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### GLOBAL JOURNAL OF COMPUTER SCIENCE AND TECHNOLOGY: C Software & Data Engineering

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## Image Compression using Walsh Functions

By Misulin Egor Anatolevich & Snapko Roman Yurievich

Belarusian State University of Informatics and Radio Electronics

Abstract- Image transfer and storage require compression to reduce memory usage and increase transmission speed. In this article, the hybrid compression algorithm is used for color/black and white images. It includes the discrete wavelet transform and the Walsh transform. The Walsh transform coefficients are quantized and arithmetically encoded. The combined output is compressed and can be transmitted over any available network in the shortest time. The compressed image is decoded and the original image is decompressed using the inverse conversion operation.

Keywords: walsh transform, lossless image compression, wavelet transform.

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# Image Compression using Walsh Functions

Misulin Egor Anatolevich <sup>a</sup> & Snapko Roman Yurievich <sup>o</sup>

Abstract- Image transfer and storage require compression to reduce memory usage and increase transmission speed. In this article, the hybrid compression algorithm is used for color/black and white images. It includes the discrete wavelet transform and the Walsh transform. The Walsh transform coefficients are quantized and arithmetically encoded. The combined output is compressed and can be transmitted over any available network in the shortest time. The compressed image is decoded and the original image is decompressed using the inverse conversion operation.

Keywords: walsh transform, lossless image compression, wavelet transform.

#### I. INTRODUCTION

he need for information is constant. For example, in the prehistoric period, knowledge about poisonous plants, dangerous animals, etc., was the key to survival for an individual. Information on obtaining food, water, making your home, etc. is vital. Without the invention of communication and the exchange of information, humanity would be doomed to extinction. Now, humankind has ample opportunities to create, store and transmit information. The concept, types, properties of data, and the number of information resources in any field of human activity are growing enormously. The amount of information transmitted is constantly increasing: from household conversations to the data flow on the Internet. The reason is the complexity of all areas of modern society. The determining factor is the development of technology and scientific progress.

#### II. Walsh Function

A Walsh[1] function is a family of functions that form an orthogonal system and take only +1 and 1 values throughout the definition. These functions are derived from Rademacher's functions.

Easy processing is one of the main advantages of transforming the Walsh basis, but special generators are needed to form such functions. There are now several Walsh function generator circuits. See Fig. 1 for one possible variant of the first eight functions generator design.



Fig. 1: Generator of the first eight Walsh functions

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The algorithm for forming Walsh[2] functions in this generator is based on the multiplication of Rademacher functions r1( $\theta$ ), r2( $\theta$ ), and r3( $\theta$ ). The function r3( $\theta$ ) of the meander type is generated directly by the assigning generator and has the maximum frequency for the set of used functions. The functions r2( $\theta$ ) and r1( $\theta$ ) are obtained by triggering the countdown input by dividing the input frequency by 2. To get the remaining Walsh functions, adders by modulo 2 with inverse outputs are used as multipliers. On the output of triggers and augmentation circuits modulo 2, the voltage has two levels, 0 and 1, while Walsh functions, by definition, have levels -1 and +1. The level conversion is carried out by operational amplifiers, which compare the input signal with the offset voltage E = 1/2.

The Walsh transform converts the signal to a set of rectangular or square signals (fig. 2).

The Walsh transform for two-dimensional signals is as follows:



Fig. 2: Walsh basis for 8x8 images



The inverse Walsh transform is determined by the formula:

$$H(u,v) = \frac{1}{N} \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} P_{xy}(-1)^{\sum_{i=0}^{n} (b_i(x)p_i(u) + b_i(x)p_i(v))}$$
(3)

#### III. WAVELET HAAR TRANSFORM

The wavelet transformation[3] decomposes the signal into a set of essential functions called wavelets. Wavelet transformation is a time-frequency transformation, that calculates moving averages and differences through scalar products with scaling signals and wavelets. Wavelets are not defined in terms of scaling and wavelet functions. Wavelet has balanced frequency characteristics. Wavelets use overlapping windows, so the spectrum of the high-frequency coefficient reflects all high-frequency changes (fig. 3).

Arithmetic coding is used to compress data without loss. It is also called entropic coding. Arithmetic coding is almost optimal for a given character set. One of the advantages of arithmetic coding is adaptation. It converts the data stream into a floating point range (0, 1). This also provides better compression, as the entire message is encoded as a new character rather than as individual characters. Wavelet Haar is the simplest type of wavelet transformation and serves as a model for other wavelet transformations, providing effective signal and image compression (fig. 4).



