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JEAS

JOURNAL OF ENGINEERING AND APPLIED SCIENCES

A Refereed Academic Journal Published by the
Publishing and Translation Center at Majmaah University

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IN THE NAME OF ALLAH,
THE MOST GRACIOUS,
THE MOST MERCIFUL

Kingdom of Saudi Arabia
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A peer-review process which is transparent and rigorous

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b) Provide an avenue for exchange of research interests and facilitate the communication among researchers.

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Journal of Engineering and Applied Sciences

Journal of Engineering and Applied Sciences

Editorial

Scientific publishing has brought many challenges to authors. With increasing number of scientific journals, varying scopes, reviewing requirements, and cost of publishing to authors, finding the right journal to publish an article is a decision many authors must bitterly confront and resolve. The publication of scientific findings is an integral part of the life of researchers. The process of publishing has evolved to become an efficient system of decimating knowledge and collaboration among scientists. Science journals have institutionalized procedures to manage large volume of article submissions per year. In many cases, journals began to define narrower scopes for a dual purpose: managing submissions and delivering outstanding research.

Based on recent studies, the scientific publishing world consists of more than 25 thousand active journals in various disciplines and fields. Science Direct hosts 3,348 journals (as of February 2014). The Directory of Open Access Journals lists in its search engine more than 9,800 open access online journals.

According to recent estimates, the number of scientific journals grows by 3% per year worldwide. With this large number of journals, journals may find it harder to stay afloat.

In its inauguration, the board of editors is honored to introduce to the scientific community the Journal of Engineering and Applied Sciences - JEAS, another scientific journal from Majmaah University. The board has pledged a commitment to JEAS authors and readers to bring the most dynamic and vibrant journal management with better satisfaction.

Dr. Mohamed Alshehri

Contents

Architecture of Patient Health Records based on Blockchain Supported by Mathematical Model and Real Prototype

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Abstract
Patients share their crucial health-related information when visiting a health center for the first time. While searching for suitable treatment, patients often move from one health center to another, and, in this process, the patients need to continuously give their health-related information. The repetitive process of information sharing leads to unnecessary time consumption for the patients and healthcare staff. For this reason, researchers utilized the Personal Health Record (PHR), providing patients with continuous access to their health data—anytime, anywhere, and with many other advantages. Blockchain is a new technology that relies on building an encrypted technical system that allows each participant in the network to join without previous knowledge and trust. It can solve many issues, including those in the healthcare sector. This paper proposes an architecture of patient health records based on blockchain technology. The current work intends to contribute to the existing body of knowledge by suggesting a mathematical model for the proposed system and developing a prototype.

Keywords: Architecture; patient health record; blockchain; mathematical model; prototype.

1. Introduction

Patients are forced to share their crucial health-related information each time they visit health centers since neither patients nor health centers have access to their previous data. This lack of accessibility of patients' health records between hospitals is a major coordination breakdown caused by a lack of proper data management and data exchange [1]. Healthcare data must be shared between different healthcare sector institutions; it is vital for quality patient care.

The focus should be given to the management of data to connect isolated systems and increase the accuracy of health records to transform healthcare. An integrated data management system can be employed to solve poor data accessibility in the healthcare sector.

Blockchain is a distributed system that records and stores transaction logs. This technology can be used to support drug prescriptions, supply chain management and pregnancy data management, and any other health-risk data management. Additionally, it supports access control, data sharing, and managing an audit trail of medical activities [2].

Blockchain technology can solve many issues concerning healthcare [3]. The research question explores the extent to which the blockchain technology can be used in the health sector. This research attempts to answer this question through the use of a

methodology consisting of three stages: proposing an architecture of patient health records, developing a mathematical model of the proposed architecture and developing a prototype for the proposal.

The advantages of this approach are presented below:

- Patients can visit different hospitals, and doctors can see the history of their patients. Patient information will be available any time it is required.
- Patients do not have to repeat the same test when they go to new hospitals. Any hospital can access and see all previous results of tests done on the patient.
- There are fewer chances of medical error because medical professionals have a full account of a patient's history at their fingertips.
- Patients can control their data by giving them the privilege to make changes in the data.
- In the past, researchers found it challenging to collect patient data. It could only be obtained in complex ways. Researchers can obtain patient data more easily using the blockchain technique for research purposes by following this proposal.
- The patient's transaction log can be shared with several parties, such as insurance companies and pharmacies, to improve the logistics of data transfer. Their participation depends on the validity of these bodies and is authorized by the patient.
- At times, a patient's health information must be obtained very quickly. A delay in obtaining any information about the patient may increase the risk to the patient's life. SAPHR will enable medical professionals to obtain patient data quickly.
- The systems designed by the Blockchain are characterized by providing security and privacy.

The organization of this paper is as follows. We will begin with a clear problem statement; outline the background of blockchain; present related work and the proposed system; introduce our proposed mathematical model; discuss how to implement this research with a great scenario; discuss and conclude with a summary.

2.Literature review

2.1.Related work

Even though blockchains can solve many healthcare issues, some works have been published in the literature on using it in healthcare since it is a new technology [3]. Research [4] aims to discover and classify blockchain applications' benefits and challenges in healthcare systems. Researchers searched several databases, such as IEEE, PubMed, and Springer.The study was dealt with in three steps, depending on the PRISMA flow diagram. The obtained data is collected and presented using tables and graphs. The study summarizes that blockchain technology can improve health data sharing and its storage system and be distributed securely and easily.

Another paper in [5] reviews a recent comprehensive study of the various challenges and problems facing the health sector. This paper integrates technical opportunities for

blockchain technology to measure security. The paper focuses on the health sector's challenges and provision of different technical solutions based on blockchain technology.

Furthermore, a paper presented in [6] offers an overview that identifies the traditional use of health sector systems and technology to develop an electronic health sector. Technology enables a shift to e-healthcare. The paper also reviewed the laws of blockchain technology. Some studies have been presented in this research that contain blockchain methodologies in the healthcare industry and present several blockchain applications currently used to explain the benefits of using blockchain in healthcare.

The paper presented by [7] shows a patient data management system using blockchain technology. The paper presents a proposal to maintain patient privacy. The main research objective is to develop a distributed patient system. The proposal focuses on the loss of encrypted data when stored in the system.

A paper presented by [8] describes a method of presenting patients' data in a decentralized way to control their data. The research applied the conversion of blockchain to a control system that does not require the credibility of a third party to keep the patient informed about the data collected and used by medical professionals. The proposal contains three elements: mobile phone, service provider, and node of blockchain.

In [9], the author presents the concept of blockchain as used in data management for data sharing in a patient's health record between healthcare providers and researchers doing scientific studies. This research presents an architecture for managing and sharing data in the electronic health record of cancer patients. It was conducted in collaboration with Stony Brook University Hospital. The researcher implements his proposal on a prototype to validate security, privacy, and availability of electronic medical records. This proposal can improve decision-making and reduce the costs of healthcare.

In [10], the proposed system is a central model that focuses on patient data management and ownership. This system can organize and collect patient data easily and flexibly. The proposed system is promising since a third party can modify the patient's file without being trusted, and the patient will know who is viewing his data. The proposal presents legal and regulatory concerns aspects for the storage and exchange of patient data. The researcher made an application for smart devices, allowing the patient to manage and monitor their health data. This was done through the management of electronic patient data on a blockchain storage system.

In paper [11], a proposal was made to implement patient privacy encryption in the health sector using internet of things technology. The proposed approach is based on controlled alternate quantum walks, consisting of two parts: substitution and permutation. The research conclusively proves that the result is strong and effective for protecting patients' privacy.

Few research studies have regarded healthcare and its monitoring, such as the research proposed in [12]. It offers an approach based on cloud computing and big data to store and analyze healthcare data and improve its classification accuracy. The proposed approach uses data mining and ontology to help deal with huge amounts of big data and improve healthcare accuracy

Other research in [13] suggests a health surveillance system to monitor soldiers in different environments using internet of things technology. The proposal uses the Internet of Things technology, where the system monitors each soldier in real-time without delay. Then, the data is sent to the system. The system processes the data and makes recommendations accordingly.

The security of patient healthcare records is very important. A paper in [14] reviews privacy and security in healthcare and tests possible solutions in this area. The study shows protection in information technology in healthcare and enables researchers to understand privacy concerns, security, and available solutions.

Other research in [15] present a new framework to ensure privacy and protection in healthcare. The proposed structure preserves patient identities and contents for patient health records. It presents a new authentication schema with patient attributes and identities. The research in [16] presents a method to prevent unintended disclosure by following the Health Insurance Portability and Accountability Act (HIPAA) laws. The research methodology is designed to protect, retrieve, and verify patient data in electronic health records. The study demonstrated that this methodology effectively ensures that patient information is both protected and private via portable storage mediums.

Blockchain and privacy preservation in healthcare have been questioned recently, such as by the researchers in paper [17]. They prepared a survey to design the blockchain technology for electronic health record systems. They exclusively focused on security and privacy. In a part of the survey, basic knowledge related to both the electronic health record and the blockchain was presented. The researchers also presented several challenges and opportunities in this domain.

2.2.Block chain background

This section presents an overview of blockchain technology. Blockchain is a distributed system that records and stores transaction logs. More specifically, blockchain is a common and unchangeable record of peer-to-peer transactions built on block-related transactions and stored in a digital record. A blockchain can be defined as “a distributed, append-only, time-stamped data structure” [18].

Blockchain relies on building an encrypted technical system allowing each participant in the network to join (to store, exchange, and watch information) without previous knowledge and trust. In the blockchain system, there is no central object such as a bank. Instead, transaction logs are stored and distributed to network participants. Then, each interaction is known to all participants and checked by the network before

adding information. This allows for trusted collaborations among network participants during registration and a non-changeable audit trail of all interactions [19]. For more information about blockchain technology, the reader can go to the white paper authored by Satoshi Nakamoto [20].

Bitcoin used blockchain technology to attract public attention. Later, many cryptocurrencies and projects based on blockchain appeared. Blockchain offers a secure framework for cryptocurrencies, where no one can tamper with the content of transactions, and all nodes participate in transactions anonymously [21]. The technical structure is a set of blocks that are linked in a list. The current block contains information about the previous block. Each block has two sections: the main body and the header. The header contains the block number, the previous block's hash value, the current block's hash value, and a timestamp. The main body of the block contains one or more transactions [22]. Consequently, blockchain technology can be widely used in various fields (e.g., the financial field, medical systems, supply chains, and the internet of things). For example, blockchain can be used to track counterfeit medicines by using the Internet of Things to track the drugs and verify their source. We can ensure that medicines are true to the original and can save many people's lives by using this technology [23].

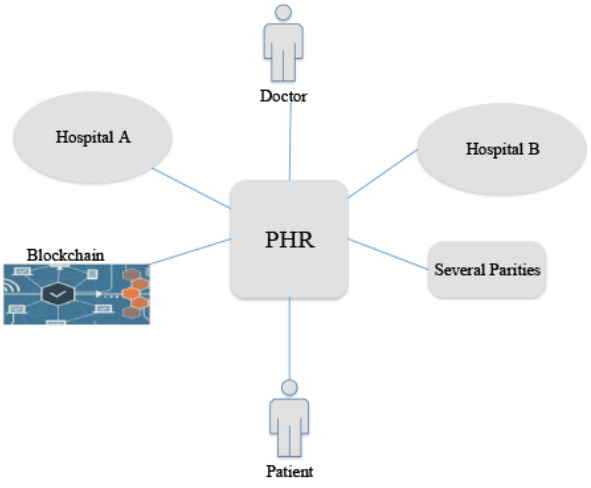
3.Proposed system

This research methodology consists of three proposed stages: architecture, mathematical model, and implementing a prototype.

3.1.Proposed architecture

This paper proposes a digital design called the Architecture of Patient Health Records based on Blockchain (APHRB). A proposal summary is presented in Fig 1 below. Using APHRB, any hospital can create a patient record and distribute it among other hospitals by using blockchain technology. Further, both patients and doctors can access the proposed system, including other relevant parties. Consequently, each hospital has a copy of the record. This patient record contains all data related to the patient.

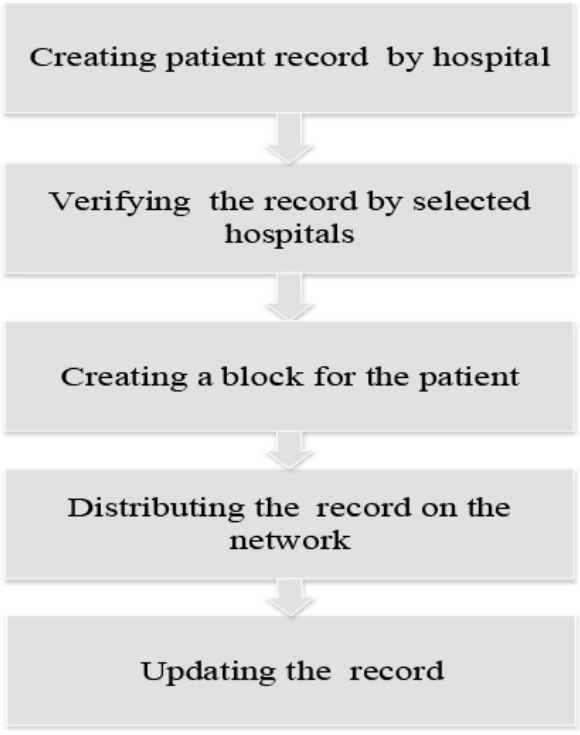
Fig. 1. Architecture of Patient Health Records



The research's proposed architecture (Fig 2) has five steps that must take place. These steps are as follows:

1. The hospital creates a record of their patient with basic information.
2. The new created record must be verified by the group of hospitals in the blockchain platform.
3. If all the selected hospitals accept the new record, the block for this patient will be created.

Fig. 1. Architecture of Patient Health Records



4.The new block will be distributed over the network. This block is immutable and cannot be changed or removed.

5.Later, the block can be updated, but the same process must be followed, starting from step 2.

The current research will demonstrate how the proposed system will work with a scenario to understand it easily. Ali is a patient of one Saudi hospital. This hospital has its Electronic Health Record (EHR), where all the patient history is stored. This hospital can create a record using blockchain technology. This record contains all the necessary information about the patient. For example, Ali's medical history, such as his full name; gender; birth data, national ID and blood type; weight history; breathing history; and blood pressure history. The selected hospitals must verify the created record. These hospitals will be selected via the main hospital where Ali is a patient. They can reject or accept this record. Once the record has been verified, it converts into a block. Then, it is distributed across the network. Next, each hospital can see a copy of the block of the patient Ali. A timestamp and encrypted signature are set in the block. With any update, such as blood pressure history, the same process must be repeated. Once all data are in a blockchain record, it is immutable, and other hospitals in the chain can track the data of Ali. In this way, blockchain produces trust among different hospitals. Every hospital can perform checks on a patient in real-time.

3.2.Mathematical model

In this section, we present a mathematical model showing how the proposal works. This is because it uses precise language and helps formulate ideas and identify underlying assumptions. Further, mathematical modeling can be used for several different explanations. The following objects have been identified for this proposal:

Hospital is denoted by H, where H can range from 1 to n. Patient is denoted by P, where P can be from 1 until m. Each patient($\boldsymbol{P}_i$) has a record ($\boldsymbol{R}_i$). This is denoted by $\boldsymbol{P}_i \rightarrow \boldsymbol{R}_i$.The patient index is denoted by i. The hospital index is denoted by j. We denoted the hospital and patient interaction by the following equation:

$\boldsymbol{X}_j = \boldsymbol{H}_j(\boldsymbol{R}_i)$ The $\boldsymbol{X}$ variable is the record of the patient in the hospital, where $\boldsymbol{X}_j$ can take a value 0 or 1, as follows:

$\boldsymbol{X}_j = \{0,1\}$; 0 = patient is not accepted, 1 = patient is accepted. The set of chosen hos-

pitals for verifying a new record is denoted by H_{th}. We denoted by 'dist' the distribution function of the record R_i to the chosen hospitals as follows:

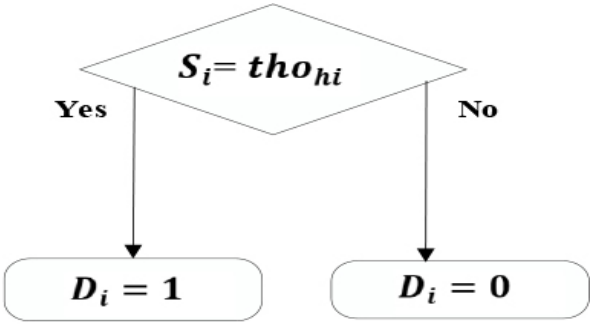
dist$(\mathbf{R}_i)$ $\{H_i/jtH_{th}\}$

Now, we have to calculate the sum (Si) of how many acceptances get back to the main hospital. This is denoted by:

$S_i=\sum_j^n=1^{Xj}$

The threshold is denoted by: tho_{hi}. A condition must be made after the sum of acceptances as presented in Fig 3.

Fig. 3. Condition after the sum of acceptances



The user can set up the value of = tho_{hi}. If D_i=1, all the hospitals have accepted the request, and, therefore, the block for this patient will be created.

If D_i= 1, then B_i=R_i Else Rej

where B_i means creating a block, and Rej means rejecting the request. To update B_i, the following condition must be true:

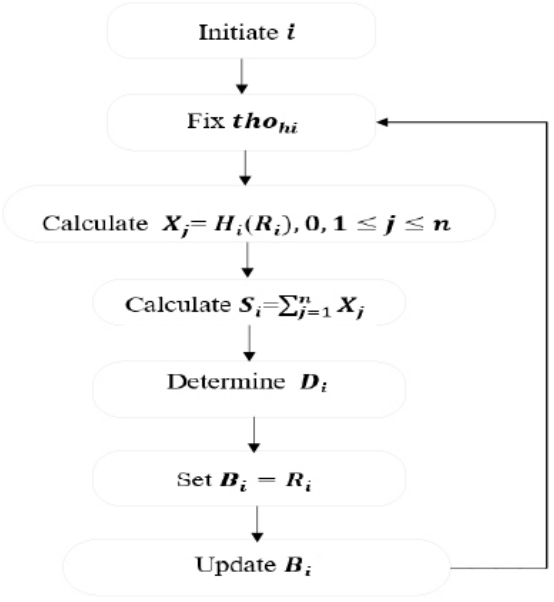
R_i^t : R_i at time > 0

R_i : $R_i$at time = 0

if $R_i \neq R_i^t$), then update B_i

This means that going back and updating the patient record is not possible. The workflow in Fig 1 below shows the process to update patient' record. The hospital should determine the patient as well as the initial information that need to be updated, after that to determine the number of hospitals to verify the updating. A request must be sent to the selected hospitals, and the algorithm determines the number of accepted requests. In the event that the number of hospitals that accepted the request is the same that was determined in initially, the modification to the data will be confirmed with a timestamp.

