does not Granger cause BTC	117	0.27543	0.7598
BTC does not Granger Cause IXUT		0.80404	0.4501
IXIS does not Granger cause GC	117	0.02168	0.9786
GC does not Granger cause IXIS		0.93098	0.3972
IXUT does not Granger cause GC	117	0.70114	0.4982
GC does not Granger cause IXUT		3.33503	0.0392
IXUT does not Granger cause IXIS	117	2.11883	0.1250
IXIS does not Granger cause IXUT		0.27989	0.7564

4. CONCLUSION AND RECOMMENDATION

4.1. Conclusion

Bitcoin (-1) coefficient: The lagged value of Bitcoin has a coefficient of 0.917958, which is statistically significant at a high t-statistic value of 23.53190. This suggests that a one-unit increase in Bitcoin in the previous period is associated with an approximate 0.917958 unit increase in Bitcoin in the current period. This indicates a positive autocorrelation effect and suggests the presence of momentum in Bitcoin prices.

4.1.1. Gold prices coefficient

The coefficient for the variable gold prices is 1.484124, but it is not statistically significant with a t-statistic of 0.326482 and a relatively high *P*-value of 0.7447. Therefore, the inclusion of gold prices in the model has little Bitcoin.

4.1.2. Insurance companies' performance coefficient

The coefficient for the variable insurance companies' performance is 110.0404, and it is statistically significant with a t-statistic of 3.614136 and a low *P*-value of 0.0005. This suggests that a one-unit increase in insurance companies' performance is associated with a significant 110.0404 unit increase in Bitcoin. This indicates a positive relationship between insurance companies' performance (a specific independent variable) and Bitcoin.

Insurance companies performance (-1) coefficient: The lagged value of insurance companies' performance has a coefficient of -96.63934, and it is statistically significant with a t-statistic of and p-value of 0.0019. This implies that a one-unit increase in insurance companies' performance in the previous period is associated with a decrease of approximately 96.63934 units in BTC in the current period. This suggests a negative relationship between the lagged value of insurance companies' performance and Bitcoin.

4.1.2. Telecommunications stock index price coefficient

The coefficient for the variable telecommunications stock index price is 0.213805, but it is not statistically significant with a t-statistic of 0.370570 and *P*-value of 0.7117. Therefore, the inclusion of the telecommunications stock index price in the model does not significantly impact Bitcoin.

4.2. Recommendations

Given the significant coefficient of Bitcoin (-1), it is essential to consider the lagged value of BTC as a predictor in the model for analyzing Bitcoin prices.

Since the coefficient for GC is not statistically significant, further investigation may be required to determine if there is a causal relationship or impact of Gold price on Bitcoin prices. Alternative models or additional variables could be explored to capture potential relationships.

The significant coefficients of Insurance companies' performance (-1) suggest that these variables play a meaningful role in explaining Bitcoin prices. It may be beneficial to investigate further the underlying factors and dynamics driving the relationship between insurance companies' performance and Bitcoin.

Considering the non-significant coefficient of the telecommunications stock index price, it may be advisable to reassess the inclusion of this variable in the model or explore alternative variables that could better capture the relevant information related to Bitcoin prices.

The high R^2 value of 0.934858 indicates that the model explains a substantial portion of the variation in Bitcoin prices. However, further robustness checks, model diagnostics, and sensitivity analyses should be conducted to ensure the reliability and accuracy of the findings.

These recommendations can guide further analysis, model refinement, and enhance the understanding of the relationships between the variables in the paper's context.

REFERENCES

[1] P. Schueffel. "DeFi: Decentralized finance-an introduction and overview". *Journal of Innovation Management*, vol. 9, no. 3, pp. 1-11, 2021.

[2] J. Mazanec. "Portfolio optimalization on digital currency market". *Journal of Risk and Financial Management*, vol. 14, no. 4, p. 160, 2021.

[3] M. I. Marobhe. "Cryptocurrency as a safe haven for investment portfolios amid COVID-19 panic cases of Bitcoin, Ethereum and Litecoin". *China Finance Review International*, vol. 12, no. 1, pp. 51-68, 2022.

[4] P. Schmidt and D. Elferich. "Blockchain Technology and Real Estate-a cluster analysis of applications in global markets in the year 2021". In *SHS Web of Conferences*, vol. 129, p. 3027, 2021.

[5] S. Agyei-Ampomah, D. Gounopoulos and K. Mazouz. "Does gold offer a better protection against losses in sovereign debt bonds than other metals?". *Journal of Banking and Finance*, vol. 40, pp. 507-521, 2014.

[6] A. H. Dyhrberg. "Bitcoin, gold and the dollar-A GARCH volatility analysis". *Finance Research Letters*, vol. 16, pp. 85-92, 2016.

[7] H. L. Majee. "Analyzing and measuring the impact of exchange rate fluctuations on economic growth in Iraq for the period (2004-2022)". *Journal of Kurdistani for Strategic Studies*, vol. 2, no. 2, p. 181-193, 2023.

[8] R. Ali, J. Barrdear, R. Clews and J. Southgate. "The economics of digital currencies". *Bank of England Quarterly Bulletin*, vol. 54, no. 3, pp. 276-286, 2014.

[9] R. Böhme, N. Christin, B. Edelman and T. Moore. "Bitcoin: Economics, technology, and governance". *Journal of Economic Perspectives*, vol. 29, no. 2, pp. 213-238, 2015.

[10] J. G. Haubrich. "Gold prices". *Economic Commentary*, 1998. Available from: http://www.clevelandfed.org/research/commentary/1998/0301.pdf?WT.oss=goldprices&WT.oss_r=446 [Last accessed on 2023 Aug 12].

[11] R. I. Dzerjinsky, E. N. Pronina and M. R. Dzerzhinskaya. "The Structural Analysis of the World Gold Prices Dynamics". In: *Artificial Intelligence and Bioinspired Computational Methods: Proceedings of the 9th Computer Science On-line Conference* 2020. Vol. 29, pp. 352-365, 2020.

[12] M. M. Veiga, G. Angeloci, M. Hitch and P. C. Velasquez-Lopez. "Processing centres in artisanal gold mining". *Journal of Cleaner Production*, vol. 64, pp. 535-544, 2014.

[13] J. G. Haubrich. "Gold prices". *Economic Commentary.* Federal Reserve Bank of Cleveland, Kentucky, 1998.

[14] H. Bulińska-Stangrecka and A. Bagieńska. "Investigating the links of interpersonal trust in telecommunications companies". *Sustainability*, vol. 10, no. 7, p. 2555, 2018.

[15] L. Torres and P. Bachiller. "Efficiency of telecommunications companies in European countries". *Journal of Management and Governance*, vol. 17, pp. 863-886, 2013.

[16] W. Bashaija. "Effect of financial risk on financial performance of insurance companies in Rwanda". *Journal of Finance and Accounting*, vol. 10, no. 5, 2022.

[17] A. Demirgüç-Kunt and H. Huizinga. "Bank activity and funding strategies: The impact on risk and returns". *Journal of Financial Economics*, vol. 98, no. 3, pp. 626-650, 2010.

[18] D. Hamadu and J. N. Mojekwu. "The impact of insurance on Nigerian economic growth". *International Journal of Academic Research*, vol. 6, no. 3, pp. 84-94, 2014.

[19] E. Bouri, P. Molnár, G. Azzi, D. Roubaud and L. I. Hagfors. "On the hedge and safe haven properties of Bitcoin: Is it really more than a diversifier?". *Finance Research Letters*, vol. 20, pp. 192-198, 2017.

[20] F. Ş. Sökmen and S. Gürsoy. "Investigation of the relationship between bitcoin and gold prices with the maki cointegration test". *Ekonomi İşletme ve Maliye Araştırmaları Dergisi*, vol. 3, no. 2, pp. 217-230, 2021.

[21] R. Kochhar, B. Kochar, J. Singh and V. Juyal. "Blockchain and its

Impact on Telecom Networks". In: *Conference: The Fourteenth International Conference on Wireless and Mobile Communications*, Venice, Italy, 2018.

[22] B. Kajwang. "Insurance Opportunities and challenges in a crypto currency world". *International Journal of Technology and Systems*, vol. 7, no. 1, pp. 72-88, 2022.

[23] D. Bams, G. Blanchard, I. Honarvar, and T. Lehnert, "Does oil and gold price uncertainty matter for the stock market?," *J. Empir. Financ.*, vol. 44, pp. 270–285, 2017.

[24] P. Boonkrong, N. Arjrith, and S. Sangsawad, "Multiple linear regression for technical outlook in telecom stock price," in *Proceedings of RSU International Research Conference*, 2020, pp. 1178–1185.

[25] Lee, H *and* Wang, Y. *"*Spillover *effects of gold prices on telecommunications companies*: A *comparative analysis".* Journal of Business and Finance, *vol.* 42*, no.* 3, *pp.* 178-195, 2020.

[26] Smith, J., Johnson, A and Lee, B. 2020.

Top of Form

Date	IXUT	IXIS	GC	BTC
4/9/2023	11,701.90	399.18	2,002.20	30,453.80
4/2/2023	11,563.70	396.79	2,011.90	27,941.20
3/26/2023	11,532.60	398.16	1,969.00	28,456.10
3/19/2023	11,134.70	383.93	1,983.80	27,475.60
3/12/2023	10,981.20	384.43	1,973.50	26,914.10
3/5/2023	11,585.00	375.79	1,867.20	20,467.50
2/26/2023	12,487.30	391.23	1,854.60	22,347.10
2/19/2023	12,344.60	390.39	1,817.10	23,166.10
2/12/2023	12,558.50	409.19	1,840.40	24,631.40
2/5/2023	12,376.60	393.52	1,862.80	21,859.80
1/29/2023	12,329.30	404.43	1,862.90	23,323.80
1/22/2023	12,128.50	401.53	1,929.40	23,027.90
1/15/2023	11,933.70	395.02	1,928.20	22,775.70
1/8/2023	12,191.70	401	1,921.70	20,958.20
1/1/2023	12,047.70	391.95	1,869.70	16,943.60
12/25/2022	11,641.90	371.45	1,826.20	16,537.40
12/18/2022	11,876.90	370.83	1,804.20	16,837.20
12/11/2022	11,636.20	369.1	1,800.20	16,777.10
12/4/2022	11,805.50	381.88	1,810.70	17,127.20
11/27/2022	12,199.60	397.47	1,809.60	16,884.50
11/20/2022	12,022.90	392.52	1,768.80	16,456.50
11/13/2022	11,728.20	384.4	1,754.40	16,699.20
11/6/2022	11,835.40	377.59	1,769.40	16,795.20
10/30/2022	11,419.70	363.5	1,676.60	21,301.60
10/23/2022	11,482.70	374.68	1,644.80	20,809.80
10/16/2022	10,689.60	347.71	1,656.30	19,204.80
10/9/2022	10,439.00	334.89	1,648.90	19,068.70
10/2/2022	10,269.90	338.48	1,709.30	19,415.00
9/25/2022	10,002.00	333.05	1,672.00	19,311.90
9/18/2022	9,986.00	342.17	1,650.00	18,925.20
9/11/2022	10,472.20	369.83	1,677.90	20,113.50
9/4/2022	10,725.40	387.47	1,723.60	21,650.40
8/28/2022	10,311.10	382.19	1,717.70	19,831.40
8/21/2022	10,581.70	392.86	1,740.60	20,033.90
8/14/2022	10,867.50	411.36	1,753.00	21,138.90
8/7/2022	10,960.60	414.75	1,805.20	24,442.50
7/31/2022	10,176.10	402.04	1,780.50	22,944.20
7/24/2022	10,036.70	394.73	1,771.50	23,634.20
7/17/2022	10,022.40	403.27	1,731.40	22,460.40
7/10/2022	9,885.60	396.26	1,707.50	21,209.90
7/3/2022	10,300.00	393.14	1,746.70	21,587.50
6/26/2022	10,399.00	393.23	1,805.90	19,243.20
6/19/2022	10,341.30	396.01	1,830.30	21,489.90
6/12/2022	9,773.50	379.79	1,840.60	18,986.50
6/5/2022	10,174.20	395.6	1,875.50	28,403.40
5/29/2022	10,596.30	411.53	1,850.20	29,864.30
5/22/2022	10,809.00	417.06	1,857.30	29,027.10
5/15/2022	10,225.30	393.43	1,844.70	29,434.60
5/8/2022	10,428.60	406.93	1,811.30	30,080.40
5/1/2022	10,612.70	402.14	1,886.20	35,468.00
4/24/2022	10,462.00	396.55	1,915.10	37,650.00
4/17/2022	11,162.00	431.11	1,934.30	39,418.00
4/10/2022	11,376.80	447.35	1,974.90	40,382.00
4/3/2022	11,450.40	454.5	1,945.60	42,767.00
3/27/2022	11,596.10	459.47	1,923.70	45,811.00
3/20/2022	11,506.10	450.78	1,956.90	44,548.00
3/13/2022	11,188.00	456.92	1,931.70	42,233.00
3/6/2022	10,650.00	441.21	1,987.60	38,814.30
2/27/2022	10,793.80	450.01	1,968.90	39,395.80
2/20/2022	11,204.80	460.89	1,889.20	39,115.50

Top of Form

Date	IXUT	IXIS	GC	BTC
2/13/2022	11,175.10	459.47	1,899.80	40,090.30
2/6/2022	11,189.50	460.86	1,842.10	42,205.20
1/30/2022	11,382.10	464.39	1,807.80	41,412.10
1/23/2022	11,035.30	455.18	1,786.60	38,170.80
1/16/2022	10,922.50	450.46	1,833.50	35,075.20
1/9/2022	11,437.80	480.21	1,818.30	43,097.00
1/2/2022	11,463.00	478.36	1,799.30	41,672.00
12/26/2021	11,416.40	496.8	1,829.70	47,738.00
12/19/2021	11,298.30	496.22	1,811.70	50,406.40
12/12/2021	11,161.10	487.76	1,804.90	46,856.20
12/5/2021	11,333.30	477.08	1,784.80	49,314.50
11/28/2021	10,983.50	481.07	1,783.90	49,195.20
11/21/2021	11,225.70	478.85	1,786.90	54,765.90
11/14/2021	11,437.90	481.6	1,852.90	59,717.60
11/7/2021	11,567.50	500.87	1,869.70	64,398.60
10/31/2021	11,694.50	505.17	1,818.00	61,483.90
10/24/2021	11,398.20	490.14	1,784.90	61,840.10
10/17/2021	11,608.00	504.93	1,796.30	61,312.50
10/10/2021	11,413.50	501.41	1,768.30	60,861.10
10/3/2021	11,309.30	505.05	1,757.40	54,942.50
9/26/2021	10,930.20	519.52	1,758.40	47,666.90
9/19/2021	10,876.60	523.32	1,750.90	42,686.80
9/12/2021	10,816.20	527.15	1,750.50	48,306.70
9/5/2021	10,930.30	540.62	1,791.00	45,161.90
8/29/2021	11,060.80	558.6	1,832.60	49,918.40
8/22/2021	11,120.80	552.89	1,817.20	48,897.10
8/15/2021	11,002.40	549.06	1,781.80	48,875.80
8/8/2021	11,044.20	545.57	1,776.00	47,081.50
8/1/2021	10,971.50	543	1,761.10	44,614.20
7/25/2021	10,689.50	543.03	1,814.50	41,553.70
7/18/2021	10,812.90	542.15	1,802.90	33,824.80
7/11/2021	10,772.30	531.67	1,815.90	31,518.60
7/4/2021	10,780.90	538.55	1,811.50	33,510.60
6/27/2021	10,966.90	538.93	1,784.10	34,742.80
6/20/2021	11,052.80	531.2	1,777.80	32,243.40
6/13/2021	10,610.00	518.24	1,769.00	35,513.40
6/6/2021	11,259.10	526.03	1,879.60	35,467.50
5/30/2021	11,306.90	522.61	1,892.00	35,520.00
5/23/2021	11,350.30	521.35	1,905.30	34,584.60
5/16/2021	11,273.50	509.01	1,877.60	37,448.30
5/9/2021	11,330.20	523.45	1,839.10	46,708.80
5/2/2021	11,478.60	521.27	1,832.40	58,840.10
4/25/2021	11,209.80	504.51	1,768.60	57,807.10
4/18/2021	10,944.50	501.46	1,777.80	50,088.90
4/11/2021	10,993.90	504.41	1,780.20	60,041.90
4/4/2021	10,916.40	492.39	1,744.80	59,748.40
3/28/2021	10,807.90	489.68	1,728.40	57,059.90
3/21/2021	10,766.80	489.91	1,733.60	55,862.90
3/14/2021	10,730.00	486.46	1,742.90	58,093.40
3/7/2021	10,857.50	493.06	1,721.20	61,195.30
2/28/2021	10,520.10	475.8	1,700.30	48,855.60
2/21/2021	10,357.00	465.96	1,730.10	46,136.70
2/14/2021	10,564.20	473.52	1,777.40	55,923.70
2/7/2021	10,559.50	484.23	1,823.20	47,168.70
1/31/2021	10,301.30	478.83	1,813.00	39,256.60
1/24/2021	9,642.30	460.24	1,850.30	34,283.10
1/17/2021	10,102.90	470.14	1,857.90	32,088.90
1/10/2021	10,286.70	465.96	1,831.70	36,019.50
1/3/2021	10,273.70	475.87	1,837.30	40,151.90

ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Link Prediction in Dynamic Networks Based on the Selection of Similarity Criteria and Machine Learning

Karwan Mohammed HamaKarim

Department of Information Technology, University of Human Development, Kurdistan Regional Government, Iraq

ABSTRACT

The study's findings showed that link prediction utilizing the similarity learning model in dynamic networks (LSDN) performed better than other learning techniques including neural network learning and decision tree learning in terms of the three criteria of accuracy, coverage, and efficiency., Compared to the random forest approach, the LSDN learning algorithm's link prediction accuracy increased from 97% to 99%. The proposed method's use of oversampling, which improved link prediction accuracy, was the cause of the improvement in area under the curve (AUC). To bring the ratio of the classes closer together, the suggested strategy attempted to produce more samples from the minority class. In addition, similarity criteria were chosen utilizing feature selection techniques based on correlation that had a strong link with classes. This technique decreased over-fitting and improved the suggested method's test data generalizability. Based on the three criteria (accuracy, coverage, and efficiency), the research's findings demonstrated that link prediction utilizing the similarity LSDN outperformed other learning techniques including neural network learning and decision tree learning. Compared to the random forest algorithm, the LSDN algorithm's link prediction accuracy increased from 97% to 99%. The oversampling in the suggested strategy, which increased link prediction accuracy, is what caused the increase in AUC. To bring the ratio of the classes closer together, the suggested strategy attempted to produce more samples from the minority class. In addition, similarity criteria were chosen utilizing feature selection techniques based on correlation that had a strong link with classes. This technique decreased over-fitting and improved the suggested method's test data generalizability.

Index Terms: Dynamic Social Network, Link Prediction, Machine Learning Algorithms, Similarity Learning Model in Dynamic Networks, Neural Network

1. INTRODUCTION

A group of social players make up a social structure known as a social network. The edges of a network are the interactions, collaborations, or influences between things, and the nodes themselves are individuals or entities found in social contexts. These communities typically develop as a result of shared interests within a strong group. People's relationships are constantly evolving; therefore, as time goes on, new edges and nodes are added to the network while maybe removing some of the older ones. Social networks are so frequently intricate and dynamic [1]. In many applications, online social networks are ambiguous and unpredictable, and those network structures and parameters vary over time. The majority of prior link prediction approaches are based on static network representations. Therefore, it is constrained to solve actual social network problems using deterministic social network models with fixed values for linkages. In other words, when the online social network behaves arbitrarily, link prediction

Access this article online

DOI: 10.21928/uhdjst.v7n2y2023.pp32-39

E-ISSN: 2521-4217

P-ISSN: 2521-4209

Corresponding author's e-mail: Karwan Mohammed HamaKarim, Department of Information Technology, University of Human Development, Kurdistan Regional Government, Iraq. E-mail: karwan.mohammad@uhd.edu.iq

Received: 04-01-2023 Accepted: 17-06-2023 Published: 03-09-2023

approaches based on static graph representation fail [2]. To better understand network evolution and the connections between topologies and functions, link prediction in dynamic networks makes predictions about the network's future structure based on previous data. For instance, we can foresee which linkages will be made in the near future in online social networks. This means that based on their past activities, we can infer who the target user is most likely to be friendships with or even with a specific person. In addition, it can be applied to research on protein-protein interactions, the spread of illness, and many other aspects of evolution [3]. Links that are likely to arise in the future can be predicted by examining the network's structure and extracting its properties at various time intervals. On the basis of time labels, various machine learning models have been employed to forecast missing links in the network [4]. The feature vector can be constructed by extracting similarity-based features from connected and unconnected node pairs based on the network topological structure at various time intervals, and by doing so, the training data produces a machine learning model for identifying links that could be generated in the future [5]. Links in dynamic social networks have been predicted using supervised machine learning methods. The findings demonstrate that whereas these models typically exhibit acceptable accuracy in educational data, their accuracy has declined in experimental data. These models struggle with over-fitting in link prediction because of the abundance of features. In other words, the designed machine learning model performs well on educational data but less well on experimental data [6]. In homogeneous networks, there is also the issue of an unbalanced data set. Unbalanced data have been used to describe a set of data where fewer samples are used to represent one class than other samples used to represent other classes. When a class, which is typically an absolute or minority class, is underrepresented in the data set — in other words, when the number of inaccurate observations in a class outweighs the number of correct observations — this condition in time classification becomes problematic. Therefore, the performance of link prediction is significantly impacted by the class imbalance or incorrect item labeling [7]. To lower the dimensions of input structures (feature reduction) in machine learning algorithms that aim to improve the accuracy of link prediction in dynamic social networks, a new method based on feature selection algorithms is provided in this paper.

2. RELATED WORKS

Common neighborhood (CN) [8] and resource allocation index (RAI) [9] are two similarity indicators that are frequently employed in static network link prediction [10]; however, they cannot be used for link prediction in dynamic social networks. Yao *et al.* [11] identified the time-varying weights for the prior graphs to understand the temporal dependencies. They then predicted the connection using a modified CN, taking into consideration the neighbors situated between the two hops.

In an enhanced RA-based dynamic network, Zhang *et al.* [12] link prediction algorithm updated the similarity between pairs of nodes as the network structure changed. These techniques, however, are less effective when dealing with strong nonlinearity and rely more on basic network statistics.

3. PROPOSED METHOD

Because static networks have a fixed structure, link prediction algorithms can only produce results by learning about the network's spatial organization and determining its links based on the distribution of the observed edges. Dynamic network links, however, undergo constant modification. The temporal characteristics of the network should also be learned by dynamic link prediction algorithms from the network sequence. Based on the selection of similarity criteria in various time intervals in accordance with the dynamics of the social network, link prediction is carried out in this paper. Using a pattern of changes in similarity criteria based on time, it is feasible to forecast the future structure of the graph and the presence or absence of linkages between two nodes.

According to the suggested method, a dynamic network is represented as a progression of graphs that are captured over time at regular intervals. A network sequence with many photographs of a discrete network taken across the time intervals G 1, G 2, and G end can be thought of as a dynamic social network. When G t = (V,E t), the k'th image of a dynamic network that reflects the network at time t, is represented by a sequence of graphs (t1,2,end). When a set of vertices, V, is represented by a set of edges, E t, which contains the connections between each pair of vertices in the network, is represented by V. The adjacency matrix G t is displayed with A t and a (t; i, j)=1 if there is a directed connection between v i and v j; otherwise, a (t; i, j) = 0. The suggested technique makes use of extracted data.

The suggested link prediction model, which makes use of correlation-based feature selection and data balancing, was

designated as a similarity learning model in the dynamic network (LSDN). As a result, the issues of enormous dimensions, non-linearity, and data dispersion can be efficiently handled by this approach. Fig. 1 shows the general layout of the suggested model.