Fig. 3: 2D Wavelet function

X

20



Fig. 4: Wavelet Haar Transform

#### IV. IMAGE COMPRESSION

Image compression[4] is a science that reduces the number of bits required to store, transmit and recover images without losing information. Lossless compression techniques are used to compress and unpack images. The compressed image can be sent via a cloud network on the recipient side, and the image can be reconstructed. The flowchart of the proposed algorithm is shown in fig. 5 and the two-level decomposition DWT is on fig. 6.



Fig. 5: Compression algorithm flow diagram



Fig. 6: Two-level decomposition DWT

The efficiency of the proposed algorithm is confirmed in terms of performance indicators, such as the ratio of peak to signal and noise (PSNR), standard error (MSE), and compression ratio (CR). Input images from datasets are shown in Fig. 7.After compression, the file will be with the.wwt. On the receiver side, inverse transformations are applied to obtain the reconstructed image (fig. 8).



Fig. 7: Input image



Fig. 8: Reconstructed image

PSNR[5] reflects the quality of the reconstructed image and indicates the effectiveness of the compression algorithm. The MSE standard error is the average error value between the input image I and the compressed one I<sup>`</sup>:

$$MSE = \frac{1}{mn} \sum_{x=1}^{m} \sum_{y=1}^{n} (I(x, y) - I'(x, y))^{2}.$$
 (4)

The PSNR peak signal/noise ratio measures the quality between the original and compressed images. High PSNR value gives better quality compressed and reconstructed images. PSNR is usually expressed as a formula:

 $PSNR = 20 \log_{10} \left( \frac{255^2}{\sqrt{MSE}} \right)$ 

The compression ratio can be defined as the ratio of the original image size to the compressed image size:

$$K = \frac{N_{\rm i}}{N_{\rm o}} \tag{6}$$

Here is the matrix of performance for wavelets db3, haar, coif3, sym3, where  $T_c$  - time for compression,  $T_d$  — time for decomposition.

Input image	PSNR	MSE	$T_c$	Td	Compression coefficient K
			db3		
1	48,474987	3,72	7,677057	10,637286	51,32578
2	47,636765	4,39	7,793296	10,553187	47,42396
3	49,512393	2,93	7,220063	10,377102	55,23157
4	48,952306	3,34	7,817294	10,865413	49,97539
5	47,940439	4,21	7,995294	10,950095	47,12561
6	45,629887	4,38	6,365905	8,198367	38,85647
			haar		
1	47,42677	4,74	7,162271	10,23863	54,13286
2	46,94007	5,30	7,581140	10,39107	50,97951
3	48,24472	3,93	6,926179	9,885088	59,79658
4	47,81663	4,33	7,422946	10,30475	52,48647
5	47,37572	4,80	7,536443	10,31744	51,89783
6	43,57184	7,03	5,811217	7,750165	39,25239
			coif3	·	
1	48,99345	3,31	7,896789	11,26030	53,18951
2	48,03012	4,13	7,909564	11,13821	50,20183
3	49,70579	2,81	7,405461	11,05338	58,76425
4	49,40175	3,01	7,988354	11,30202	53,37582
5	48,27024	3,90	8,155997	11,57530	50,09869
6	44,86736	5,22	6,785390	8,942609	34,75683
sym3					
1	48,47499	3,72	7,658239	10,72807	51,15623
2	47,76368	4,39	7,815626	10,55944	47,16854
3	49,51239	2,93	7,620959	10,52366	54,99863
4	48,95231	3,34	7,926224	10,85511	50,08605
5	47,94044	4,21	8,008160	10,86697	47,38945
6	45,62989	4,38	6,184347	8,135875	38,67824

#### Table 1: Performance matrix for different wavelets

(5)

Fig. 9 shows a comparative analysis of the compression ratio for wavelets db3, haar, coif3, and

sym3. The results show that the wavelet Haar transform provides better compression.





#### V. Conclusion

The article offers a hybrid compression algorithm for various types of images. Wavelet transformation, Walsh transform, and arithmetic coding are used together to obtain the best results, such as at least 39 times compression, without loss of quality in decoding. The performance evaluation is based on signal/noise ratio, standard deviation, and compression ratio. The quality of the restored image matched the quality of the original. The proposed algorithm can be used in many areas, as image transmission has become an integral part of everyday life.