Fig. 4. Updating the patient record



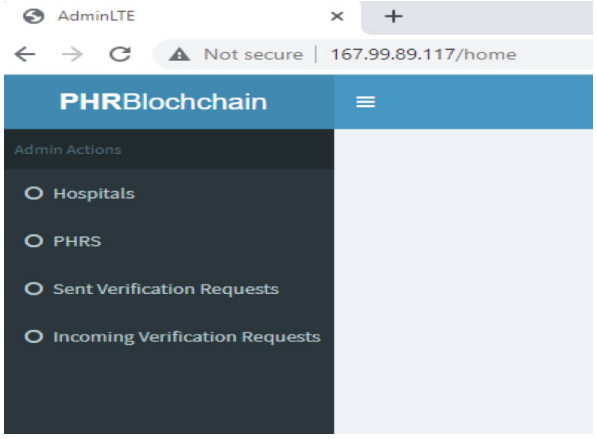
3.3.Implementing a Prototype

Implementing a prototype is creating a preliminary model of a product so that the model varies in accuracy. The prototype's aim is presented in this section to explain the architecture and enhance the system's analysts and users' understanding. The prototype provides conditions for a real system, providing a functioning example through which a new model can be derived. The prototype will show and describe how the proposed approach will work in the real world. It will show how a patient record can be created and how selected hospitals can verify this record. It

will also describe how the block will be verified and updated.

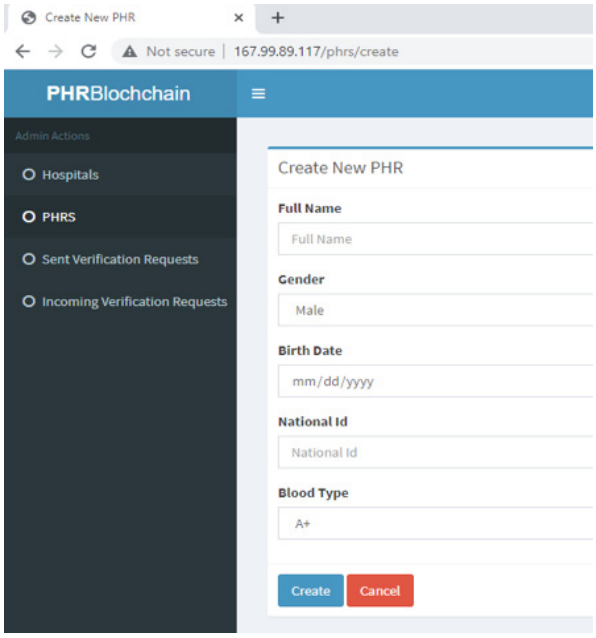
This prototype has been created by PHP (Hypertext Pre-processor) languages, which is used to develop web applications. The prototype uses the Laravel framework and My SQL database. The prototype can be reached by the URL name http://167.99.89.117/. Accessing the prototype requires a username and password. Once the system user has entered the username and password, the next page will appear, as shown in Fig 5 below. This page's main menu is presented on the left, which consists of four elements: Hospitals, PHRs, Sent verification requests, and Incoming verification requests.

Fig. 5. Main menu for the prototype



When the system user clicks on the "Hospitals" button, a new screen will appear. The user of the system can add new hospitals. To add a new hospital requires having some basic information about a hospital. The name of the hospital, an email address, and a password must be added to the system. Our proposal's second element is the PHR, where any hospital can create a record for their patient. Some basic information belonging to the patient must be added, such as full name, gender, birth data, national ID, and blood type, as shown in Fig 6.

Fig. 6. Interface for Patient information



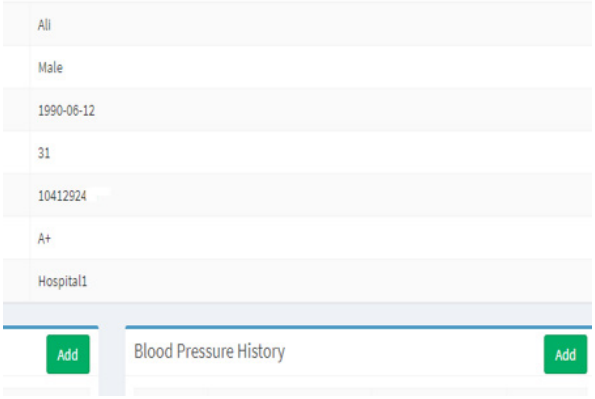
The other two elements are "send verification request" and "incoming verification request." We will discuss these functions more in the case study since these functions require real data to understand them clearly. We will show how the prototype works in real life. First, we must add some hospitals to our system to verify patient information later. The five hospitals' names are Hospital 1, Hospital 2, Hospital 3, Hospital 4, and Hospital 5. Each hospital must have an email address.

4.Scenario

This section presents a scenario for one patient called "Ali" to simulate the real word. One hospital can create a record for this patient via this system. Hospital 1 has created a record for patient Ali since he is a regular

patient. Hospital 1 can create a profile for this patient using the proposed system, as shown in Fig 7. The patient's basic information has been inserted including such as full name, gender, birth data, age, nationality, and blood type. Further, the hospital name that created this profile will appear.

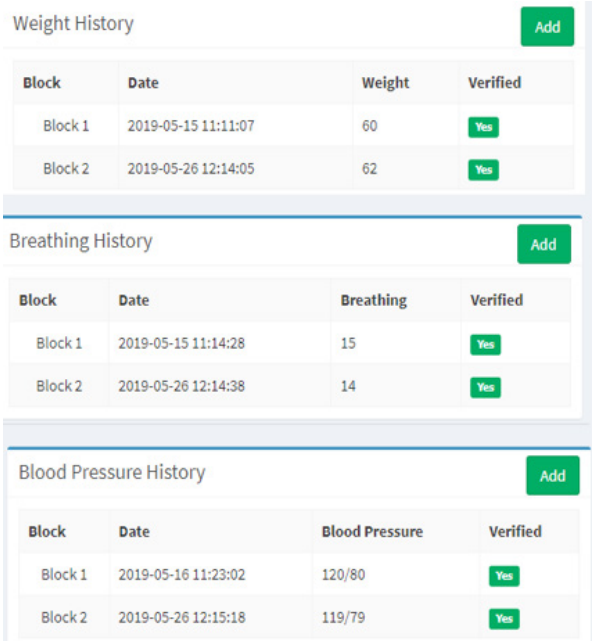
Fig. 7. Creating profile for patient



The hospital can also add health-related information for this patient, such as weight, breathing ability, and blood pressure. However, this information must be verified by the other hospitals in the system. This is a policy for blockchain technology. From Fig 8, it can be observed that the weight history has been updated on 2019-5-26 at 12:14 pm to 62 kg. Further, the breathing history has been updated to 14, and blood pressure has been updated to 119/79 on 2019-5-26. The new updates must be sent to the other hospitals to be verified. The new update will be on a red line, which means it must be verified and approved by other hospitals.

Ali's information must be sent to other hospitals to verify his data by selecting the red icon called "send a verification request." Then, a list of hospitals will be presented in front of the user. The responsible doctor

Fig. 8. Adding health-related information for patient



in Hospital 1 can select which hospitals to choose from. Two hospitals are selected, which are Hospital 4 and Hospital 5. Next, each hospital must check their records and verify Ali's information by replying "accept this request" or "reject this request." In the web page of Hospital 4, by pressing on "incoming verification request" on the page's left, we see that this is a request from hospitals to verify Ali's information.

Hospital 4 must reply to this request by pressing on the icon "reply now." Then, a new screen should appear. Based on the available hospital information, the hospital will reply "yes" or "no." Let us assume that this information is correct so that the reply will be "yes." Assuming that both Hospitals 4 and 5 accepted and verified this request, the main hospital, Hospital 1, that sent this request can see the request's state. This patient's block has been approved and created. The new data added has specific features. They are highlighted by adding a

date and time for this update.

5.Discussion

Blockchain technology can solve many problems in healthcare and add real value. The blockchain model's establishment will enable hospitals and all other related healthcare sectors related to gain access to patient data without complications in data transfers.

Patients data can be tracked and modified by the patient, doctor, hospital, and other parties who have access. The electronic exchange of patient data between the patient and their doctors can help provide health services to the right person at the right place and time. Reliability is maintained, given that several sources confirm each record. Secondly, the data will remain unchanged over time. No one will make changes to the record without agreeing with other sources. Further, the data will be secure from the modern threat of data theft.

The mathematical model shows the process to update patient' record. In the beginning, the hospital determines the name of the patient, as well as the initial amendment to his data, then determines the number of hospitals that will verify the amendment, and sends the request to the selected hospitals, and the algorithm determines the number of accepted requests, in the case that the number of hospitals that accepted the request is the same that was determined in Initially, the modification to the data will be confirmed a with timestamp.

A main aspect of quality healthcare is how easy it is for the patient to access their health data. With APHRB, patients always have immediate access to their health records entered on the system by each hospital they attend. Finally, when a patient is unsure which hospital will provide the required healthcare, the best secure way to share the patient's data between the hospitals that the patient visits is to use SAPHR described above. In this way, hospitals can better collaborate, understand, and diagnose the patient correctly.

The difference between existing health projects and the prosed system in this research is that most of the literature reviews focused on the theory part of using blockchain in healthcare, the privacy and security of patient data, and mentoring the patient using the internet of things technology. However, this paper aimed to propose an architecture of Patient Health Records based on blockchain technology supported by a mathematical model for a developed prototype.

This approach's advantages are that patients can visit different hospitals and that doctors can see their histories. Patient information will be available at any time it is required. Therefore, patients will not have to repeat the same test when they go to new hospitals. Any hospital can access and see all previous results of tests done. The proposal is aimed to reduce medical errors since medical professionals can gain a full account of a patient's history at their fingertips. Patients can control their data. This can be done by giving them the privilege to make data changes.

Table 1 below shows comparison study

that compares our proposal in this research with other studies. Three critical studies have been chosen which are the following presenting an architecture, proving a mathematical model and doing a real prototype. The result shows that our research proposal has got all the three features, whereas others studies only have either one or two features.

Table 1. Comparison table

No	Related work	Architecture	Mathematical Model	Real Prototype
1	Reference 4	√	X	X
2	Reference 5	X	X	X
3	Reference 6	√	X	X
4	Reference 7	√	√	X
5	Reference 8	√	√	X
6	Reference 9	√	X	X
7	Reference 10	√	X	√
8	Reference 11	√	√	X
9	Reference 12	√	√	X
10	Reference 13	√	√	X
11	Reference 14	X	X	X
12	Reference 15	√	√	X
13	Reference 16	√	X	X
14	Reference 17	√	X	X
15	PHRB	√	√	√

Researchers have found it challenging to collect patient data in the past. It could only be obtained in complex ways. By using this proposal, researchers can obtain patient data more easily using the blockchain technique for research purposes. Further, the patient's transaction log can be shared with several parties, such as insurance companies and pharmacies, to improve the logistics of data transfer. Their participation depends on the validity of these bodies and is authorized by the patient. The patient's health information must be obtained very quickly at times. A delay in obtaining any information about the patient may increase the risk to the patient's life.

6.Conclusion

Patients often leave their data at several health centers and move from one hospital to another. In this process, patients lose access to their previous data. Presently, the lack of connection between hospitals is a major challenge for patient data transfer. There is a deficiency in data management and exchange. Blockchain is a new technology that can solve many issues in diverse fields, including the healthcare sector. For these reasons, this paper has proposed an architecture of Patient Health Records based on blockchain, proposed a mathematical model for the system, and developed a prototype. As for further research, blockchain is still a new technology in healthcare, and new ways for employing it to solve current problems can still be found and researched.

Conflict of Interest

The author declares that the manuscript is original, has not been published before, and is not currently being considered for publication elsewhere.

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Readiness of Qassim University for e-Learning during COVID-19 pandemic: Students' Perspective

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Abstract
Most governments across the world have temporarily shuttered education institutions to halt the spread of the COVID-19 epidemic. The epidemic has caused countrywide lockdowns that might put technology to the test for finding solutions to distant learning. Saudi Arabia, as a country, has accomplished online and remote learning despite the persistent closure of schools. However, a few systems have been identified to help with distance learning. Many countries and schools had not prepared for such systems and had little equipment to facilitate distance learning. The access to technology by households varies as some middle-income nations have less access to cellphones and broadband internet. Therefore, the study aims to identify the extent to which institutions have incorporated IT technology in e-Learning systems. The study focuses on 250 students at Qassim University during the outbreak of the COVID-19 pandemic. A link to an online questionnaire was sent to the students as they were asked to complete and mail the report. A chi-square test and standard deviation were used to test and analyze the results. The results showed the efficiency of using IT technology in achieving e-Learning systems. Therefore, the degree of readiness of institutions for the COVID-19 pandemic was low, and the study has shown a statistical significance of IT technology to be included in the e-Learning system to combat the effects of the pandemic.

Keywords:
COVID-19 epidemic; e-Learning; readiness; Saudi Arabia.

1.Introduction

University learners around the world have had their training seriously disturbed that time due to the COVID-19 pandemic, as universities find it difficult to deal with repeated closures and reopening's, and move, if an option, to online education. However, it is the students who are most affected by the emergency procedures. Universities closing because of health and other crises are not novel, about limited into the developing world, plus the possibly overwhelming results are well apprehended, including learning loss and high dropout rates [1].

Students with the least potential and the poorest are the most affected when universities close, so governments have been fast to call to the connection of education also the protected availability of universities, wherever feasible, as nations begin to impose closure actions. "Unfortunately, the range and rate of the modern changes in education is unique and, if prolonged, could advance the right to learning," stressed "the Director-General of the United Nations Educational, Scientific and Cultural Organization (UNESCO)."

Nevertheless, the idea of a virtual study

online is a far-fetched vision for millions. In April, UNESCO reported gaps in digital technology-based distance education, by data explaining that some 830 million learners do not have a path to a computer. The picture is especially severe in low-income countries: approximately 90% of learners in some countries do not have a home computer, while 82% cannot connect to the Internet. Last June, the "United Nations Children's Fund (UNICEF) responsible for education," Robert Jenkins, said, "Us are soon studying at a deeper and extra divisive learning crisis. But, in several developing countries where online or computer education is not an option for greatest learners, radio has been instrumental in reaching millions of people and is being used to maintain some form of education The study aimed to reveal the degree of readiness for digital learning in the Kingdom of Saudi Arabia during the Corona pandemic from the perspective of Qassim University students, and to identify the extent of students' readiness and availability of possibilities to use digital learning in the Kingdom of Saudi Arabia, and the availability of digital infrastructure at Qassim University, and to identify the impact of the capabilities of And the skills of students and faculty members in dealing with the technology necessary to prepare for digital learning.

Mobile learning (M-Learning) is acquiring a lot of significance among the new generation. Mobile learning upgrades for understudies thinking and spurs them for profound learning and hence prompts significant production of information. Among the benefits of versatile learning, scarcely any significant ones incorporate; Mobile learning is an extra or supporting wellspring of discovering that are accessible any time; wherever; any organization; on any remote gadget, and so on Versatile learning raises the learning revenue and correspondence of students as it gives learning material in various configurations that are open whenever. Portable learning upholds better approaches for learning through cell phones, for example, cell phones, PDAs and MP3 players. Innovations focused on Mobile learning are bound to significantly affect fair and square of proficiency in the learning system. This has prompted most learning organizations to embrace versatile innovations in the different fields of learning exercises [2].

1.1. Structure

1.1Definition

The pervasiveness of portable technologies is one reason why it might demonstrate hard to characterize the m-learning idea (Grant 2019; Ferreira et al. 2015). Its definition is relevant to online schooling (e-learning). "E-learning can take place through various electronic media such as PCs and PCs, among others, because these devices may connect to both online and offline programs. Regardless, mobile customers may access m-learning information from any location, whilst others are scattered around the city. Several studies consider m-learning to be an advancement or a subset of e-learning rather than a separate discipline. Portable education, ac-

cording to Garcia-Cabot, de-Marcos, and Garcia-Lopez [3], is a subset of e-learning since it is a more evolved invention than the previous one. Conversely, several fresh studies suggest that this form of learning is a distinct discipline 4 [4]. Some argue that the 'portable' portion of m-learning refers to their users' mobility [5] [6]."

1.2.Value gained in education through mobile learning

Mobile technologies can be of incredible assistance in the teaching learning process. Since mobiles are small, helpful and easy to use, those features can be used while planning portable learning environment. Coming up next are the benefits of mobile learning:

- Cellphonesassiststudentswithgettingto learningcontentanyplaceandwhenever.
- Learners can learn while they are commuting and voyaging and time is saved.
- Mobile can store tremendous measure of data in spite of its size. Subsequently, the printing of learning materials can be diminished.
- Mobile technology enables understudies to intently interface with their friends, instructors, far off and even vested parties around the world. This enables interactivity.
- Helps to upgrade abilities , with a level of security that might be missing when utilizing shared PC offices.
- Good help for supported methods of interaction.
- Introduced opportunities for students to give prompt feedback on their learning performance.
- Psychological help for those in danger of dropping out, through interpersonal organizations or individual direction from a guide.
- Learning materials can become available to a bigger crowd, through digital recordings, versatile applications, web journals and digital books, and so forth
- Support student retention, movement and progress.
- One can get to illustrations, video clips and sound libraries from anyplace, including public places and moving transports [7].

1.3 The use of m-learning in instruction (with examples)

Diverse education organizations should take on various techniques for portable learning. For example, a few schools practice distance learning online modules, tablets which are generally utilized since note pads, plus different gadgets. Example of such frameworks that help the utilization of these assets is a reality-based versatile education framework. This framework is utilized to do explore exercises dependent on requests. Chiang, Yang, and Hwang [8] undertook an examination on a reality-based flexible teaching framework, which was initially tested in a Taiwanese primary school where an instructor was forced to show 57 understudies from two distinct courses. The study was intended to determine how effective the framework is at inspiring and teaching understudies. "The outcome was favorable, and the framework was found to be appropriate for further improving learning and motivation

in undergraduates. Further discoveries reveal that such understudies were moved to have confidence, became attentive, and had many aspects of life that were highly relevant to schooling [8]."

Mobile technologies are extremely allluring and simple to deal with and access data. They are cheap, can be effectively conveyed and in this way have extraordinary potential for arriving at underestimated gatherings and furnishing them with admittance to additional learning and improvement. Cell phones and advancements that help portable learning contain:

- E – Book
- Handheld game control center, new gaming consoles
- individual sound player for hearing digital broadcasts
- iPod
- Tablet Computer
- PDA in the homeroom and outside
- Handheld sound and interactive media guides, in exhibition halls and displays
- Mobile and Smart Phone

2.Learning Management Systems

Recently, students and teachers have been focused on keeping the learning system as easy and engaging as possible. Thusly, such countless developments have come up to get rid of the conventional learning techniques. Researchers are introduce concocting virtual frameworks of instruction, one of which includes an administration framework named as the learning management system.

The LMS, "which is frequently used in face-to-face and online learning, blended learning, and internet learning settings, has been increasingly used by gaining knowledge foundations to help with educational conveyance [9] [10]. The LMS is growing at a growth yearly rate of 24.7 percent from 2016, with a global LMS market estimated to reach USD 15.72 billion by 2021 as a cost-effective option for massive scope dispersion of learning resources, along with unbounded reception of sophisticated innovation [11]."

The LMS may be utilized either on-premises or in the cloud. It takes advantage of the web's whenever and whenever availability, breaking down genuine study hall barriers " [10] to provide capabilities such as course management, content administration, student executives, and so on. Students benefit from the LMS in a variety of ways, including easier access to learning resources, communitarian learning with classmates (Islam and Azad, 2015), and online instructor feedback [12]."