In the following, the steps of implementing the proposed method are explained:

3.1. Creating a Subgraph

Given a sequence of graphs of length N, $S=\{G_t, G_{t-1}\}$, the purpose of predicting a dynamic network link is to learn a function that represents the input sequence S to G_t. In predicting link in dynamic network, time labels T in the network sequence are used to calculate the probability of all links in the next time label t through network information, which can be shown as follows:

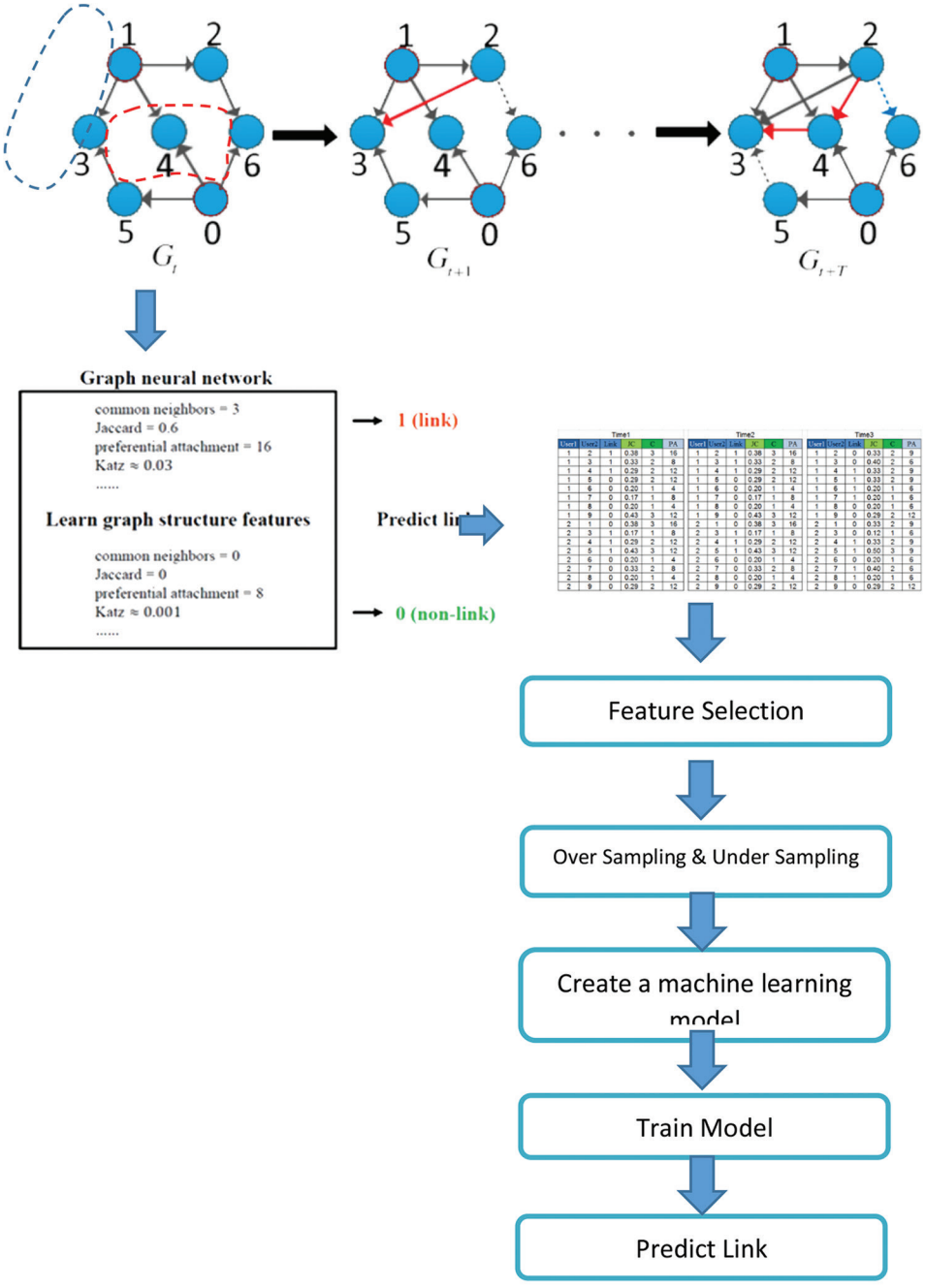


Fig. 1. Learning similarity in dynamic network model.

$$A'_t = argmax P(A_t \mid A_{t-T}, A_{t-T+1}, \cdots, A_{t-1}) \quad (1)$$

that $(A_t \mid A_{t-T}, A_{t-T+1}, \cdots, A_{t-1})$ represents the network adjacency matrix in the previous T, A_t represents real adjacency matrix in time t, A'_t is the adjacency matrix predicted by dynamic network link prediction.

The structure of a dynamic network evolves over time. As shown in Fig. 2, some links may appear while others may disappear. According to the variable structure of the social network, we can extract multiple graphs at any time.

3.2. Creating Feature Vector

Pairs of related nodes are found by converting the subgraph intended for implementation in the preprocessing step to edge list form. To show that a link exists between these node pairs, they are given the number 1. On the other hand, there can be a lot of node pairs in the network for which there is not a link yet. The processing of missing node pairs may not be complete. Only node pairs that fall inside the double-hops interval are taken into account to ensure steady computational complexity. These node pairs are marked with the number 0, which denotes the absence of linkages.

A subgraph produced by the correlation of neighbors x and y with h hops from the pair's origin is known as an enclosing subgraph for a pair of nodes (x;y).

Fig. 3 shows the one-hop enclosing subgraphs for (A, B) and (C, D). These enclosing subgraphs are very instructive for link prediction – all similarity-based link prediction methods can be calculated directly from single-hop enclosing subgraphs.

3.3. Creating a Training Set from Subgraphs

At time t, the training set is taken from the subgraphs. There are two training sets in this set: NL and HL. In the NL training set, node pairs without linkages are taken out of the graph. For these node pairs, the similarity criterion is calculated and extracted as one of their attributes. The following phase involves extracting connected pairs of nodes from the network. In addition, retrieved and saved as an HL training set are their similarity features.

3.4. Correlation-Based Feature Selection Method

A subset of characteristics is deemed a good subset in this feature selection approach if, on the one hand, they have a strong correlation with the target feature and, on the other, they are not correlated with one another [8]. The relationship

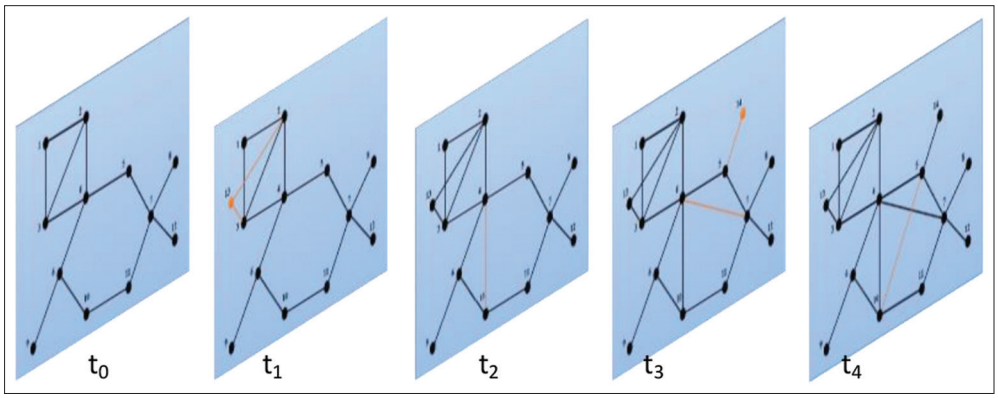


Fig. 2. The change of the graph structure over time and the extraction of subgraphs.

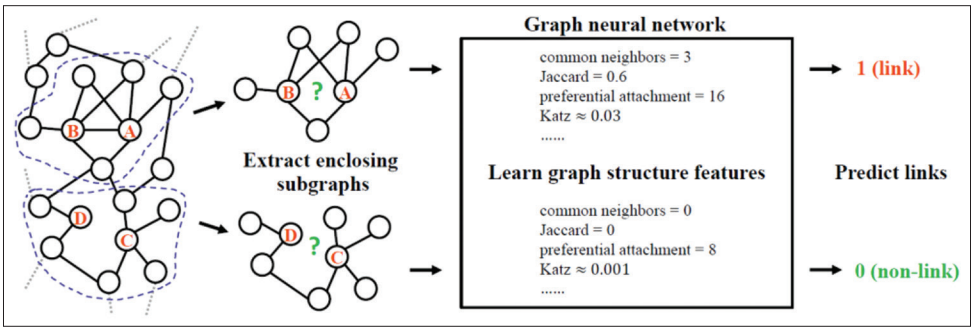


Fig. 3. The enclosing subgraphs.

between node-pair attributes (similarity criteria) and the presence or absence of a link (response) is taken into account in this method as a scenario. In this feature selection scenario, our goal is to find similarity criteria that are significantly dependent on the response. Equation (2) determines a subset of characteristics' Merit:

$$Merit_{S_k} = \frac{k\,\bar{r}_{cf}}{\sqrt{k + k(k(k-1)\,\bar{r}_{ff})}} \quad (2)$$

In this equation, $\bar{r}_{cf}$ is the mean of the calculated correlation between the target feature and all the features in the data set and $\bar{r}_{ff}$ is the mean of the one-to-one correlation calculated between the features [8]. Finally, the correlation-based method is formulated as follows:

$$CFS = \max_{Sk}\left[\frac{r_{cf_1} + r_{cf_2} + \ldots\ldots + r_{cf_k}}{\sqrt{k + 2(r_{f_2f_1} + \ldots. + r_{f_if_j} + \ldots\ldots + r_{f_kf_1})}}\right] \quad (3)$$

In this regard, the variables $\bar{r}_{cf_i}$ and $\bar{r}_{f_if_i}$ are called correlation values.

3.5. Balancing Data

Data classification issues include unbalanced data. Data that are out of balance have drastically differing class proportions. The data are unbalanced if one class (the dominating or majority class) comprises 90% of the data and the remaining 10% of the data. Under-sampling and over-sampling are two techniques used in machine learning to handle uneven data. To put it another way, either the dominant class is under-sampled, or the minority class is over-sampled, or both approaches are combined. The performance of machine learning algorithms in mistake detection may be impacted, which makes the unbalanced categorization a concern. To make the class ratios more similar, oversampling seeks to provide more samples from the minority class. In addition, the goal of under-sampling is to take fewer samples from the majority class. To get the ratio of classes closer to one another, we actually do not use all the samples from the majority class in this technique [9].

Oversampling is the process of selecting random samples from the minority class to select the same sample more than once by replacing and adding to the training data. In fact, to increase the number of samples, this method reproduces minority samples. Many machine learning algorithms are highly adept at handling uneven data by using sampling techniques. However, because we are either copying current data or deleting samples, properly adjusting the data ratio is crucial. The outcome may be significantly impacted if these samples are taken carelessly. The rising cost of computation is another issue we need to be mindful of. There may be more calculations required if there are more samples in the minority class, especially if the dataset is very imbalanced. When combined, the under-sampling and over-sampling random approaches in the suggested method perform better as a whole than when used alone. This implies that we can reduce the size of the majority class while increasing the size of the minority class. This approach makes an effort to utilize the benefits of the earlier approaches while attempting to avoid their drawbacks.

3.6. Training Learning Model

The dataset is constructed using a vector set of features and node-pair labels (link = 1 and non-link = 0). The training dataset is chosen and the validation dataset is chosen from the remaining portions of the dataset. To provide the ability of fitting model parameters (the weight of connections between neural cells in artificial neural networks) using a set of feature vectors and each vector's label, the learning model is taught on a set of training data using a supervised learning method, such as optimization methods like gradient descent or random gradient descent (link or not-link). The similarity criterion of the two nodes in the training data set is compared with the label of each input vector to produce a result.

4. EVALUATION OF THE PROPOSED METHOD

4.1. Description of the Dataset

Now, working on Facebook data begins. In this example, the combined "Ego Networks" dataset is used. This dataset contains the aggregated network of ten Facebook friends list. The facebook_combined.txt file can be downloaded from the website https://snap.stanford.edu/data/egonets-Facebook.html. The interested people can receive their Facebook/Twitter data using the Facebook/Twitter API and use it to do this example and analyze their data. To do this project, first, the file is read and then its graph is created.

Fig. 4 shows the Ego Networks dataset graph. This dataset contains the aggregated network of ten Facebook friends. The color and size of the nodes vary according to the degree the centrality, respectively.

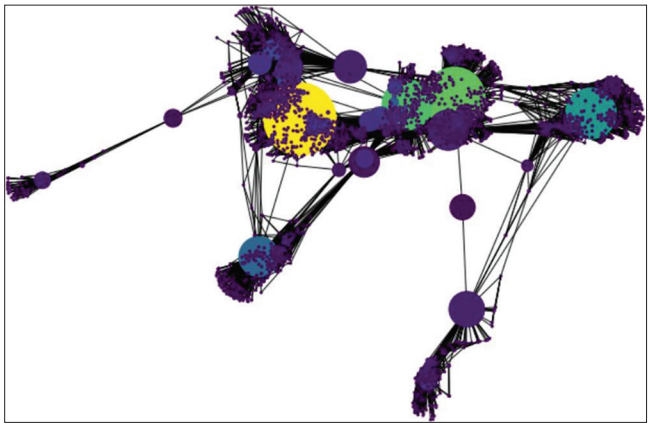


Fig. 4. Ego networks dataset graph.

The feature vector is constructed by considering all pairs of nodes that exist at double-hop intervals. Therefore, various global similarity criteria have been adopted in the methodology section. Fig. 5 shows the simulation result that we gave him the graph that created a several subgraphs for prediction between anode and neighbors. In the proposed framework, seven local similarity indicators involving CN, Jaccard coefficient, Adamic and Adar criterion, preferred connection, RAI, Salton index), and Sorenson index are considered as a measure of similarity in the feature construction process.

4.2. Evaluated Methods

In this section, the evaluated methods of this research are presented in Table 1.

4.3. Evaluation Metrics

4.3.1. Area under the precision-recall curve

Recall quantifies the proportion of positive results that were obtained. The degree of precision indicates the proportion of real positive findings. A Precision-Recall Curve that shows how an increase in recall impacts precision is created using these metrics. This curve's area under it serves as a measure of link equality.

4.3.2. Recall

The ratio of the number of correctly predicted results to the total number of predicted results.

$$recall = \frac{tp}{tp + fn} \tag{4}$$

4.3.3. Precision

The ratio of the number of correctly predicted results to the total number of predicted results is related.

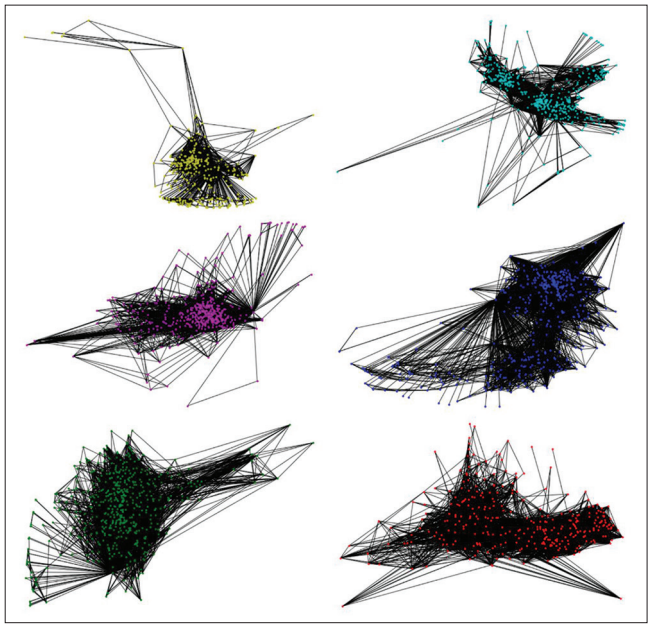


Fig. 5. Subgraphs extracted from ego network.

Table 1: Evaluated methods

Evaluated methods
Support vector machine
Decision tree
Random forest
Bayes naïve
K-nearest neighbor
MLP
LSDN

MLP: Multi-layer perceptron, LSDN: Learning similarity in dynamic network

$$precision = \frac{tp}{tp + fp} \tag{5}$$

4.3.4. Performance (F-score)

Measures system performance by considering recall and precision; the formula is as follows:

$$F - Score = 2 * \frac{Precision * Recall}{Precision + Recall} \tag{6}$$

4.4. Experimental Setting

The proposed work has been done on the CPU i5 2.29 GHz. For experimental purposes, we used the Networkx package to obtain structure-based similarity among network nodes. To use link prediction models, we have written programs in Python.

Table 2: Evaluate the proposed method in the ego network

Methods	Class	Precision	Recall	F-Score	Accurcy
SVM	Link	0.9302	0.9884	0.9584	0.9225
	No link	0.7387	0.3057	0.4325	
DT	Link	0.9799	0.9797	0.9798	0.9635
	No link	0.8105	0.8119	0.8112	
RF	Link	0.9785	0.99	0.9842	0.9712
	No link	0.8946	0.7962	0.8425	
KNN	Link	0.9346	0.9786	0.9561	0.9188
	No link	0.6423	0.3597	0.4611	
MLP	Link	0.9627	0.9776	0.9701	0.9455
	No link	0.7549	0.6454	0.6959	
NB	Link	0.9667	0.9484	0.9575	0.9238
	No link	0.5898	0.6945	0.6379	
LSDN	Link	0.9932	0.9933	0.9931	0.994
	No link	0.9971	0.9978	0.9975	

MLP: Multi-layer perceptron, LSDN: Learning similarity in dynamic network, SVM: Support vector machine

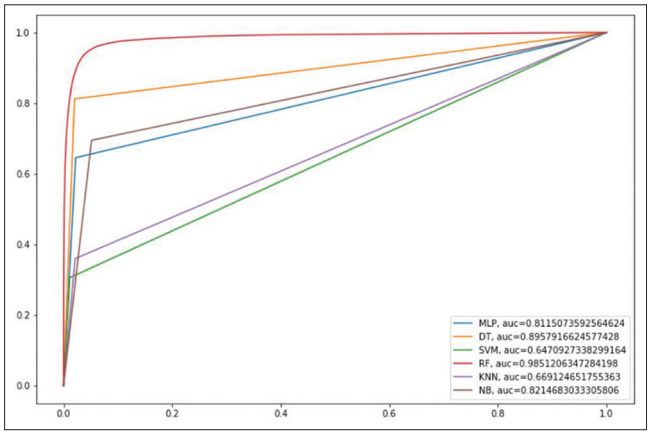


Fig. 6. The ROC curve evaluation of the proposed method.

5. RESULTS AND ANALYSIS

Based on the results obtained from Table 2, it can be seen that the similarity LSDN and KNN have the best and worst performance in terms of the accuracy of the prediction model, respectively. According to the results of three criteria (accuracy, coverage, and efficiency), link prediction using similarity LSDN provides better results than other learning methods such as neural network learning and decision tree. The accuracy of the link prediction in the LSDN algorithm has been improved from 97% to 99% compared to the random forest algorithm.

We also evaluated performance in terms of area under the curve (AUC) values. Fig. 6 shows the analysis of the receiver operating characteristic graph link prediction in terms of AUC value.

From (Fig. 6), it can be seen that the LSDN model has the highest AUC value and the SVM model has the lowest AUC values compared to other algorithms. Based on the obtained AUC criteria, the LSDN is 99%, which is a better result than the decision tree 89%, simple Bayesian 82%, MLP 81%, KNN 66%, SVM 64%, and RF 97%.

6. CONCLUSION

One of the quickly developing study areas in the field of social network analysis is link prediction, which has a wide range of applications, including identifying and simulating the growth of various social network types. To apply the model to successfully identify lost ties, social network interpretation may be helpful. To forecast missing links, a link prediction framework based on the global similarity criterion is proposed in this research. According to research records, several scholars have chosen to use a variety of structure-based similarity criteria to solve the link prediction problem. For capturing structural data in complicated networks, we suggest link-based predictive machine learning algorithms. Through a variety of machine learning models, we attempted to aggregate all the global similarity criteria to forecast future linkages. It may be inferred from this experiment that none of the distinct similarity criteria (by themselves) can reliably forecast the missing links. However, the prediction of missing links becomes more precise when these universal standards are taken into account as aspects of machine learning algorithms. Standard evaluation parameters such as AUC, accuracy, F-criteria, recall, and accuracy have been used for validation purposes. For ease of operation, we have provided only a weightless and static network for implementation purposes. In the future, this can be extended to a dynamic network where nodes and edges are added over time.

REFERENCES

[1] C. Muro, B. Li, K. He. Link prediction and unlink prediction on dynamic networks. *IEEE Transactions on Computational Social Systems*. vol. 10, no. 2, pp. 590-601, 2022.

[2] A. Mohan and K. V. Pramod. "Link prediction in dynamic networks using time-aware network embedding and time series forecasting". *Journal of Ambient Intelligence and Humanized Computing*, vol. 12, no. 1, pp. 1981-1993, 2021.

[3] L. Hu, X. Wang, Y. A. Huang, P. Hu and Z. H. You. "A survey on computational models for predicting protein-protein interactions". *Briefings in Bioinformatics*. vol. 22, p. bbab036, 2021.

[4] A. K. Singh and L. Kailasam. "PILHNB: Popularity, interests, location used hidden Naive Bayesian-based model for link prediction in dynamic social networks". *Neurocomputing*, vol. 461,

pp. 562-576, 2021.

[5] M. Zhang, Y and Chen. "Link prediction based on graph neural networks". *Advances in Neural Information Processing Systems*, vol. 31, pp. 5165-5175, 2018.

[6] G. J. De Bruin, C. J. Veenman, H. J. van den Herik and F. W. Takes. Experimental Evaluation of Train and Test Split Strategies in Link Prediction. In: *International Conference on Complex Networks and their Applications*. Springer, Cham, 2020, pp. 79-91.

[7] T. D. Hua, A. T. Nguyen-Thi and T. A. H. Nguyen. Link prediction in weighted network based on reliable routes by machine learning approach. In: *2017 4th NAFOSTED Conference on Information and Computer Science*. IEEE, 2017, pp. 236-241.

[8] M. E. Newman. “Clustering and preferential attachment in growing networks”. *Physical Review E*, vol. 64, no. 2, p. 025102. 2001.

[9] T. Zhou, L. Lü and Y. C. Zhang. “Predicting missing links via local information”. *The European Physical Journal B*, vol. 71, no. 4, pp. 623-630, 2009.

[10] L. Lü and T. Zhou. Link prediction in complex networks: A survey. *Physica A: Statistical Mechanics and its Applications*, vol. 390, no. 6, pp. 1150-1170, 2011.

[11] L. Yao, L. Wang, L. Pan and K. Yao, K. Link prediction based on common-neighbors for dynamic social network. *Procedia Computer Science*, vol. 83, pp. 82-89, 2016.

[12] Z. Zhang, J. Wen, L. Sun, Q. Deng, S. Su and P. Yao. “Efficient incremental dynamic link prediction algorithms in social network”. *Knowledge-Based Systems*, vol. 132, pp. 226-235, 2017.

ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Fully Homomorphic Encryption Scheme for Securing Cloud Data

Mohammed Anwar Mohammed, Tara Nawzad Ahmad Al Attar

Department of Computer Science, College of Science, University of Sulaimani, Sulaimaniyah, Iraq

ABSTRACT

One of the pioneer and important fields in the computer science area is cloud computing. The data within cloud computing are usually transformed to it from local storage; therefore, the security of this data is an important issue. To solve this data security issue, it is important that cloud service providers (CSPs) store encrypted versions of user data. Before transmitting data to the cloud provider, it was encrypted using traditional encryption schemes. Nevertheless, for these schemes, the private key must be provided to the server to be used for the decryption on the other side before any calculations, yielding a security risk and issue for the cloud data. Homomorphic encryption provides a capable solution to this issue since it enables calculations on encrypted data with no need to be decrypted and the private encryption key is not compromised. A new fully homomorphic encryption scheme to protect cloud data is proposed in this paper, it is called NAZUZ. The NAZUZ scheme is based on prime modular operations and encrypts messages by operating on each character without converting them to binary. NAZUZ security relies on the difficulty of factoring large integer numbers and introduces noise complexity to the plaintext through the number of CSP users.