#### **References Références Referencias**

- 1. Gonorovsky I. S. (1986) *Radio Engineering Circuits and Signals.* Moscow, Radio and Communication Publ. (in Russian).
- Trakhtman A. M., Trakhtman V. A. (1975) Fundamentals of the Theory of Discrete Signals at Finite Intervals. Moscow, Soviet Radio Publ. 208 (in Russian).
- Kasami T., Tokura N., Ivadari E., Inagaki Ya. (2006) Coding Theory, Transl. from Japan. Moscow, Mir. 571 (in Russian).
- 4. Losev V. V., Brodskaya E. B., Korzhik V. I. (1988) Search and Decoding of Complex Discrete Signals. Moscow, Radio and Communications Publ. (in Russian).
- 5. Kharkevich A. A. (1962) Spectra and Analysis. Moscow, Fizmat (in Russian).

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# Use of Design Sprint in PBL Modules - A Longitudinal Case Study Approach

By Tharanga Peiris & Umanga Pilapitiya

Abstract- Project Based Learning (PBL) modules have become an inevitable part in SE curriculums. Industry relevance of PBL mechanisms have further strengthened this crucial need. Design Sprint is well known as a PBL approach which enhances transferable skills in students. Design Sprint is also a widely used mechanism in software industry projects. Therefore, Design Sprint could be used to enhance the outcomes of SE undergraduate PBL projects. This study makes use of a longitudinal case study approach to investigate the effectiveness of using Design Sprint approach in a SE undergraduate module which used PBL. The study focusses a group of students (111) and academics (12) in SE degree program in a private higher education institute in Sri Lanka. Qualitative data gathered from the target audience in two distinctive occasions to investigate the effectiveness of Design Sprint in PBL projects. The results showcased that Design Sprint has a positive impact in improving performance criteria such as problem solving, teamwork, analytical skills, communication skills and acquiring new knowledge. The results indicated that majority of the students (more than 80%) had positive opinions about the Design Sprint. The academics further strengthened this finding as they also agree that there was a significant improvement in student performance in PBL projects after introducing Design Sprint mechanism.

Keywords: design sprint, PBL, SE.

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# Use of Design Sprint in PBL Modules – A Longitudinal Case Study Approach

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#### Keywords: design sprint, PBL, SE.

#### I. INTRODUCTION

Software Engineering (SE) is an ever-evolving field which introduces platforms, techniques and methodologies for the betterment of its students, employees and body of work. SE industry is a dynamic industry which demands students to pose transferable skills such as problem solving, analytical skills, communication skills, teamwork and acquiring new knowledge. Therefore, SE curriculums should be equipped with methods which strengthens these transferable skills.

Project Based Learning is one such approach used in SE curriculums especially for group projectbased modules. Via these PBL based modules institutes try to inculcate real-life project experience for their undergraduates to prepare them for their industrial aspirations

Many SE industries utilize Design Sprint for their project endeavors (MARIN-GARCIA1 & JAIME, 2008) due to the quick and effective delivery of customer requirements. Design Sprint is a comprehensive approach where essential project elements such as designing, prototyping and real-time customer feedback gets merged in one single platform. Compared to other approaches, a sprint produces a deliverable within a shorter duration with Design Sprint (Knapp, Zeratsky & Kowitz, 2016). Due to its value additions; Design Sprint is more and more used in PBL methods. Therefore, it is suitable to embed Design Sprint in to PBL modules in SE curriculums as well.

The study investigates a group of students in their first year and second year of study following a PBL module. The same group of students (111) is observed in these two occasions following a longitudinal study. The academics who have guided and instructed the group following these modules have also been targeted to collect data to further strengthen the findings. The case for the study was a private higher educational institute which offers SE degrees.

The study initiates by investigating literature and producing a theoretical framework which showcases performance indicators which is required to successful project engagement. Then a hypothesis was derived, and research questions were formed. Data gathered in two occasions via a longitudinal study and were analyzed via qualitative approaches.