2.1Using mobile learning in conjunction with LMS

"This is the most common way of applying learning management instruments in a versatile learning environment. It necessitates that understands completely the system of a portable learning and match them with those of learning the learning management system. For example, coordinating 'miniature lectures' with mobile learning [13]. Any blend of a learning the management framework with mobile learning leads to another substance. In the previously mentioned mix, the subsequent tool is a miniature learning gadget which supports the

utilization of portable terminals in learning. The mix of portable learning and a learning management system additionally results into an entirely unexpected framework known as the mobile learning system (MLS). Such a framework empowers understudies and educators to get to taking in materials from their PCs and furthermore from Smartphone. The framework is supposed to be successful since different platforms be utilized simultaneously. The framework incorporates improvement of androids, explanation of recordings, examination of how grouping happens, push knowledge, Lucien full-text search, and other helpful inventories. The utilization of various stages guarantees that understudies and instructors associate from any spot, and whenever they need, since resources can be shared even in significant distances."

Mobile learning and education can also be combined through a variety of activities and events. As a result, the technique utilized is known as distant learning. Because of the accessibility of better specialized gadgets, educators may get access to modules, assign duties and chats to understudies, and receive feedback on all errands assigned to substantial distance pupils. Because it is engaging, time-bound, and energizes execution and assessment measurements, the framework encourages understudies to engage more in the learning system. Such a framework is accordingly more powerful in affecting information and executing the school educational plan than the customary strategies for learning.

Likewise, integration allows learning adaptability where there are such a large number of necessities for learning. Customarily, a solitary learning the executives framework was answerable for creating, overseeing, and furthermore for course and content conveyance. Since most such frameworks are not viable with one another, there is need for the advancement of a wide range of frameworks with various usefulness. Such frameworks permit students to just work on what they need and dispose of that which they detest [14].

One more method of integration is the utilization of cell phones that are incorporated with moodle learning the management systems. This mix builds the capacity of understudies to deal with specialized conceivable outcomes in fusing exercises of versatile learning during the time spent e-learning. The partnership also permits the usage of an application interface which has been coupled to several kinds of smartphones for the purported "mainstreaming" of all portable technologies in electronic learning [15].

3.AIM OF STUDY

The main objective of this work revolves around finding out the future college student' opinions regarding the future trends in e-learning field, to identify the future of using IoTs technology in e-learning applications.

3.1.Finding

a) Sample and procedure

To collect empirical data for this research, the survey questionnaire method was tacked up. The questionnaire was admin-

istered to students in five public faculty in Qassim university. 250 students, from Qassim university, were enrolled for the current study. The students sample consisted of 130 (52%) males and 120 (48) females. All 250 students contributed to the survey voluntarily. A link sent using university emails to the online questionnaire was mailed to them through and they were asked to complete the questionnaire.

b) Measurement Instrument

In this respect, the Instrument was developed to measure the questionnaire that measures the willingness of Qassim University learners for e-learning and distance education during the Corona pandemic. As there are no tested plus reliable means to learning students' viewpoints, the questions were created by the researchers after a review of the literature, also psychometric studies were not transferred. The estimation objects depended on a five-point class Likert scale, going from (1-5) strongly disagree to strongly agree. The interior consistency unwavering quality was 0.84 and Cranach's α (≥ 0.88), which was utilized to assess the dependability of the instrument. Thusly, the survey had adequate acceptable quality. The questionnaire items consisted of 23 items with five constructs as follows: Hardware and software Components (HS), Internet services and capabilities (IC) - Usability and Resiliency (UR) - Ease of learning (EL) - Efficiency and achievement (EA). focus on practices in undergraduate education consistently predict development during the 2020-2021 academic year's first semester. the questionnaire form and the scales were mailed (online) to voluntary students provided link.

3.2.RESULTS

The internal consistency validity was gathered to guarantee that there are relationship among develops and inquiries of the instrument. As displayed in Table 3, the worth of the inner consistency validity goes from 0.843 to 0.935. The worth alludes to an OK worth of inside consistency validity which is measurably huge (at $p < 0.05$) overall. Adequate worth dependability is 0.70. Hence, the estimation things have Validity and dependability and there is a solid relationship between's the connection coefficient between things of each develop things. Our finding shows that, Hardware and software Components (HS), Internet services and capabilities (IC) - Usability and Resiliency (UR) - Ease of learning (EL) - Efficiency and achievement (EA). have a significant positive affected on Preparedness of Qassim University students for e-learning. Inversion of the results of previous research, our results show that Preparedness of Qassim University students for e-learning are the most important factor in e-learning in the future. In our study, IoTs changes students' academic perceptions and actions at the identification level. The employment of IoTs and context-aware technologies for educational objectives in higher education may result in a technological progression in the academic world.

Hardware and software Components (HS), Internet services and capabilities (IC) -

Table 1 "A correlation matrix between constructs"

Constructs	1	2	3	4	5	6
HS	.856	-				
IC	.871	.834	-			
UR	.834	.835	.862	-		
EL	.728	.918	.863	.837	-	
EA	.922	.801	.783	.884	.891	-

2-tailed p values; *p < 0.05, **p < 0.01.

Usability and Resiliency (UR) - Ease of learning (EL) - Efficiency and achievement (EA).

Table 2 discrimination validity of constructs

constructs	Cronbach's Alpha
HS	.856 **
IC	.834 **
UR	.862 **
EL	.837 **
EA	.891**

2-tailed p values; *p < 0.05, **p < 0.01.

Table 1 shows the statistical results of students' perceptions about e-learning. Responses to the first Constructs Hardware and software Components (HS) show that most students believe that they own a computer (Mean, SD 1.76±.430), have access to a dependable computer (Mean, SD 1.45±.498), approach a PC with the vital programming introduced (Mean, SD1.60±.491), A printer is joined to my computer(Mean, SD1.53±.500), they have willing to acquire admittance to a PC and Internet connection at home (Mean, SD1.841±.84), they approach a PC in campus or Internet bistros with stable Internet connection(Mean, SD1.39±.488).

Table 3 shows the statistical results of students' perceptions about e-learning. "Responses to the second Constructs about Internet services and capabilities that have

Table 3 Means, Standard deviations (SD), Chi-square and Reliability for construct (Hardware and software Components)

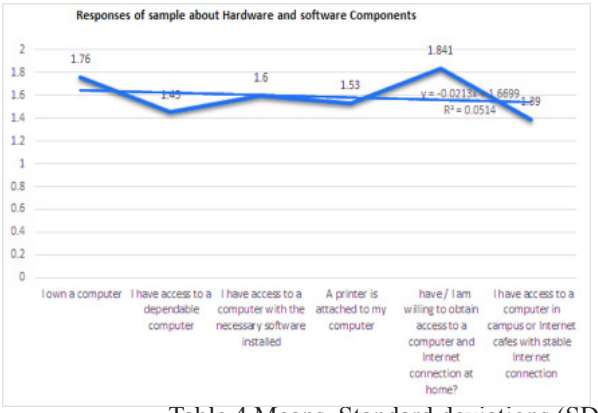
(Hardware and software (HS			
Items	Mean ± SD	Chi-squared a	P value
1. I own a computer	1.76±.430	65.536	.000
2.I have access to a dependable computer	1.45±.498	2.704	.100
3. I have access to a computer with the necessary software installed	1.60±.491	10.000	.002
4 A printer is attached to my computer	1.53±.500	.784	.376
5 . I have / I am willing to obtain access to a computer and Internet connection at home?	1.841±.84	115.600	.000
6. I have access to a computer in campus or Internet cafes with stable Internet connection	1.39±.488	12.544	.000

2-tailed p values; *p < 0.05, **p < 0.01.

one of these Java-empowered internet browsers Netscape™ 6.2 (PC and Mac), or 7.0(PC); Internet Explorer 5.0 or higher (Mean, SD 1.45±.498) ,that have virus protection on my PC (Mean, SD 1.45±.499), I know the essential elements of PC equipment parts (CPU and screen) including its peripherals like the printer, speaker, mouse etc(Mean, SD 1.66±.475), I realize how to save/open archives to/from a hard plate or other removable stockpiling device(Mean, SD 1.74±.230),I expertise to turn on and shutdown the PC properly (Mean, SD 1.94±.230), I realize how to determine normal equipment or programming issues, or I can get to a specialized help on the off

chance that I experience a problem(Mean, SD 1.94±.230), I can arrive at specialized help in the event that I experience a problem(Mean, SD 1.48±.500).”

Figure 1 Responses of sample about Hardware and software Components



As a result, conduct on fig1 Responses of sample about Hardware and software Components (HS) show that most students believe that they own a computer (1.76), have access a reliable PC (1.45), approach a PC with the essential programming introduced (1.60). “A printer is appended to my computer(1.53), they have willing to acquire admittance to a PC and Internet connection at home (1.841), they approach a PC in campus or Internet bistros with stable Internet connection(1.39).”

Table 4 displays the statistical results of students’ perceptions about e-learning. Responses to the third Construct about Usability and Resiliency, “I have an email address (Mean, SD 1.88±.330) “I can open/send an email with document attachments(Mean, SD 1.60±.492), I realize how to sign in to the network access supplier (ISP) (Mean, SD 1.69±.464), I realize how to explore the site pages (go to straightaway, or past page) (Mean, SD 1.57±.496), I realize how to download records utilizing any programs (Internet voyager, maxilla)(Mean, SD 1.80±.398), I know how to resolve common errors while surfing the Internet, for example, ‘page not found’ or ‘association planned out’ (Mean, SD 1.80±.398), I realize how to get to a web-

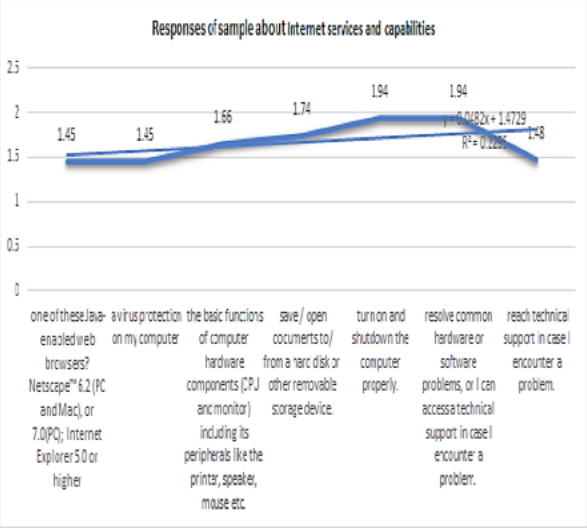
Table 4 Means, Standard deviations (SD), Chi-square and Reliability for construct (Internet services and capabilities)

Internet services and capabilities			
Items	Mean ± SD	Chi-squared a	P value
1. I have one of these Java-enabled web browsers? Netscape™ 6.2 (PC and Mac), or 7.0(PC); Internet Explorer 5.0 or higher	1.45±.498	2.704	.100
2. I have a virus protection on my computer	1.45±.499	2.304	.129
3.I know the basic functions of computer hardware components (CPU and monitor) including its peripherals like the printer, speaker, mouse etc.	1.66±.475	25.600	.000
4. I know how to save / open documents to/ from a hard disk or other removable storage device.	1.74±.230	55.696	.000
5. I know how to turn on and shutdown the computer properly.	1.94±.230	197.136	.000
6. I know how to resolve common hardware or software problems or I can access a technical support in case I encounter a problem.	1.94±.230	.576	.448
7. I can reach technical support in case I encounter a problem.	1.48±.500	128.815	.000

2-tailed p values; *p < 0.05, **p < 0.01.

based library and other resource databases (Mean, SD 1.53±.500).

Figure 2 Responses of sample about Internet services and capabilities



Furthermore, it on figure 2 Responses of a sample about Responses Internet services and capabilities that have one of these Java-empowered internet browsers Netscape™ 6.2 (PC and Mac), or 7.0(PC); Internet Explorer 5.0 or higher (1.45) , that have infection assurance on my PC (1.45), I know the fundamental elements of PC equipment parts (CPU and screen) including its peripherals like the printer, speaker, mouse, and so forth(1.66), I realize how to save/open reports to/from a hard plate or other removable stockpiling gadgets (1.74), I realize how to turn on and shut down the PC appropriately(1.94), I know how to resolve common hardware or software problems, or I can get to specialized help on the off chance that I experience an issue (1.94), I can arrive at specialized help in the event that I experience an issue(1.48).

Table 5 displays the statistical results of

Table 5 Means, Standard deviations (SD), Chi-square and Reliability for construct (Usability and Resiliency)

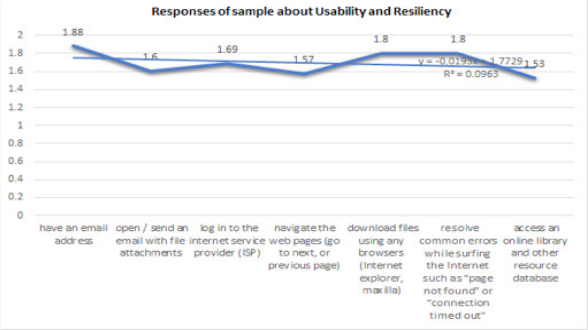
Usability and Resiliency			
Items	Mean ± SD	Chi-squared a	P value
1. I have an email address	1.88±.330	141.376	.000
2. I can open / send an email with file attachments	1.60±.492	9.216	.002
3. I know how to log in to the internet service provider (ISP)	1.69±.464	53.344	.000
4. I know how to navigate the web pages (go to next, or previous page)	1.57±.496	5.184	.023
5. I know how to download files using any browsers (Internet explorer, maxilla)	1.80±398	4.096	.043
6. I know how to resolve common errors while surfing the Internet such as “page not found” or “connection timed out”	1.80±.398	92.416	.000
7. I know how to access an online library and other resource database	1.53±.500	1.024	.312

2-tailed p values; *p < 0.05, **p < 0.01.

students’ perceptions about e-learning. Responses to the fourth construct about Ease of learning, I have attended online classes before (Mean, SD 1.85±.356), have recently participated in internet based conversations and online forums(Mean, SD 1.83±.378), “I know what PDF documents are and I can download and see them (Mean, SD 1.41±.493), I know about word preparing and use it serenely (Mean, SD 1.49±.501),” I am able to have a few ap-

plications opened simultaneously and move effectively between them(Mean, SD 1.49±.501).

Figure 3 Responses of sample about Usability and Resiliency



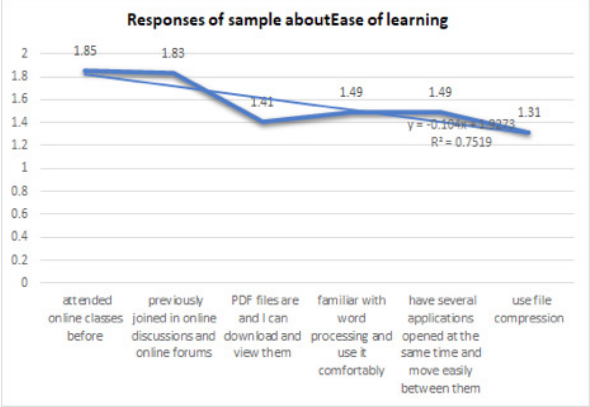
As a result, conduct on figure 3 Responses of a sample about Responses Usability and Resiliency, I have an email address (1.88), I can open/send an email with document connections (1.60), I realize how to sign in to the web access supplier (ISP) (1.69), I realize how to explore the site pages (go to straightaway, or past page) (1.57), I realize how to download records utilizing any browsers (Internet pilgrim, maxilla) (1.80), I know how to resolve common errors while surfing the Internet, for example, "page not found" or "association planned out"(1.80), I realize how to get to a web-based library and other resource data sets (1.53).

Table 6 Means, Standard deviations (SD), Chi-square and Reliability for construct (Ease of learning)

Ease of learning			
Items	Mean ± SD	Chi-squared a	P value
1. I have attended online classes before	1.85±.356	1123.904	.000
2. I have previously joined in online discussions and online forums	1.83±.378	3.600	.058
3. I know what PDF files are and I can download and view them	1.41±.493	107.584	.000
4. I am familiar with word processing and use it comfortably	1.49±.501	7.744	.005
5. I am able to have several applications opened at the same time and move easily between them	1.49±.501	.064	.800
6. I know how to use filecompression	1.31±.463	36.864	.000

2-tailed p values; *p < 0.05, **p < 0.01.

Figure 4 Responses of sample about Ease of learning



As a result, conduct on figure 6 Responses of a sample about Ease of learning, I have attended to online classes previously (1.85), have recently participated in internet based conversations and online discussions (1.83), "I know what PDF documents are and I can download and see them (1.41), I know about word handling and use it serenely (1.49), I am ready to have a few applications opened simultaneously and move effectively between them (1.49)."

Table 7 Means, Standard deviations (SD), Chi-square and Reliability for construct (Efficiency and achievement)

Efficiency and achievement			
Items	Mean ± SD	Chi-squared a	P value
1.When I have an important assignment , I get it done ahead ofti me	3.781±.481	198.040	.000
2. I prefer to figure out instructions for assignment by myself / I prefer to study or work alone	3.741±.553	190.360	.000
3. I look forward to leaning new skills and master them quickly	3.591±.581	178.360	.000
4. As a learner, I an highly independent	3.651±.493	199.320	.000
5. I am able to refrain from distractions and stay on task while working or studying	3.541±.503	211.880	.000
6. When asked to learn new technologies, I do not put it off or avoid it.	3.201±.628	197.000	.000
7. I can analyze class materials and formulate opinions on what I've learned.	3.471±.492	232.360	.000
8. I am determined to stick to studies despite challenging situations	3.521±.658	171.960	.000
9. I do not need direct lecture to understand materials	3.331±.712	166.840	.000
10. I am able to express my thoughts and ideas in writing	3.671±.533	186.920	.000

2-tailed p values; *p < 0.05, **p < 0.01.

Figure 5 Responses of sample about Efficiency and achievement

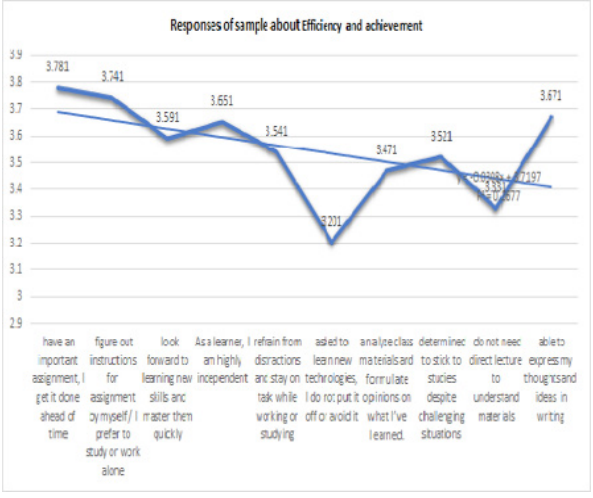


Table 7 displays the statistical results of students' perceptions about e-learning. Responses to the fifth construct about Efficiency and achievement, At the point when I have a significant task, I get it happen ahead of time(Mean, SD 3.781±.481), I like to sort out guidelines for task without anyone else/I like to study or work alone(Mean, SD 3.741±.553), I anticipate acquiring new abilities and master them rapidly (Mean, SD 3.591±.581), As a student, I am exceptionally independent (Mean, SD 3.651±.493), I can forgo interruptions and remain focused while working or studying (Mean, SD 3.541±.503), "When requested to learn new advancements, I don't put it off or keep away from it (Mean, SD 3.201±.628), I can analyze class materials and formulate opinions on what I've learned. (Mean, SD 3.471±.492), not really set in stone to adhere to examines regardless of testing circumstances (Mean, SD 3.521±.658), I don't require direct talks to comprehend materials (Mean, SD 3.331±.712), I am ready to offer my viewpoints and thoughts recorded as a hard copy (Mean, SD 3.671±.533)."