Index Terms: Cryptography, Cloud, Data security, Data privacy, Information security

1. INTRODUCTION

The significance of cloud computing raised due to the fast and rapid progress of computer networks as well as the spread of big data. Cloud computing provides means to store and process huge amounts of data [1]. It provides users with suitable access to remote storage and computational resources that are flexible and on-demand. There is little control over the data in the cloud environment; therefore, the security, confidentiality, and integrity of cloud computing became an issue. The presentation of data leaks and the protection of personal privacy is crucial for both individuals and enterprises that are planning to move their data to cloud storage [2]. To protect the privacy of cloud data, data protection is considered a vital mechanism. To protect the data, either traditional encryption methods and techniques or homomorphic encryption methods are used. For the traditional methods, no process or calculations on the cloud-encrypted data can be performed before decrypting it, and this will result in putting the data at risk and compromising its security. On the other hand, decrypting the data is not required in homomorphic encryption and any operation required can be directly performed on the encrypted version of the data, plus the fact that the results were the same when performing the same calculation on both the original dataset as well as on the encrypted data. Homomorphic encryption has two general categories, partial homomorphic encryption (PHE) and fully homomorphic encryption (FHE). Either addition or multiplication is permitted on the encrypted data for PHE [3]. While on the hand, FHE allows a random number of additions and multiplications on the encrypted data, so it is more comprehensive [4]. The organization of

Access this article online

DOI: 10.21928/uhdjst.v7n2y2023.pp40-49

E-ISSN: 2521-4217
P-ISSN: 2521-4209

Corresponding author's e-mail: Tara Nawzad Ahmad Al Attar, Department of Computer Science, College of Science, University of Sulaimani, Sulaimaniyah, Iraq . E-mail: tara.ahmad@univsul.edu.iq

Received: 19-07-2023 Accepted: 23-09-2023 Published: 10-10-2023

the remaining sections of this paper is as follows: Section II presents the motivation behind the proposed work. Next, in Section III, a comprehensive review of the relevant literature is presented. A brief explanation of homomorphic encryption is illustrated in Section IV. In Section V, the proposed algorithm named NAZUZ is introduced. All the results and analysis of the proposed work are presented in Section VI including several case studies. A comparative analysis of the proposed algorithm is provided in Section VII. Then, Section VIII discusses the limitations of the work, and finally, the conclusion of the paper is in Section IX.

2. MOTIVATION OF THE WORK

The need of accessing private information anytime and anywhere increases. Individuals and enterprises deploy their private information onto cloud storage, and this requires addressing of extra amount of risks, which makes it challenging to maintain the security outlines such as data security, confidentiality, integrity, authentication, and privacy. For instance, in 2011, the PlayStation Network was hacked causing the leak of information for millions of user accounts such as passwords, physical addresses, credit card information, and other personal information. Later, Sony announced that they could have taken special protection by encrypting the data on their network [5]. Therefore, to protect users' privacy, it is required from cloud service providers (CSPs) to save an encrypted version of the user's data. There are several techniques that perform encryption on users' data. However, as the data resides in cloud storage, it is required to be encrypted before performing any operation on the data. Privacy and confidentiality issues to the stored data might be caused. Homomorphic encryption allows performing computations on the encrypted data without decrypting it, and the results of the computations are the same as they were processed on the corresponding plaintext data. Thus, homomorphic encryption solves the problems of confidentiality and privacy of the stored data inside the cloud.

3. RELATED LITERATURE

The first homomorphic encryption was suggested by Rivest *et al.* [6] which was partially homomorphic encryption (PHA). Then RSA provided the multiplicative homomorphism [7]. Afterward, Yao, Goldwasser and Micali, Elgamal, Paillier [8]-[11] presented a PHA scheme. Subsequently, a FHE scheme suggested by Gentry [12] allows the calculation of any number of addition and multiplication and hence computing arbitrary functions of encrypted data. However, the scheme was based on somewhat homomorphic encryption (SWHE) which increases the length and noise of cipher text when calculation performs on the cipher text as shown in Fig. 1. Consequently, the authors of Dijk *et al.* [13] have introduced a FHE scheme that uses elementary modular arithmetic and use Gentry's techniques to convert a somewhat homomorphic cryptosystem to a FHE scheme. Afterward, in Smart and Vercauteren [14], an improved version of the Smart-Vercauteren encryption scheme was proposed, which allowed several times a decrease in the cipher text and key lengths. In 2013, HElib software package was released by IBM which implements homomorphic encryption, which made many optimizations to make homomorphic evaluation run faster, focusing mostly on the effective use of the Smart-Vercauteren cipher text packing techniques [15]. In addition, in Xiao *et al.* [16], the authors have proposed homomorphic encryption in which the security of a homomorphism depends on the hardness of large integer factorization using symmetric keys. The authors also show how key size and computational time are reduced enough for practical deployment. Then, several authors worked on homomorphic encryption and also examined it in cloud computing systems. In Maha and Said [17] the authors have studied different homomorphic encryption cryptosystems such as El-Gamal, Paillier, RSA, and Gentry in a cloud computing environment. In addition, the application of an algebraic homomorphic encryption mechanism was introduced in Reem and Khaled [18], this mechanism was aimed at better security and was based on Fermat's little theorem on cloud computing. In addition, in Hayward and Chiangb [19], the authors have proposed parallel processing for Gentry's encryption and were tested in a private cloud computing domain. Furthermore, the authors of Frederik *et al.* [20] have introduced the simplified and structured wide definitions in the homomorphic encryption discipline and questioned whether presently existing applications need homomorphic encryption supposed as an explainable solution to their problems, both in theoretical, along with practical approaches. In Hamad and Sagheer [21], the authors have implemented FHE over integers named SAM and show how the algorithm meets both additive and multiplicative homomorphism.

Recently, Xiao *et al.* [22] have proposed a privacy data protection method for industrial field equipment based on FHE scheme. In addition, the authors of Hashim and Benaissa [23] proposed their FHE accelerator on a hardware platform to speed up the encryption process so that practical encryption time could be achieved. They argued an optimization on digital signal processing utilization on modern field programmable gate array (FPGA), Virtex7.

Moreover, an efficient private database query proposal has been argued by Tan *et al.* [24], the protocol supports compound conditions with equality and order comparisons.

4. HOMOMORPHIC ENCRYPTION (HE)

This section will illustrate the basics of homomorphic encryption theory, then explain the different types of (HE). Homomorphic encryption can be categorized into three different types FHE, SWHE, and PHE. An encryption scheme is called homomorphic over an operation "+" if it supports the following equation:

$$E(Msg_1) + E(Msg_2) = E(Msg_1 + Msg_2), \quad \forall Msg_1, Msg_2 \in M \tag{1}$$

4.1. PHE

In PHE, either addition or multiplication is allowed regardless of the number of times. There are several useful examples of PHE such as RSA, Goldwasser-Micali, El-Gamal, Benaloh, and Paillier. While SWHE allows some types of operations with a limited number of times, some examples of SWHE are BNG by Dan *et al.* (Boneh-Goh- Nissim) [25] and Polly Cracker introduced by Fellows and Koblitz [26] in 1994. Nevertheless, FHE performs both addition and multiplication at the same time, and it can compute any operations, examples of FHE are Ideal Lattice-based FHE schemes [27], FHE schemes Over Integers [28], LWE-based FHE schemes [29], NTRU-like FHE schemes [30], Gen10 [31], and simple FHE scheme [32].

5. THE PROPOSED ALGORITHM (NAZUZ)

We have named our proposed algorithm NAZUZ; it is the nickname of the first author's mother who passed away during performing his research study. Unlike DGHV and SDC schemes, our proposed scheme instead of converting each plaintext character into binary values (0, 1). NAZUZ converts each plaintext character into ASCII code and passes it to the encryption algorithm as,

$$Enc = Msg + L(rK_s + Iter) \tag{2}$$

Where Enc is the ciphertext, Msg is the message $Msg \in [0, L-1]$, r is the noise, L is a big prime integer, K_s is the secret key generated by the key generation algorithm, and $Iter$ is a counter added as extra noise to the plaintext, these all are resulting in one ciphertext for each character in the plaintext, the rest of this section illustrates NAZUZ algorithm in details.

Secret key generation Ks:
Generate L, where L a big prime number is, then generate $r \in Z_n$, where r is the noise and ($r < L/4$ or $2r < L/2$), then calculate the secret key K_s as follows:

Choose multiple n prime numbers $p_1, p_2, p_3, \ldots p_n$ as secret keys, then calculate n as $n = p_1 \times p_2 \times p_3 \ldots \times p_n$, calculate M as $M = (p_1+1)(p_2+1)\ldots(p_n+1)$, then calculate $N_{sum} = \sum_{i=1}^{m} F_i$, where F_i = set of prime numbers up to M, and then calculate the average value of the sum of all prime numbers as $N_{avg\_sum} = \frac{N_{sum}}{M}$, then choose a random number R that satisfies $\gcd(R, N_{avg\_sum}) = 1$, then select U_s as it is the number of existing users of the cloud system $\{U_{s1}, U_{s2}, \ldots, U_{sn}\}$, where $U_s \geq 1$, calculate $\theta(n) = (p_1-1)\ldots(p_1-1)$, and calculate $Q = U_s \times (\theta(n) \bmod N_{sum})$ and finally calculate K_s as Flowchart shown in Fig. 2:

$$K_s = (R \times Q) \bmod 256 \tag{3}$$

Encryption Flowchart shown in Fig. 3:

$$Enc = Msg + L(rK_s + Iter) \tag{4}$$

Decryption flowchart shown in Fig. 4:

$$Msg = Enc \bmod L \tag{5}$$

Homomorphic evaluation:
Suppose there are two ciphertexts Enc_1 and Enc_2 as:

$$Enc_1 = Msg_1 + L(r_1 K_s + Iter)$$

$$Enc_2 = Msg_2 + L(r_2 K_s + Iter)$$

$Enc \bmod L = Msg$, where $Msg < L$, otherwise we must take ($Msg \bmod L$)

Additive Homomorphism:
First, we illustrate the sum of two ciphertexts Enc_1 and Enc_2 denoted by ($Enc^+ = Enc_1 + Enc_2$)

$$Enc^+ = Enc_1 + Enc_2 = (Msg_1 + Msg_2) + L(r_1 K_s + Iter) + L(r_2 K_s + Iter)$$

But

$$L(r_1 K_s + Iter) + L(r_2 K_s + Iter) = LK_s[(r_1 + r_2) + 2Iter] = 0$$

Then

$$Msg^{+} = \left(Enc_1 + Enc_2\right) \mod L = Msg_1 + Msg_2$$

Multiplicative Homomorphism:
To begin with, we illustrate the multiple of two ciphertexts Enc_1 and Enc_2 denoted by ($Enc^* = Enc_1 * Enc_2$)

$$Enc^{*} = [Msg_1 + L\left(r_1 K_s + Iter\right)] * [Msg_2 + L \left(r_2 K_s + Iter\right)]$$

$$Enc^{*} = [Msg_1 * Msg_2 + Msg_1 * L\left(r_2 K_s + Iter\right)] + L\left(r_1 K_s + Iter\right) * Msg_2 + L\left(r_1 K_s + Iter\right) * L\left(r_2 K_s + Iter\right)]$$

Since

$$L * [Msg_1 * \left(r_2 K_s + Iter\right) + \left(r_1 K_s + Iter\right) * Msg_2 + L * \left(r_1 K_s + Iter\right) * \left(r_2 K_s + Iter\right) \mod L] = 0$$ So that

$$Enc^{*} = Msg_1 \times Msg_2 + 0 = Msg_1 \times Msg_2$$

6. RESULTS AND ANALYSIS

To test the proposed algorithm NAZUZ, we have implemented a simulation using Java programming language and tested it on a computer with 16 GB RAM, an Intel Core i7 processor, and the Windows 10 64-bit operating system. In the following, various case studies will be presented to demonstrate the generation of the secret key and its corresponding values and to show how these values are used for encrypting and decrypting the plaintext value.

Case Study No.1
First, generate K_s as p_1=3, p_2=5, and p_1=7, assume U_s=10, $\theta(n)$=2×4×6=48, n=3×5×7=105, M=(3+1)(5+1)(7+1)=192, N_{sum}=102001, N_{avg_sum}=531 Q=10×(48mod102001)=480, R=5, K_s=(5×48)mod256=96, then choose a prime number L=457679, random numbers r_1=102235482 and r_2=782542926, assume $Iter$=3, and the messages are Msg_1=97 and Msg_2=98, then calculate the ciphertexts Enc_1 and Enc_2.

$$Enc_1 = Msg_1 + L\left(r_1 K_s + Iter\right)$$
$$= 97 + 457679 * (102235482 \times 96 + 3)$$
$$= 4491939185335822$$

$$Enc_2 = Msg_2 + L(r_2 K_s + Iter)$$
$$= 98 + 457679 * \left(782542926 \times 96 + 3\right)$$
$$= 34382732528933519$$

Proof of Additive Homomorphism:

$$Enc^{+} = Enc_1 + Enc_2 = 4491939185335822$$
$$+34382732528933519 = 3887467171426934$$

$$Msg^{+} = Enc^{+} \mod L =$$
$$38874671714269341 \mod 457679 = 195$$

$$Msg^{+} = Msg_1 + Msg_2 = 97 + 98 = 195$$

Proof of Multiplicative Homomorphism:

$$Enc^{*} = Enc_1 \times Enc_2 = 4491939185335822$$
$$*34382732528933519 =$$
$$154445143545637098259373527217 62e + 32$$

$$Msg^{*} = Enc^{*} \mod L =$$
$$154445143545637098259373527217 62e + 32 \mod$$
$$457679 = 9506$$

$$Msg^{*} = Msg_1 \times Msg_2 = 97 \times 98 = 9506$$

Case Study No.2
This time we have tested NAZUZ on a plaintext file. Choose a prime number L=457679, a random number r=102235482, which is generated as illustrated in case study number one, and a text file that contains the message Msg = Hello This is my text to be: -->Encrypted "HELLOOOOW WORLD" please keep my file in a safe location. After encrypting the plaintext file, the ciphertext file contains:

4491939183962772	4491939184420471
4491939184878151	4491939185335840
4491939185793436	4491939186251188
4491939186708877	4491939187166473
4491939187624229	4491939188081920
4491939188539510	4491939188997273

4491939189454937	4491939189912635
4491939190370310	4491939190827905
4491939191285668	4491939191743342
4491939192200942	4491939192658687
4491939193116369	4491939193574005
4491939194031671	4491939194489350
4491939194947046	4491939195404732
4491939195862452	4491939196320120
4491939196777814	4491939197235500
4491939197693170	4491939198150853
4491939198608517	4491939199066195
4491939199523806	4491939199981487
4491939200439204	4491939200896880
4491939201354566	4491939201812245
4491939202269927	4491939202727606
4491939203185285	4491939203642964
4491939204100651	4491939204558275
4491939205016009	4491939205473680
4491939205931362	4491939206389035
4491939206846706	4491939207304351
4491939207762028	4491939208219787
4491939208677462	4491939209135134
4491939209592809	4491939210050506
4491939210508171	4491939210965781
4491939211423535	4491939211881208
4491939212338887	4491939212796577
4491939213254176	4491939213711932
4491939214169623	4491939214627213
4491939215084962	4491939215542644
4491939216000326	4491939216457998
4491939216915608	4491939217373360
4491939217831044	4491939218288645
4491939218746389	4491939219204003
4491939219661765	4491939220119426
4491939220577110	4491939221034788
4491939221492398	4491939221950153
4491939222407835	4491939222865502
4491939223323179	4491939223780877
4491939224238545	4491939224696230
4491939225153908	4491939225611523

Case Study No. 3

This time we have also tested NAZUZ on a plaintext file with different values for the algorithm. Choose a prime number L=15485863, a random number r=882235482, which is generated as illustrated in case study number one, and a text file that contains the message *Msg*= Hello This is my text to be:-->Encrypted "HELLOOOOW WORLD" please keep my file in a safe location. After encrypting the plaintext file, the ciphertext file contains:

1311569069567132820	1311569069582618703
1311569069598104567	1311569069613590440
1311569069629076220	1311569069644562156
1311569069660048029	1311569069675533809
1311569069691019749	1311569069706505624
1311569069721991398	1311569069737477345
1311569069752963193	1311569069768449075
1311569069783934934	1311569069799420713
1311569069814906660	1311569069830392518
1311569069845878302	1311569069861364231
1311569069876850097	1311569069892335917
1311569069907821767	1311569069923307630
1311569069938793510	1311569069954279380
1311569069969765284	1311569069985251136
1311569070000737014	1311569070016222884
1311569070031708738	1311569070047194605
1311569070062680453	1311569070078166315
1311569070093652110	1311569070109137975
1311569070124623876	1311569070140109736
1311569070155595606	1311569070171081469
1311569070186567335	1311569070202053198
1311569070217539061	1311569070233024924
1311569070248510795	1311569070263996603
1311569070279482521	1311569070294968376
1311569070310454242	1311569070325940099
1311569070341425954	1311569070356911783
1311569070372397644	1311569070387883587
1311569070403369446	1311569070418855302
1311569070434341161	1311569070449827042
1311569070465312891	1311569070480798685
1311569070496284623	1311569070511770480
1311569070527256343	1311569070542742217
1311569070558228000	1311569070573713940
1311569070589199815	1311569070604685589
1311569070620171522	1311569070635657388
1311569070651143254	1311569070666629110
1311569070682114904	1311569070697600840
1311569070713086708	1311569070728572493
1311569070744058421	1311569070759544219
1311569070775030165	1311569070790516010
1311569070806001878	1311569070821487740
1311569070836973534	1311569070852459473
1311569070867945339	1311569070883431190
1311569070898917051	1311569070914402933
1311569070929888785	1311569070945374654
1311569070960860516	1311569070976346315

NAZUZ has also been tested on different file sizes including large text file size of 93 MB, and as it is illustrated in Table 1, Figs. 5 and 6, the proposed algorithm has a better performance for file encryption and decryption.

6.1. Noise Complexity and Security Enhancement

The term "noise complexity" relates to introducing unpredictable variations during mathematical operations in FHE. This introduces a layer of security, making it arduous for unauthorized parties to extract meaningful information from encrypted data. These variations, termed "noise," act as a barrier against decryption attempts without proper authorization.

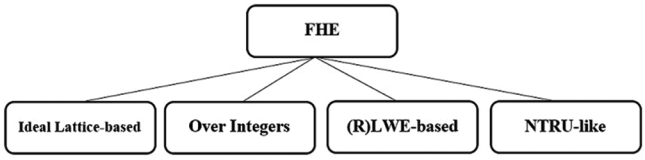


Fig. 1. Main fully homomorphic encryption schemes after Gentry's discovery [33]

6.2. Impact on Performance

While noise complexity significantly elevates security, it brings about a trade-off with performance. The inclusion of noise requires additional computational steps during decryption to handle its effects. This leads to increased processing time

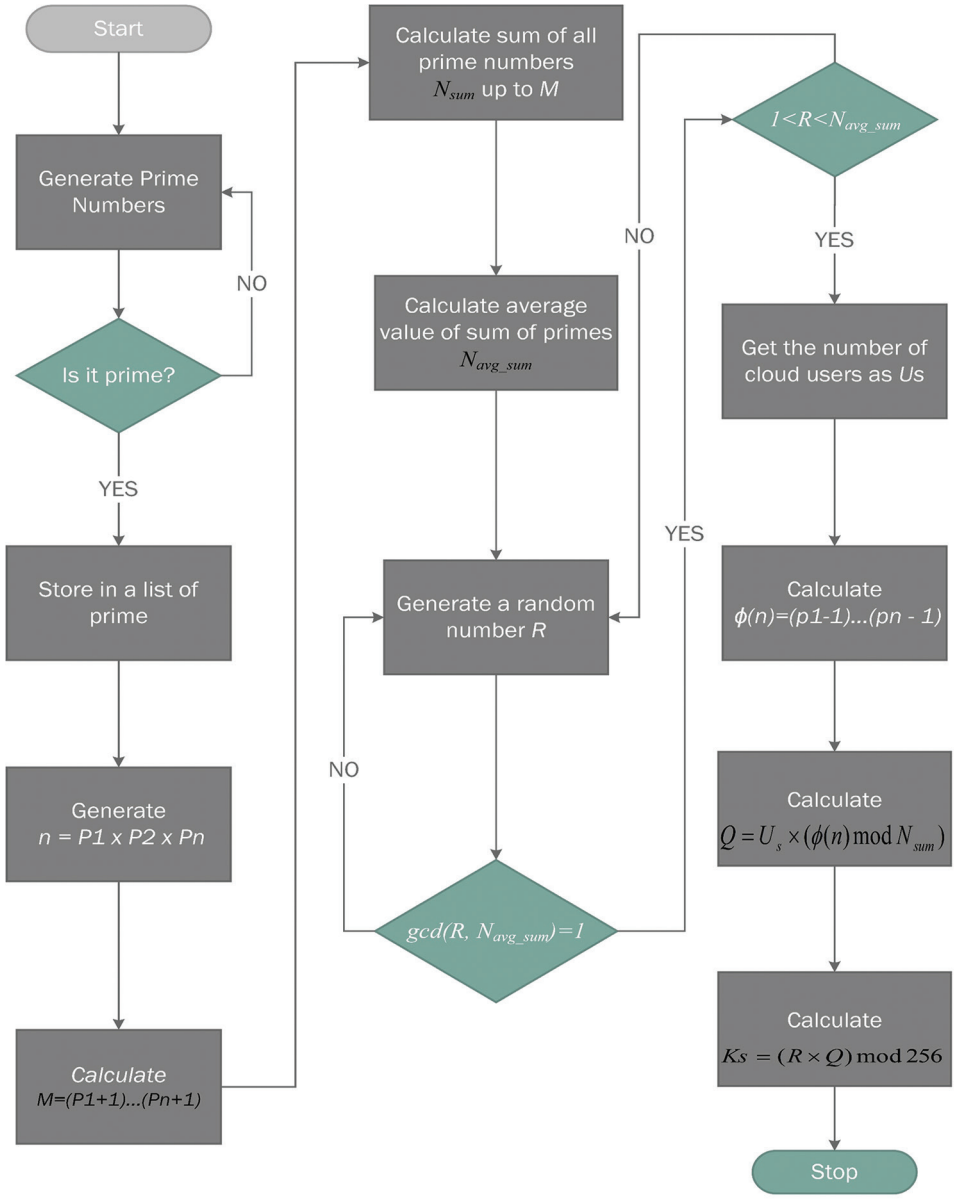


Fig. 2. Key generation flowchart

and resource utilization. This trade-off becomes particularly crucial when dealing with scenarios involving numerous users.

Table 1: NAZUZ performance on different file sizes

File size	Encryption time in seconds	Decryption time in seconds
10 KB	0.054	0.116
20 KB	0.116	0.201
50 KB	0.176	0.337
100 KB	0.263	0.456
200 KB	0.401	0.67
500 KB	0.783	1.288
1000 KB	1.419	2.322
2 MB	2.669	4.327
4 MB	4.744	6.686
8 MB	7.121	9.001
12 MB	9.783	12.451
16 MB	12.315	15.919
24 MB	15.460	25.158
47 MB	26.856	49.989
93 MB	56.968	98.212

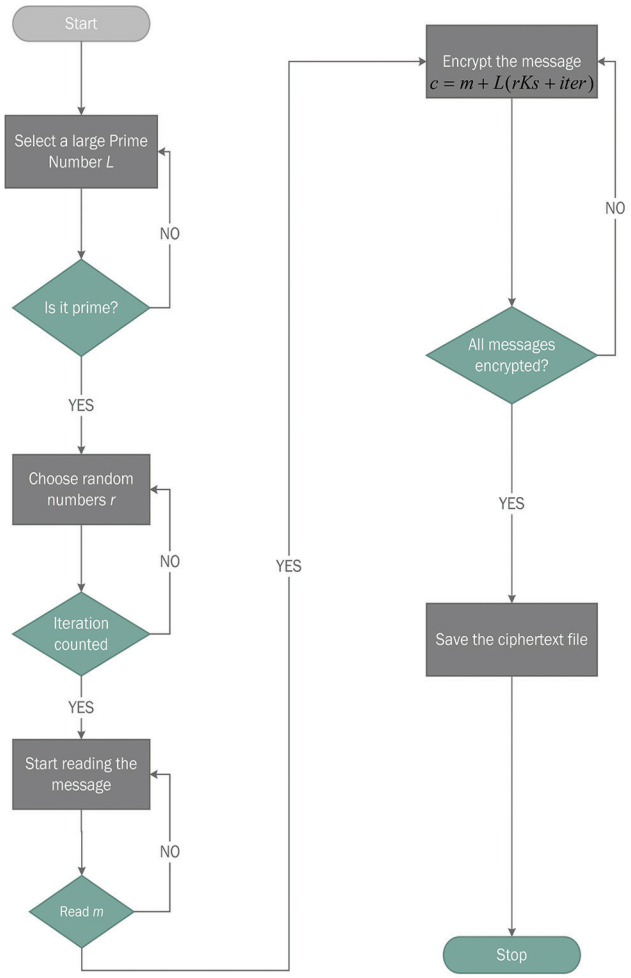


Fig. 3. Encryption flowchart

6.3. Strategies for Noise Management

To tackle the performance implications associated with noise complexity, several strategies are employed. These include monitoring noise levels, altering mathematical parameters, and employing controlled noise reduction techniques. These techniques are vital to ensure data integrity during decryption while maintaining acceptable performance levels.