#### a) Transferable Skills

MacKeracher & Marsh (2020) in their study of improving Australia's marine science postgraduate training system to meet the needs of the "Blue economy" has identified the following transferable skills which is required in MSc and PhD students:





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Weber, Borit, Canolle, Hnatkova, O'Neill, Pacitti & Parada(2018) defines transferable skills as "skills learnt in one context that are useful for another. They can serve as a bridge from study to work and from one career to another, as they enable subject and researchrelated skills to be applied and developed effectively in different work environments." The following table showcases transferable skills under competence categories such as career development, cognitive, communication, digital, enterprise and interpersonal.

Competence Category	Transferable Skills and Competences
Career Development	Career planning and assessment CV writing Interview techniques Job application Job searching Skills documentation and verification Skills gap identification and development
Cognitive	Abstraction and creativity Analysis and synthesis Critical thinking Organisation and optimisation Problem-solving
Communication	Academic writing Formal correspondence Oral presentation Science for non-technical audiences Science for policy making Social media and webinar usage
Digital	Information accessing and retrieval Information presentation and visualisation Information processing and exchange Programming Software usage and development
Enterprise	Commercialisation Entrepreneurship Innovation Intellectual Property Rights (IPR) Knowledge transfer within and across sectors Legal and business standardisation Patenting
Interpersonal	Conflict management Discipline and perseverance Diversity awareness Independence and responsibility Leadership

# *Fig. 2:* Transferable skills related to competencies (Weber, Borit, Canolle, Hnatkova, O'Neill, Pacitti & Parada (2018))

Adamopoulos (2019) explains that unlike any other type of education, higher education is always judged by based on the value it provides for its undergraduates. Furthermore, he adds that this value addition is strengthened based on how transferable skills are provided by higher education. He lists some of the most important transferable skills as teamwork, problem solving, decision making and critical thinking.

#### b) Transferable Skills needed for SE undergraduates

Transferable skills are the essential skill set that is necessary for a person to adopt to a new or a different situation. Transferable skills can be further described as the skills, knowledge and abilities developed in a certain situation which are applicable to another situation (Career and Employment Service, Macquarie University, 2019). These skills are also referred as soft skills and are undoubtedly valuable to employers in all sectors. Transferable skills can be categorized into Basic and Generic skills. Basic skills include basic literacy skills, basic numeracv skills. critical thinkina skills. Individuals who possess high transferable skills are highly valued by employers since it reduces the employer investment in employee skill development. It further increases the chances of securing one's employment (Nägele & Stalder, 2017).

Software Engineering (SE) is a field that constantly adopts new technological trends for better software development. To thrive in the field of SE, individuals must have strong technical skills, soft skills, and transferable skills. SE industry critically demands teamwork and networking skills (Santana et al., 2017). Therefore, it is essential that the SE curriculums interweave development of these skills to cater to the growing demands of the SE industry. According to the study by Gurcan & Şevik (2020). Communication skills is the highest rated skill needed in the SE industry. It is mainly because SE industry is based on communication between and within teams. Moreover, Matturro (2013) states Teamwork. Communication Skills. Proactive skills. Initiation skills, Analytical skills, Problem solving skills, and interpersonal skills ranks as the top required skills in SE industry. Therefore, imparting transferable skills SE curriculum is a vital segment.

# c) Transferable Skills gained from PBL modules and its importance

Higher education is a phase in a student's life where a combination of skills is required to be instilled in them. These skills include cognitive skills, hard skills, problem solving, teamwork, soft skills and professional skills. It is not possible to grow these skills with just conventional learning and teaching mechanism (Vogler, Thompson, Davis, Mayfield, Finley & Yasseri, 2018). One of the main objectives of providing a higher education for a student is to ensure that he/she is equipped with skills required to become employable. However, due to various factors it is clear to see a gap in employable skills such as soft skills in students with regards to following conventional learning and teaching methods (Holmes, 2012). Therefore, higher education institutions must adopt learning and teaching methods which provides a structure, real-life-problem-solving method which builds employable skills in its students. Project Based Learning (PBL) is such a methodology.

Project Based Learning "is based on the premise that learning is a dynamic, interactive process, the final objective of which should be engagement with a real-world context" (Granado-Alcón, Gómez-Baya, Herrera-Gutiérrez, Vélez-Toral, Alonso-Martín & Martínez-Frutos, 2020). Dias & Brentley-Dias (2017) defines Project Based Learning as "a kind of collaborative work carried out by a group of people within the confines of an academic program".