As a result, conduct on figure 5 Responses of a sample about Efficiency and achievement, At the point when I have a significant task, I get it done ahead of time (3.781), I like to sort out guidelines for task without anyone else/I like to study or work

alone(3.741), I anticipate acquiring new abilities and expert them rapidly (3.591), As a student, I am profoundly independent (3.651), I can cease from interruptions and keep focused while working or contemplating(3.541), "When requested to learn new innovations, I don't put it off or stay away from it (3.201), I can analyze class materials and formulate opinions on what I've learned. (3.471), I can still up to adhere to examines in spite of testing circumstances (3.521), I don't require direct talks to get materials (3.331), and I am ready to express my thoughts and ideas in writing (3.671)."

The study revealed that the five constructs have a positive impact on the university readiness. The findings showed that most students can access a computer, the computers are equipped with important components such as java empowered internet browsers and virus protection, the students are have basic computer skills such as opening and shutting down the computer, the students also have prior experience with virtual learning, and they have willingness to participate in e-learning.

The degree of readiness for most institutions to use e-Learning systems experienced some struggles, especially in the Kingdom of Saudi Arabia during the COVID-19 pandemic. For instance, most students did not have access to digital infrastructures such as mobile devices and the internet to facilitate them in conducting distant learning. Some students came from a poor background that halted them from accessing e-Learning systems during the onset of the pandemic. Some developing counties with no access to computers or online learning services opted to radio as an instrument to provide a learning experience to most learners. UNESCO's study has shown that more than 830 million learners had no access to computers and the internet, especially in low-income countries. This made the closure of schools and country lockdowns significantly impact education as there was no smooth transition to distance learning.

The availability of digital infrastructure in Qassim University facilitated more students to enroll in distant learning. Most students did not have access to IT technology and e-Learning systems during the pandemic, which made the institution invest more in digital infrastructure until the ISP has given all student access to the internet for free with Government support. When IT technology was incorporated in the institution, there was a significant jump in e-Learning technology that made more students access education. Some institutions consider mobile learning as a way to curb the effects of COVID-19 on education. Students could use various mobile devices such as tablets, smartphones, and e-Books to participate in distance learning. The study's responses on various variables identified what needs to be done for institutions to facilitate distant learning. The institutes need to consider multiple hardware and software components to facilitate remote learning, internet services, and an excellent digital learning experience. Other variables that need to be considered in-

clude efficiency, ease of learning, usability, and resiliency of the e-Learning systems. Therefore, it is high time for institutions to have IT technology and infrastructure to improve their e-Learning capabilities to facilitate distance learning.

3.3.Conclusion:

In conclusion, readiness for Qassim university for e-learning is quite well. Despite the problems foreseen in developing countries where availability of computers is very low in the students population, in Qassim university, most students have computers are rather can assess computers. The computers are also well maintained in terns of browsers and virus protection. Additionally, the students are also computer literate and are willing to be involved in e-learning. Therefore, the university can introduce e-learning to the students to save the curriculums which have been affected by closure of learning institutions due to Covid-19 pandemic. However, studies should also be done to show the readiness and willingness of the professors to be involved in e-learning. Frequent studies should also be done to assess the efficacy of e-learning to the students.

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Friction and wear properties of oriented Polyamide 12 objects manufactured by SLS Technology

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Abstract

White Polyamide 12 (PA12) is the most usable material for additive manufacturing. PA12 parts manufactured by Selective Laser Sintering (SLS) process are chemically stable, environmentally friendly, and have reasonable mechanical properties. As a result, PA12 powder has been used for rapid prototyping purposes and manufacturing of end-user products. Although, the mechanical properties of PA12 manufactured by SLS technology have been the focus of many investigations, so far, the effect of build orientation on the tribological properties PA12 parts have not received sufficient attention in previous research. Therefore, this study is devoted to investigating the dry sliding friction and wear characteristics of PA12 parts manufactured by SLS technique at three different orientations (X, Y, and Z). For this purpose, the coefficient of friction (COF) and the approximate contact temperature of PA12 pins loaded against a stainless steel disc are measured using a Pin-on-disc test apparatus. The experimental results revealed that under dry sliding conditions, the COF, frictional heat, and specific wear rate of PA12 specimens oriented along the Y-axis are significantly smaller than those oriented along X and Z axes. Furthermore, the transfer film observed on the steel disc surface acts to decrease the COF and wear rate of Y-oriented test specimens. On the other hand, the results showed that at the steady-state wear stage, PA12 specimens oriented along X and Z axes experienced a combination of abrasive wear, adhesive wear, and sometimes surface fatigue wear. The results from this study can help designers to orient the active rubbing surface of PA12 during SLS process in the proper way to reduce the COF, frictional heat, and wear rates of PA12 objects.

Keywords:

Polyamide 12 (PA12); Selective Laser Sintering; Tribological properties, build orientation

1.Introduction

Polyamide 12 (PA12) is the most frequently used powder in selective laser sintering (SLS) process due to the resulting mechanical and functional properties of 3D printed objects. The particle size, melting temperature, surface energy, and fluidity make PA12 powder a suitable material for additive manufacturing which is a layer-by-layer object building technique. Hence, despite the recent developments in thermoplastic powders, around 95% of laser sintered objects are made of PA12 [1]. Hence, increasing research have been carried out in the last two decades to investigate the mechanical properties of PA12 parts manufactured by SLS process [2]. Also, the effects of SLS fabrication parameters (laser power, scanning speed, and scan spacing) on the geometry, density, tensile, compressive, and flexural properties of SLS parts were the focus of a rea-

sonable number of researches [3-7]. Recently, a handful number of research works have addressed the effect of build orientation on the mechanical properties of PA12 composite objects manufactured by SLS [4,8,9]. Most recently, artificial intelligence technique was used to predict the mechanical properties of SLS objects in an attempt to produce objects with customized mechanical properties [10].

The drastic increase of using PA12 end-user products in application where it rubs against a metallic/polymeric counter surface calls for further research on the tripological properties of PA12 surfaces manufactured by SLS. As a result, the dry/lubricated sliding parameters that affect the tribological features of PA against other surfaces were analyzed [11], and several attempts were carried out to enhance the surface roughness of PA12 parts manufactured by SLS technique [12-14]. Since the SLS objects are known to exhibit anisotropic mechanical properties, the tribological properties of PA12 objects are expected to be orientation dependent. Despite the anticipated significant effect of build orientation on the tribological properties of laser sintered PA12, very few research studies were found in open literature on the anisotropic wear properties of PA12 [15,16].

Therefore, the present work is devoted to investigating the effect of build orientation of the friction and wear properties of laser sintered PA12 parts rubbing against a stainless steel disc. The study aims at measuring the COF, frictional heat, and the specific wear rates of PA12 pins manufactured by SLS technology at different build orientations (pins are oriented along X, Y, and Z axes). Furthermore, the PA12 tribo-surfaces are to be examined by Scanning Electron Microscopy (SEM) to investigate the dominant wear pattern at each orientation.

2.Experimental Methods

2.1. Samples preparation

The samples were fabricated from Polyamide 12 powder (PA 2200) on a commercial SLS machine. Each test specimen is a rod of 4 mm diameter and 25 mm length. During manufacturing, the rods are oriented along the X-axis, Y-axis, and Z-axis, and the build direction is along the positive Z-axis. A set of three test specimens was manufactured along each orientation. Once the fabrication process is completed, the parts are taken off the support and cleaned with sandblasting to remove any sticking powder. During manufacturing of the test specimens, scanning vector was along the X-axis of the SLS machine (parallel to the machine front face).

Fig.1 Orientations of manufactured test specimens

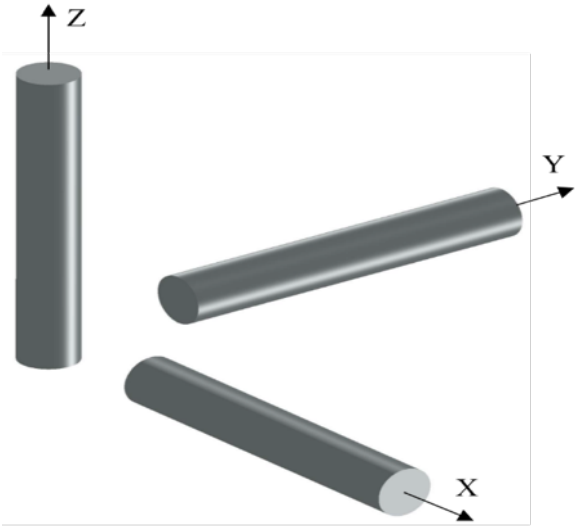
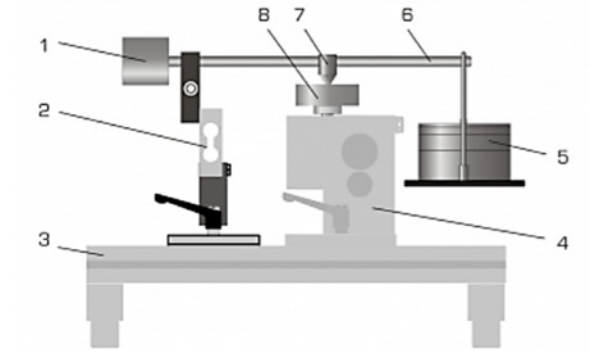


Fig.2 Pin-on-disc test apparatus



1. Counterweight
2. Force sensor,
3. Frame of TM 260
4. Drive unit
5. Applied Load
6. Load lever
7. Pin holder
8. Steel disc

2.2. Pin-on-disc test apparatus

Friction and wear properties of PA12 were examined using pin-on-disc test-rig, see Fig.2. The test specimen (in the form of rod) is inserted in the pin-holder and loaded against the rotating Stainless Steel disc by means of second-class lever. The pin-on-disc TM 260 apparatus is designed in such a way that the load on test specimen is twice the applied dead weight, and the friction force is measured by means of a double-bending beam force sensor. The rotation speed of the Stainless Steel disc is controlled by means of a drive unit with a gear reducer to give a maximum sliding speed of 0.5 m/sec. The experiments were carried out in dry sliding mode. The contact temperature was measured using infrared temperature sensor. The active tribosurfaces of pins are coated with a thin gold coating before investigation by the scanning electron microscopy (SEM).

3.Results and Discussions

The experiments were carried out in room temperature, and relative humidity was around 15%; thus, dry sliding condition was maintained. The circular end of the test specimen was loaded against the stainless steel rotating disc. In the following results, the disc is rotating at 120 rpm, the load on the pin (test specimen) is 50 N, and the experiment is run for 30 minutes. As the pin diameter is 4 mm and the diameter of the sliding track is 40 mm, the average pressure (P) on the pin is about 4 MPa and the sliding speed is 0.25 m/sec. With such levels of contact pressure and dry sliding speed, the test specimens are considered to be in a heavily loaded operating condition. The average value of surface roughness parameter (Ra) of the steel disc was 0.3m. The measured COF of PA12 test specimens built along the three different orientations is given in Fig.3. Several important remarks can be drawn from Fig.3: (1) at the running-in stage, the COF of X- and Z-oriented test specimens remains almost constant for about 6 minutes then increases rapidly toward the end of this stage, (2) at the steady-state wear stage, the COF of X- and Z-oriented specimens increases slowly where the COF of X-oriented specimen is always higher than that of Z-oriented specimen, (3) the parts built along the Y-axis exhibits a significantly lower COF compared with other orientations.

The behavior of the COF of X- and Z-oriented specimens suggests that abrasive wear dominates the first few minutes of dry sliding contact, then the real area of contact increases and, consequently, a combination of adhesive and abrasive wear exists; this results in the rapid increase of the COF at

the end of running-in stage. On the other hand, the gradual increase of the COF for Y-oriented specimens may be attributed to a dominating adhesive wear throughout all stages of dry sliding condition.

The results from Fig. 3 are further explained when connected with the variations of approximate contact temperature at the different build orientations, shown in Fig. 4. It is noticeable from Fig.4 that the measured contact temperature of specimens built along the X- and Z- axes are higher than that of the specimen built along Y-axis (a difference of about 10 oC was noticed after 30 minutes of dry sliding). This result is in accordance with the fact of mutual effects of the COF and contact temperature; higher COF results in high flash temperature (manifested by the measured contact temperature) which in turn softens the substrate layer causing further increase in the COF.

As a result of the performance characteristics outlined in Figs 3 and 4, the specific wear rates are as shown in Fig.6. The specific wear rate (Ks) in (mm3/N.m) is calculated as [17];

$$K_s = \frac{\Delta V}{(P \times L)}$$

where ΔV is the wear volume (mm3), P the applied load (N), and L is the sliding distance (m).

Figure 5 shows clearly that the parts built along the Y-axis direction, which exhibits low COF and low contact temperature, has the lowest specific wear rates compared with those having high COF accompanied

Fig.3 Coefficient of friction of tested specimens

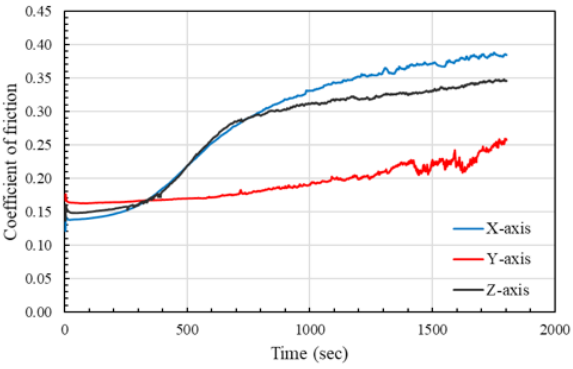


Fig.4 Average contact temperature of tested specimens

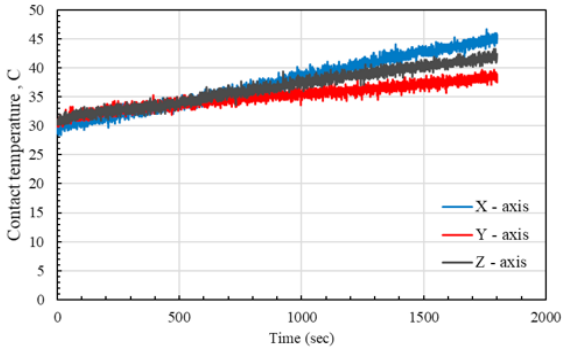
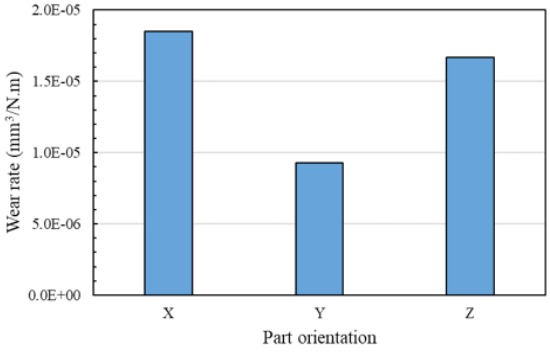


Fig.5 Average wear rate of PA12 after 30 minutes of dry sliding against steel disc



by high contact temperature (i.e., X- and Z- oriented PA12 specimens). The results from Fig.5 further emphasize the relationship between specific wear rate, the COF, and average contact temperature; higher coefficient of friction causes a corresponding increase in contact temperature which in turn increases the plastic deformation and shearing tendency of tribosurface lay-

er resulting in an increase in wear specific wear and vice versa [18].

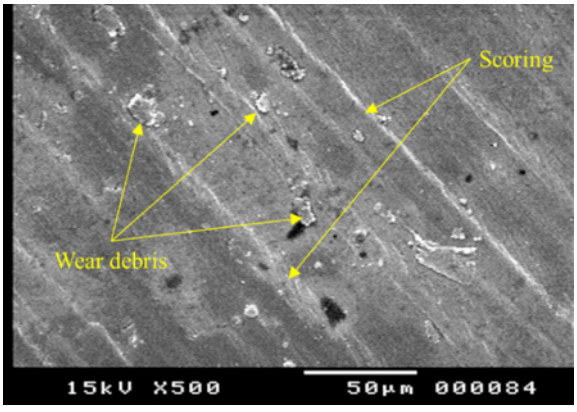
SEM (Scanning Electron Microscope) The active tribosurface of all PA12 pins was coated with a thin gold film so as to be suitable for investigation with the aid of SEM. The scanning electron micrograph of tribosurface of X-oriented PA12 specimens after 30 minutes of dry sliding wear test is shown in Fig.6. The scoring marks (groove/ridge pairs) shown clearly on the tribosurface along with free wear debris are an evidence of abrasive wear. Furthermore, the existence of embedded hard particles indicates a mutual material transfer between the counter surfaces; the hard embedded wear debris may roughen the counter surface causing further increase in wear rate of the soft PA12 surface. Moreover, PA12 flakes on the tribosurface are evidence of large plastic deformation (localized adhesive wear). Hence, interpretation of the tribosurface reveals that a combination of abrasive and adhesive wear dominates the steady state wear stages.

The SEM of wear surface of Y-oriented PA12 specimen is shown in Fig.7. As was predicted from Fig.3, the large plastic deformation of wear surface shown in Fig. 7 (b) is a clear evidence of sever adhesion which seems to be the dominating wear pattern throughout all stages of the interactions between mating surfaces. It is important to point out that other forms of dry sliding wear may exist side-by-side but, in case of Y-oriented PA12 specimens, sliding adhesive wear dominates.

Similarly, the SEM of wear surface of Z-oriented PA12 specimen after 30 minutes of dry sliding against the rotating steel disc is shown in Fig. 8. The wear pattern shown in Fig.8 suggests that a combination of abrasive wear, adhesive wear, and consequent surface fatigue wear may have occurred. The surface micrograph shown in Fig.8 may be explained as follows: the increase in PA12 real area of contact makes it prone to recurrent adhesion with steel counter surface, and hence large plastic deformation of PA12 surface layer accompanied by surface micro cracks may occur. The surface micro cracks propagate as the tangential shearing of surface layer continues and, eventually, flakes of PA12 are separated from the surface. Later, the separated flakes either stick to the PA12 face of transferred to the steel counter face forming a transfer film which may act to decrease the COF and subsequent wear rates, see Fig. 9. The transfer film shown in Fig.9 is partially continuous, however the hardened wear debris may detach from the disc face and then entrapped between the sliding surfaces causing a three-body abrasive wear pattern [19, 20].

Fig.6 SEM of tribosurface of the specimen aligned along X-axis (50 N and 0.25 m/s after 30 minutes).