6.4. Noise Complexity in Nazuz and Scalability Evaluation

The NAZUZ encryption approach integrates noise complexity intrinsically into the encryption process. As data undergo mathematical transformations, noise is introduced

Fig. 4. Decryption flowchart

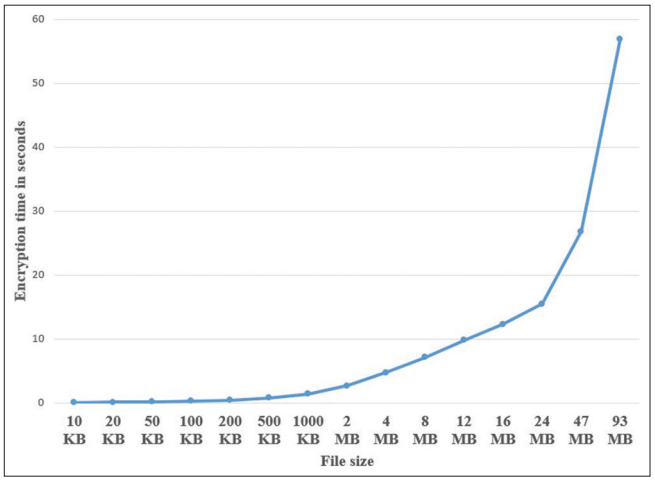


Fig. 5. Encrypting different file sizes measured in seconds

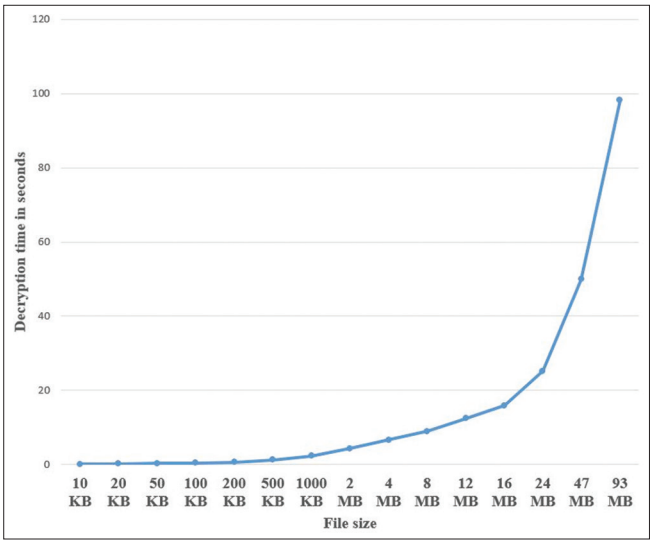


Fig. 6. Decrypting different file sizes measured in seconds

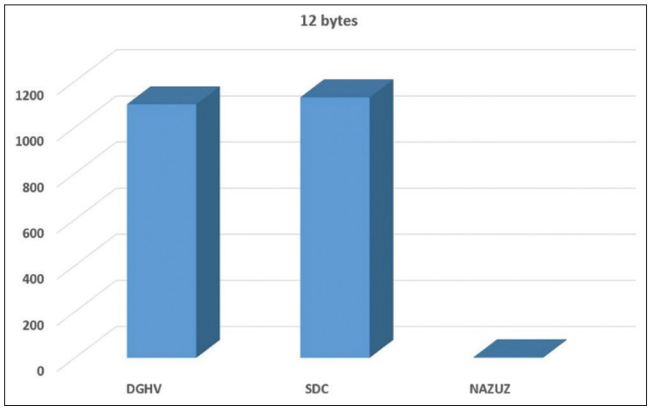


Fig. 7. Comparing NAZUZ to DGHV and SDC over a message of size 12 bytes

into the encrypted output. Our methodology encompasses noise management techniques, balancing security and performance considerations.

7. COMPARING NAZUZ TO DGHV AND SDC SCHEMES

The proposed algorithm (NAZUZ) has been compared to both DGHV and SDC schemes in terms of performance and it shows that the proposed algorithm works better than the other mentioned schemes, Table 2, Figs. 7-9 illustrate the comparison on different lengths of messages.

7.1. Limitations of the Work

The encryption process generates a ciphertext file that is larger than its corresponding plaintext file, and these results in

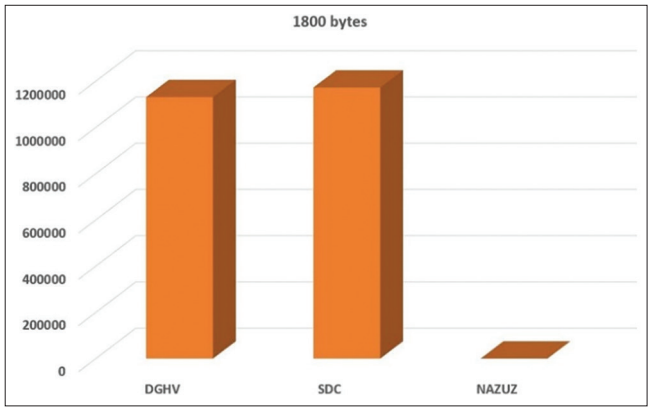


Fig. 8. Comparing NAZUZ to DGHV and SDC over a message of size 1800 bytes

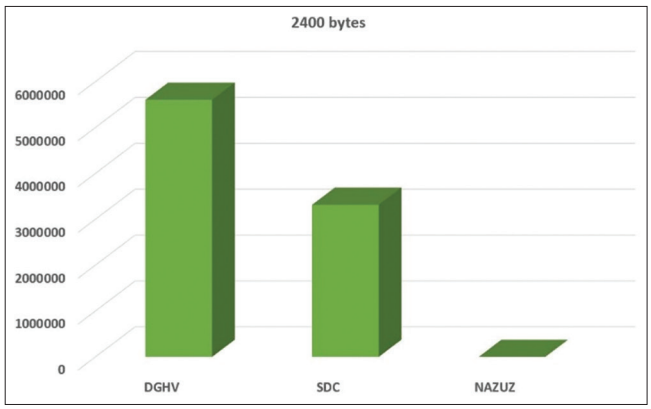


Fig. 9. Comparing NAZUZ to DGHV and SDC over a message of size 2400 bytes

Table 2: Comparing performance of DGHV, SDC, and NAZUZ measured in millisecond

Message length	DGHV (MS)	SDC (MS)	NAZUZ (MS)
12 bytes	1100	1130	3
1800 bytes	1130710	1172057	20
2400 bytes	5604037	3314788	35

the decryption process taking longer time than the encryption process.

8. CONCLUSION

A new dimension to cloud storage will be introduced using homomorphic encryption. The data will not be exposed at any stage so its confidentiality is guaranteed. Using FHE, the security of cloud computing will have a new concept and that is to perform calculations on encrypted data and produce the results without the knowledge of the original

data, and the confidentiality of data is respected. In this paper, we have proposed a FHE scheme named NAZUZ to protect cloud data at rest; this is by saving an encrypted version of the user's data. NAZAUZ works on converting each character of plaintext into a corresponding ASCII value, then passing it to the encryption algorithm. The results show that our proposed algorithm works better than other proposed algorithms in terms of security and performance, which works on encrypting large file sizes. NAZUZ provides very high security as it depends on the difficulty of factoring large integer numbers, which is still an open problem in mathematics. It also adds the complexity of noise to the plaintext, by taking the number of users of the cloud system. As well as the characteristic of FHE that allows performing calculations on ciphertext solves the problem of key management. It also generates different ciphertext even if the same character appeared more than once in the plaintext file. Therefore, it protects the plaintext file from being guessed or retrieved based on character repetition.

REFERENCES

[1] B. Alabdullah, N. Beloff and M. White. "*Rise of Big Data-Issues and Challenges*". Society National Computer Conference (NCC), Saudi Arabia, 2018.

[2] D. Gonzales, J. M. Kaplan, E. Saltzman, Z. Winkelman and D. Woods. "Cloud-trust-a security assessment model for infrastructure as a service (IaaS) clouds". *IIEEE Transactions on Cloud Computing*, vol. 5, no. 3, pp. 523-536, 2017.

[3] R. Hamza, A. Hassan, A. Ali, M. Bashir, S. Al Qhutani, T. Tawfeeg and A. Yousif. "Towards secure big data analysis via fully homomorphic encryption algorithms". *Entropy*, vol. 24, no. 4, p. 519, 2022.

[4] B. Vankudoth and D. Vasumathi. "Homomorphic encryption techniques for securing data in cloud computing: A survey". *International Journal of Computer Applications*, vol. 160, no. 6, pp. 1-5, 2017.

[5] K. Sangani. "Sony security laid bare". *Engineering and Technology*, vol. 6, no. 8, pp. 74-77, 2011.

[6] R. L. Rivest, L. Adleman and M. L. Dertouzos. "On data banks and privacy homomorphisms. In: *Foundations of Secure Computation*". Academic Press, New York, 1978, pp. 169-180.

[7] M. Alia. "Combining public-key encryption with digital signature scheme. In: *Advances in Intelligent Systems and Computing*". Springer, Germany, 2016, pp. 870-878.

[8] A. C. Yao. "*Protocols for Secure Computations. Proceedings of the 23rd Annual Symposium on Foundations of Computer Science* (*SFCS '82*)". IEEE Computer Society, 1982, pp. 160-164.

[9] S. Goldwasser and S. Micali. "Probabilistic encryption". *Journal of Computer and System Sciences*, vol. 28, no. 2, pp. 270-299, 1984.

[10] T. Elgamal. "A public key cryptosystem and a signature scheme based on discrete logarithms". *IEEE Transactions on Information Theory*, vol. 31, no. 4, pp. 469-472, 1985.

[11] P. Paillier. "Public-key cryptosystems based on composite degree residuosity classes. In: *Advances in Cryptology-Eurocrypt* '99". vol. 1592, Springer, Germany, 1999, pp. 223-238.

[12] C. Gentry. "*Fully Homomorphic Encryption Using Ideal Lattices. In: Proceedings of the Forty-First Annual ACM Symposium on Theory of Computing* (*STOC '09*)", 2009, pp. 169-178.

[13] M. Dijk, C. Gentry, S. Halevi and V. Vaikuntanathan. "Fully homomorphic encryption over the integers. In: *Advances in Cryptology-Eurocrypt*". Springer, Germany, vol. 6110, pp. 24-43, 2010.

[14] N. Smart and F. Vercauteren. "Fully homomorphic encryption with relatively small key and ciphertext sizes. In: *Public Key Cryptography-PKC*". *2010*, Springer, Germany 2010, pp. 420-443.

[15] J. H. Cheon, H. Choe, D. Lee and Y. Son. "Faster linear transformations in HElib, revisited". *IEEE Access*, vol. 7, pp. 50595-50604, 2019.

[16] L. Xiao, O. Bastani and I. L. Yen. "*An Efficient Homorphic Encryption Protocol for Multi-User Systems*". IACR Cryptology, Bellevue, WA, 2012.

[17] T. Maha and E. L. H. Said. "Secure cloud computing through homomorphic encryption". *Computing Research Repository*, vol. 1409, 2014.

[18] A. Reem and E. Khaled. "*Cloud Computing Algebra Homomorphic Encryption Scheme Based on Fermat's Little Theorem*". The American Society of Engineering Education, United States, 2013.

[19] R. Hayward and C. Chiangb. "Parallelizing fully homomorphic encryption for a cloud environment". *Journal of Applied Research and Technology*, vol. 13, no. 2, pp. 245-252, 2015.

[20] A. Frederik, C. Boyd, C. Carr, K. Gjøsteen, A. J¨aschke, C. A. Reuter and M. Strand. "*A Guide to Fully Homomorphic Encryption*". vol. 1192. IACR Cryptology, Bellevue, WA, 2015.

[21] S. S. Hamad and A. M. Sagheer. "Design of fully homomorphic encryption by prime modular operation". *Telfor Journal*, vol. 10, no. 2, pp. 118-122, 2018.

[22] F. Xiao, J. Wang, M. Wei, C. Liu, V. Le and J. Xu. "*Privacy Data Protection Scheme of Industrial Field Equipment Based on Fully Homomorphic Encryption. In: 2023 International Conference on Information Networking* (*ICOIN*)". Bangkok, Thailand, 2023, pp. 236-241.

[23] S. Hashim and M. Benaissa. "*Fully Homomorphic Encryption Accelerator Using DSP Embedded Multiplier. In: 2023 15th International Conference on Computer Research and Development* (*ICCRD*)". Hangzhou, China, 2023, pp. 278-284.

[24] B. H. M. Tan, H. T. Lee, H. Wang, S. Ren and K. M. M. Aung. "Efficient private comparison queries over encrypted databases using fully homomorphic encryption with finite fields". *IEEE Transactions on Dependable and Secure Computing*, vol. 18, no. 6, pp. 2861-2874, 2021.

[25] B. Dan, G. Eu-Jin and N. Kobbi. "*Evaluating 2-DNF formulas on ciphertexts. In: Proceedings of Theory of Cryptography Conference*". vol. 3378, 2005, pp. 325-341.

[26] M. Fellows and N. Koblitz. "*Combinatorial Cryptosystems Galore!. In: Second International Conference on Finite Fields: Theory, Applications, and Algorithms August* (*Contemporary Mathematics*) *of Finite Fields: Theory, Applications, and Algorithms*, vol. 168, 1993, pp. 51-61

[27] G. Craig. "*A Fully Homomorphic Encryption Scheme. Ph.D. Dissertation*". Stanford University, 2009.

[28] L. Cardoso dos Santos, G. Rodrigues Bilar and F. Dacêncio

Pereira. "*Implementation of the fully homomorphic encryption scheme over integers with shorter keys*". *In: 2015 7th International Conference on New Technologies*, Mobility and Security (NTMS), Paris, 2015, pp. 1-5.

[29] R. Oded. "*On Lattices, Learning with Errors, Random Linear Codes, and Cryptography*. *In: Proceedings of the Thirty-Seventh Annual ACM Symposium on Theory of Computing* (*STOC '05*)", 2005, pp. 84-93.

[30] H. Jeffrey, P. Jill and J. S. Joseph. "*NTRU: A Ring-Based Public Key Cryptosystem. In: International Algorithmic Number Theory Symposium*". Springer, Germany. pp. 267-288, 1998.

[31] G. Craig. "Computing arbitrary functions of encrypted data". *Communications of the ACM*, vol. 53, no. 3, pp. 97-105, 2010.

[32] J. Li, D. Song, S. Chen and X. Lu. "*A Simple Fully Homomorphic Encryption Scheme Available in Cloud Computing. In: 2012 IEEE 2nd International Conference on Cloud Computing and Intelligence Systems*". Hangzhou, 2012, pp. 214-217.

[33] A. Acar, H. Aksu, A. S. Uluagac and M. Conti. "A survey on homomorphic encryption schemes: Theory and implementation". *ACM Computing Surveys*. vol. 51, no. 4, pp. 1-35, 2018.

ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Acoustic Comfort Evaluation in Traditional Houses and its Impact on Inhabitant Satisfaction in the City of Sulaimani

Shilan Ameen Mustafa, Banaz Nasraldeen Muhealdeen

Department of Architecture, College of Engineering, University of Sulaimani, Sulaymaniyah, Iraq

ABSTRACT

Acoustic comfort is one of the essential needs for people to live in calm and comfort in dwellings. Because of technological and industrial development, noise pollution became one of the big dangers that impacts human psychologically and physiologically. The historical neighborhoods in Sulaimani City are affected by this technological advancement, the demolishing of traditional houses and changed to commercial has increased the environmental noise. Therefore, this research aims to evaluate residents' satisfaction in traditional houses in term of acoustic conditions, also aims to investigate if the design characteristics of traditional houses have role in providing acoustic comfort, and to promote traditional designs in today's architecture. The absence of a practical study evaluating acoustic conditions in traditional houses and their impact on inhabitants' satisfaction in Sulaimani city formed the main problem of the research. The results from the questionnaire and the *in situ* measurements have shown that, although most of these old houses were demolished and changed to commercial areas, the acoustic environment inside most houses is comfortable and most inhabitants are satisfied with the acoustic conditions. The traditional design turned the houses to be a barrier against transmitting noise whether from outside to inside or vice versa.

Index Terms: Acoustic comfort, Noise, Inhabitant's satisfaction, Noise control, Traditional characteristics, Traditional house.

1. INTRODUCTION

Comfort and relaxation are two crucial basic needs for human life. Comfort can also be explained in terms of pleasantness and satisfaction, these two features have also been involved alongside noise annoyance in acoustic surveys relating to subjective noise evaluation [1, p. 21]. In the historical neighborhoods in Sulaimani city, the changing of land use from residential to commercial, and mixing residential areas with commercial arias has increased the environmental noises in these neighborhoods.

Therefore, this research focused on human's satisfaction in term of acoustic comfort inside dwellings. Furthermore, it focused on the traditional houses in the city of Sulaimani as study cases, because of its unique design and construction if compared to modern or contemporary architecture in the city. Moreover, there is a gap of knowledge about this type of houses in term of acoustic comfort.

Hence, the main problem of this research is the lack of such research focusing on acoustic conditions and noise problems, and its impact on people's satisfaction, in Sulaimani city. Furthermore, there is a lack of such attempt to assess traditional house design in term of acoustic comfort, in the city of Sulaimani.

Access this article online

DOI: 10.21928/uhdjst.v7n2y2023.pp50-68

E-ISSN: 2521-4217
P-ISSN: 2521-4209

Corresponding author's e-mail: shilan.mustafa@univsul.edu.iq, banaz.muhealdeen@univsul.edu.iq

Received: 07-08-2023 Accepted: 08-11-2023 Published: 14-12-2023

Therefore, the research aims to: Evaluate residents' satisfaction in traditional house in term of noise and acoustic conditions inside their house, also, aims to investigate if the design characteristics of traditional houses have the core role in providing acoustic comfort, in order to enhance the traditional design in today's house design.

2. LITERATURE REVIEW

There are many studies and research examining the issue of the noise problem in residential projects, especially residential buildings, in various regions and around the world in general [1], [2], [3]. Furthermore, there are many studies that evaluate traditional house in the Kurdistan region in terms of, formation type, thermal comfort, visual comfort, and indoor air quality [4], [5], [6], [7].

However, studies that address the issue of the acoustic conditions of traditional houses, whether in Iraq or the Kurdistan region in general, and the city of Sulaymaniyah in particular, are rare or non-existent. The only source or research that has a weak relation with this topic is a study by Susan Abd Hassan, entitled "Sound environment of Cities: A Comparison Study for Sound Environment between Modern and Traditional urban fabric in Baghdad city," the study focused on comparison of acoustic environments between traditional and modern urban fabric in Bagdad city. Moreover, it emphasized on technological changes that have changed urban traditional fabrics and acoustic environments [8]. However, the evaluation of acoustic conditions of the traditional houses, and people's satisfaction of the indoor sonic environment has not been considered. The researcher did not find a study that specifically studies the traditional houses in Sulaimani city in term of acoustic comfort and its impact on residents' satisfaction and wellbeing.

After observing previous studies and ensuring that this problem has not been studied, the research hypothesized following basic points:

1. Although, the environmental noise has increased in old neighborhoods in Sulaimani city. There is a strong relationship between acoustic comfort inside traditional houses and inhabitants' satisfaction and preferences.
2. The design characteristics of Sulaimani's traditional houses have the key role in providing acoustic comfort.

2.1. Acoustic Comfort

Comfort is "the state of being physically relaxed and free from pain"; as well as "the state of having a pleasant life, with everything that you need" (www.oxfordlearnersdictionaries.com) [9]. Hence, "Acoustic comfort is the state of comfort which relates to the acoustic conditions in general, the sound environment, and the sound stimuli around" [1]. Cummins was the first to use the concept of acoustic comfort concerning buildings, in his book "*Classes of acoustical comfort in Housing"* Daniel Commins defined Acoustical comfort as: *"The ability of buildings to protect the users against noise and to provide an acoustical environment suitable to human activity."* [10, p. 1]. Then, acoustic comfort is characterized by Rindel and Rasmussen [11], as: "Absence of unwanted sound, presence of wanted sound of desired level and quality. Opportunities for acoustic activities without annoying or disturbing other people and without being heard by unauthorized persons" [11, p. 3], [12, p. 400].

The design, the planning, and the construction methods are all considered to be the features that affect acoustic performance. When sound behaviors in reflection and absorption are perfectly controlled, the outcome of which determines the nature of the efficiency of acoustic performance in space [13, p. 3].

2.2. Noise and Source of Noise

Szokolay (2004) defines noise as "random vibrations, showing no regular pattern". Noise is regarded to be a subjective phenomenon, that is, one person may enjoy a sound but the same sound could be a noise for someone else. The only meaningful definition of noise is therefore "unwanted sound" [14, p. 153]. Furthermore, any sound undesired by the recipient is classed as noise, as it detracts from the quality of human life [15, p. 38]. According to Cowan, "noise, as a sub-discipline of acoustics can be described in terms of two key parameters, namely, frequency and wavelength. These parameters are quantities that describe the nature of pressure fluctuations in a medium, such as air, which is eventually interpreted as sound in the brain. Both of the parameters are influenced by the speed of sound, direction of sound travel, and the time that sound arrives at a listener's ears" [2, p. 162]. According to Commins and Meier [10], noise sources consist of:

- Human source: Voice, steps, movements, radio, television
- Individual equipment: Apartment heaters, washing machines, and other domestic equipment.
- Collective equipment: Heaters, lifts, transformers, air conditioners.
- Outdoor noise: Automobile, bus, railway, aircraft noise, industrial noise, etc. [10, p. 4].

Based on Rindel [12], the most serious problem may be exposure first to traffic noise and the need for sound insulation of windows and façades. Second noise from neighbors and the need for sound insulation of internal walls and floors [12, p. 395], to prevent sound transmission through separating elements. Besides, it is crucial to prevent noise propagation through the adjoining, so-called flanking components. Accordingly, building acoustics has to consider and evaluate both the separating and the flanking components [16, p. 25].

Accordingly, noise can be classified into three types according to their sources:

1. Noise from outside: Such as traffic noise, motorcycles, children playing, dogs barking, industries, construction, etc.
2. Noise from neighbors: Such as TV, appliances, people talking, children playing/crying.
3. Internal noise: such as acoustic resonance, TV, people talking, noise from kitchen, and appliances.

2.3. Impact of Noise on Humans

Hearing as a physical process and listening as a psychological act are regarded as two different processes in which the listening process suggests a connection to what we are hearing [17, p. 1]. Regarding human health, noise can have short-term as well as long-term effects. The effects are not directly observable and can vary according to the time of day [18, p. 16]. Exposure to high levels of noise may trigger stress reactions, sleep-stage changes, and other biological and biophysical effects which consequently result in a worsening of different health risk factors such as blood pressure. These changes, within a small part of the population, may develop serious clinical symptoms, such as insomnia and cardiovascular diseases that, as a consequence, can increase rates of premature mortality [19, p. 8].

2.3.1. Annoyance

According to the oxford dictionary Annoyance is "the feeling of being slightly angry" (www.oxfordlearnersdictionaries.com) [20]. Furthermore, described to be a feeling of displeasure toward an agent or a condition that seem to affect an individual or a group by Koelega, 1987, cited in [19, p. 9]. Apart from traffic noise which has been seriously known as a source of annoyance, the investigation of LARES (Large Analysis and Review of European housing and health Status) confirmed that neighbor noise as a chronic noise is associated with hypertension, depression, and migraine. Neighbor noise annoyance is a highly underestimated risk factor for healthy housing [3].

2.3.2. Sleep disturbance

According to WHO (1999), uninterrupted sleep is known to be a prerequisite for good physiological and mental functioning of healthy persons; however, sleep disturbance is considered to be one of the effects arising from exposure to environmental noise. Noise can cause difficulty in falling asleep, awakening, and alterations to the depth of sleep, especially a reduction in the proportion of healthy rapid eye movement sleep [19, p. 8]. Sleep disturbance is thought to have the greatest effect on health because it can have impacts on alertness, performance at work and general quality of life [21, p. 5]. Based on the findings from a large survey by The World Health Organization in eight European cities from 2002 to 2003, of all responding residents, 24% reported that noise exposure at night was the main reason for sleep disturbance, especially traffic noise and noise from neighbors were identified as the most dominant cause of sleep disturbance [12, p. 396].

2.3.3. Negative human emotion

In addition to annoyance following exposure to prolonged high levels of environmental noise, people may also feel a variety of other negative emotions, for example, feelings of anger, depression, helplessness, anxiety, and exhaustion [19, p. 9], that will affect daily social life and productivity [15, pp. 38-39]. Based on Rendil's findings [12], neighbor noise may affect people in different ways. some people may react with curiosity, changing to annoyance and anger and, in severe cases, ending with hatred and other similar reactions. On the other hand, other people may react with irritation, growing to tension and depression [12, pp. 396-397].