Gary (2015) discuss that PBL is a method very much suitable for Computing students to achieve their learning outcomes and long-term outcomes. The author further adds that PBL enrich Computing students in getting familiar with real-world problem solving. Sheppard S.D, Kelly.M, Colby & William (2008) agrees that PBL can be the "spine" of a Computing degree structure as it provides a solid foundation on problem solving professionalism where new knowledge is acquired very frequently.

Humphrey (2005) indicates that PBL helps students to synthesize their basics and gradually produce the intended end-result and PBL can be applied to many Computing related curriculums to teach data structures, web and mobile development and algorithms. These technical areas are usually very challenging to teach with traditional teaching methods.

Arizona State University (ASU) is one of the success stories which showcases the applicability of PBL in to Computing higher education. At ASU, they have embedded PBL as the backbone in their Software Engineering Degrees. Undergraduates benefit from a plethora of skills as they engage in PBL based modules throughout their semesters including system analysis, design and professional skills. Gary (2015) ASU further have noticed that since the incorporation of PBL into their Software Engineering degree curriculums they have gained many advantages such as higher acceptance rates from industries for their graduates and higher student satisfaction rates as they are able to enjoy and interact more in subject matters. Gary(2015) adds that PBL has shown better results compared to other conventional teaching methods used in ASU before PBL such as reflections, lectures and problem-based labs.

# d) Transferable Skills gained from PBL modules and its importance

According to Haan (2010), Rieckmann (2012) & Withycombe & Redman (2011) the key Wiek, competencies searched by employers are critical thinking, collaborative work and integrated problem solving. Eby. J.W, Herrell. A.L, & Jordan(2009) identifies that PBL modules enhance several aspects of a student such as collaborative skills while working in groups, a positive attitude towards exploring and discovering knowledge and to develop aptitudes such as critical thinking. Adding to this discussion, Flores-Fuentes & Juárez-Ruiz(2017) declares that PBL modules improve the student's abilities in self-directed work, research, internalization of competencies while at work, presentation skills and use of many resources. The PBL methodology also focuses on the process of learning of a student via research and reflection aimed at problem solving (which is provided by the lecturer). This process includes students' actions which are coordinated in determining solutions and incorporating Sustainability in working both alone and in a group (Warr & West,2020). It is clear to see that these skills qualify as transferable skills and will come to the student's aid when they get employed.

There is numerous research which discusses the transferable skills provided for students via PBL modules. Granado-Alcón. Alonso-Martín. Vélez-Toral. Gómez-Baya, Herrera-Gutiérrez & Martínez-Frutos (2018) discuss that PBL modules develop effective learning strategies such as problem solving and inculcate cross-cutting skills transferable to new situations or other academic subject areas. Mioduser & Betzer(2007) further adds as they explain that. PBL method aids students to retain the competencies gained for a longer period. Acquiring new knowledge, accepting constructive learning and increased motivation are some of the other few transferable skills which can be installed in students via PBL method Willard & Duffrin (2021). In many instances, it is a requirement of the IT industry that its employees are able to acquire knowledge from many sources, integrate the acquired knowledge and go back to the initial problem with a more dynamic overall view. PBL trains its students to do just this (Braßler, 2016). It is also crucial that the employees are comfortable in integrating knowledge when it comes to solving real-life problems at workplace. Holley(2017) in their research express how PBL method install this skill in students. Granado-Alcón, Gómez-Baya, Herrera-Gutiérrez, Vélez-Toral, Alonso-Martín & Martínez-Frutos (2020) in one of their studies has conducted a research to explore the competencies acquired by students via PBL methods. In their study they have used a total of 387 students following a module called "Higher Education Teaching Innovation Project" at the Universities of Huelva and Murcia in Spain. The study results indicate that, PBL aided the students to improve their ability to work in groups, improve their analytical skills, manage and integrate knowledge and ability to work with different individuals. Furthermore, the study results indicated that PBL aids the students to use tools in different disciplines and strengthen other transferable skills such as research abilities, autonomous learning and critical thinking. The study in their other observations, explains that PBL also plays an important role in enhancing student experience in learning and also to gain the ability to transfer their knowledge in to the required platforms.