(a) evidence of abrasive wear



(b) evidence of transfer film

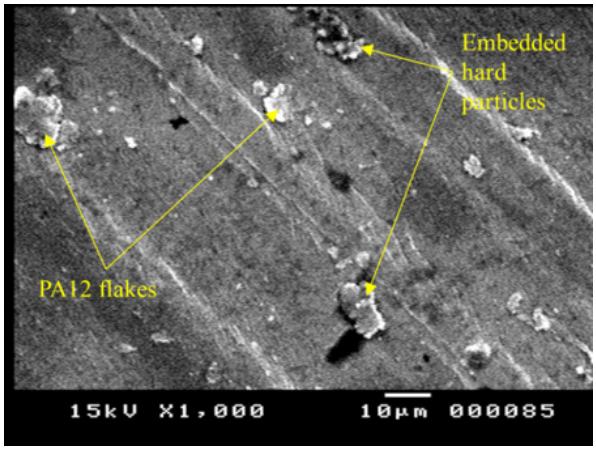
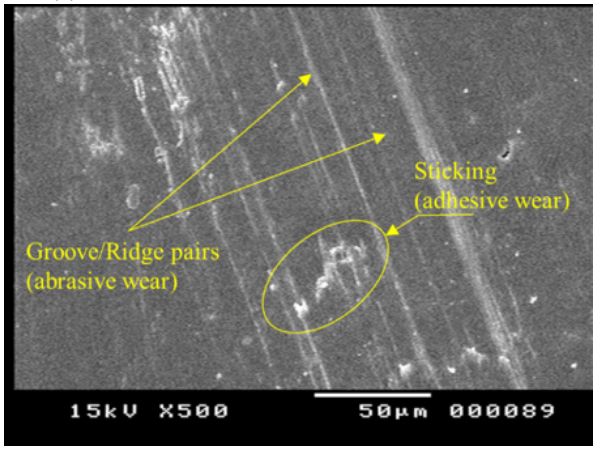


Fig.7 SEM of tribosurface of the specimen aligned along Y-axis (50 N and 0.25 m/s after 30 minutes).

(a) combination of adhesive and abrasive wear



(b) sever adhesion results in large plastic deformation

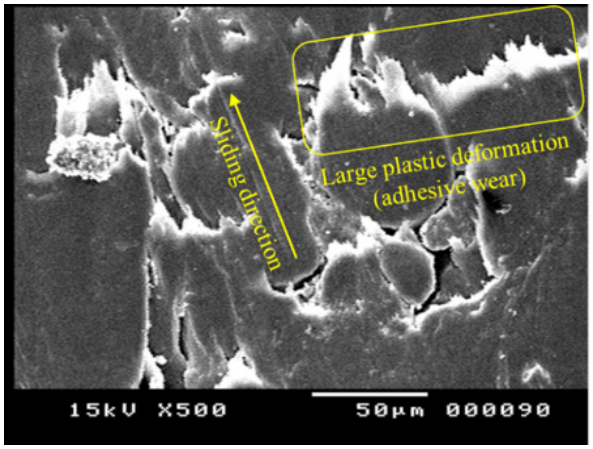
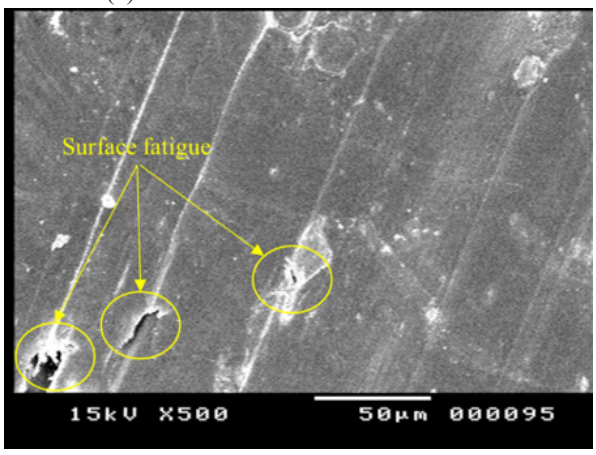


Fig.8 SEM of tribosurface of the specimen aligned along Z-axis (50 N and 0.25 m/s after 30 minutes).

(a) existence of surface microcracks



(b) adhesive and surface fatigue wear

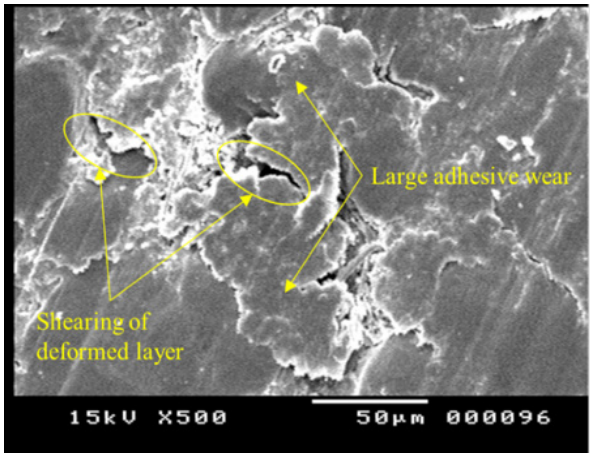
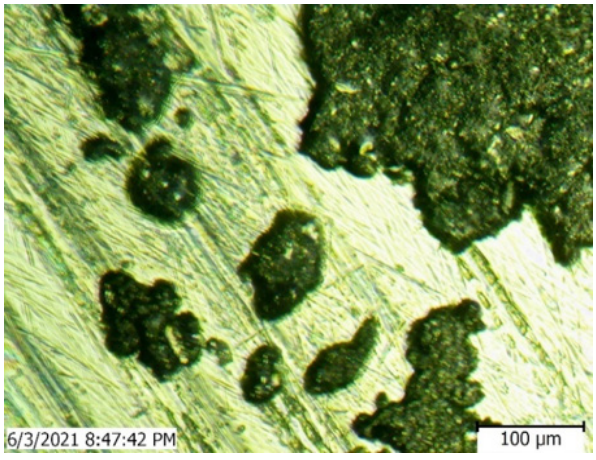


Fig.9 Microscopic picture showing wear debris and transfer film on rotating steel disc (after Y- axis specimen experiment)



4.Conclusions

In the present study, the dry sliding friction and wear characteristics of PA12 parts manufactured by SLS technology, considering the effect of object orientation in the build chamber, were investigated. The experiments were carried out to measure the coefficient of friction (COF) and the approximate contact temperature of PA12 pins loaded against a stainless steel rotating disc with the aid of Pin-on-disc test apparatus. The following important findings could be drawn out from the experimental results:

- The COF, contact temperature, and specific wear rate of PA12 specimens oriented along the Y-axis are significantly smaller than those oriented along X and Z axes.
- The transfer film observed on the steel disc surface acts to decrease the COF and wear rate of Y-oriented test specimens.
- For PA12 specimens oriented along X and Z axes, abrasive wear dominates the running-in stage while a combination of abrasive and adhesive wear prevails the subsequent steady-state wear stage.

The results from this study can help designers and manufacturers to properly align the active tribosurface during SLS process so as to minimize the COF, frictional heat, and wear rate. However, it should be pointed out that the application of introduced results is limited to the cases of dry sliding wear of PA12 against stainless steel at low sliding speed and heavy loads.

Conflict of Interest

The author declare that there are no conflicts of interest regarding the publication of this paper.

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Investigation Of The Reference Korean Man Radiography Using Different Build Up Factor Models

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Abstract
In order to quantify the scattered photon beam during X-ray radiography, deterministic particle transport algorithm uses the buildup factor (BUF) and the primary beam. However, from existing models describing such parameter for multilayer attenuators, we investigated three commonly used ones (Lin & Jiang, Kalos and Burke & Beck). Thus, the High Definition Reference Korean man (HDRK) was exposed to 150keV photon point source and particle histories were computed comprising the attenuation of the primary beam and the scattered beam contribution. For that purpose, we developed an in-house C++ based program to store projected phantom images, at an imaging detector distant with 1m far from the source, with possible choice between concerned BUF models. The thorax part only of the HDRK man was irradiated and based on specific Geometric Progression (GP) fitting parameters, Compton and total attenuation coefficients and equivalent atomic number of 25 organs, computations were carried out. We found a close image similarity for both models of Lin & Jiang and Kalos (SSIM=0.94). Also, the projected image resolution was ordered in the following way from better to worst: Lin & Jiang, Kalos and Burke & Beck. A correct model choice will be of great interest to the large community of radiation physicists, in general, and to medical imaging, teletherapy and brachytherapy physicists, in particular, since multilayer BUF parameters are the key parameter for point kernel calculations..

Keywords:
Buildup Factor; Multilayer; Human Tissues ; Radiography; HDRK man

1.Introduction

In contemporary medical education, radiology plays a unique role in integrating science and medicine [1]. No other medical specialty regularly interacts with such a wide range of medical disciplines. The practice of neurology, neurosurgery, otolaryngology, cardiology, pulmonology, urology, gastroenterology, orthopedic surgery and a host of other pediatric and surgical specialties would be virtually impossible without the regular presence of diagnostic imaging [2].

From the many existing computational tools used for imaging process selection, we cite the point-kernel method [3-5] and the Monte Carlo simulation technique [6-11]. In terms of particle transport handling, the major difference between the two techniques is that one takes a microscopically-oriented approach to solving the problem, whereas the other takes a macroscopically-ori-

ented approach. By assuming beam-like propagation, the point-kernel (PK) technique gains time for decision-making. In addition to the important parameters that form a PK core, we also quantify the scattering contribution to the unscattered beam during particle-matter interactions via the buildup factor (BUF). As well as Monte Carlo simulation programs such as EGS4 [12] and Geant4 [13,14], many existing tools have been used for BUF computations, like PALLAS [15] and ASFIT [16]. Moreover, from the many modeling of BUF such as the Invariant embedding method [17,18], the Moments method [19], the Iterative method [20], we found the more sophisticated one called Geometric Progression (GP) fitting method [21]. Additionally, for GP fitting, we noted the one provided by Kalos [22] and by Burke and Beck [23] for monodirectional parallel-plane beams and stratified shields and the more recent one by Lin & Jiang [24] for isotropic point sources. However, all materials with high density and atomic number were not studied, especially for human tissues (since they assumed water medium to approximate most of them). On the other hand, there is increasing use of deterministic models in practical research and clinical applications, including ray-tracing methods and analytical models [25-26]. They have fewer computational problems compared to Monte Carlo (MC) technique and can deal with statistics correctly, so that fast simulations of transmission images are possible. By using deterministic methods, it is possible to treat photon scattering and reflection in medical imaging [27-28].

The main goal of this work is to develop a point-kernel method able provide projected image of the High Definition Reference Korean (HDRK) man phantom [29] irradiated with a photon point source. As part of the study, the ray-tracing method, combined with exposure dose buildup, was applied to the simulation of a radiographic image. Different buildup factor models were analyzed in terms of their effect on the image quality. Although our study was limited to monochromatic photon point source, our present work can be thought of as building on the attention already given by radiation physicists, especially in relation to point kernel-based preparation of treatment plans and diagnosis imaging of tumors.

2.Materials and Methods

Here, we will briefly describe the proposed parameterization models for BUF calculation of monolayer and multilayer attenuators followed by the C++ developed program for the needed computations. Finally, we will describe the followed image analysis.

2.1. BUF parameterization models

According to the GP fitting method, the BUF for monolayers can be written in the following form [21]:

$$\frac{B(X)-1}{b-1}=\begin{cases}\frac{K^X-1}{K-1}, if\ K\neq 1\\ X, if\ K=1\end{cases} \qquad (1)$$

where b = BUF(1) ± 5% and the depth X is expressed in mean free paths: 1mfp=$1/(\mu\times\rho)$, with μ and ρ correspond to the linear attenuation coefficient and the atom-

ic density, respectively.

For $X \leq 40\ mfp$:

$$K = c \times X^a + d \times \frac{\tanh((X/X_k) - 2)) - \tanh(-2)}{1 - \tanh(-2)} \quad (2)$$

where, a, b, c, d and Xk are the five fitting parameters.

Meanwhile, the general BUF formula for multilayers can be written in the following form:

$$B\left(\sum_{i=1}^{n-1} X_i, X_n\right) = B_n(X_n) + \left[B_n\left(\sum_{i=1}^{n} X_i\right) - B_n(X_n)\right] \times \boldsymbol{K} \times C_n \quad (3)$$

with the geometric progression parameter:

$$\boldsymbol{K} = \frac{\mathrm{B}(\sum_{\mathrm{i}=1}^{\mathrm{n}-2} \mathrm{X_i}, \mathrm{X_{n-1}}) - 1}{\mathrm{B_n}(\sum_{\mathrm{i}=1}^{\mathrm{n}-1} \mathrm{X_i}) - 1} \quad (4)$$

where X1, X2, ..., Xn the thickness of n consecutive material forming the multi-layered shield, B_n ($\sum_{i}^{n}{}_{=I} X^i$) and B_n (X_n) correspond to the BUF of the n^{th} layer for the overall and the last layers, respectively. The correction parameter, C_n, has many general forms. It depends on the arrangement of consecutive materials, especially in terms of equivalent atomic number *Zeq* (for each material it depends on the photon energy). From existing theories, we will study three commonly used models:

1.Kalos [22]:

1.

$$C_n = \begin{cases} 1.0, HZ/LZ \\ e^{-1.7X_n} + (\gamma\beta/K)(1 - e^{-X_n}), LZ/HZ \end{cases} \quad (5)$$

2. Burke & Beck [23]:

$$C_n = \begin{cases} e^{-X_n/\gamma} + 1.5(1 - e^{-X_n}), HZ/LZ \\ e^{-\gamma X_n} + (\gamma\beta/K)(1 - e^{-X_n}), LZ/HZ \end{cases} \quad (6)$$

3. Lin & Jiang [24]:

$$C_n = \begin{cases} \mathrm{e}^{(-1.08\beta \mathrm{X_n})} + 1.13\beta\ell(X_n), HZ/LZ \\ (\gamma/K)e^{-X_n} + 0.8\ell(X_n), LZ/HZ \end{cases} \quad (7)$$

with

$$\gamma = \frac{(\mu_C/\rho)_{n-1}}{(\mu_C/\rho)_n} \quad (8)$$

$$\beta = \frac{(\mu_t/\rho)_{n-1}}{(\mu_C/\rho)_n} \quad (9)$$

and

$$\ell(X_n) = \frac{\mathrm{B_n(X_n)+1}}{\mathrm{B_{n-1}(X_n)+1}}(1 - \mathrm{e^{-X_n}}) \quad (10)$$

where, *HZ/LZ* means the arrangement of medium with high *Zeq* followed by medium with low *Zeq* and μ_C/ρ and μ_t/ρ are the Compton and the total mass attenuation coefficients

Table 1. Exposure GP fitting coefficient (a, b, c, d and Xk) and equivalent atomic number for studied organs and 150keV photon source energy

Mat ID	Zeq	a	b	c	d	X_k
Adipose tissue	6.486	-0.227	4.173	2.657	0.1	14.125
Adrenal	7.424	-0.189	3.929	2.284	0.081	14.273
Bladder	7.731	-0.175	3.901	2.167	0.072	14.385
Blood	7.795	-0.172	3.895	2.144	0.07	14.408
Bone	11.534	-0.084	3.104	1.509	0.019	14.911
breast	6.486	-0.227	4.173	2.657	0.1	14.125
Colon	7.507	-0.185	3.921	2.252	0.078	14.304
ET	7.424	-0.189	3.929	2.284	0.081	14.273
Esophagus	7.424	-0.189	3.929	2.284	0.081	14.273
Gall bladder	7.424	-0.189	3.929	2.284	0.081	14.273
Heart wall	7.628	-0.179	3.91	2.206	0.075	14.348

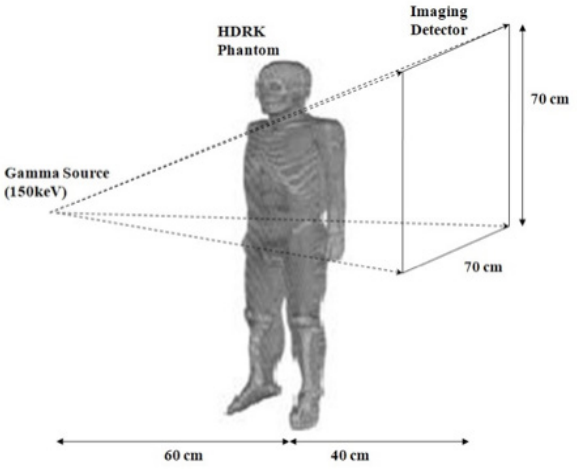
Mat ID	Zeq	a	b	c	d	X_k
Kidney	7.66	-0.178	3.907	2.194	0.074	14.36
Liver	7.69	-0.177	3.905	2.183	0.073	14.371
Lung	7.721	-0.175	3.902	2.171	0.072	14.382
Muscle	7.673	-0.177	3.906	2.189	0.073	14.364
Oral mucosa	7.413	-0.189	3.93	2.288	0.081	14.269
Pancreas	7.505	-0.185	3.922	2.253	0.078	14.303
RBM	7.282	-0.195	3.942	2.339	0.085	14.22
salivary glands	7.328	-0.193	3.938	2.321	0.084	14.237
Skin	7.397	-0.19	3.932	2.294	0.082	14.263
Small intestine	7.507	-0.185	3.921	2.252	0.078	14.304
Spleen	7.69	-0.177	3.905	2.183	0.073	14.371
Stomach	7.507	-0.185	3.921	2.252	0.078	14.304
Thymus	7.424	-0.189	3.929	2.284	0.081	14.273
Thyroid	8.702	-0.145	3.696	1.939	0.054	14.541

2.2.Computation procedure

An in-house C++ program has been developed for computation purposes. The program inputs are the five GP coefficient and the Zeq arrays corresponding to 25 tissues and organs of the thorax irradiated zone of the HDRK phantom, as tabulated in Table 1. Also, μ_C/ρ and μ_t/ρ attenuation coefficients extracted from NIST website [30] and atomic density from literature [29], arrays have been included.

The photon irradiated zone, with point source located at 1m far from the imaging detector, as shown in Figure 1, correspond to 247×141×250 voxels of size 1.981×1.981× 2.0854 mm3. The photon energy was 150 keV and the detector plane has the dimensions of 700×700 mm2 and pixilated into 1×1 mm2. After reading the HDRK data, we have the possibility to choose the BUF parameterization model. During the computation we calculate the travelled distance between the point source and the detector pixel and determine the number layers (from 250 planes) with same material and the corresponding distance for each one. The program output has been saved into ascii file, which will be converted into image.

Fig. 1. Schematic view of the computational geometry setup



2.3. Statistical analysis

We used the Fiji [31] to read ascii output data of the developed program. Thanks to SNR [32] and SSIM [33] plugins, we are able to compare images in terms of signal-to-noise ratio (SNR), peak of signal-to-noise

ratio (PSNR), root mean square error (RMSE), mean average error (MAE) and structural similarity index (SSIM).

3.Results and Discussion

Figure 2 shows the projected image of the phantom without taking into account BUF. Moreover, such image results only from the exponential attenuation of the gamma ray along its trajectory from the source to the detector. We only see the overall shape of the phantom leading to a difficult interpretation of the image.

Fig. 2. Projected phantom image without taking into account for BUF parameter (BUF=1)

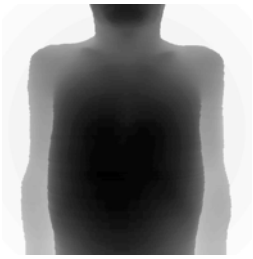
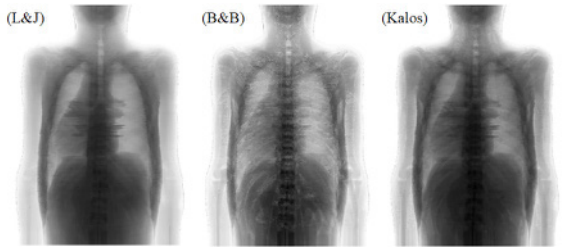


Fig. 3. Projected phantom image with BUF consideration for three models: Lin & Jiang (L&J), Burke & Beck (B&B) and Kalos (Kalos)



However, when we consider the BUF, describing the scattered flux contribution, the image becomes more interpretable and realistic, as shown in Figure 3. Also, from the same figure, we observed that Lin & Jiang model leads to better image resolution than that of Kalos model, which itself has better resolution image than Burke & Beck one. Such observation was clearly explained with vertical and horizontal image profiles shown in Figures 4 and 5.