The explanation of the impact of noise on humans demonstrated that exposure to noise whether short-term or long-term has its effect on people, such as sleep disturbance, annoyance, and human emotions. Following exposure to prolonged high levels of environmental noise, people may also feel a variety of other negative emotions that affect daily social life and productivity as well as cause neuro-vegetative-hormonal regulatory disturbances followed by illness. Noise problems were surveyed as the greatest single source of dissatisfaction related to where people live.

2.4. Human Satisfaction and Acoustic Conditions

To achieve real satisfaction, the human body should therefore be at a level of comfort, that depends on the adaptation of the inside to the outside environment. Navay and Veitch identified that acoustic satisfaction is a dimension of environmental satisfaction, which is defined as "a state of contentment with physical environmental conditions."

Moreover, they explained that the name acoustic satisfaction refers specifically to satisfaction, with acoustic conditions, as, the term "*dissatisfaction*" has the same meaning as the term "*distracting,"*, irritating, and annoying and is often used to evaluate annoyance with acoustic conditions such as noise level [22, p. 9].

Accordingly, the environment is one of the key factors to influence human comfort, thus; to provide human comfort, one must pay attention to specific designs and techniques in construction approaches or methods of designing a place [4, p. 238]. According to Zannin (2003) and Lee (2007), the mean value for acoustic conditions that listeners can adapt to should not exceed 62–65 dBA, as cited in [2, pp. Ch. 7, 13], also the Iraqi requirements for noise level inside houses indicated 45dB as an acceptable level of acoustic conditions during 24 h according to external noise [23, pp. Ch. 2, 31].Based on Yu's study, a number of positive sounds are in existence in the environment and that pleasant sounds allow people to enjoy their living environment [18, p. 17]; however, Hewitt (2015) in his book "Conceptual Physics" classified Sound into pleasant or unpleasant sounds, most unpleasant sounds are several noise types, and, pleasant sounds are often related to music, as cited in [24, p. 2]. The parameters that impact on human satisfaction include:

2.4.1. Sound level effects

Loud or silent describes a sound that produces a large or small auditory sensation, which is related to the physical intensity of the sound. However, the subjective sensation is not in simple proportion to the objective intensity [15, p. 17]. According to Navay and Veitch's review (2003), ambient noise levels (from all sources) that exceed 45–50 dB(A) are associated with annoyance. However, they added, "There could be some sources that are more annoying even at lower levels or others that are tolerable at higher levels" [22, p. 15].

2.4.2. Sound frequency

Middle- and high-frequency sound wavelengths occupy dimensions on the order of the scale of the diameter of the human ear canal. It is these frequencies, then, that resonate in our auditory system, which is why we are more sensitive to frequencies at 500 Hz and above than to those at 250 Hz and below. However, low-frequency sounds should command our attention too, despite our diminished sensitivity to them. Low-frequency sounds are what build up annoying resonances (also called standing waves) in small spaces. Finally, fans, pumps, elevators, garbage disposals, generators, trash compactors, and garage, door openers, many of the machines found in buildings generate considerable low-frequency noise [25, p. 22]. The investigation on the impact of sound frequency on satisfaction showed that too much high-frequency contribution to ambient noise can be unsatisfactory or annoying to occupants [22, p. 17].

2.4.3. Type of sound source

The previous studies demonstrated that traffic noise and neighbor noise are associated with annoyance [3], and both were highlighted as the dominant cause of sleep disturbance [12, p. 396]. In addition to annoyance and sleep disturbance following exposure to prolonged high levels of environmental noise, people may also feel a variety of other negative emotions, for example, feelings of anger, depression, helplessness, anxiety, and exhaustion [19, p. 9].

Studies have proven that people's satisfaction with their houses and where they live will depend on acoustic conditions and many acoustic parameters, such as sound level, sound frequency, and sound source are identified to have strong relation with people's satisfaction. It has been investigated that the psychological and physiological effects that noise has on people imply a key role in dissatisfaction related to where people live.

2.5. Controlling Noise Inside Buildings

According to studies, controlling noise is the main aspect that improves acoustic comfort inside buildings especially during the design process. Mommertz [16] in his book demonstrated the importance of noise control, especially in housing because it plays a great role in the health and well-being of people [16, p. 49]. It can be possible to improve acoustic comfort in dwellings using architectural and structural design, such as.

2.5.1. Space planning of the interior layout

Positioning noisy areas so that they are far from quiet areas is often the best of the solutions available [25, pp. 185-186]. Commins and Meier have classified rooms according to acoustic comfort in dwellings into "Noisy" rooms, which include kitchens, bathrooms, play-room, toilets, and living-room. Moreover, "Sensitive" rooms: Including bedrooms [10, p. 51], However, living room is also required quite location in the house according to Mommertz [16].

2.5.2. Room Orientation

Wherever possible, bedrooms and living rooms should be placed on the side facing away from the noise, because, the sound level in front of the windows on the side of the building facing away from the source of the noise is about 5–10 dB lower than that on the side facing the source [16, p. 46]. Ermann has recommended that it is important to

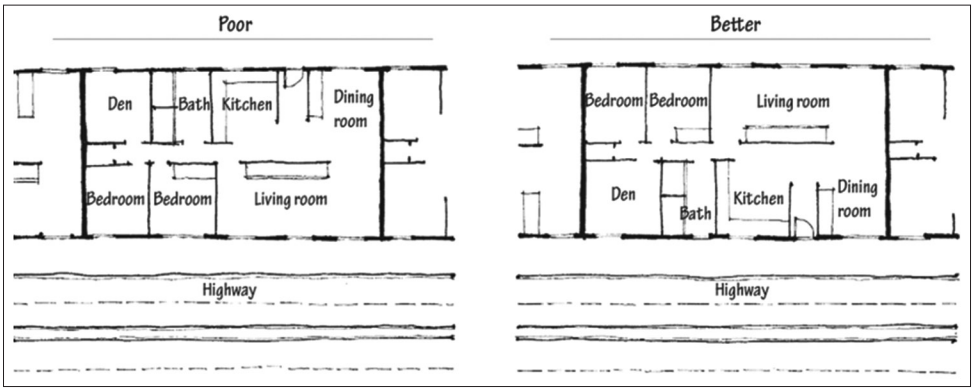


Fig. 1. The impact of room orientation on reduction of noise [23, p. 203].

orient quiet spaces, such as bedrooms, so their wall exposure is on a building face away from the noise source. Moreover, noisier spaces such as kitchens, bathrooms, and utility spaces can be used as buffers on the noisy face of the building. [25, p. 216] (Fig. 1).

2.5.3. Small windows (windows to wall ratio)

The larger the glazing area, the greater the amount of noise energy able to pass through it. The impact of single glass window size in a brick wall as the sound insolation of the glass is so much lower than the sound insolation of the brick [26, p. 188] (Fig. 2).

2.5.4. Outdoor Barriers

Outdoor barriers can be used to reduce environmental noises, especially high-frequency sound energy [26, p. 253]. According to Ermann, barriers provide noticeable attenuation when properly designed, the distance of the barriers from the source and the receiver and its height will impact the amount of sound attenuation. And also, barriers should, at a minimum, break the line of sight between the source and the receiver. Higher is better [25, p. 210]. As illustrated in Fig. 3.

In the Fig. 3 above, the barrier is effective when it is tall which break acoustical line of sight between the source and the receiver, and the barrier should be close to the source and far from the receiver.

2.5.5. The weight (mass) of the building elements (wall thickness)

The building weight (mass) has an effect on the reduction of vibration and noise, less sound is transmitted and the building can seriously resist the vibration when the building weight is great [26, p. 174]. The rule here is "the higher the mass per unit area of the wall, the higher its sound insulation value" [16, p. 29] (Fig. 4). Furthermore, Egan claimed the heavier the materials are, the better sound isolation is. This is the fundamental principle of sound isolation for architectural acoustics [26, p. 177]. Due to their mass, brick walls are among the top materials for reducing the transmission of airborne sounds. In comparison to wood and solid constructions built of poured concrete. Mostly, masonry — whether it be clay brick, cement brick, concrete block, or stone — performs better at sound control. When an external brick wall is created as a barrier between two spaces as well as between the space and the road, exterior environmental noise can be reduced. Textured face-brick walls reduce reflected sound [27, pp. 8-11] (Table 1) and illustrate methods and standards for some construction materials according to sound transmission loss.

Fig. 5 shows that the thickness of construction materials impact on the value of sound transmission loss, the greater the thickness of the materials, and the greater value of its sound transmission loss.

2.6. Traditional Dwelling' Technique and Solutions

Based on Ragette [26], the term tradition is "Deriving from the Latin word *Tradire*, or passing on, it is based on age-old practical experience, also, called native, indigenous or vernacular, meaning home-born or derived from the locality" [28, p. 9]. According to Ettouney and Fricke's study [29], regarded houses with courtyards as the traditional form of housing in many countries which have several inherent advantages over other housing types. Windowless walls are directed to the outside, all the rooms facing the courtyard, from which only the sky could be seen [29, p. 120].In traditional dwelling patterns, there is a high degree of harmony between buildings, locations, and geography. Moreover, the use of readily available materials and forms as well as local culture creates a lasting and direct consensus

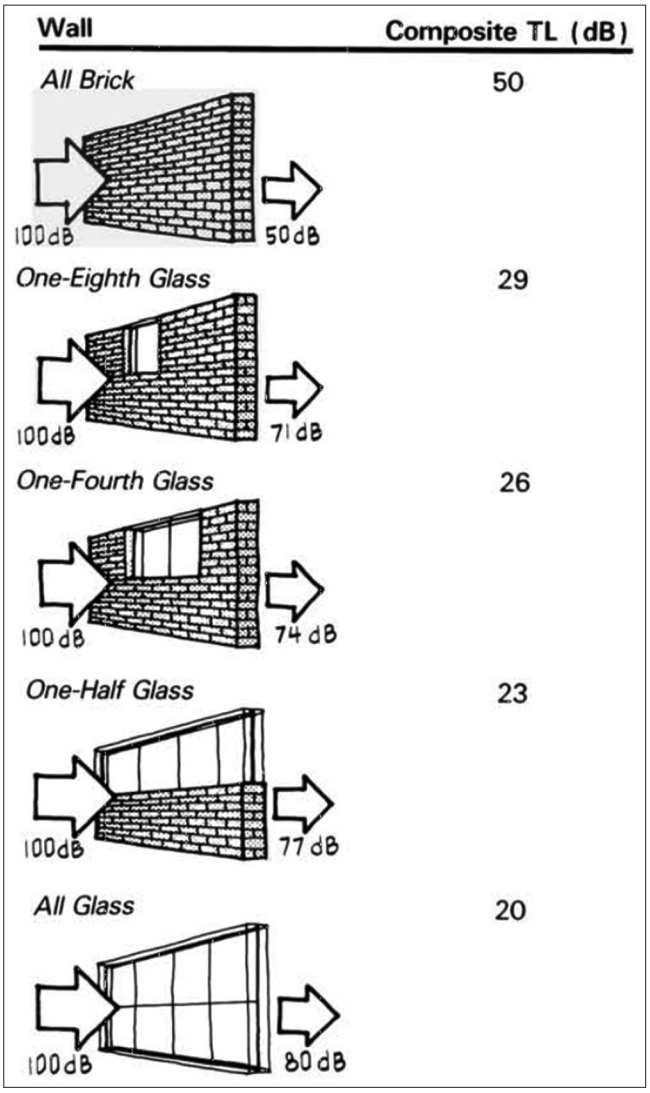


Fig. 2. The impact of windows size on transmitting noise through two spaces [24, p. 188].

between the buildings. It can be said that the traditional house achieves solutions at a high level of environmental planning [4, pp. 238-239].

There are many similarities between Kurdish architecture and Islamic architecture. According to Ragette [28], the traditional house in the Islamic and the Arab region has many characteristics, including, closed cells, courtyard houses, gallery, Iwan, [28, pp. 54-60], in term of construction methods and materials, the traditional house in Islamic cities is characterized by constructing load bearing walls with narrow openings and a low door, flat roofs, which were made of mud, mud brick, and stones [28, pp. 26-32]. Furthermore, Kurdish traditional house has that several

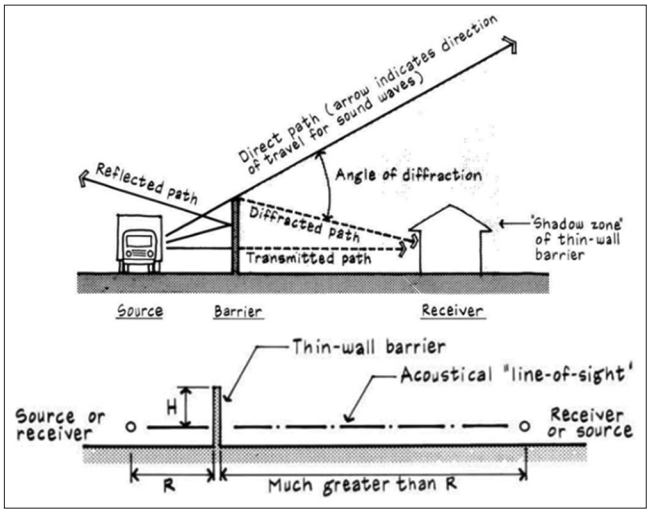


Fig. 3. The impact of height of the barrier, and the distance between noise and the receiver [24, pp. 256-257].

similar techniques were used, such as; clay bricks, thick walls, small windows, and courtyards with partial greening [4, pp. 238-239].

As well as, many building materials were used as main materials, such as brick or stone for the walls, wooden structures for the roof, and hard limestone [4, p. 244]. Except of the formation type, as a study by Qaradaghi has found that the formation type of courtyard house in Sulaimani city is similar to rural houses not derived from Arab or Islamic architecture [6]. Moreover, he described the traditional house in the old neighborhoods in the city is characterized by courtyards, the houses are of an oriental style overlooking a side or front yard (yard), and the yard is open, and it may contain a basin of water and a small garden [6, p. 166].

From the theoretical part, the research reached:

1. Noise level as a parameter of acoustics has negative impacts on humans. It is important to investigate noise levels inside dwellings, to control its propagation and reduce its negative impacts.
2. Acoustic comfort of in dwellings, impacts on people's satisfaction toward their houses, as bad acoustic conditions may cause residents move to another house to live in.
3. There are several ways to control noise propagation, whether inside or from outside to interior spaces, during design dwellings or buildings. Such as plan layout, room orientation, opening ratios, barriers, and the weight of the structure.

Table 1: Sound transmission loss in some construction materials [13, p. 303]

Construction	Average	Octave- Centre frequencies (Hz)					
		125	250	500	1000	2000	4000
Walls							
110 mm brick, plastered	45	34	36	41	51	58	62
150mm concrete	47	29	39	45	52	60	67
220 mm brick, plastered	50	41	45	48	56	58	62
330 mm brick, plastered	52	44	43	49	57	63	65
130 mm hollow concrete blocks	46	36	37	44	51	55	62
75 mm studs, 12 mm plaster boards	40	26	33	39	46	50	50
75 mm studs, 6 mm ply both sides	24	16	18	26	28	37	33
Do. but staggered separate studs and ply	26	14	20	28	33	40	30

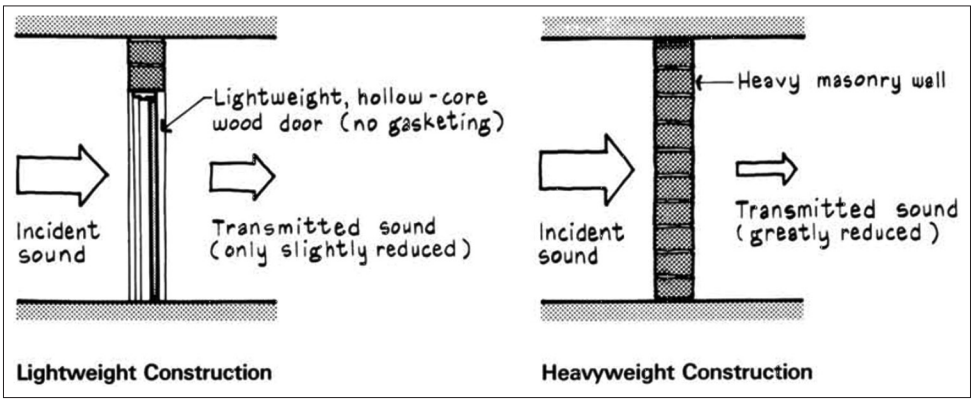


Fig. 4. Sound transmission through heavyweight and lightweight materials [24, p. 174].

Fig. 5. The old seven neighborhoods in the city of Sulaymaniyah (Source: Google Earth) highlighted (by Researcher).

3. MATERIALS AND METHODS

3.1. Methodology of Data Collection and Measurement of Variables

Based on scope of the research and to reach the validity of the research's hypothesis, several methods were carried out in this study:

- The questionnaire form.
- The *in situ* measurements for noise level.
  - For the questionnaire form, the questionnaire was filled out by the inhabitants who live in these types of traditional houses, which included indicators that derived from the theoretical part of this research. The answers were classified according to a rule that comprises five classifications of (strongly disagree), (disagree), (neutral), (agree), and (strongly agree). Aiming to get a general outline of the most common noise annoyances for residents, and comfort level of acoustic conditions inside traditional dwellings.
  - For the *in situ* measurements, the sound level meter instrument (Ambrope sm-20a sound meter) was used to measure the A-weighted Sound pressure Level (LAeq), by which reads the minimum, maximum, and average (LAeq) values of noise level.

This measurement is used, to find out the level of acoustic environment, whether inside or outside building. The aim behind using this measurement in this research is to investigate the impacts and roles of traditional design in noise reduction.

And finally, a statistical analysis using SPSS is carried to compare the result from the *in situ* measurement with the result from questionnaire form, to find the relationship between inhabitants' satisfaction acoustic comfort, and the relationship between acoustic comfort and traditional design in Sulaimani's traditional architecture.

3.2. Study Area and Samples

First, the old neighborhoods in the city were selected as study area. The city of Sulaymaniyah was founded in 1784 and then established by Ibrahim Pasha Baban as the capital of Baban princedom [30, p. 75]. Based on some sources mentioned in Qaradaghi's book [31], Malkandi is the old neighborhood in the city, which belongs to its foundation in 1784, then other neighborhoods such as Sabunkaran, KaniAskan, Dargazeen, and Chwarbakh were later founded as separate neighborhoods of the city [31, p. 22]. Fig. 5 shown the seven old neighborhoods of the city of Sulaimani.

3.3. Descriptions of Samples

Within the old neighborhoods in the city of Sulaimani, five traditional houses were chosen, which equals 8% of the total sample size of traditional houses that are still used by people., the houses were selected randomly in this study, and have these characteristics:

1. Historical, that were constructed before or from 1900-1960 AC, houses that belongs its construction to the traditional stage in the city, which the buildings have an old structure with an age of more than 50 years or built before (1960) according to [29], to find out the effectiveness of traditional Kurdish architecture according to acoustic comfort.
2. The houses are in use by residents to investigate their satisfaction with acoustic conditions in their houses.

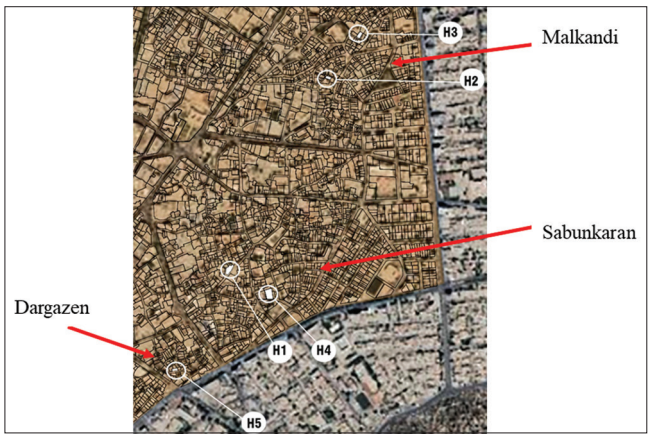


Fig. 6. The five case study houses in the three old neighborhoods in the city (Source: Researcher).

3. The houses remain untouched structurally or have few modifications. To investigate the role of the traditional style in term of acoustic comfort.

In Fig. 6 and Table 2, it shows the location of each case, which they locate in Sabunkaran and Malkandi and Dargazen, as they are the eldest neighborhoods in the city (Fig. 6), as well as, the detailed descriptions of each house illustrated by drawings and real pictures (Table 2).

4. RESULT AND DISCUSSION

4.1. Result from Questionnaire Form

The questionnaire form filled out by 34 participants as they are inhabiting in traditional houses. were asked to evaluate noise, and the impact of noise according to its source, also they were asked to evaluate several spaces in their traditional house according to noise external noise, neighbor noise, internal noise, or none of them, to identify their preference according to the internal spaces. Finally, they were asked about their satisfaction with their traditional houses in terms of acoustic conditions. Shown in Table B1.

- The questions started by describing the acoustic environment in the traditional houses, by asking them (which types of sounds 'pleasant or unpleasant' do you hear the most in your house?), the answer "pleasant sounds" such as birdsongs and wind in trees, was the most frequent sound that heard by participants which act as noise masking against external noise, comprising 41.2%, whereas only 17.6% of participants hearing unwanted sounds. as the courtyard itself has the role of masking outside noises by its trees, which increasing hearing birdsongs and wind sound inside their leaves and branches (Table 3).
- According to the question about the evaluation of noise type according to their impact on inhabitants, which was classified into three types; outside noise, neighbor noise, and internal noise, the result was that noise from outside sometimes could be annoying comprising 30.5% of participants, and 38.9% have neutral answer. According to Table 3, the analysis of the results which examines the sources of annoyance due to surrounding noise when at home appears logical and realistic. Majority of participants express their belief that, noise from external sources, sometimes could be annoying. On the other hand, noise from internal sources or neighbor did not cause them annoyance. These findings highlight a positive perception among the majority of participants toward acoustic conditions inside their houses (Table 4).

Table 2: Samples descriptions, with its detailed drawings (plans, sections, Elevations and Perspectives), and real pictures (Source, Researcher)

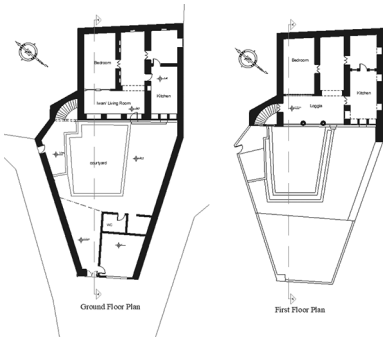
1. House one (Haji Abdulrahman Hidayat house)- Sabunkaran (1910-1920)

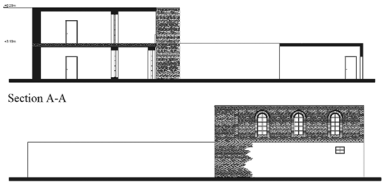
Description

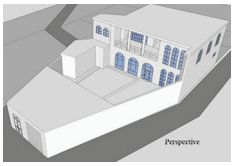
This house locates in Sabunkaran, and built around 1910-1920 AD [29, p. 367], and falling into the (H- shaped) category, as, the main rooms of the house is located on the side which opposite to the street, and locating other secondary rooms on the other side of the plot such as bathrooms. On the plot area of (354m square) approximately, which consist of two floors.

Rooms are separated from each other by clay brick walls with thickness of 70 cm, and the slabs were constructed in wooden structure with mud.

Drawings







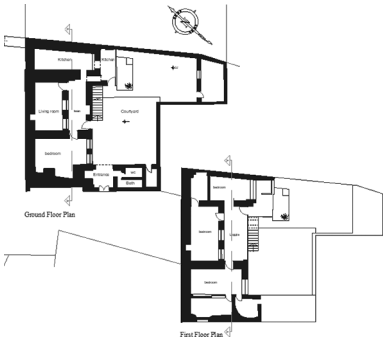
2. House two (Ali boskani house)- Malkandi (1910-1920)

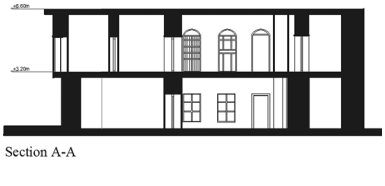
Description

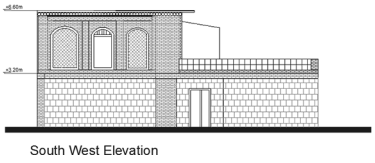
This house locates in Malkandi, and built around 1910-1920 AD [29, p. 229], falling into (L- shaped) type, as, the main rooms of the house is located on the side perpendicular to the street, and locating service area on the other side of the plot such as bathrooms. On the plot area of (312 m square) approximately, which consist of two floors.