#### e) Design Sprint original approach

Design Sprint is a new approach invented by J. Knapp for software product development (Knapp et al., 2016). This is a process of prototyping and testing SE solutions quickly via a structured five-day approach. This methodology is a partnered endeavor with Google ventures. World renowned companies such as Google, Uber, Slack, Facebook, Twitter, and Airbnb use this methodology for software development (Design Sprint SA, 2023).

Design Sprint is an efficient method which includes tools and mechanisms to come up with innovative solutions enriched with customer feedback. The customer centric process provides guidance as to set the stage for the whole process. This guidance is provided in an easy-to-understand five-day approach starting form initial preparation.

A design sprint is conducted by a facilitator also known as a sprint master and his/her first task is to clarify the problem and recruit a team to conduct the sprint. A sprint team comprise with 5–7 members, with diverse skillsets including a facilitator, a designer, a developer, a customer service representative, and a marketer at minimum (Knapp et al., 2016). Main roles involve,

- A facilitator, to ensure that the team stays on track
- A customer service representative, for user insight
- A designer, for their knowledge of design software and User Experience Design
- A developer, for their understanding of any technical limitations
- A marketer, who can determine if the solution has a market value
- A decider, who'll have the final word on decisions (assigned to one of the above)

After the team is selected the 5-day process starts.

- Monday Map, where the team understands the goal of the sprint involving all the stakeholders. The requirements will also be prioritized for the first sprint.
- Tuesday Remix, improve and sketch, where the teams will propose solutions for the prioritized requirements of Monday. The teams will also perform lightning demos where they will review what others have done for similar solutions.
- Wednesday Decide; where team members individually vote on the proposed solutions of Tuesday and then select the best solution to build.
- Thursday Prototype; build the prototype.
- Friday Test and customer feedback; where the prototype will be tested and improved with end user feedback.
- f) Design Sprint as a PBL technique

Elena, Andrés, López-Vázquez & Fernández-Ibáñez(2022) defines Design Sprint as "an agile methodology (implemented in 5 days) with the goal of creating innovative design based on user needs (User Experience)." The below 5 stage Design Sprint (DS) based on Google Ventures, goes well hand in hand with PBL modules.



*Fig. 3:* Design Sprint Phases (Elena, Andrés, López-Vázquez & Fernández-Ibáñez, 2022)

The first phase understand, is where the participants understand the problem in hand and come up with their specific objectives. The second phase "sketch" is where the participants search for solutions for the identified problems in phase 1. During the third phase(decide) the team needs to pick one idea out of the many searched in the second phase. In order to pick one idea, the team will have to vote and then create storyboards in terms of the prototype of the system. During prototype phase the team come up with a suitable prototype for the picked design in the decide phase. The last phase test/validate is where the teams evaluate their prototypes.

Elena, Andrés, López-Vázquez & Fernández-Ibáñez (2022) in their study of "enhancing STEAM and engineering education through agile prototyping and testing ideas", targeting 56 first year students at the University of A Coruna has found out that, students are motivated to engage in PBL modules when using design sprint and they also think that Design Sprint is a more multipurpose and useful tool that they can enjoy. The study moves on to say that Design Sprint technique adds more value for PBL modules as it increases student interactions and enhances the way students face challenges during PBL.

#### g) Performance criteria of SE group projects

Group projects facilitates students to develop both basic and generic skills required by employers. Khamis & Sulong (2011) states that the strengths and weaknesses of group members can be identified through the peer review and lecturer assessment from presentation sessions. These assessments further help to detect passive students in group projects. They further point out the drawbacks of this approach. They claim that in peer reviews students tend to give almost the same score to his/her group members. In lecturer assessment, it is difficult to detect students' behaviors directly based on their presentations.

As stated by Marin-Garcia & Llore (2008) on their research on assessing teamwork in projects mention a set of criteria to assess group processes. These criteria were presented by analyzing various publications. Their criteria include amount or frequency of participation in the group, attendance at meetings, quality of participations in the group or of documents presented, preparation of meetings, gathering and processing of information prior to the meeting, meeting deadlines, interpersonal communication, delegating/ Leading without dominating, accepting and assuming responsibilities, suitable handling of disputes, decisionmaking/Group problem-solving and Creativity.

Wateridge (1995) classified a set of performance criteria that is frequently used in industrybased IT/SE projects. He investigates the key success criteria and the factors that influence the success or failure of IT/SE projects. The main success criteria he outlines are meet requirement of users, accomplished purpose, meet deadlines, complies with schedule, contributes to user satisfaction, and contributes to quality goal.