Fig. 4. Vertical profiles of projected phantom image with (Lin & Jiang, Burke & Beck and Kalos) and without BUF considering

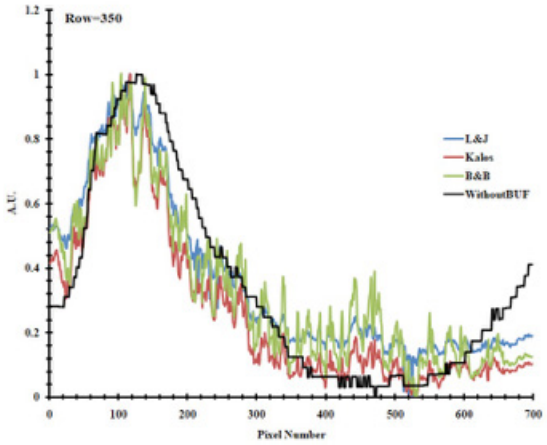
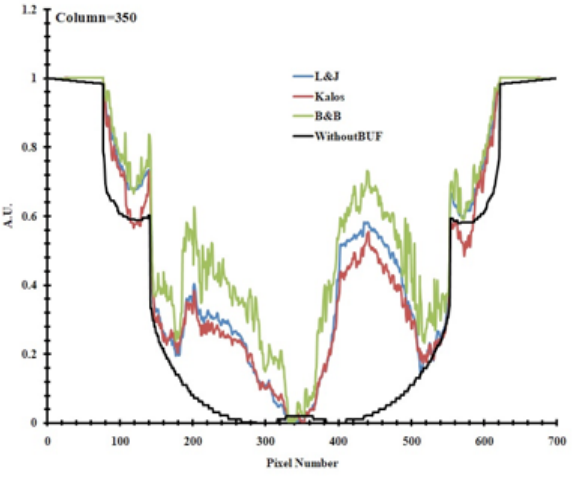


Fig. 5. Horizontal profiles of projected phantom image with (Lin & Jiang, Burke & Beck and Kalos) and without BUF considering



From profiles plotting, we see the close behave for L&J and Kalos models. Moreover, as horizontal profiles cross arms, lung and heart organs, they are configured with two peaks on the right side and three peaks on the left side. On the other hand, the BUF effect on imaging internal organs is well explained when comparing different models to the simple "WithoutBUF" model.

Tabulated statistical analysis of different images were given in Table 2, confirming the closeness of L&J and Kalos models. However, this study was limited to current setup of photon particle with 150 keV energy and can be extended to polychromatic exposure and to other kind of particles. Also, a straightforward application for radiotreatment purposes (Brachytherapy, Teletherapy) other than diagnosis, can be conducted allowing the large physicist community to advance knowledge on point-kernel ray-tracing technique for analysis of photon transport in a patient's body.

Table 2. Statistical image analysis for comparing the three studied models: signal-to-noise ratio (SNR), peak signal-to-noise ratio (PSNR), root mean square error (RMSE), mean average error (MAE) and structural similarity index (SSIM.)

Ref Image	Test Image	SNR	PSNR	RMSE	MAE	SSIM
L & J	B & B	19.095	22.136	13.215	11.026	0.940
L & J	Kalos	22.105	25.146	9.345	7.459	0.886
B & B	Kalos	16.243	19.687	19.696	17.305	0.879

4.Conclusion

An important parameter to quantify scattered beam contribution to the exposure is the buildup factor of a material for gamma-ray attenuation. Among the existing models describing BUF for multilayer shielding, we developed a C++ program able to choose between Lin & Jiang or Kalos or Burke & Beck ones. Such in-house program was able to produce the projected image of the thorax part of HDRK man irradiated with photon point source with energy 150 keV on a 700×700 mm2 detector. Hence, based on the developed computer code, a simple and flexible tool for computation of radiographic image is presented. Through the developed computer code, the influence of different multilayer BUF models on the image quality is investigated. Using this method requires little computational time on a single-processor PC compared to probabilistic methods. Moreover, we found that Lin & Jiang and Kalos models are statistically close to each other and the best resolution was seen for Lin & Jiang studied case. Despite this, we can conclude that the proposed results are important for medical imaging and radiation treatment planning for the vast majority of existing examination scenarios.

Conflict of Interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Automatic Cloud-based Digital Forensics Artifacts Categorization

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Abstract
Cloud Computing technology enables to delivery of online services on-demand to clients. The boom of cloud computing reaches its peak and now available services from different aspects right from education to entertainment. The world top organizations run with the base of cloud services. On the other side, there is a drastic growth in cybercrimes. The top-notch technology called Digital Forensics emerges to control the Cybercrimes in part. This research focuses on performing digital forensics process on cloud computing in such a way that prevent security breaches through cloud services and trace the incidents and forgeries. It is explored some ways in which the digital artefacts can be collected from cloud services that are widely being used by every other corner of the world in this paper. The ways to retrieve forensic evidentiary artefacts from the cloud services are engineered using digital forensic tools. Pilot tests are conducted to analyse the success of artefacts retrieval from current cloud SaaS.

Keywords:
Cloud Forensics; Digital Forensics; Cloud Cyber Security; Cloud Computing

1.Introduction

The utilization of distributed computing has expected advantages to companies, including expanded adaptability and effectiveness. The virtual applications deliver more elasticity over an in-house physical IT framework since the applications [1] can be vastly reconstructed or squamous to map with the latest and emerging requirements deprived of the necessity to acquire the newest and possibly respective hardware. Correlative to this, the utilization of distributed computing can decrease the expenses of giving IT administrations, by taking out excess registering force and capacity, lessening support necessities and diminishing fixed capital responsibilities. The research studies reveal that there is 37% of cost savings have been obtained by organizations who migrate the IT infrastructure from the datacenters to Amazon Cloud. Digital forensics in distributed computing is another discipline identified with the expanding utilization of PCs, organizations and computerized stockpiling gadgets in various crimes in both conventional and High Tech. Then, cloud computing seems to be an existing research issue to digital investigations, it is very important to understand the effect that pertains to cloud by forensic processes and what way the old techniques, application controls and techniques might adapt to cloud environments. As an outcome, the existence of the boom of cloud forensics in its infancy,

an emergency is raised to sort out the digital investigation with the use of some tools and techniques in the cloud platform. With the motivation of understanding the opportunities and limitations of conventional digital forensics methods deployed to the distributed computing termed Cloud, it has been performed a research study based on a set of popular SaaS cloud applications, to see if captured IP packets and traces are available in the local machine, extracted with openly available forensic tools, are enough to take legal action against the culprit in court [2]. I rejected ahead of time the choice of making a solicitation to hold onto a cloud server in the unfamiliar locale as it is a tedious action, with restricted added esteem from a specialized stance.

1.1. Technical Background

For enterprises, Digital Forensics is an important part of the Incident Response process. Forensic Investigators determine and log facts of a criminal incident aided to be the evidence to be used for law enforcement. A digital investigator is a person who desires to follow the proof and prove the crime. Consider a security vulnerability [3] that exist at an enterprise, ends with data steal. In the present circumstance, a computer forensic analyst would enter and identify what way the hackers escalate the privileges of the target network to penetrate the network. Moreover, it is being analyzed that they are the steps the hacker go across the network scanning, any malware has been installed or hooked to the operating system and so on. The role of the digital forensic investigator is to recover deleted documents, artefacts that are susceptible to the criminal incident occurrence from computer data storage devices such as zip and USB drives and diskettes, with erased, harmed, or handled in any different type of manipulation on the data. The meaning of the phrase cloud forensics is defined as an inter-disciplinary between cloud computing and digital forensics [8]. Cloud forensics is the composition of the multifaceted system to serve organizational, legal and technical implications. There are a set of tools and techniques are used from a technical perspective to perform forensic processes in cloud computing environments. The design structure for internal staffing, producer-consumer relationship and external assistance fulfilling the specific incident response roles are termed as organizational perspectives. The legal perspective activities of digital forensics include the agreements and regulations defined for carryout the forensic process to be secured and will not breach any laws or regulations under any jurisdictions where the data is stored, throughout the investigation [5]. Broad network access, rapid scalability, metered services, on-demand self-service and resource pooling are the fundamental characteristics of cloud computing. Cloud design depends fundamentally on three centre advancements: web applications and web administrations, virtualization, and cryptography. As per the previously mentioned NIST definition [2], administrations in the cloud are given by the accompanying essential models: Infrastructure as a Service (IaaS), Platform as

a Service (PaaS) and Software as a Service (SaaS). Specifically, with IaaS an entire operating system, services, and stored information are remotely available to the client whereas, with PaaS, clients are assigned the plugins to build and host internet services on a user computer, and with SaaS key applications and data based on a remote machine are made available on-demand to users [6,7]. According to the National Institute of Standards and Technology, the cloud models are classified into four elements. They are Public, Private, Hybrid and Community cloud [2]. The resources are pooled, applications and services are available on-demand regardless of the type of devices on the cloud. The impact of on-demand availability encourages the users to make use of mobile phones and other digital gadgets to avail cloud services at any time.

Fig. 1. Cloud forensics workflow

1.2. Paper Outline

The overview of the following section of the paper is as follows: Section-2 mention the threats of cloud computing in Section-3 and describe the outline of the conducted research study and in Section-4 discuss the relevant results. I finally conclude our research in Section 5.

2.Cloud Computing essentials

There is consistently a danger that client information can be gotten to by others. So it is important to maintain storage protection and cloud protection as data confidentiality relies on cloud protection. The web is the best way to distribute computing. When there is no web association in your place, or the web way to the cloud supplier is in a difficult situation, consequently, admittance to your distributed computing machine will be separated. Presently this is the place where the greatest snag is occurring in agricultural nations and distant regions that don't have great web access. The public cloud is the server where if it expands to danger, the server will down. Security and privacy are the most doubtful things in cloud computing [4,5]. The practical usage of a cloud computing system assures the security and confidentiality of data for the consumers so that becomes a trusted server. The clients cannot face the server legally when it performs insecure resulting in the error in data. Cloud computing is receiving queries to solve by computing in online, hence there is more exposure to data security attacks by the attackers hence the data privacy is not assured. Cloud Computing is vulnerable to data privacy and security as it is online. The aspect of the data is being shared online employing Data mobility characteristics, the user knows to retrieve data from the cloud if at all the server is down for one day. Cloud Computing is enabled with customer service 24/7 which provides data availability in the form of maintaining temporary data storage service and serving from that whenever the server is down. The degree of excellence of cloud computing servers is a notorious account to decide to provide cloud computing server service, providers. When the server is down or the performance is not good, the users get af-

fected poorly as the server quality is not good. These aspects are called the pros and cons of Cloud Computing services. Predominantly I cannot say that Cloud is always good. From the study, it is understood that there is no privacy for data as the data is stored in different places of the cloud, but also at the same time, it shares the resources efficiently and is also being scanned for virus attacks periodically. At another end, the client devices use the IaaS, PaaS and SaaS service models where the evidence can be extracted for cloud forensics. The only source from which data can be collected related to cloud computing in the user device is SaaS applications installed in client computers. This is the reason for conducting an exhaustive forensic investigation in the client computer to collect evidentiary materials. [7].

3.Client Evidence Analysis

I made a pilot study of cloud forensics where the tests are planned on SaaS applications to prove that, searching PC artefacts, it is possible to identify specific evidentiary material about the user-computer communication. Based on this, I have identified and reviewed document editing and photo sharing SaaS plugins, such as Google Drive [11], Central Desktop and Cintas [12], to demonstrate that potential evidence may be found in file systems and registry, SQLite databases, web browsing history, downloads and cookies of the Web browsers. I also analyzed Dropbox, a familiar file sharing SaaS application that may work both as a net via cloud service, as Google Document. The service of Google Drive is providing platforms for users can edit the document with the sword in their browser and can be stored in local machine as well as in the cloud on their account. They could then download it as an Office consistent record, or offer it with other Google clients, who could be allowed to see just or to alter. At the point when different clients saw it all the while, with altering consents, they could at the same time see each other's cursors, and type in the report. Google Drive gulped this, developing the file system and altering abilities. Desktop Central followed Google Drive by additional characterizing what was going on with record the document accounting. This framework is intended for a wide cluster of expert purposes including accounting, teaching-learning, finance, law, corporate and pretty much whatever else that is for the most part standard. It utilizes SQL and is adaptable enough for a wide scope of business extensions and business growth, and has the most extreme security. It's somewhat costly at $90/month, however, it's justified for the appropriate association, sharing, altering and dispersion of significant convention archives and business information. Cintas is a multi-administration proficient organization giving human resources, accounting, and presently managing official documents through SaaS stages. This is like Desktop Central, however offers the increased of a ton more languages, and a few formats and conventions for additional archive types, similar to land management and clinical management industries. Along these lines, I see that SaaS manage

the executives advanced from a common document framework and altering limit in a lovely crude structure, to a refined, task-situated kind of programming, which exceptionally experienced proficient organizations then, at that point, proceeded to refine further, into an extremely standard and generally grew new programming industry. Consider the SaaS video editing applications such as InVideo[14], VSDC, Filmora [13]. InVideo makes drawing in content and makes it appropriate marking with the utilization of the most recent video altering programming. As fledglings might not have a specialist hand at altering yet, the in-assembled layouts in InVideo can be useful. It helps make an expert looking video with the best utilization of plan and components accessible on the product. In digital forensics, video type is investigated to know whether illegally produced? This examination likewise leads video source ID and video steganography investigation to uncover stowed away data. In particular, the video source ID is a significant proof source to distinguish the sources [8]. Filmora application performs video editing simplified tasks. It is an amazing asset choice to give shape to your imaginative thoughts and works out positively for all video makers. The features can help work on audio effects, cut background noise, and effects to video. Related to the evidence collection from the cloud, I doctored five pilot tests plans, numbered from 1 to 5, where the basic steps are establishing a manifest with the cloud service and creating a user account. In each scenario, I performed the tests listed below, each labelled with a unique sequence number and a description of the performed action.

Test Plan 1: Google drive accessed via a web browser

1.1: Logging to www.drive.google.com

1.2: Upload folder of files

1.3: Update the documents

1.4: Delete the folder

Test Plan 2: Desktop Central access through web

2.1: Software installation

2.2: Manage patches

2.3: User logging

2.4: Project creation

2.5: Create document using template

Test plan 3: Cintas access through a Web browser

3.1: Software installation

3.2: Manage patches

3.3: User Logging

3.4: Project creation

3.5: Create a management document using a template

Test plan 4: Access shutter stock using a web browser

4.1 Logging to www.shutterstock.com

4.2 Upload picture

4.3 Download picture

4.4. Keyword search of a picture

Test plan 5: Access Grammarly from a web browser

5.1 Logging www.Grammarly.com

5.2 Upload word document file

5.3 Check grammar in word document

5.4 Save corrected word document to Grammarly local folder

4. Pilot test result study and discussions

The author tested the cloud services against the most widely used web browsers (i.e. Mozilla Firefox, Google Chrome and MS Internet Explorer) through the test plans from one to five on the client-side. I collected the evidence of interaction between the local computer and the cloud as such the browser cookies, cache and history information of the browser and network traffic using digital forensic tools and packet sniffer tools. According to test plans two and three, a set of traditional forensics tools is used to validate the plugins installed by Desktop Central the cloud application version is known as iMeetCentral and Cintas project management Saas software. The SaaS names Central Desktop, Cintas and iMeet Central are refer to the same cloud application. Hence the terms are used at different places of the document denotes the same cloud application. The evidentiary files are analyzed to view the meta information of the file such as file creation time, last access time and file size. The pilot tests are performed 3 to four times each, the former using live forensics tools on a powered-on laptop computer running Windows 10 Home Edition 64 bit and the latter with post mortem forensics tools on a physical image of its hard disk and with FRED system. The following web browser versions are used to test Google Drive, Grammarly and Shutter Stock.

1.Google Chrome 9.7
2.MS Internet Explorer 5.5
3.Mozilla Firefox

As well as the tested against the following openly available Nirsoft live forensics tools [9], on the powered-on system. The forensic tools used in this research are license free tools available in online. This section describes the results obtained after analysis of pieces of evidence collected from the cloud from the pilot tests from 1 to 5.

4.1Test Plan 1- Google Drive accessed via the Web browser

It has been viewed the history, cache and cookies of IE, Google Chrome and Mozilla Firefox using forensic tools such as IECookiesView, IEHistoryView, MozillaCacheView, MozillaCookiesView and MozillaHistoryView after the test one. The history information states that Drive. Google login page is present in the access list of the history of the browser. The traces of folder creation in Google drive is present in the cookies of the browser. The copy of the files created is present in the cache as shown in figure 1. The Wireshark packet sniffer is used to scan the traffic where it returns that Google drive uses SSL transmission which is a secured mode for eavesdrop by viewing the TCP port 443 is open in the target server. The ChromeCacheView shows secure file upload as stated in figure 6 the. column server-response has the value “HTTP” which is secure communication.

Test Plan 2- Desktop Central access through the web browser

The windows registry is explored using regscanner and Regedit forensic tools and found that the product id entry was add-

ed for the newly created IT management application named Desktop Central cloud service that is shown in figure 4. The Wireshark packet sniffer is used to scan the traffic where it returns that Desktop Central uses SSL transmission which is a secured mode for eavesdrop by viewing the TCP port 443 is open in the target server which is shown in figure 2. Also as specified by the screen of Chromecookies-View captured in figure 5, Central Desktop cloud service uses unsecured communications, the secure column shows "No" value for all the Central.com urls.

4.2Test Plan 3- Cintas SaaS project management software accessible through the web browser

The windows registry is explored using regscanner and Regedit forensic tools and found that the product id entry was added for the newly created project management service by Cintas cloud service. The Zenmap packet sniffer is used to scan the traffic where it returns that Cintas [10] uses SSL transmission which is a secured mode for eavesdrop by viewing the TCP port 443 is open in the target server as shown in figure 2. But it has been identified as the server is Heartbleed vulnerable means anyone can access the server remotely.

4.3Test Plan 4- Access Shutter Stock using the web browser

The forensic tools IE history view, ChromehistoryView and Mozilla history view shows that there is a trace of files downloaded from Shutter Stock and trace of login page access was present, the meta-information of the files has been expanded using Sleuthkit. The picture files were found to be legal files as it shows the owner of the files is authorized. The file sizes are matching with exact file size whatever folder explorer shows and the Sleuthkit result shows. The browser CacheView extracts the copy of the uploaded picture file and downloaded picture files.