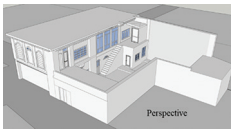
Rooms are separated from each other by clay brick walls with thickness of (80–100cm), and the slabs were constructed in wooden structure with mud. With an external stone barrier.

Drawings









3. House three (Abdulla Ahmad Abdulla house)- Malkandi

Description

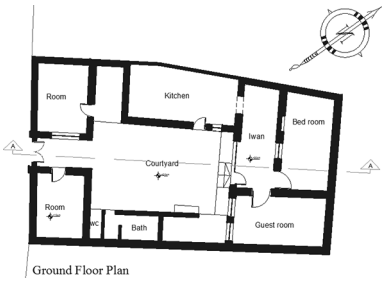
This house locates in Malkandi; however, its date not known according to [29, p. 308], but according to residents in this house its construction date might return to (2930-1940). The house is (C- shaped or close to O- shape house) type, as, the main rooms of the house is located on the two opposite side to the street, and locating service area between these two sides of the plot such as kitchen and bathroom. On the plot area of (200 m square) approximately, which consist of one floor.

Rooms are separated from each other by clay brick walls with thickness of (40 cm), and the slabs were constructed in wooden structure with mud, with an external stone barrier.

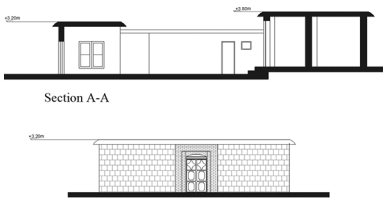
(*Contd...*)

Table 2: *(Continued)*

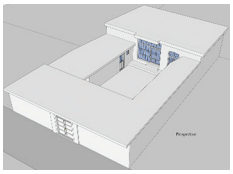
Drawings



Ground Floor Plan


Section A-A

South West Elevation

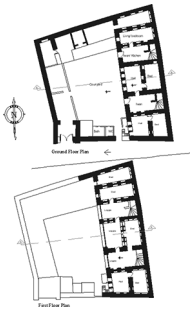


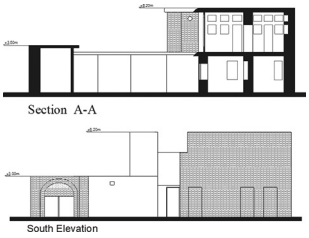
4. House three (Kareemi Alaka house)- Sabunkaran

Description

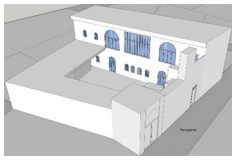
This house locates in Sabunkaran, its construction date belongs to before 1900 [29, p. 375]. The house is (I- shaped) type, as, the main rooms of the house is located on the one side perpendicular to the street. On the plot area of (373 m square) approximately, which consist of two floors. Rooms are separated from each other by clay brick walls with thickness of (80cm), and the slabs were constructed in wooden structure with mud.

Drawings




Section A-A

South Elevation

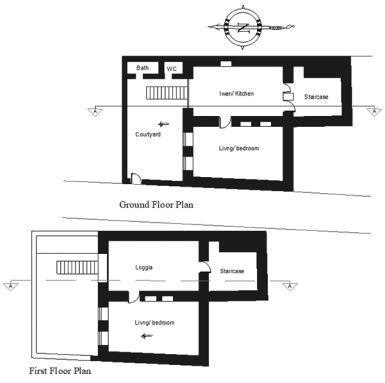


5. House Five - Dargazen

Description

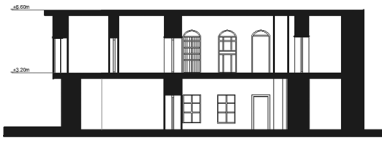
This house locates in Dargazen, its construction date belongs to before 1910–1920 [29, p. 118]. The house is (I- shaped) type, as, the main rooms of the house is located on the one side perpendicular to the street. On the plot area of (170 m square) approximately, which consist of two floors. Rooms are separated from each other by clay brick walls with thickness of (80 cm), and the slabs were constructed in wooden structure with mud. Moreover, the courtyard has an external stone barrier.

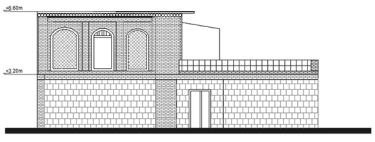
Drawings

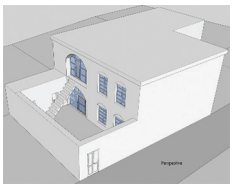


Ground Floor Plan

First Floor Plan


Section A-A


South West Elevation



- When the participants were asked (if any noise irritated participants when they are in the courtyard, living room, and bedroom.) the result was (70.6%, 73.5%, and 85.3%) of participants ensured that they do not receive any noise when they are in the courtyard, living room and bedroom respectively (Tables 5 and 6), the results and the statistical analysis, indicated that majority of participants were feeling comfortable in these spaces of their traditional

Table 3: The analysis of the result of Q1 & Q2 (Source: Researcher)

Participants	Pleasant or natural sounds like (bird songs…)	Unpleasant or unwanted sound
N		
Valid	34	34
Missing	0	0
Mean	3.24	2.59
Mode	3	3
Standard deviation	1.372	1.234

Table 4: Statistical analysis of the results of Q3, Q4, and Q5 (Source: Researcher)

Participants	Noise from outside (traffic noise, motorcycles, children playing, dog barking, industries, construction…)	Neighbor noise (TV, appliances, people talking, children playing/ crying…)	Internal noise (acoustic resonance, TV, people talking, noise from kitchen, appliances…)
N			
Valid	34	34	34
Missing	0	0	0
Mean	3.21	1.68	1.65
Mode	3	1	1
Standard deviation	1.067	1.173	0.849

Table 5: The results of Q6, Q7, and Q8 (Source: Researcher)

In the courtyard			In the living room			In the bedroom		
Type of noise source	Fi	%	Type of noise source	Fi	%	Type of noise source	Fi	%
Noise from outside	8	23.5	Noise from outside	6	17.6	Noise from outside	2	5.9
Neighbor noise	1	2.9	Neighbor noise	3	8.8	Neighbor noise	1	2.9
Internal noise	1	2.9	Internal noise	0	0	Internal noise	2	5.9
None of them	24	70.6	None of them	25	73.5	None of them	29	85.3
Total	34	100	Total	34	100	Total	34	100

Table 6: The analysis of the results of Q6, Q7, and Q8 (Source: Researcher)

Rating scale	In the courtyard	In the living room	In the bedroom
N			
Valid	34	34	34
Missing	0	0	0
Mean	3.21	3.29	3.71
Mode	4	4	4
Standard deviation	1.298	1.219	0.799

Table 7: The analysis of the results of Q9, Q10 (Source: Researcher)

Rating scale	Sleeping in the bedroom	Sleeping in the living room
N		
Valid	34	34
Missing	0	0
Mean	3.65	2.71
Mode	4	4
Standard deviation	0.917	1.447

Table 8: The result of Q11 (Source: Researcher)

Willing to continue living in this traditional house forever?		
Rating scale	Frequency	Percent
Strongly Disagree	1	2.9
Disagree	5	14.7
Neutral	5	14.7
Agree	13	38.2
Strongly Agree	10	29.4
Total	34	100.0

house, as the house design has significant role in reducing the propagation of noise.

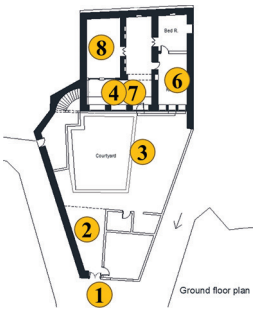
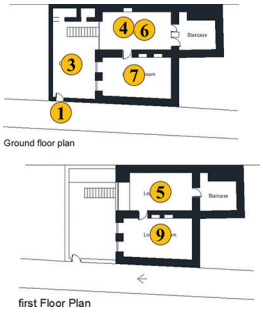
- When they were asked, about their sleep quality in the bedroom or living room, the substantial majority of participants, indicated bedroom as a most preferable room for sleeping without noise disturbance (Table 7).
- And finally, when the participants were asked to evaluate their satisfaction with their traditional house, the result was that most of them were strongly satisfied and wanted to continue living in their houses which comprise 67.6%

of participants, by collecting (strongly agree and agree) together. Whereas, 17.6% were not satisfied, hence, these results demonstrated that the acoustic conditions have positively impacted residents (Table 8).

4.2. Result from *In situ* Measurements

The A-weighted Sound pressure Level (LAeq) was measured during the daytime for (1min) duration of time for outside and for (5-6 locations) inside each house, to make a comparison

Table 9: Detailed sound pressure level in each location in the study houses (Source: Researcher)

No.	Houses	A-weighted average sound pressure level (LAeq) in (dBA) during 1 min for each location								
		Outside 1	Entrance 2	Courtyard 3	Iwan 4	Loggia 5	Kitchen 6	Living 7	Bed (G.F.) 8	Bed (F.F.) 9
1		61.9	48.3	43.4	40.9		45.2	40.9	38.6	
2		57.8	55.7	49.5	41.9	41.3	46.4	41.9	34.8	34.8
3		63.3	55.5	49	47.3		43	42.5	38.9	
4		51.9		48.7	49.8	42.4	49.8	38.6	36.8	36.6
5		57.6		46.5	43.2	42.1	43.2	42.4		37.8

between interior spaces with the outside noise level, to find the role of traditional characteristics of the house in reducing noise transmitting from outdoor to indoors. Table 9 showed the samples and location of each measurement outside and inside the dwellings. And also see Table A1.

The results of the *in situ* measurements indicated that the average level of sound pressure (LAeq) inside each house decrease dramatically according to their design characteristics. Fig. 7 illustrated the noise level of each house between outside and interior spaces, showed the hierarchy from the highest noise level of outside to the lowest noise level living rooms and bedrooms.

Furthermore, it is found that noise levels inside courtyards, Iwans, kitchen, living room, and bedroom were from "minimum to maximum" (43.4–49 dBA), (41.8–49.8 dBA), (43.0–49.8dBA), (38.6–42.5 dBA), and (34.8–38.9 dBA), respectively, whereas noise level outside houses were from (51.9 dBA–63.3 dBA). The statistical analysis for the *in situ* measurements in Fig. 8 shows the reduction of noise level from outside to inside the houses, by finding (median) for noise level for each location and space in all cases.

4.3. Comparing the Result from the Questionnaire with the *In situ* Measurement

- From the result of the questionnaire data and the *in situ* measurements, we prove the first study hypothesis that there is a significant relationship between acoustic conditions and residents' satisfaction in traditional houses. In Table 10 and Fig. 9, it showed that with decreasing the sound pressure level, the percentage of satisfaction will increase in each space inside the dwelling.

In Fig. 9, it demonstrated that with the increasing level of acoustic comfort by reduction of noise level, the level of satisfaction will increase.

- And from the results from the *in situ* measurement, such as noise reduction from outside to interior spaces and

Table 10: The relationship between the level of sound pressure and inhabitants' preference in the five study houses, within the specified measurement locations (Source: Researcher)

Locations/spaces	Median For measured data	Percentage of participant's preference
1. In the courtyard	48.7 dBA	70.6
2. In the living room	41.9 dBA	73.5
3. In the bedroom	37.8 dBA	85.3

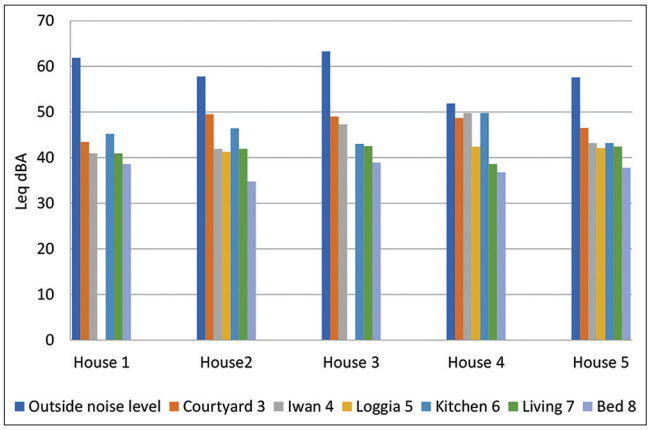


Fig. 7. The hierarchy of noise level between outside and inside (Source: Researcher).

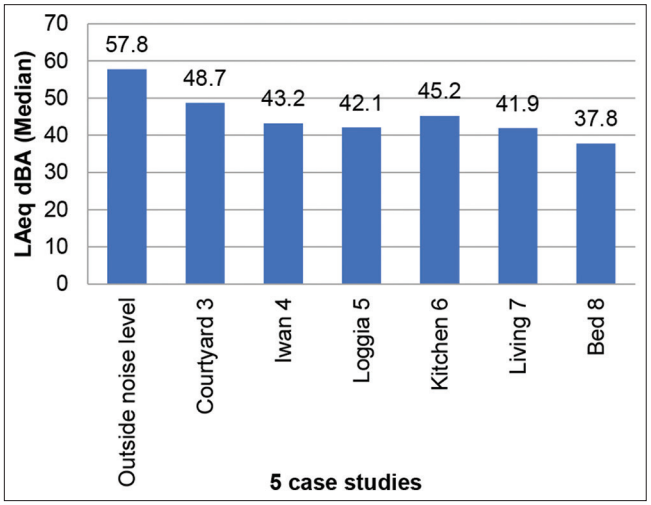


Fig. 8. The statistical analysis for the in situ measurements by finding Median. The hierarchy of sound reduction from outside to the bedroom (Source: Researcher).

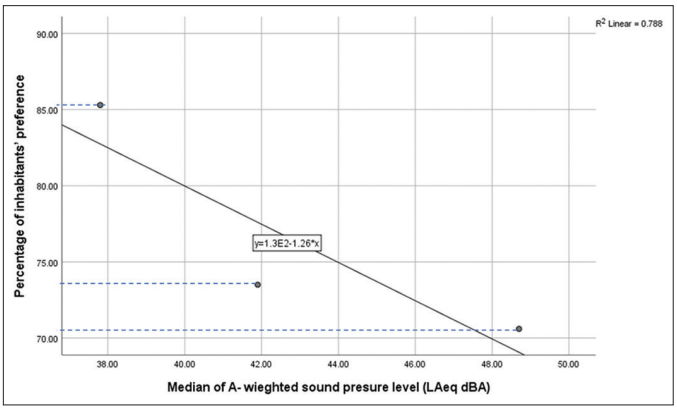


Fig. 9. The impact of noise level on participant's satisfaction (Source: Researcher).

Table 11: Analyzing traditional characteristics by two-dimensional detailed sketches according to noise sources, case-1, testing indicators from section (2.5) (Source: Researcher)

Graphical details of the case one:

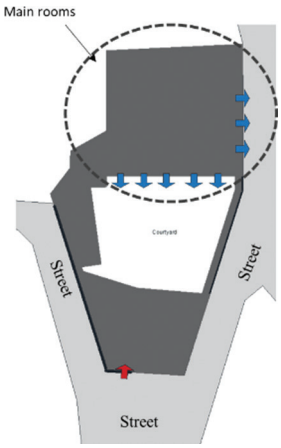
1 **Reduction of noise propagation by the plan layout (noise from kitchen):**

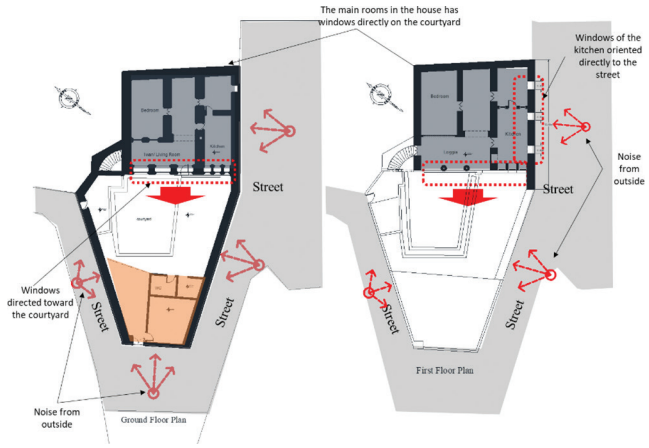
Plan layout

The organization of the spaces: locating bedrooms far from noisy spaces (kitchen) and the street.

2 **Reduction of noise because of room orientation:**

Room Orientation

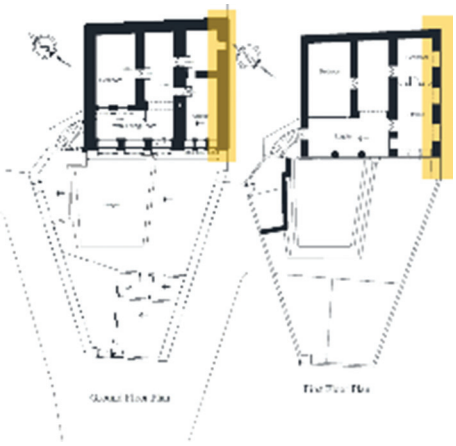


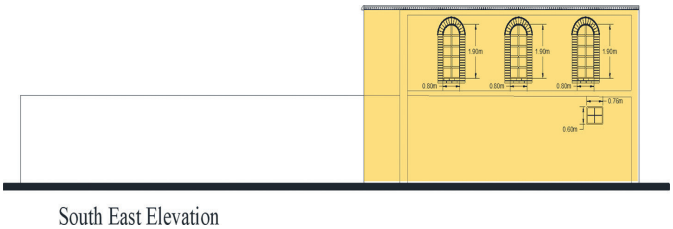


The majority of rooms orientation is toward inner yard.

3 **Noise reduction by small windows:**

Small windows





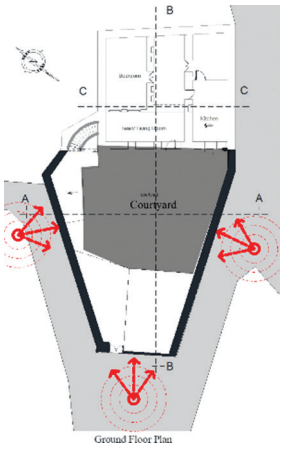
The windows have filled only a very small area of the wall.

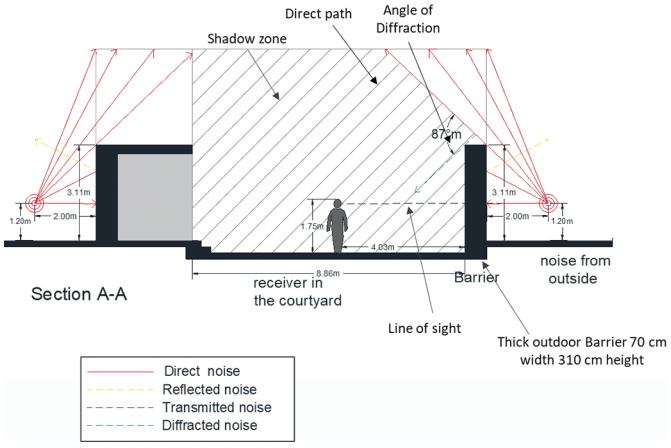
(Contd...)

Table 11: *(Continued)*

4 **Reduction of noise transmitting by barriers (Noise from outside to the courtyard):**

Barrier

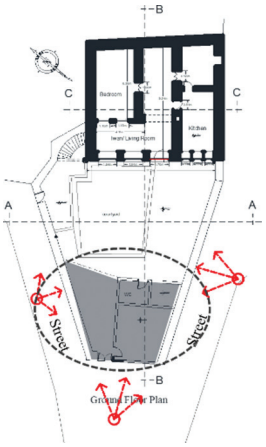


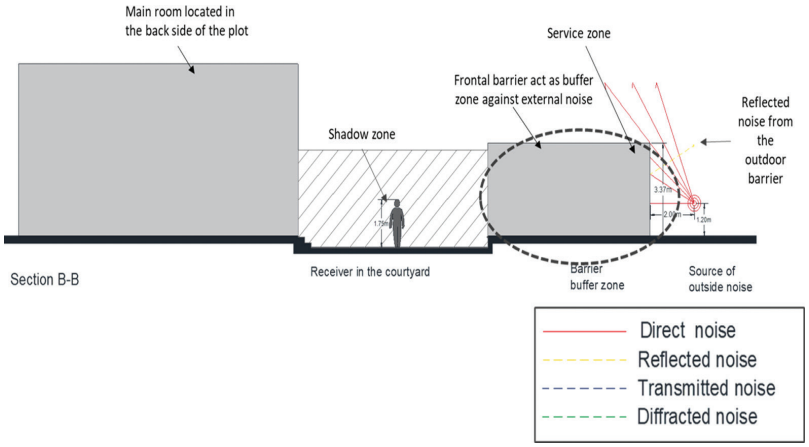


The height of side barrier is 3.11 m, which breaks the line of sight between source and receiver. And attenuate noise by diffracting it on the top of the barrier.

5 **Reduction of noise transmitting by front barrier (noise from outside to the courtyard):**

Barrier

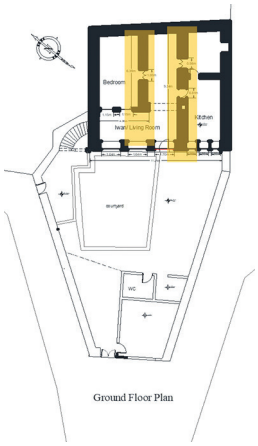


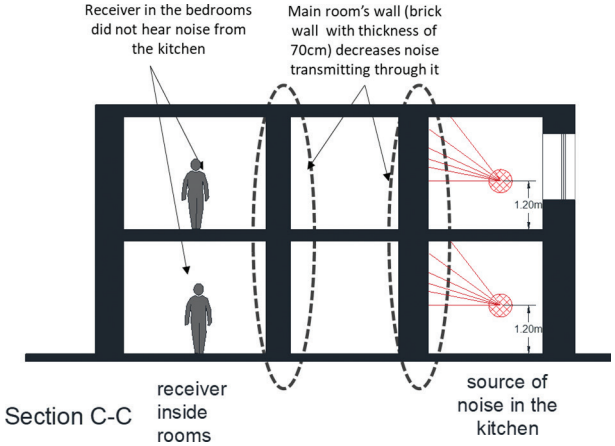


The existing buffer zone in front of the yard and the rooms, prevent noise transmitting into the inner yard.

6 **Reduction of noise by wall thickness (noise from the kitchen to the bedroom):**

Wall thickness- internal walls

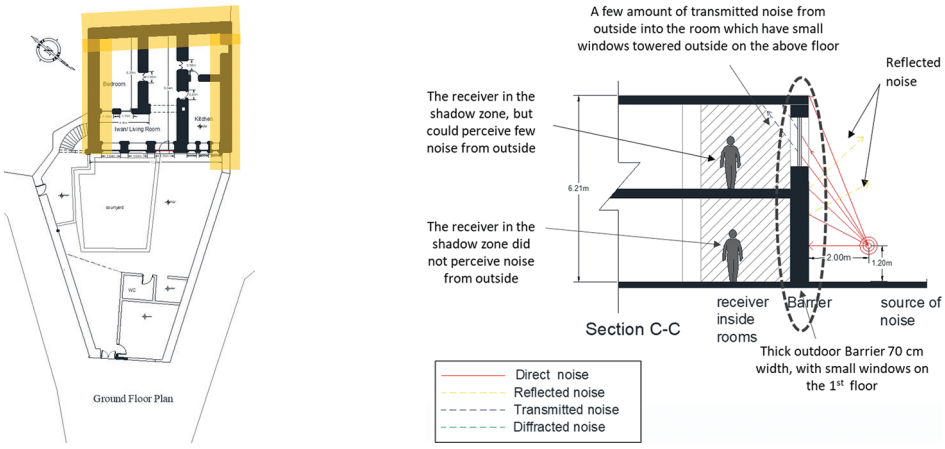




The thickness of the internal walls 70 cm, which reduce noise transmitting between adjacent rooms.

(Contd...)

Table 11: *(Continued)*

7 Wall thickness-external walls	**Reduction of noise by wall thickness (noise from outside to the rooms):** 	The thickness of the external wall 70 cm, which reduce noise transmitting between indoors and outdoors and between neighbors.

reducing of noise propagation between adjacent rooms, has proved that the characteristics of traditional house in the city has a significant role in this attenuation of noise in interior spaces. Table 11 showed two dimensional detailed sketches, to analyze and evaluate the design characteristics of the case-1 according to noise sources. Two dimensional sketches used by Erman [23] and Egan [24] for analyzing according to noise source and the receiver.