4.4Test Plan 5- access of Grammarly service by the web browser

The forensic tools such as reg edit, registry viewer are used to view the registration information after test five is completed. There is a trace of a new product ID in the registry for installation of Grammarly service in the local disk. The cloud server communication is scanned and identified TCP port 443 is open which uses SSL transmission to ensure data security. The document file uploaded to the cloud is secured against eavesdrop is ensured

Figure 1 Chrome cache view artifacts

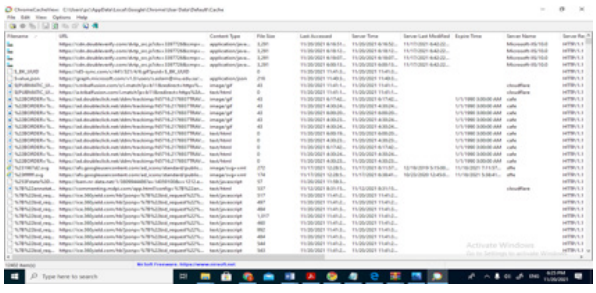


Figure 2 Wireshark artifacts

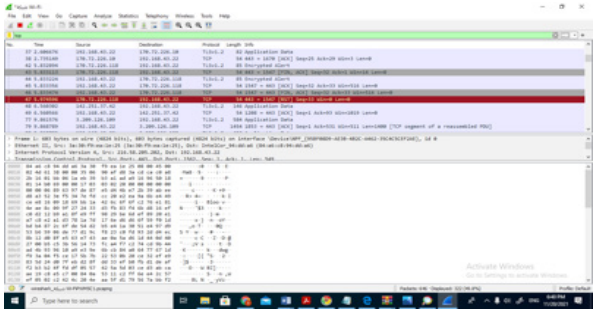


Figure 3 Wireshark artifacts for iMeet Central

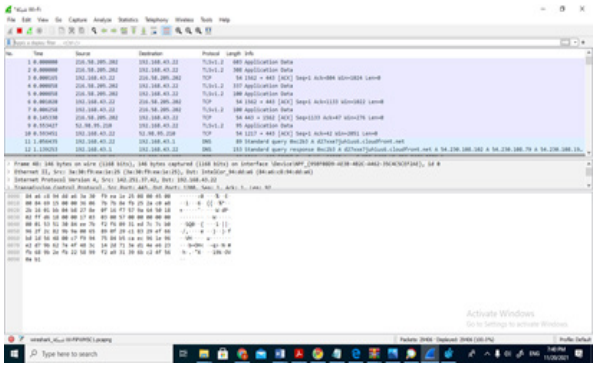


Figure 4 Regedit Web client entry (iMeet Central) artifacts

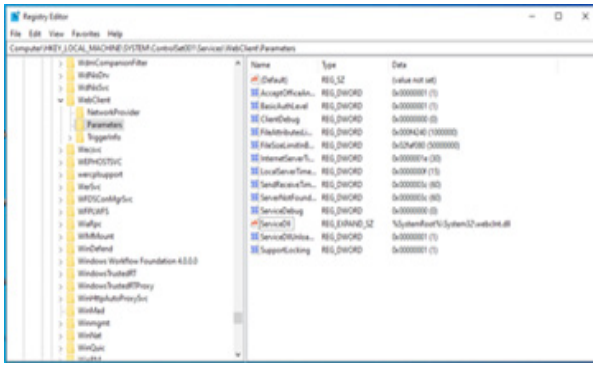


Figure 5 Chromecookiesview Central desk artifacts

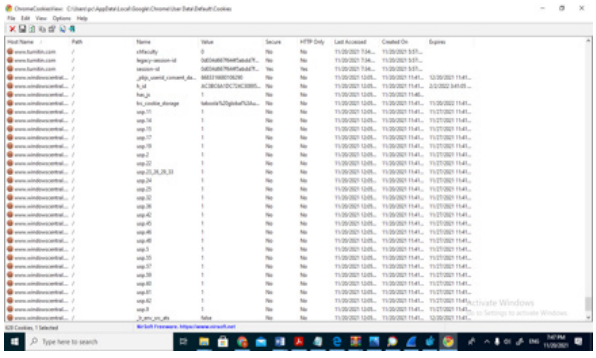
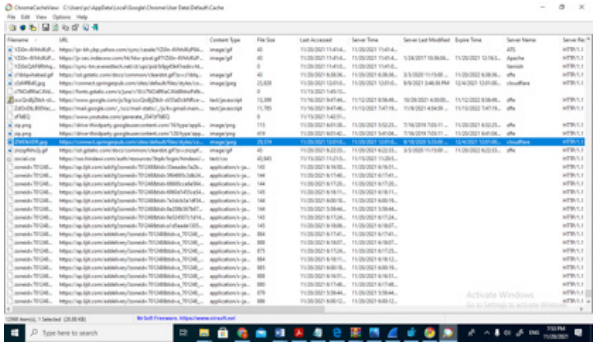


Figure 6 ChromeCacheview- Google Drive file download artifacts



5 Conclusion

In this research, Could Computing threats against the security breaches are discussed, the role of Digital forensics in cloud computing is emphasized. Cloud forensics and its challenges are addressed partly by utilizing digital forensics tools. The research question "What and how the cloud artefacts can be collected as evidentiary artefacts to test against digital crime?" is answered through five pilot tests result and discussion. It has been utilized digital forensic tools such as browser component viewers, Banner Grabbing using WireShark and Zenmap tool to identify Eavesdrop of communication between the local machine and cloud server. This research is a way to explore the new ways of collecting cloud artefacts using conventional digital forensic tools and in future, the challenges of digital forensics in the cloud using Network devices and Mobile devices will be analyzed.

Conflict of Interest

The author has no conflict of interest.

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Predicting Academic Performance of Students from Formative Assessment Methods using Machine Learning Algorithms

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Abstract

Predicting the academic performance of students is always an interesting area of research for academicians. Different inputs were considered to predict the academic performance of students in several research publications. If predictions are made too early, accuracy of results will be affected as the performance of the students depend upon several factors during the semester the student is studying. We are postponing the predictions until the middle of the semester to have better monitoring and control of the students for the final grades. We use key formative assessment methods to predict the performance of the students at the end of the semester. We used popular machine learning classification methods Naïve Bayes, Random Forest, and Support Vector Machine (SVM) to predict the end of the semester performance.

Keywords:

Grade Prediction, Machine Learning, Naïve Bayes, Random Forest, Support Vector Machine

1.Introduction

Academic Grade prediction is an interesting problem for academicians at the university level for several years. Many researchers have attempted to predict the grades in upcoming exams using previous semester subject grades which are related to that subject. Dropout of students was predicted using previous semester grades based on nationality, gender, and background.

Several researchers attempted academic performance prediction using machine learning. Predictive analytics is used to derive key performance indicators for all education levels, one of them being student grades. These grades can be used to monitor the academic performance of the students [1]. Predicting the academic level of students helps identify the weak students and to support those students to overcome educational challenges [2]. Predicting student performance became an important goal for educational institutes which will help students at risk and to maintain their retention by providing learning resources in turn improving university reputation [3]. The evaluation and development of prediction of college students are the prime area of student management in universities. The prediction of grades of students' future academic performance is of great importance in strengthening education management [4]. In higher education, several students struggle to complete various courses because of the lack of support offered to students who need special focus. Predicting the grades in the courses will enable the instructors to assist those students [5]. Grade prediction of

students for their future courses will help in advising the students to take up personalized course plans based on their performance [6]. The role of a tutor is to prevent the dropout of students in courses which they have taken and at the same time to improve their performance. The information hidden in the student academic data can be effectively used for personal guidance [7]. Educational Data Mining can be used to observe interesting patterns and knowledge in educational organizations [8]. Every institute's primary concern is to improve the graduation rate of students. To achieve this, students' future grade prediction in the next enrolment became a priority issue[9].

We attempted to predict the academic grade performance using the formative assessment methods of the same semester for the first time in the literature. This study helps teachers to counsel the students who are going to be performing "Poor" in the upcoming final exam as per the prediction. It gives a fair chance to the students who are unable to perform in the formative assessment methods due to their background, medical, or any other reasons.

To improve the teaching-learning process, teachers need to indicate their students about their performance at regular intervals in the continuous evaluation process. However, some assessment methods will impact their end-semester grades and will be considered as indicators of their end-semester grades. Several assessment methods are used during the teaching-learning process such as Assignments, Quizzes, Class Tests, Exercises, Mid Term Tests, Puzzles, Surprise Tests, Case Studies, and Homework assignments. Some assessment methods reflect the students' cognition level and others may depend on their interaction with other students and the regularity of their attendance.

Our outcome of the research was very interesting as we could predict the performance of the students using two formative assessment methods Mid and Quiz scores with the highest accuracy of 87.72% using Naïve Bayes classification.

2. Literature Survey

Many researchers attempted to predict the grades of students using different techniques. However, all the grade predictions are based on the previous course grades. In the present work, we are predicting end-term grade performance using the formative performance in the same semester.

Sweeney et al.[9] predicted next term semester grades using Factorization Machine and collaborative filtering algorithms. They modeled the grade prediction system as a recommender system. Saa[8] has shown that personal and social factors in the previous semester will affect the grades in the next semester. The author constructed a survey with multiple questions containing personal and social factors and predicted students' performance from these factors. Rovira et al. [7] predicted student dropout rate in the first year to know the possibility of students seeking admission in second or third years from the first-year data and modeled as a binary classification problem and compared popular classification techniques in machine learning such as Gauss-

ian Naïve Bayes, Support Vector Machine, Logistic Regression, Random Forest and Adaptive Boosting. They also predicted the grades using previous academic year grades using the linear regression model. Iqbal et al.[5] used Collaborative Filtering, Matrix Factorization, and Restricted Boltzmann Machines to analyze the data collected from the university in Pakistan. They predicted the GPA scores of students using these techniques. They evaluated the models using repeated random sample cross-validation. They claim that the predicted GPA scores can be used to warn students who are scoring low. Morsy et al.[6] developed a Cumulative Knowledge-based Regression Model to predict the grades of the courses which the students going to take. They found that the knowledge learned in the past courses will affect grades in future taking courses.

X. Zhang et. al.[4] used Naive Bayes, Decision Tree, Multilayer Perceptron, and Support Vector classification models to predict students' academic performance. In their study, the multi-layer perceptron model has demonstrated powerful effectiveness, which achieved 65.90% accuracy on the training set and 62.04% accuracy in the test set. L. M. Abu Zohair et. al.[3] proved the possibility of training and modeling a small dataset size and the feasibility of creating a prediction model with a credible accuracy rate. This work focused on identifying the key indicators in the small dataset, which will be utilized in creating the prediction model, using visualization and clustering algorithms.

A. E. Tatar et al.[2] made a study using Student records populated from Imam Abdulrahman bin Faisal University(IAU) learning management system containing features of three different nature: the demographic features, the pre-college features, and the college records including enrolment information and college performance. They used two approaches one is based on the previous semester courses and the other one is based on the cumulative performance from the date of joining the college. They observed that the prediction performance improved as more semesters were included in the cumulative model and reached up to 94.9%. Using the first approach after term1 they got an accuracy of 65.6% using the Logistic regression method.

S. D. A. Bujang et al.[1] predicted students final grades based on their previous course performance records in the preceding semesters' performance records. They used SMOTE (Synthetic Minority Oversampling Technique) to handle the imbalanced datasets and then grades were predicted in the next semester.

3.Present Work

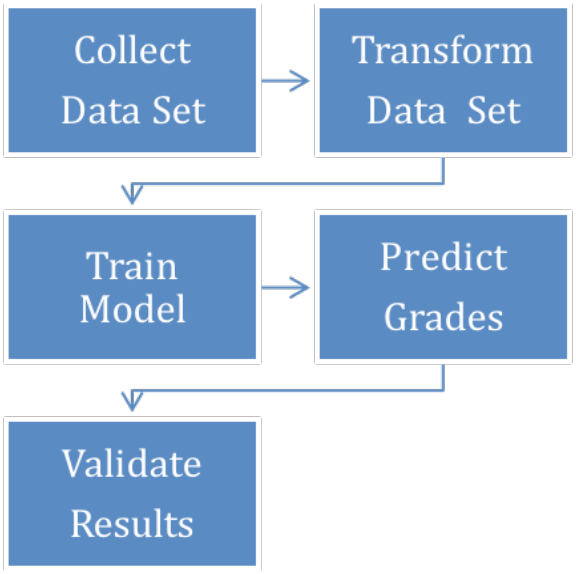
In this paper, we have taken data of 194 students data collected from various academic semesters which include Mid Term, Quiz marks, and End Semester Grades in 10 subjects namely Programming Languages, System Administration, Software Engineering, System Integration, Programming in C++, Software Modeling and Analysis, Parallel and Distributed Computing, Software Evolution, Software Architectures,

and Low-Level Software Design.

The collected data set contains Subject Code, Mid Term Marks, Quiz Marks, and End Semester Grades. We transformed the data by eliminating subject codes and mapped the Grades A+, A, B+, B, C+, C to the label "Good" and D+, D, and F to the label "Poor". Now predicting the end semester performance became a binary classification problem by identifying the students' performance as "Good" or "Poor" on the test data set.

The steps in the grade performance prediction process are shown in Fig. 1.

Fig. 1. Steps in grade performance prediction



3.1 Data Set

The Student Grade data set contains three fields Mid (Number), Quiz(Number), and Grade(Label). The range of Mid Marks is 0-20. The range of Quiz marks is 0-10 and the Grade can be "Good" or "Poor". A few rows of the data set are shown in Table 1.

We have chosen the Mid Term Exam and Quiz exam as the students need to write these exams with reasonable preparation.

Table 1. Sample rows in Data Set

Mid	Quiz	Grade
18	7	Good
20	9	Good
19	9	Good
19	4	Good
17	7	Good
13	5	Poor
19	9	Good
17	7	Good
11	6	Poor
14	7	Poor
18	9	Poor

These exams focus on the fundamentals of subjects. We observed that the other assessment methods such as Assignments, Case Studies, and Exercises will allow enough time to solve the problems. So, the most influencing factors for the end semester grades will be Mid Term and Quiz exams. Our results strongly indicate the influence of these assessment methods on the end-semester grades. Formative assessment methods are used to evaluate the students' performance during the semester. These assessment methods will give an overview of the strengths and weaknesses of the students.

The density estimate of Mid Score and Quiz scores are shown in Fig. 2. and Fig. 3.

Fig. 2. Density estimate of Mid Score

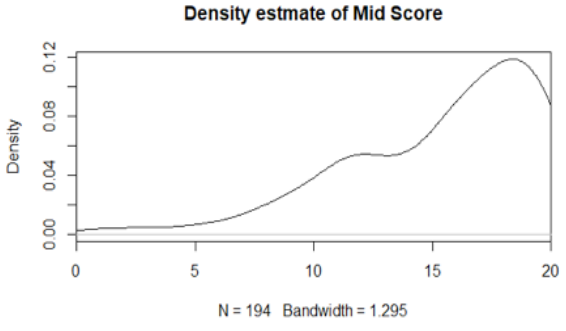
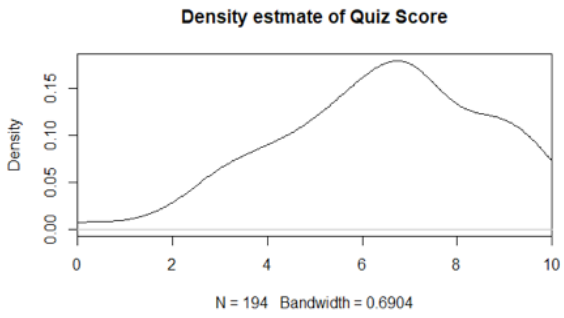


Fig. 3. Density estimate of Quiz Score



The density estimates of Mid score and Quiz scores show that the data is distributed in the range and not skewed. It is important to have the data distributed when the data set size is limited otherwise it may lead to overfitting.

3.2 Experimental Results

We used the Split Validation technique to predict the labels using three popular Machine Learning-based Classification Algorithms Naïve Bayes, Random Forest, and Support Vector Machine (SVM). Then we compared the predicted labels with available labels and found very interesting results. We implemented all three models in R Language. On 194 student records, split validation was used, so 137 records were used for training the models and 57 records with known labels were used for testing and validation. Naïve Bayes gave the highest accuracy of 87.72% whereas Random Forest gave an accuracy of 82.46% and Support Vector Machine gave an accuracy of 85.96% as shown in Table 5.

In each of the Figures below dots represent false predictions and triangles represent correct predictions. When the academic performance is predicted, the students who are labeled as "Poor" will be focused more to perform well in the coming assessment methods.

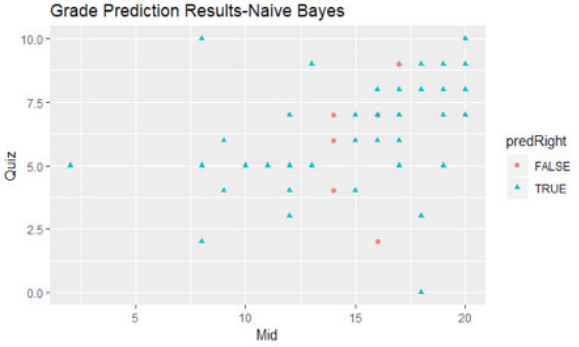
3.2.1 Naïve Bayes Classification

Naive Bayes is based on the Bayes Theorem. It predicts the membership probabilities of each class for a data point that belongs to a particular class. The class with the highest probability is taken as the expected class.

Table 2. Confusion Matrix and Statistics

	Reference	
Prediction	Good	Poor
Good	35	5
Poor	2	15

Fig. 4. Naïve Bayes Prediction



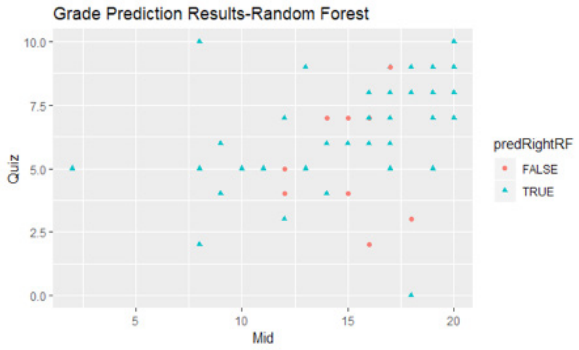
3.2.2 Random Forest

The Random Forest algorithm is a collection of several decision trees. This algorithm chooses random samples from training data for constructing the trees and extracts a random subset of features during splitting of the nodes. During training, each tree in Random Forest learns from randomly selected samples. During testing, prediction from each tree is taken and the average of all these predicted values is considered as the final prediction.

Table 3. Confusion Matrix and Statistics

	Reference	
Prediction	Good	Poor
Good	33	6
Poor	4	14

Fig. 5. Random Forest Prediction



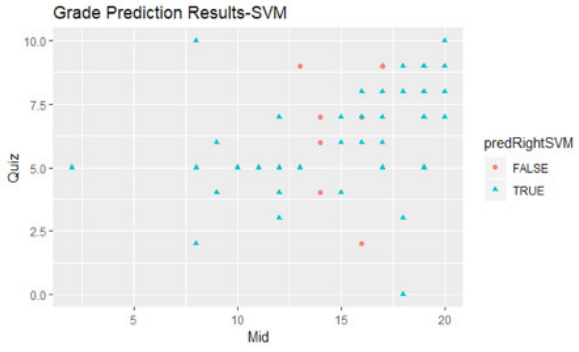
3.2.3 Support Vector Machine (SVM)

A support vector machine is a supervised learning model which can identify two basic classes from the set of labeled data. The function of SVM is to detect a hyperplane that can distinguish between two classes.

Table 4. Confusion Matrix and Statistics

	Reference	
Prediction	Good	Poor
Good	34	5
Poor	3	15

Fig. 6. SVM Prediction

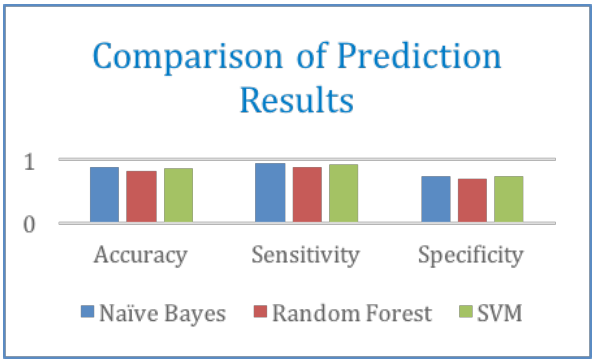


3.2.4 Comparison of Results

Table 5 Comparison of Prediction Results

Model\Parameter	Accuracy	Sensitivity	Specificity
Naïve Bayes	0.8772	0.9459	0.7500
Random Forest	0.8246	0.8919	0.7000
SVM	0.8596	0.9189	0.7500

Fig. 7. Comparison of Prediction Results



Accuracy (ACC) is the ratio of the number of all correct predictions to the total number of the dataset. The best accuracy is 1.0, whereas the worst is 0.0. Sensitivity (SN) is the ratio of the number of correct positive predictions to the total number of positives. It is also called recall (REC) or true positive rate (TPR). The best sensitivity is 1.0, whereas the worst is 0.0. Specificity (SP) is the ratio of the number of correct negative predictions to the total number of negatives. It is also called true negative rate (TNR). The best specificity is 1.0, whereas the worst is 0.0.

Execution Environment:

Core i7, 4GB RAM,256GB HDD, Windows OS, R version 4.0.2

Time of execution of each model:

Naïve Bayes: 0.4 sec

Random Forest: 3.3 sec

SVM: 0.63 sec

4. Conclusion and Future Work

Our present work is useful in advising the students for improving their performance before final exams. When the academic performance is predicted, the students who are labeled as "Poor" will be focused more to perform well in the coming assessment methods. Many related works are using past semester grades to predict the present grades, but our approach reduces the error in prediction as we are using the formative assessment results of the same semester.
Our experimental setup considered only the data related to the College of Computer and Information Sciences, Majmaah University. However, it can be extended to other universities in Saudi Arabia.

Conflict of Interest

The author has no conflict of interest.

Acknowledgment

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Classifying Student's Academic Performance using SVM

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Abstract
Learning management systems are mainly concerned to educational sectors play a dominant role in leading the nation across the globe. These days as everything goes online in terms of data storage across the globe. Lots of data emerges from learning systems and makes very promising to predict and classify learner's performances. In order to classify students' performance, various techniques are available. One of the most popular techniques to classify students' performance is Machine Learning (ML) and is widely used in learning systems to process Informative facts about learners. Processing Educational data involves usage of several data processing methods like forecasting, clustering and finding out associations in order to extract the valuable information of the learners, their mood changes in shifting of subjects and accordingly their performances by extracting the hidden knowledge. Subsequently the obtained useful information and patterns can be used in predicting student's performance. This research work suggests the effective technique in order to process and classify learner's performance. Data is gathered from a middle east university concerning to graduate course. ML techniques like Support Vector Machine-SVM, Multi-Layer Perceptron-MLP, Random Forest-RF, Decision Tree-DT, Naïve Bayes-NB and K-Nearest Neighbor-KNN are applied after preprocessing the data. The outcomes attained are assessed on few metrics like Accuracy, TPR, TNR, Kappa Statistics and ROC Curve. SVM outperforms in classifying learners' part linked to other methods by yielding optimal classification results like high accuracy and Sensitivity followed by MLP, RF, DT, NB and KNN.

Keywords:
Educational Data; Support vector Machine (SVM); Multi-Layer Perceptron (MLP); Random Forest (RF); Decision Tree (DT); Naïve Bayes (NB); K-Nearest Neighbor (KNN).

1.Introduction

Currently, Educational data mining (EDM) is demanded and attaining additional response due to increase in the data generation from learning management systems. EDM is an evolving area, startled with progressing methods to distinguish different categories of data emerging from learning systems. Simultaneously, valuable patterns are recognized so that improvements can be suggested at learner's front [1]. Accordingly, conventional data search can offer

solutions to identify the learner's performances and suggestions can be made to improve their performance by finding out where the learners lack in understanding the concepts or fail to perform well in the exams etc. for the complete course duration in particular learning systems. The task is make this data wisely in improving the educational process.

Imminent learning systems advanced the learner prototypes in order to boost the performance of learners. Prediction and classification of learner's performance plays a key role in learning systems and is the hot area among the researchers as nations target to improve the learning experience and attract the learners for new courses. Consequently, lots of academicians and scholars are in full swing to explore several methods using machine learning so that course instructors can get benefitted in to assisting the learner's performance towards a particular course according to their interest [2]. Middle East student's data was classified using different machine learning classifiers and it was observed that neural networks attained good classification results compared to rest of the classifiers in predicting and classifying students' academic performance [3].

In this paper, Section II covers the detailed related work and Section III presents the proposed methodology and methods. Section-IV consists of classification results and discussions followed by Section-V describing conclusion and future work.

2. Related Work

Learner's interactive attributes in learning the course, difficulties faced and absent rate are given priority along with some other attributes and a method was suggested using machine learning techniques which yielded an improved classification accuracy of more than 22% by taking out interactive attributes. Moreover, classifiers were ensemble to improve the classification accuracy and it was observed that by using ensemble process, more than 25% accuracy was obtained [4]. Sentiments were analyzed to interpret the learner's way of dealing with the course right from start of the course till course completion, in this whole process how learners plan their schedule was analyzed so that a teacher can change the way of his or her approach towards the learner's. A brief comparative analysis was performed using other methods of ml and it was found that MLP attained the highest classification results in classifying learner's data [5]. Also, sentiment analysis of Telugu language tweets was performed to classify user sentiments of learning in Telugu. ML methods were applied and models were built accordingly and it was observed that Passive Aggressive Classifier attained utmost accurateness near to 80% with high precision rate-0.77, recall rate-0.78 and F1_score of 0.77 [6].

ML techniques are being used in processing the natural language of any medium and it was observed that they yielded promising results in classifying NLP data [7]. Discovering facts and gaining useful insights from big data pertaining to health sector [8,9] to link goods using association rules, one of the mining technique used in

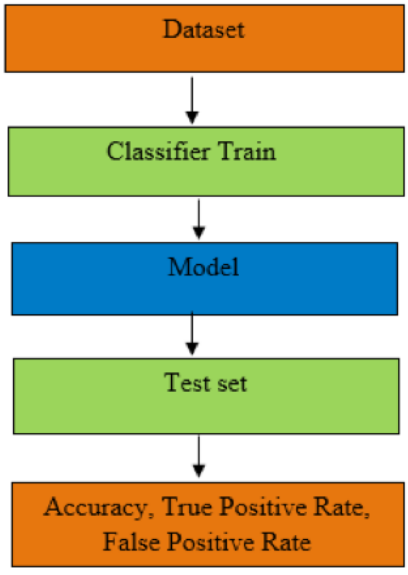
market basket analysis [10] and educational sectors [11], necessitate and slender in the direction of knowledge discovery methods to understand the ML methods expectancy. Traditional classifiers of deep learning were used to understand the models way of classifying learner's data gathered from a middle east university. Similarly, educational data was collected from Twitter to understand the public demanded courses and their way of approach in learning the new courses. Tweets were well processed and classified using ML and DL classifiers and it was observed DL classifiers yielded supreme results compared to ML classifiers [12, 13]. To analyze the academic potential of students, classification was performed on learner's data using ML and DL methods and found that both the methods yield superior results in classifying the students into groups based on their performances[14]. Basing the above studies, we suggest a method to classify student's academic performance on real time data collected from a middle east university database.

3.Proposed Methodology

Data was gathered from a LMS System of a middle east university database in order to predict the learners' performances. The dataset consists of 1300 instances with 11 different features namely Student id, section id, age group, grades, student absent count, raised hands, resources visited, participating discussions, viewing announcements, student answering, parent's feedback. Data had nominal and numerical features and therefore data was normalized. Further data was categorized into three classes based on the learner's total marks or internal values. The students who scored more than 85% of marks are been classified as high level and the students who scored between the range of 70% to 85% were classified as Middle level and furthermore the students who scored below 70% were classified as low level.

The below figure 1 demonstrates the suggested methodology in a frame work for classifying real time data using ML classifiers.

Fig.1: A Frame Work to Classify Real time data



3.1 Methods Used

SVM: Support vector machines are mainly utilized to perform supervised classification tasks. Linear and non-linear classifications can be performed using SVM by employing a kernel function. Also, used for regression tasks and it performs classification by constructing ideal hyperplane on the trained data. Two parallel hyperplanes are constructed on the sides of the separating hyperplane. The distance between the

two parallel hyperplanes gets maximized by separating the hyperplane. Test data is imparted on the model built after training grounded on this hyperplane using SMO classifier. SVMs can be used for the classification of complex datasets in sophisticated applications such as handwritten digit recognition, object recognition, and text classification. [15].

MLP: Back propagation algorithm is used to train perceptron's; a model is built. Functions like logistic and hyperbolic tangent sigmoid functions are used to activate the perceptron's. There are some layers involved in this classifier where inputs are trained and are associated with proper weights and summed up to generate the activation function and is passed to other layers until results are attained in MLP [16].

Naive-Bayes: It is a classifier which constructs a model on trained data grounded on probabilities using Bayes concept. Cluster of attributes categorized by NB is free of each other. It is a technique to model the future possibilities in a class based on previous experiences. It predicts new classes on the imparted test data by utilizing numerical values on the model built. Naive Bayes classifier can be applied to binary and multi-class classification problems [17].

Random Forest: It is used for classification tasks with known class and is quite powerful in classifying the data. Unlike decision tree, random forest constructs many decision trees and considers the decision tree which yields the best results. RF's are constructed in a random fashion and in vast manner, gives us the impression like a forest. [18].

Decision Trees: DT's are constructed beginning from the root and continues till it stretches to its leaf nodes using if-then rules. The branches in the tree represent non similar attributes and the nodes at leaves on each branch represent a class. The training data is used to make the system learn the rules of classification. The decision tree is simple, doesn't require complex data representation, and gives exceptional performance for categorical and numerical data features. The decision tree construction is a two-step process, namely tree building, and tree pruning. Tree building refers to generating a decision tree on the training data employing a recursive breadth-first search algorithm. The tree pruning uses the remaining data to test the tree and correct the errors. The decision tree algorithm features simplicity, easy analysis, high accuracy in classification, and efficiency in execution [19].

KNN: K-Nearest Neighbor, is a basic classifier widely used in ML in classifying data with unknown class labels. Samples which resemble some similarity are grouped by calculating distance measures from a certain sample. It performs classification by grouping similar samples and calculates Euclidean distance measure to group them accordingly [20].

3.2 Metrics

Accuracy: Accuracy is a metric which describes or classifies data into proper class label or class. The extent to which classification of data is done correctly is observed by calculating accuracy.

Accuracy = (TP+TN)/(TP+FP+FN+TN)

TPR: True Positive Rate is known as TPR. It is also called as sensitivity. It is the possibility of classifying actual data belonging to positive class into positive class instead of other class. It is calculated as

TPR = TP/(TP+FN)

TNR: True Negative Rate is known as TNR. It is also called as specificity. It is the possibility of classifying actual data belonging to negative class into negative class instead of other class. It is calculated as

TNR = TN/(TN+FP)

ROC: It is significantly used to measure the performance of a classifier in classifying data. It signifies how well the model created by the classifier is classifying the data. The ROC curve signifies the better performance of the model. It is plotted with respect to TPR against FPR.

4.Classification Results on Educational Dataset

Student's academic data was classified using ML classifiers, training and testing the data was carried on with the help of Rapid Miner tool. Classification results were analyzed in terms of accuracy, TP rate, FP rate, ROC curve area and Kappa statistics.

Table 1. Shows the Classification Results by ML Models

Methods	Accuracy	TPR	FPR	ROC	Kappa Statistics
SVM	93.90	1.00	0.10	0.94	0.89
MLP	86.72	1.00	0.00	1.00	0.75
Random Forest	78.33	0.34	0.78	0.89	0.66
DT	76.66	0.33	0.76	0.89	0.64
Naive Bayes	75.83	0.36	0.75	0.83	0.62
KNN	67.70	0.39	0.67	0.85	0.51

It was observed that SVM outstands by yielding 93% classification accuracy compared to other techniques like MLP, RF, NB. Whereas MLP yields the promising classification results of 86%, followed by RF-78%, DT-76%, NB-75% and KNN-67% attains the finest outcomes next to SVM. Also, SVM tops in achieving highest TP rate of 1.00, FP rate of 0.10, ROC curve of 0.94 followed by RF, DT, NB and KNN.

The below Fig.2 shows that SVM attains highest accuracy of 93.90 in classifying students into low level, medium level based on various attributes. MLP yields better results with an accuracy of 86.72% followed by Random Tree and decision tree. KNN failed to yield accurate results and is prone to incorrect classification by yielding low accuracy of 67% among the rest of the classifiers.

The below graphs show the comparison of all ML Classifiers used.

Fig.2: Shows Accuracy obtained by ML Classifiers

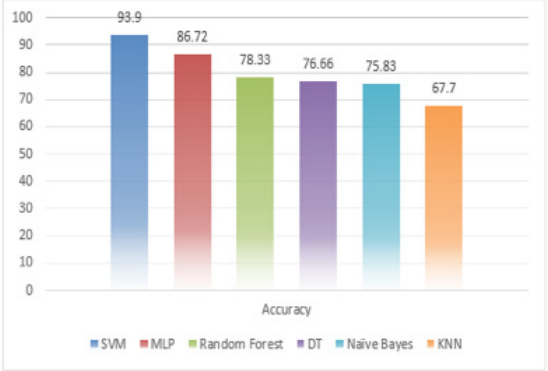


Fig.3: Shows TP rate obtained by ML Classifiers.

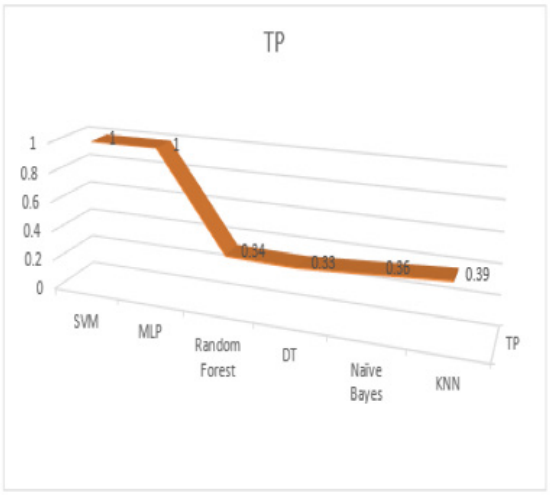


Fig.4: Shows FP rate obtained by ML Classifiers.

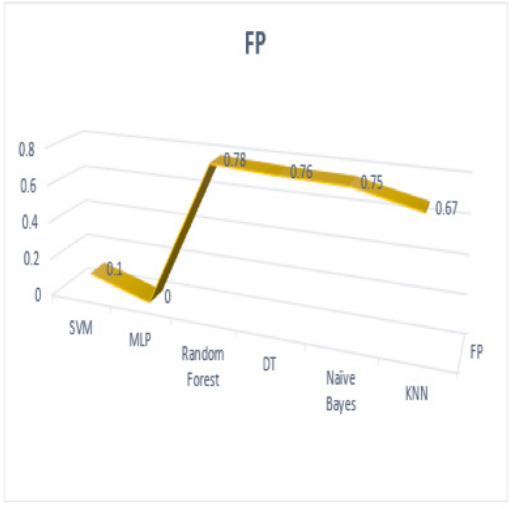


Fig.5: Shows ROC obtained by ML Classifiers.

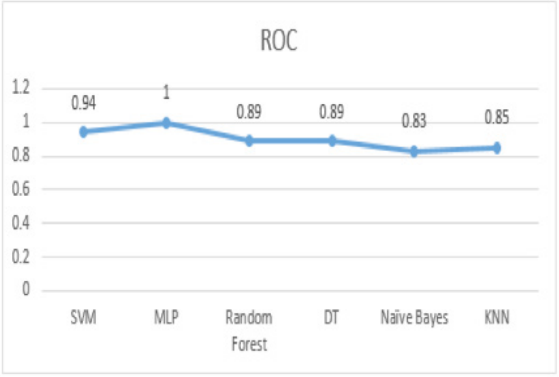


Fig.6: Shows Kappa Statistics obtained by ML Classifiers

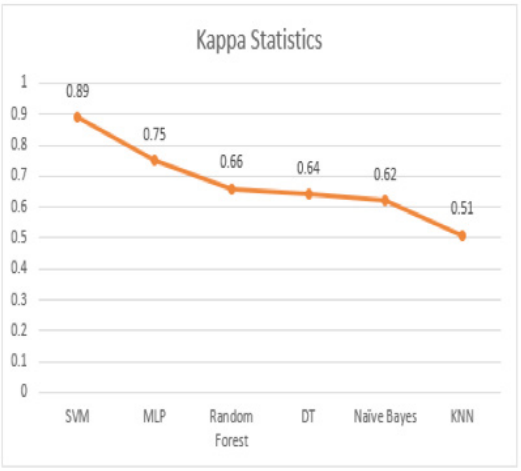
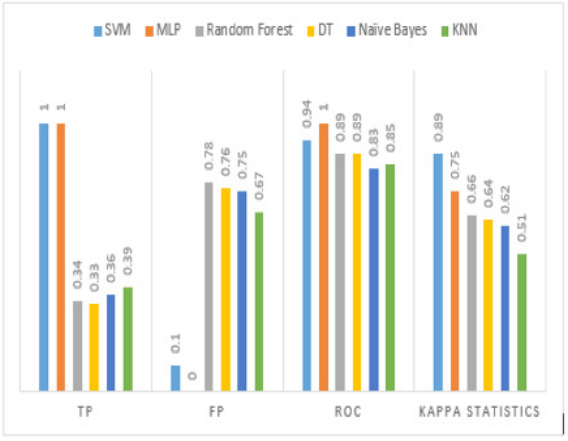


Fig.7: Shows TP, FP rate, ROC and Kappa Statistics obtained by ML Classifiers.



5.Conclusion and Future Work

In this research, we discuss about the proposed framework for classifying students' performance over Real time data using EDM. ML classifiers are used to classify learner's data into 3 classes namely slow level learners, middle level learners and top level learners, which was collected from a middle east university. in different class categories like High, medium and low. The results of all the machine Learning techniques are assessed based on few

metrics like accuracy, sensitivity, specificity and ROC curve area. Data was well preprocessed and classified into proper class labels. SVM outstands by yielding 93% classification accuracy compared to other techniques like MLP, RF, NB. Whereas MLP yields the promising classification results of 86%, followed by RF-78%, DT-76%, NB-75% and KNN-67% attains the finest outcomes next to SVM. Even though MLP and DT yield good classification results but here on this data they failed to yield appropriate results. Also, Random Forest usually yields better performance on different data, here it fails to yield accurate results. KNN attains poor performance and is prone to incorrect class prediction. In future, we try to boost the performance of MLP and DT by using feature selection techniques. Also, Random Forest and KNN performance has to be boosted in the future work by using hybrid classifiers.

Conflict of Interest

None declared

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