From the detailed sketches analysis for all cases, the study has found that,

1. The space organization increase acoustic comfort inside the house as noisy areas, such as kitchen bathrooms were located far from the main rooms like bedrooms.
2. These houses with indirect orientation to the street, allowed rooms to be oriented towards the inner courtyard, which caused to receive the minimum noise from outside
3. The houses are rarely having small windows facing the streets, this helps room's orientations toward inner yards and reduces transmitting outside noise through it.
4. The tall barriers that fencing the courtyards have its significant role in preventing transmission of outdoor noise. As tall barriers increase noise shadow behind it, by breaking the line of sight between the source and receiver.
5. The thickness of walls of these traditional houses are between (40–100 cm) and more that prevent noise propagation in the house.

Hence, this study can prove the second hypothesis concluding that there is a strong relationship between traditional characteristics of dwellings and noise reduction from inside spaces, as well as from outside to inside, and vice versa. The design characteristics of Sulaimani's traditional houses have the key role in providing acoustic comfort.

5. CONCLUSIONS

The study from the analysis of the results from the practical study (questionnaire form and *in situ* measurement) concluded that there is a strong relationship between acoustic conditions inside the traditional houses and the inhabitants' satisfaction toward their traditional houses in the city of Sulaimani. As the acoustic comfort increase in interior spaces by decreasing the noise level, the inhabitant's satisfaction increases. Furthermore, the study demonstrated that the traditional design of dwellings has a crucial impact on noise reduction whether between the rooms, from outside to inside, or vice versa.

1. The study indicated that the traditional houses in Sulaimani city provide a good satisfactory level of acoustic comfort, and the residents are satisfied with living in this type of dwelling, in term of providing good acoustic conditions in its interior spaces.
2. The most observable and hearable sounds inside the traditional houses are pleasant sounds such as birdsongs and wind in trees, as the sound from inner yards masks the outside noise.
3. There is a hierarchy in noise level between outside and interior spaces of traditional houses, because of the significant role of traditional characteristics in these types

of dwelling.

Hence, it is important to take into consideration the impact of acoustic comfort on human's satisfaction inside dwelling in which they spend most of their time inside. And also, it is important to promote Kurdish traditional design, as it has a key role in reducing noise propagation and providing acoustic comfort by consider its characteristics in contemporary dwellings and buildings in the city.

REFERENCES

[1] N. Vardaxis. "*Evaluation of Acoustic Comfort in Apartment Buildings*", PhD diss., Lund University, Sweden, 2019.

[2] N. D. Dahlan. "*Occupant's Indoor Comfort Perceptions through Thermal, Visual and Acoustic Assessments in Typical Multi-Storey Hostels in Malaysia*". Cardiff University, Wales, 2009.

[3] C. Maschke and H. Niemann, "Health effects of annoyance induced by neighbour noise," *Noise Control Engineering Journal*, vol. 55, no. 3, pp. 348-356, 2007.

[4] B. Y. Raof, S. D. Bahaadin and H. Q. Rasul. "The thermal performance of vernacular houses as an identity of kurdish traditional architecture". *Kurdistan Journal of Applied Research*, vol. 5, no. 1, pp. 236-257, 2020.

[5] A. N. Abtar, A. Q. Ahmed and H. H. Abdulrahman. "Parametric studies on solar performance of Iwan in traditional houses in sulaymaniyah's old town," *Sulaimani Journal for Engineering Sciences*, vol. 6, no. 2, pp. 11-20, 2019.

[6] A. M. A. Qaradaghi. "The effect of rural building types informing the type of traditional courtyard houses in Sulaimaneyah city". *Journal of the Planner and Development*, vol. 25, no. 2, pp. 158-183, 2020.

[7] H. A. Abdulkareem. "Thermal comfort through the microclimates of the courtyard. A critical review of the Middle-Eastern courtyard house as a climatic response". *Procedia-Social and Behavioral Sciences*, vol. 216, pp. 662-674, 2016.

[8] S. Abd Hassan. "Sound environment of cities: A comparison study for sound environment between modern and traditional urban fabric in Baghdad city". *The Iraqi Journal of Architecture and Planning*, vol. 12, no. 27, pp. 24-35, 2013.

[9] Available from: https://www.oxfordlearnersdictionaries.com/definition/english/comfort_1?q=comfort [Last accessed on 2023 Oct 24].

[10] D. E. Commins and A. V. Meier. *Classes of Acoustical Comfort in Housing*. B. D. Conseils, ed. COMMINS-BBM Sari, Gif-sur-Yvette, 1978.

[11] J. H. Rindel and R. Bright. "*Buildings for the future: The concept of acoustical comfort and how to achieve satisfactory acoustical conditions with new buildings*". Comet-Savior Course noise Control in Buildings-Up-to-date practice, CSTB, Grenoble, France, pp. 16-18, 1995.

[12] J. H. Rindel. "*Ound Insulation in Buildings*". CRC Press, United States, 2018.

[13] R. A. Mahmood and S. Hussain. "The information technology effmts on acoustic comfort in exhibition halls by using. Ecotect" program". *Iraqi Journal of Architecture and Planning*, vol. 9, no. 19, pp. 384-410, 2010.

[14] S. V. Szokolay. "*Introduction to Architectural Science*". Architectural Press, An imprint of Elsevier Science, Netherlands, 2004.

[15] Z. Maekawa, J. Rindel and P. Lord. "*Environmental and Architectural Acoustics*". 2nd ed. CRC Press, London, 2010, p. 376.

[16] E. Mommertz. "*Acoustics and Sound Insulation: Principles, Planning, Examples*". De Gruyter, Germany, 2009.

[17] Castro R. *"Proceedings, Invisible Places Sounding Cities-Sound, Urbanism and Sense of Place*". Sonic Arts Research Centre, Viseu, Portugal, 2014.

[18] C. J. Yu. Environmentally Sustainable Acoustics in Urban Residential Areas. Doctoral Dissertation, University of Sheffield, England, 2008.

[19] European Environment Agency. "*Noise in Europe 2014*". Publications Office of the European Union, Luxembourg, 2014.

[20] Available from: https://www.oxfordlearnersdictionaries.com/definition/english/annoyance?q=annoyance [Last accessed on 2023 Oct 24].

[21] M. Basner, W. Babisch, A. Davis, M. Brink, C. Clark, S. Janssen and S. Stansfeld, "Auditory and non-auditory effects of noise on health". *The Lancet*, vol. 383, no. 9925, pp. 1325-1332, 2014.

[22] M. Navai and J. A. Veitch. "*Acoustic Satisfaction in Open-Plan Offices: Review and Recommendations*". National Research Council of Canada, Ottawa, 2003.

[23] Ministry of Construction. "*Urban and Rural Housing Standards in Iraq*. University of Bagdad, Planning Consultant Bureau, Iraq, 2018.

[24] E. H. Idrobo-Ávila, H. Loaiza-Correa, L. V. Noorden, F. G. Muñoz-Bolaños and R. Vargas-Cañas. "Different types of sounds and their relationship with the electrocardiographic signals and the cardiovascular system-review. *Frontiers in Physiology*, vol. 9, pp. 525, 2018.

[25] M. Ermann. "*Architectural Acoustics Illustrated*". John Wiley and Sons, New Jersey, 2015.

[26] M. D. Egan. "*Architectural Acoustics*". J. Ross Publishing, New York, 2007.

[27] D. Volek and C. Dickinson. "*TN# 38 Built-in Soundproofing with Clay Masonry Walls*". The Clay Brick Association, South Africa, 2020. Available from: https://www.claybrick.org.za/tn-38-built-soundproofing-clay-masonry-walls [Last accessed on 2023 Oct 17].

[28] F. Ragette. "*Traditional Domestic Architecture of the Arab Region*". Edition Axel Menges, London, 2003.

[29] S. M. Ettouney and F. R. Fricke. "Courtyard acoustics". *Applied Acoustics*, vol. 6, no. 2, pp. 119-132, 1973.

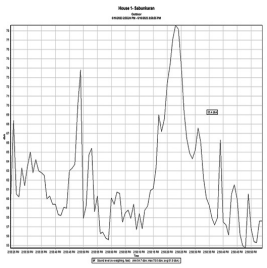
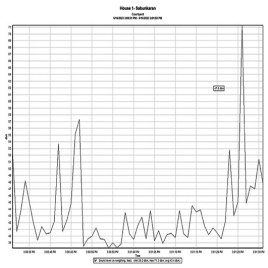
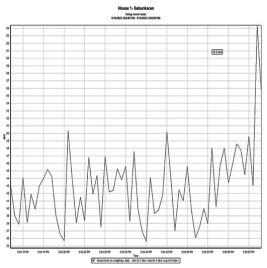
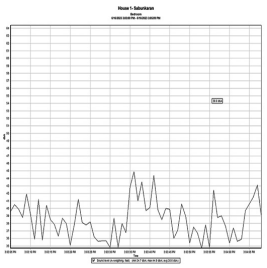
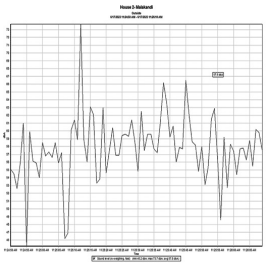
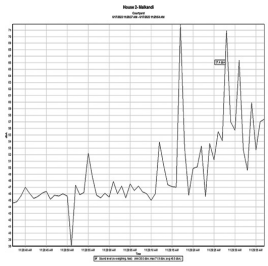
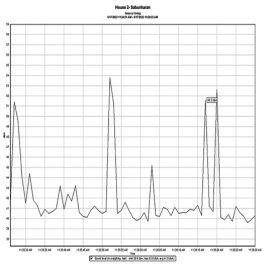
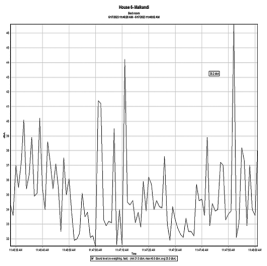
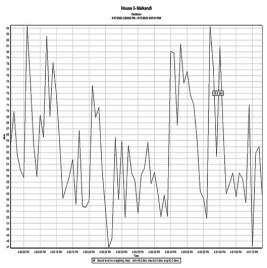
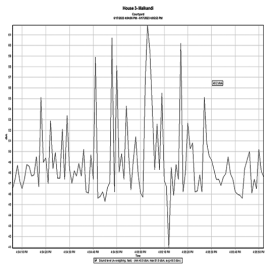
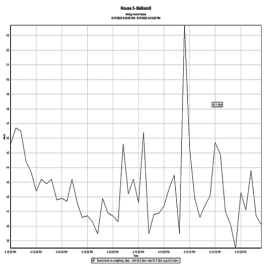
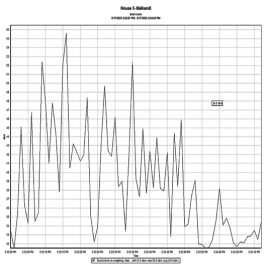
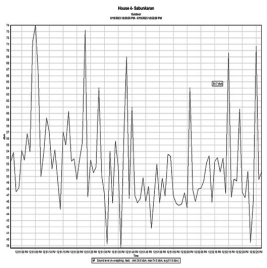
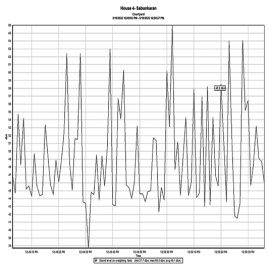
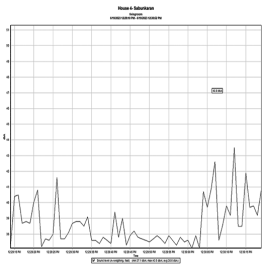
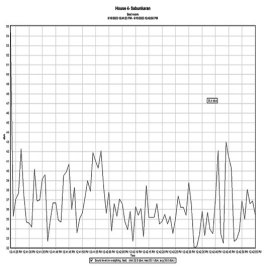
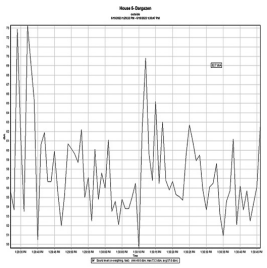
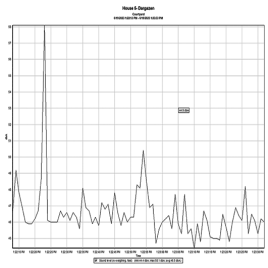
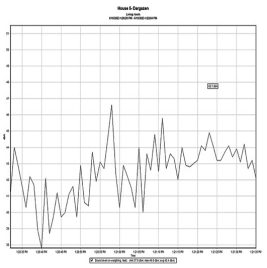
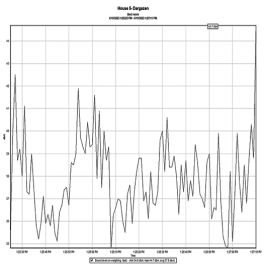
[30] B. N. Muhealddin and. A. F. Ali. "The impact of architectural conservation policies on the continuance of heritage buildings-Study of conservation in Sulaymaniyah governorate". *Sulaimania Journal for Engineering Sciences*, vol. 6, no. 4, pp. 71-85, 2019.

[31] A. M. A. Qaradaghi. "*Documentation of old Neighborhoods and Buildings in Kurdistan Sulaymaniyah City*". 1st ed. CITYLAB, Sulaimani, 2022, p. 664.

Appendices

Appendices A

Table A1: Sound pressure level graphs for case studies, for the three main locations inside the house and the outside location:

Houses	Outdoor	Courtyard	Livingroom	Bedroom
House 1				
House 2				
House 3				
House 4				
House 5				

Appendices B

Table B1: Questionnaire design

Section A: Evaluating types of sounds inside traditional house	Strongly disagree	disagree	Neutral	Agree	Strongly Agree
Q1. Do you hear pleasant or natural sounds like (bird songs, wind in trees…) most, when you are at home?					
Q2. Do you hear unpleasant or unwanted sound most, when you are at home?					
Q3. Is Noise from outside such as (traffic noise, motorcycle, children playing, dog barking, industries, construction…) annoying you when you are at home?					
Q4. Is neighbor noise such as (TV, appliances, people talking, children playing/crying…) annoying you when you are at home?					
Q5. Is internal noise such as (acoustic resonance, TV, people talking, noise from kitchen, appliances…) annoying you when you are at home?					

Section B: Inhabitants preference about courtyard, living room, and bedroom.	Noise from outside	Neighbor noise	Internal noise	None of them
Q6. When you are in the courtyard which noise annoy you most?				
Q7. When you are in the living room which noise annoy you most?				
Q8. When you are in the bedroom which noise annoy you most?				
Q9. When you are sleeping in the bedroom which noise annoy you most?				
Q10. When you are sleeping in the living room which noise annoy you most?				

Inhabitant's satisfaction of the traditional house in term of acoustic comfort:	1	2	3	4	5
Q11. Willing to continue living in this house forever? In term of its acoustic comfort?					

ORIGINAL ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

COVID-19 Diagnosis Applied DWT and CNN on X-ray Chest Images

Muzhir Shaban Al-Ani[1]*, Qeethara Al-Shayea[2], Shokhan M. Al-Barzinji[3], Dimah Mezher Shaban Al-Ani[4], Zainab Mezher Shaban Al-Ani[5]

[1]Department of Information Technology, College of Science and Technology, University of Human Development, Sulaymaniyah, Iraq, [2]Department of MIS, Al-Zaytoonah University of Jordan, Amman, Jordan, [3]Department of Information Technology, College of Computer Science and Information Technology, University of Anbar, Ramadi, Iraq, [4]Department of Pharmacy, College of Pharmacy, University of Philadelphia, Amman, Jordan, [5]Ramadi Teaching Hospital, Ramadi, Iraq

ABSTRACT

Background: Medical images have many important applications, and this importance increased when the emergence of the COVID-19 pandemic. These applications have been focused on computed tomography chest images and X-ray images. This research will focus on special X-ray medical image applications of coronavirus (COVID-19).

Methods: Many methods are applied on medical images to achieve certain features. The designed approach is implemented through many steps starting from preprocessing up to classification step. The proposed approach focusing on generating efficient features using discrete wavelet transform (DWT) then applying convolutional neural network (CNN) to classify between normal and abnormal COVID-19.

Results: The COVID-19 diagnosis approach is implemented to achieve high performance system. The obtained result of COVID-19 diagnosis applied CNN tool leading to validation accuracy of 92.31%.

Conclusion: Hybridizing two technologies (DWT and CNN) is intended to reach the best results in the diagnostic process. In addition, X-ray chest image is an important tool for detection and diagnosis of COVID-19 diseases.

Index Terms: Coronavirus, Diagnosis, Chest Images, Discrete Wavelet Transform, Convolutional Neural Network

1. INTRODUCTION

Coronavirus began in China at the end of 2019 and then spread to all parts of the world and has led to many economic and social impacts. In addition to that it led to large numbers of dead, and this greatly affected medical staff, because they are in direct contact with people with this disease. Then, the World Health Organization (WHO) classified COVID-19 as a pandemic and developed a number of procedures and recommendations for reducing this disease [1], [2], [3].

Many medical companies have sought to work and persevere to find an effective drug for this disease, but all these efforts did not succeed, but many of the proposals were tested with the use of drugs that already exist and have been used for other diseases. All of this led to great pressures on doctors and researchers in the medical field, especially so far, there is no glimmer of hope for an effective vaccine for this disease [4], [5], [6].

After the appearance of the coronavirus several weeks ago, at the beginning of the year 2020, many leaders and politicians began to say that treatment for this disease would soon be accessible to all, and among them are the leaders of the superpowers countries,

Access this article online

DOI: 10.21928/uhdjst.v7n2y2023.pp69-76

E-ISSN: 2521-4217
P-ISSN: 2521-4209

Corresponding author's e-mail: Muzhir Shaban Al-Ani, Department of Information Technology, College of Science and Technology, University of Human Development, Sulaymaniyah, Iraq. email: muzhir.al-ani@uhd.edu.iq

Received: 22-09-2023 Accepted: 26-11-2023 Published: 19-12-2023

but all of this has become windy after the number of infected people exceeded 12 million and the number of dead becomes more than half million, and the question that arises is whether this virus was found to remain [7], [8], [9].

The overcoming and complete control of the coronavirus issue has become a matter of no less, to implement many procedures and tests without reaching satisfactory results that can be generalized [10], [11], [12]. Therefore, it is necessary to continue the research work with the support of all countries to reduce this pandemic and stand on the latest developments [13], [14], [15].

There have been many tests to confirm infection with the coronavirus, and some of these tests are focusing on radiographs. A method has been suggested to COVID-19 diagnosis applied discrete wavelet transform (DWT) and convolutional neural network (CNN) on X-ray chest images.

2. CORONAVIRUS (COVID-19)

This section explains two main aspects of COVID-19: Protection and mechanism.

2.1. COVID-19 Protection

Six months after the appearance of the coronavirus in China and its spread throughout the world, researchers have been working hard on this disease, but so far no effective treatment has been found for this disease [16], [17]. Several tips have emerged to prevent coronavirus and some of these wills have been confirmed by the WHO [18], [19]. In general, since this disease is still prevalent in all countries of the world and that some of the patients have symptoms that appear lightly, therefore, care must be taken and caution, and there are a set of things that are preferred to be adhered to prevent this disease [20], [21], [22]:

- Wash hands regularly with soap and water or use an alcohol disinfectant
- Use gloves to leave the house to avoid hand contact
- Avoid going to crowded places, preferably using a mask when necessary
- Avoid approaching a lot of people, because there is a high risk of infection
- Avoid touching your eyes, nose, and mouth, as this is a very dangerous of infection
- All purchases that you bring from the market must be sterilized before entering the home
- Leave shoes outside the home to ensure that viruses and bacteria that are attached to them do not get inside.

2.2. COVID-19 Mechanism

COVID-19 virus gets in the human body through many ways: Eyes, nose, and mouth [23], [24]. There are two main directions for the virus: either go to the stomach and kill there or go to the respiratory system, and here, the problem occurs [23], [24].

The main problem of the new generation of coronavirus appeared in December 2019 (COVID-19), there are many scenarios in which it affects the human body [25]. One of these scenarios focusing when of the virus enters the respiratory system, it passes through human body in 12 steps to perform its mechanism, as shown in Fig. 1 [26], [27]. These steps starting by entering the coronavirus to the human body up to their effects on breathing that causes many difficulties [11], [22]. The problem becomes dangerous when the virus starts attack the cells then the cell become resources of virus that the cell multiply itself, then new copy of the virus will be generated and so on, in this case, the problem becomes more dangerous in which affected the breathing system [28], [29].

3. RELATED WORK

Given the proliferation of coronavirus significantly since the beginning of the year 2020, therefore, researchers have begun working on this pandemic and that there is a lot of research papers focused on this topic. In this paragraph, we will focus on a number of recent research papers published on this topic.

Mitra *et al.* (2020) presented the risk of LQTS and TdP with chloroquine, hydroxychloroquine, or azithromycin used alone or in combination, previous reports of combined treatment in patients with malaria suggested that the risk is very low. In COVID-19, hospitalized patients may increase the risk of QT interval prolongation and TdP due to previous or concomitant medications, age, sex, and metabolic disorders (pH, hypoxia, electrolyte, and system failure abnormalities). They suggested that direct damage to the viral or autoimmune myocardium may also occur in patients with COVID-19 [30].

Vahia *et al.* (2020) anticipated the need for timely and valid scientific information on a wide range of COVID-19. They included the risk of death from coronavirus, stress around behaviors that can lead to contact/infection (including contact with caregivers). Taking social distance and isolation measures implemented by governments around the world and the neurobiological consequences of stress and resulting inflammation, which can increase vulnerability to mental health

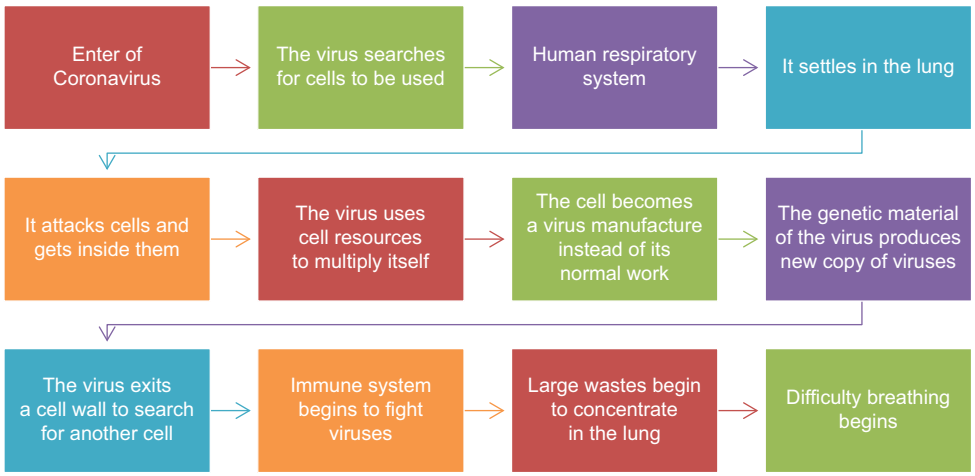


Fig. 1. Steps to enter coronavirus.

problems. In a population where loneliness and isolation have already been described as an epidemic, the impact of social distancing measures needs to be studied in detail [31].

Shaker *et al.* (2020) developed recommendations using a modified and adapted Delphi methodology to reach a consensus. During the COVID-19 pandemic, social distancing is required; most allergy immunology care could be delayed or treated with virtual care. With the exception of many patients with primary immunodeficiency, patients with venom immunotherapy, and patients with asthma of some severity, personal visits in these conditions are limited. These suggestions are required to adjust the service to mitigate risks to medical staff and patients. It is important to note that individual community circumstances may be unique and require contextual consideration [32].

Price *et al.* (2020) implemented (through limiting exposure) a coded classification system that allows us to prioritize and provide appropriate care to each patient. They implemented a key step of this model as soon as possible in combination with teledermatology, and they suggested other practices. Patients with high acuity, such as those with life-threatening lesions and rashes, have priority for in-person visits. In addition, patients can continue long-term management while reducing the risk of exposure [33].

Vervoort *et al.* (2020) explained the requirement of critical medical at the levels of the health systems. They demonstrate the collaboration, to provide the care that needed for the patients, while improving the understanding of the complexities of people's cardiovascular health due to COVID-19 pandemic. Canadian Cardiovascular Society introduced their efforts to promote cardiovascular physicians' engagement on social media and encourage everyone to join the health system in fighting the day's epidemic using their voices as physicians to educate during the COVID-19 pandemic [34].

Xu and Zhang (2020) Described pneumonia resulting from covid-19, which has been widespread in China since December 2019. There was no verified effective treatment for this disease, so the morbidity and mortality rate is assumed to be higher than the normal flu. Traditional Chinese medicine is widely used in clinical practice in China, but in many other countries around the world to treat conditions that remain clinically difficult. They suggested that Traditional Chinese Medicine might be useful for worldwide people infected with coronavirus disease [35].

Post *et al.* (2020) studied the case of low sodium rising the high risk factor through COVID-19 infection. The regular dietary salt intake, more acute changes in sodium balance may also influence ACE2 receptor expression. Intermittent loss of sodium, due to diarrhea, vomiting, or sweating, could put patients who acquire COVID-19 infection at an increased risk of developing a more serious or fatal disease. It seems prudent to monitor sodium intake and start resuscitation with sodium and fluids at the start of a more severe COVID-19 infection and perhaps also refrain from strong sodium restrictions during the current COVID-19 epidemic [30].

Li *et al.* (2020) presented a reported literature including statistical factors related to COVID-19 disease. In this study, 2506 patients with COVID-19 were included, of whom appearance of diarrhea was 5.8%. However, the analysis

of data indicated that 6.3% was the frequency of diarrhea. Differential onset of diarrhea between studies may be due to different criteria for determining diarrhea. Therefore, patients with COVID-19 should pay special attention to hand hygiene and avoid sharing the bathroom with family members [36].

Lippi and Henry (2020) implemented a concise meta-analysis demonstrate that chronic obstructive pulmonary disease (COPD) is associated with a significant risk, including severe infection with COVID-19. Patients with a history of COPD should be encouraged to take more restrictive measures to minimize potential exposure to COVID-19 and contact with suspected or confirmed cases of COVID-19. Physicians should also carefully monitor all COPD patients suspected of infection and it may be advisable to consider COPD as a variable in future risk stratification models [37].

Ali *et al.* (2020) suggested a remarkable genomic similarity to the 2019-nCoV severe acute respiratory syndrome. With evidence of nosocomial spread, a number of diligent measures are being used to limit its spread. Therefore, the WHO established the Public Health Emergency of International Concern with strategic objectives for public health to limit its impact on health and the global economy [38].

Goh *et al.* (2020) indicated that coronavirus infected a variety of animals, including humans, with different levels of respiratory and fecal-oral transmission depending on the behavior of the virus and optimal viral capacity. They constructed a model to classify and predict the levels of the respective respiratory and fecal-oral transmission potentials of different viruses before the outbreak of COVID-19 using artificial intelligent and empirical molecular tools to predict the level of protein disorder [39].

Underner *et al.* (2020) studied the effect of smoking through coronavirus disease COVID-19. In this case, the prevalence of smoking is very high among men (52.1%) and low in women (2.7%). This high prevalence of smoking in men, the cause of tobacco-related lung and heart disease, could worsen in coronavirus disease (COVID-19) [40].

Al-Ani and Al-Ani (2020) applied statistical measurements on the published works using coronavirus as a keyword. Their work concentrated on the selected 100 research papers on COVID-19. The human respiratory system is infected directly by this virus as mentioned by the literature review. The analysis of these papers indicated that medicine filed is the most weighted published papers of COVID-19 and China is the top country of the research papers [41].

In general, most of the above related works are focusing on effect of COVID-19 with the existing of other diseases. In addition, there are many guidance through COVID-19 pandemic such as: The guidance steps of medical treatment, healthcare guidance, statistical measures of infections, risk factor infection, and so on.

4. METHODOLOGY

The research methodology is divided into two parts: X-ray images (collected data) and corona virus detection approach.

4.1. X-ray Images

Two sets of X-ray images are used in this approach, as shown in Fig. 2, the first set regarding to normal X-ray images and the second set is abnormal X-ray images. These images are prepared to be ready for the implementation process.

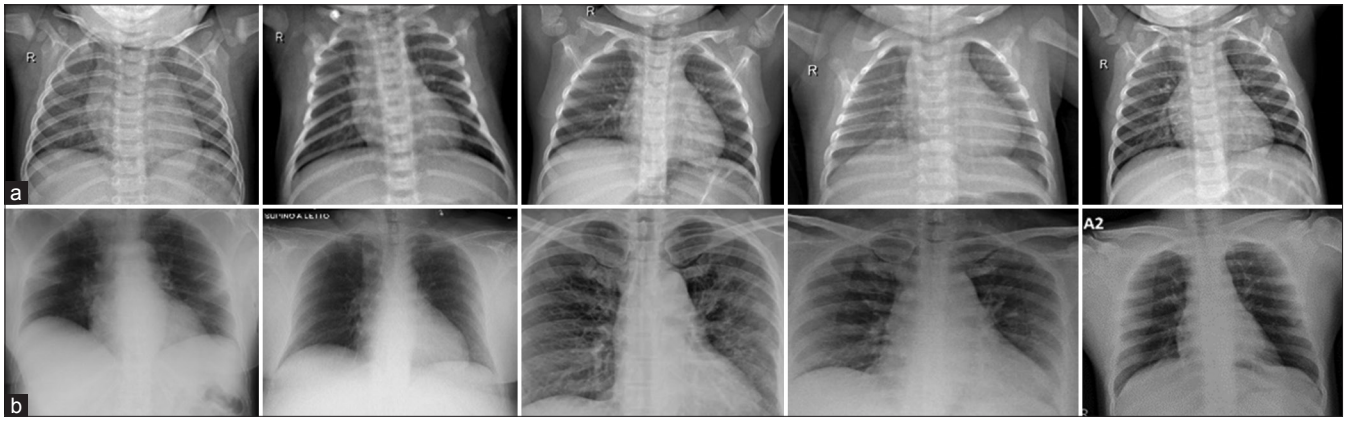


Fig. 2. X-ray images dataset. (a) normal X-ray images and (b) abnormal X-ray images.

4.2. Coronavirus Classification Approach

As it is mentioned previously that coronavirus affects the human respiratory system, so it can be detected through X-ray images processing. The implemented system including the following steps, as shown in Fig. 3:

- X-ray images: Normal and abnormal X-ray images are collected to be used in this research.
- Image acquisition: Different sizes of X-ray images are collected then converted into digital forms to be ready for processing.
- Preprocessing: The digital images are resized to be in standard size, then the images are converted into gray scale images.
- Feature Extraction DWT: DWT is applied to extract efficient features for the images. First level 2D-DWT is applied to achieve one quarter features of the original image concentrated in low-low band.
- CNN: The first step on CNN is converting the input image into vector and feed it to a multi-level perceptron for classification purposes. The CNN architecture comprises several main components: input of the original image, convolutional ReLu, 1st pooling, convolutional ReLu, 2nd pooling, 1st fully connected, 2nd fully connected, and output prediction. These components are presented inFig. 4.
- Decision-Making: The decision is made to differentiate between normal and abnormal cases. Statistical measurements such as mean value and standard deviation are applied to classify the output.

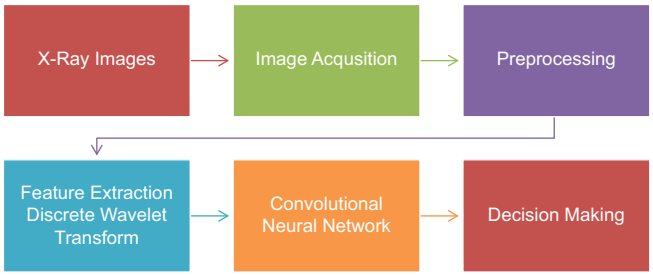


Fig. 3. Coronavirus classification approach.

5. RESULTS AND DISCUSSION

Medical image classification is an important issue in the field medical image processing. The accuracy this field is very important and depends on many factors including preparing image dataset and preprocessing these image to be ready for the classification process. Sixty three chest X-ray images are used in these approach 30 normal cases and 33 abnormal cases (infected with COVID-19), these images are passed into all steps of the implemented system. These images passed to all the steps of the proposed COVID-19 diagnosis system. Then, these images are feeded to the pre-trained CNNs tool to diagnose COVID-19 and differentiate between normal and abnormal cases to achieve the recognition accuracy. Fig. 5 demonstrates the binary classification between normal chest from 30 patients and 33 patients who infected by corona which recognized through ground-glass opacity, based on their X-ray modality, the image sizes are 256 by 256, in which the validation accuracy is 92.31%.

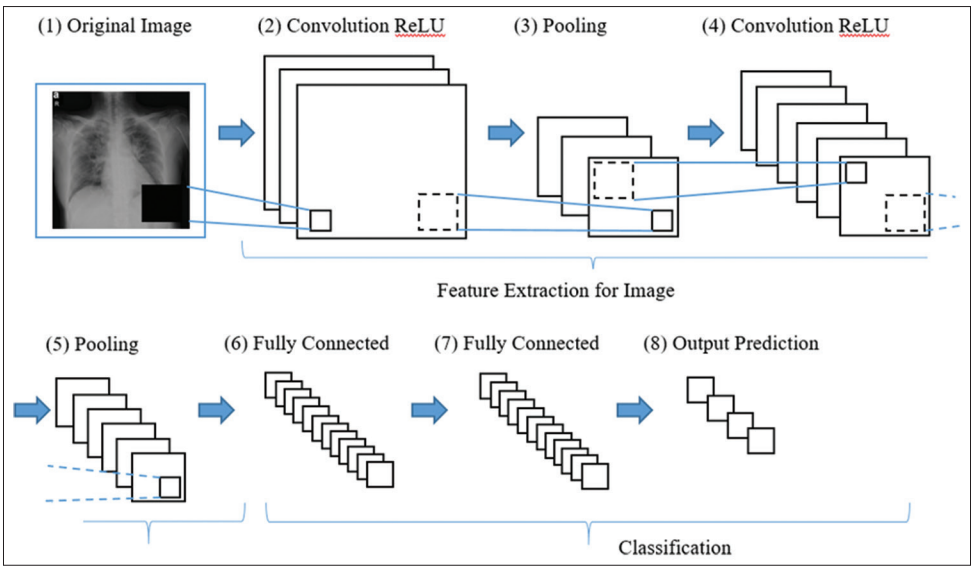


Fig. 4. Convolutional neural network architecture layers.

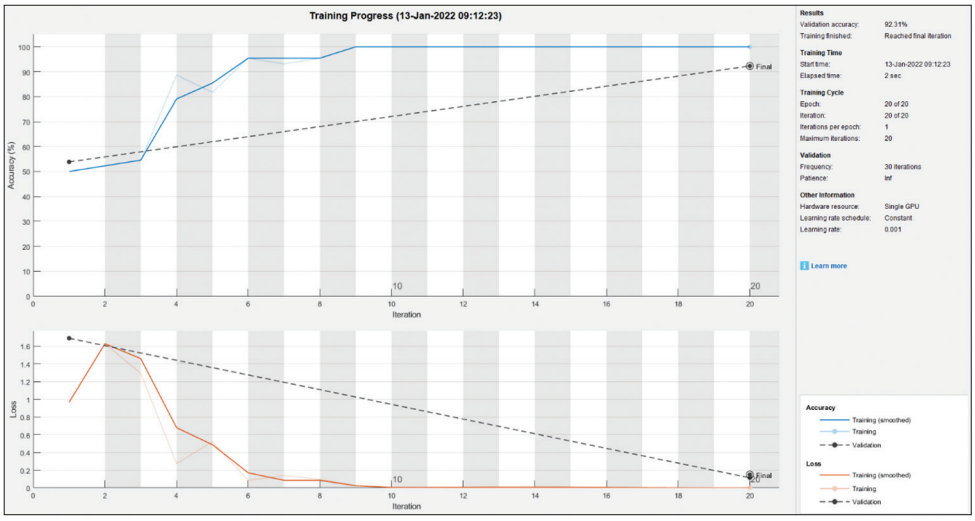


Fig. 5. Training progress applied convolutional neural network.

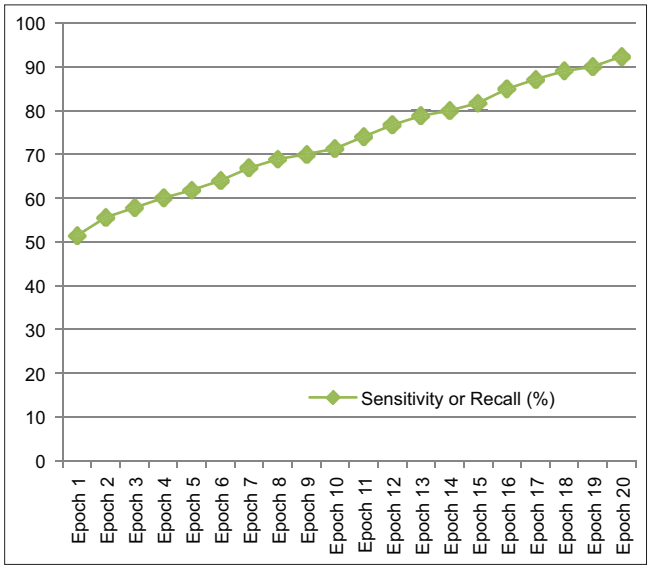


Fig. 6. Feature learning sensitivity based on the number of epochs.

Moreover, as demonstrated in Fig. 6, feature learning sensitivity or recall in the proposed system had an outstanding increase with a rise in the number of epochs, such that the sensitivity was 51.4% in case of having 1 epoch, while it became 92.31% when there reach 20 epochs.

6. CONCLUSION

This approach hybridizing both DWT and CNN to achieve high performance. This implemented approach differentiate between the classes of X-ray chest images related to COVID-19. Recognition accuracy is very important in diagnosing diseases in relation to medical images. This accuracy is more important and needs fast decision-making in relation to COVID-19 disease. The obtained classification of COVID-19 diagnosis applied CNN tool achieved a validation accuracy of 92.31%. Some important conclusion can be raised here that some of flu diseases have similar effects as COVID-19 so they interrupt the results.

7. ACKNOWLEDGMENT

On this occasion, we would like to extend our sincere thanks and appreciation to the ScienceDirect database that contributed to supporting the research of COVID-19 by providing open access of research papers.

REFERENCES

[1] W. Lu, H. Wang, Y. Lin and L. Li. "Psychological status of medical workforce during the COVID-19 pandemic: A cross-sectional study". *Psychiatry Research*, vol. 288, p. 112936, 2020.

[2] COVID-19 Clinical Research Coalition. "Global coalition to accelerate COVID-19 clinical research in resource-limited settings". *Lancet*, vol. 395, pp. 1322-1325, 2020.

[3] K. Slim and J. Veziant. "Urgent digestive surgery, a collateral victim of the Covid-19 crisis?" *Journal of Visceral Surgery*, vol. 157, pp. S5-S6, 2020.

[4] A. Ather, B. Patel, N. B. Ruparel, A. Diogenes and K. M. Hargreaves. "Coronavirus disease 19 (COVID-19): Implications for clinical dental care". *Journal of Endodontics*, vol. 46, pp. 584-595, 2020.

[5] A. Hormati, A. Shahhamzeh, M. Afifian, F. Khodadust and S. Ahmadpour. "Can COVID-19 present unusual GI symptoms?" *Journal of Microbiology, Immunology and Infection*, vol. 53, pp. 384-385, 2020.

[6] K. Zhang. "Is traditional Chinese medicine useful in the treatment of COVID-19?" *The American Journal of Emergency Medicine*, vol. 38, p. 2238, 2020.

[7] J. S. Hulot. "COVID-19 in patients with cardiovascular diseases". *Archives of Cardiovascular Diseases*, vol. 113, pp. 225-226, 2020.

[8] B. Pichi, F. Mazzola, A. Bonsembiante, G. Petruzzi and R. Pellini. "CORONA-steps for tracheotomy in COVID-19 patients: A staff-safe method for airway management". *Oral Oncology*, vol. 105, p. 104682.

[9] Z. S. Ulhaq and G. V. Soraya. "Interleukin-6 as a potential biomarker of COVID-19 progression". *Médecine et Maladies Infectieuses*, vol. 50, pp. 382-383, 2020.

[10] N. K. Kansal. "COVID-19, syphilis, and biologic therapies for psoriasis and psoriatic arthritis: A word of caution". *Journal of the American Academy of Dermatology*, vol. 82, p. e213, 2020.

[11] V. D. Powell and M. J. Silveira. "What should palliative care's response be to the COVID-19 pandemic?" *Journal of Pain and Symptom Management*, vol. 60, pp. e1-e3, 2020.

[12] C. D. Codispoti, S. Bandi, J. N. Moy and M. Mahdavinia. "Running a virtual allergy division and training program in the time of COVID-19 pandemic". *Journal of Allergy and Clinical Immunology*, vol. 145, pp. 1357-1359, 2020.

[13] A. Haleem, M. Javaid and R. Vaishya. "Effects of COVID-19 pandemic in daily life". *Current Medicine Research and Practice*, vol. 10, pp. 78-79, 2020.

[14] S. H. F. Hagmann. "COVID-19 in children: More than meets the eye". *Travel Medicine and Infectious Disease*, vol. 34, p. 101649, 2020.

[15] N. Montemurro. "The emotional impact of COVID-19: From medical staff to common people". *Brain, Behavior, and Immunity*, vol. 87, pp. 23-24, 2020.

[16] D. Nicola, V. Martella, L. J. Saif and C. Buonavoglia. "COVID-19 from veterinary medicine and one health perspectives: What animal coronaviruses have taught us". *Research in Veterinary Science*, vol. 131, pp. 21-23, 2020.

[17] S. G. Kwatra, R. J. Sweren and A. L. Grossberg. "Dermatology practices as vectors for COVID-19 transmission: A call for immediate cessation of nonemergent dermatology visits". *Journal of the American Academy of Dermatology*, vol. 82, pp. e179-e180, 2020.

[18] B. Xu, M. U. G. Kraemer and Open COVID-19 Data Curation Group. "Open access epidemiological data from the COVID-19 outbreak". *The Lancet Infectious Diseases*, vol. 20, p. 534, 2020.

[19] J. M. Classe, G. Dolivet, S. Evrard, G. Ferron and O. Sgabura. "Recommandations de la société Française de chirurgie oncologique (SFCO) pour l'organisation de la chirurgie oncologique durant l'épidémie de COVID-19". *Bulletin du Cance*r, vol. 107, pp. 524-527, 2020.

[20] C. Chica-Meza, L. A. Peña-López, H. F. Villamarín-Guerrero, J. E. Moreno-Collazos and M. P. Vargas-Ordoñez. "Cuidado respiratorio en Covid-19". *Acta Colombiana de Cuidado Intensivo*, vol. 20, pp. 108-117, 2020.

[21] I. H. Hamzavi, A. B. Lyons, I. Kohli, S. Narla and D. M. Ozog. "Ultraviolet germicidal irradiation: Possible method for respirator disinfection to facilitate reuse during the COVID-19 pandemic". *Journal of the American Academy of Dermatology*, vol. 82, pp. 1511-1512, 2020.

[22] S. N. Emadi and B. Abtahi-Naeini. "Coronavirus disease 2019 (COVID-19) and dermatologists: Potential biological hazards of laser surgery in epidemic area". *Ecotoxicology and Environmental Safety*, vol. 198, p. 110598, 2020.

[23] B. Robson. "Computers and viral diseases. Preliminary bioinformatics studies on the design of a synthetic vaccine and a preventative peptidomimetic antagonist against the SARS-CoV-2 (2019-nCoV, COVID-19) coronavirus". *Computers in Biology and Medicine*, vol. 119, p. 103670, 2020.

[24] E. Asperges, S. Novati, A. Muzzi, S. Biscarini and COVID-19 IRCCS San Matteo Pavia Task Force. "Rapid response to COVID-19 outbreak in Northern Italy: How to convert a classic infectious disease ward into a COVID-19 response centre". *Journal of Hospital Infection*, vol. 105, pp. 477-479, 2020.

[25] M. D'Arienzo and A. Coniglio. "Assessment of the SARS-CoV-2 basic reproduction number, R 0, based on the early phase of COVID-19 outbreak in Italy". *Biosafety and Health*, vol. 2, pp. 57-59, 2020.

[26] C. Wenham, J. Smith, R. Morgan and Gender and COVID-19 Working Group. "COVID-19: The gendered impacts of the outbreak". *The Lancet*, vol. 395, no, 10227, pp. 846-848, 2020.

[27] N. Penel, S. Bonvalot, V. Minard, D. Orbach and J. Y. Blay. "Options thérapeutiques de prise en charge des sarcomes durant la pandémie COVID-19: Propositions du groupe sarcome français". *Bulletin du Cance*r, vol. 107, pp. 398-399, 2020.

[28] A. Post, R. P. F. Dullaart and S. J. L. Bakker. "Is low sodium intake a risk factor for severe and fatal COVID-19 infection?" *European Journal of Internal Medicine*, vol. 75, p. 109, 2020.

[29] G. Lippi, C. J. Lavie and F. Sanchis-Gomar. "Cardiac troponin I in patients with coronavirus disease 2019 (COVID-19): Evidence from a meta-analysis". *Progress in Cardiovascular Diseases*, vol. 63, pp. 390-391, 2020.

[30] R. L. Mitra, S. A. Greenstein and L. M. Epstein. "An algorithm for managing QT prolongation in Coronavirus disease 2019 (COVID-19) patients treated with either chloroquine or hydroxychloroquine in conjunction with azithromycin: Possible benefits of intravenous lidocaine". *Heart Rhythm Case Reports*, vol. 6, pp. 244-248, 2020.

[31] I. V. Vahia, D. G. Blazer, G. S. Smith, J. F. Karp and C. F. Reynolds 3rd. COVID-19, mental health and aging: A need for new knowledge to bridge science and service". *The American Journal of Geriatric Psychiatry*, vol. 28, pp. 695-697, 2020.

[32] M. S. Shaker, J. Oppenheimer, M. Grayson, D. Stukus and M. Greenhawt. "COVID-19: Pandemic contingency planning for the allergy and immunology clinic". *The Journal of Allergy and Clinical Immunology*, vol. 8, pp. 1477-1488e5, 2020.

[33] K. N. Price, R. Thiede, V. Y. Shi and C. Curiel-Lewandrowski. "Strategic dermatology clinical operations during COVID-19 pandemic". *Journal of the American Academy of Dermatology*, vol. 82, pp. e207-e209, 2020.

[34] D. Vervoort, X. Ma, J. G. Y. Luc and S. Zieroth. "Rapid scholarly dissemination and cardiovascular community engagement to combat the infodemic of the COVID-19 pandemic". *Canadian Journal of Cardiology*, vol. 36, pp. 969.e1-969.e2, 2020.

[35] J. Xu and Y. Zhang. "Traditional Chinese medicine treatment of COVID-19". *Complementary Therapies in Clinical Practice*, vol. 39, p. 101165, 2020.

[36] X. Y. Li, W. J. Dai, S. N. Wu, X. Z. Yang and H. G. Wang. "The occurrence of diarrhea in COVID-19 patients". *Clinics and Research in Hepatology and Gastroenterology*, vol. 44, pp. 284-285, 2020.

[37] G. Lippi and B. M. Henry. "Chronic obstructive pulmonary disease is associated with severe coronavirus disease 2019 (COVID-19)". *Respiratory Medicine*, vol. 167, p.105941, 2020.

[38] S. A. Ali, M. Baloch, N. Ahmed, A. A. Ali and A. Iqbal. "The outbreak of Coronavirus disease 2019 (COVID-19)-an emerging global

health threat". *Journal of Infection and Public Health*, vol. 13, no. 4, pp. 644-646, 2020.

[39] G. K. M. Goh, A. K. Dunker, J. A. Foster and V. N. Uversky. "Shell disorder analysis predicts greater resilience of the SARS-CoV-2 (COVID-19) outside the body and in body fluids". *Microbial Pathogenesis*, vol. 144, p. 104177, 2020.

[40] M. Underner, G. Peiffer, J. Perriot and N. Jaafari. "Tabagisme et maladie à Coronavirus 2019 (COVID-19)". *Revue des Maladies Respiratoire*s, vol. 37, pp. 433-436, 2020.

[41] M. S. Al-Ani and D. M. Al-Ani. "Review study on sciencedirect library based on Coronavirus Covid-19". *UHD Journal of Science and Technology* (*UHDJST*), vol. 4, no. 2, p. 46, 2020.

p-ISSN 2521-4209
e-ISSN 2521-4217

زانکۆی گەشەپێدانی مرۆیی
جامعة التنمية البشرية
UNIVERSITY OF HUMAN DEVELOPMENT

UHD Journal of Science and Technology

A Scientific periodical issued by University of Human Developement

Vol.7 No.(2) December 2023

2023 2723

e.mail:jst@uhd.edu.iq