Devlin (2004) states that criteria for the assessing group work can be determined by lecturers, students or by both parties. Moreover, she claims that groups are much more successful when students are also involved in assessment. She suggests regular meeting attendance, equity of contribution, evidence of cooperative behavior, appropriate time and task management, application of creative problem solving, use of a range of working methods, appropriate level of engagement with task, development of professional competencies, evidence of capacity to listen and responsiveness to feedback/criticism as the main performance criteria.

#### h) Use of Design Sprint for pedagogy

Soyupak's (2021) has conducted a study on embedding design sprint into industrial design education. This study examines the potential usage of the design sprint framework, its strengths, weaknesses and how to use it as an educational tool. Study was conducted via a design sprint workshop, for 12 industrial design students who are currently in their 5th semester. Students were given an imaginary company and imaginary data with a problem. Students selected the problem via a dot voting process. Usually, the ideal scenario for students is to start the design process with a thorough user and market research, it is omitted and replaced by imaginary data. There were 2 student groups and the first group focused on developing a thermos for mountain hikers and climbers which is easy to carry, chargeable self-heating, easy to clean and easy to find. The second group intended to design a thermos for the public with addressing stability problem and tilting, to visualize the remaining liquid inside, tracking the product and with a way to easily handle it by visually impaired audience. Results indicated that many students valued the design sprint approach compared to the traditional design studio approach because the whole process is done in the studio environment with less intense having an outcome at the end of each stage. Moreover, students valued their own peer's decision-making power compared to the decisions given by a jury of experienced studio executives. As a

negative point, students mentioned about the time limitation. Due to this reason students had to develop 2D prototypes instead of 3D prototypes as required.

According to Arce et al.'s (2022) design sprint approach can be used in engineering Drawing classroom. The study was conducted at the University of ACoruña, for 56 first-year students who follows the STEAM degree. There were 18 groups in total. Their problem was to come up with solutions to the problems of masks during the COVID pandemic. As a result, students designed mask ear-savers (10 projects), nose clips (3 projects), eyeglasses rings (2 projects), and door openers (2 projects). It was conducted in both physical and online method using MS. Teams. Moodle was used to provide instructions and to monitor student progress. The Moodle Workshop tool was used for the prototype evaluation via a video. Evaluation rubrics consists of 3 segments such as co-evaluation, heteroevaluation, and self-evaluation. Autodesk software is used to develop the prototype. After the project completion a survey was used to evaluate student satisfaction. Results showed positive effects on grades. This implies that the Design Sprint method has fostered an interactive learning environment. Additionally, students felt less overloaded due to proper time management.

Ferreira & Canedo (2020) claims that Design sprint in combination with project-based learning (PBL) is an effective method to implement high quality software products. They have conducted 2 exploratory case studies with a customized reduced version of design sprint approach for IT undergraduate students. With the use of 2 case studies, they suggest that the minimalistic version they suggest in Design Sprint can be adopted into any PBL unit. The results indicated that student experience is satisfactory and Design Sprint methodology requires a considerable amount of time for learning and fxing, addressing students' delays, students' shyness, and motivation issues. It is advisable to take measures to reduce these problems. Moreover, they state that the duration of design sprint should be not less than 4 days and using cutting edge technology will fasten the process.

Klynhout (2022) has conducted research on nurturing entrepreneurial skills in undergraduates using Design Sprint approach. Study is focused on understanding how the design sprint can be adopted by university degree programs of applied sciences to teach entrepreneurship. 22 students were participated during the 5-day design sprint and recorded their daily diary entries. Results indicated that "teaching through entrepreneurship" approach is supported via design sprint, and therefore students went through an actual and proper entrepreneurial learning process. Research concludes that design sprint can be used as a form of entrepreneurial education, and as a means of value creation outside the classroom. Murgu et al (2021) details a pedagogical collaboration used for Music. The end product of the design sprint was the Mapping Sentiments through Music (MStM) application. The design sprint was conducted with a digital humanities librarian, a professor of music and digital media, and a second-year music student. Research concludes that both humanities and music composition can incorporate design sprint.

Ferreira & Canedo (2019) have conducted a study on Brazilian's higher education colleges on using Design Sprint for active learning in requirements engineering courses. They state that Design Sprint is a good approach because of its flexible structure and short duration. An exploratory case study approach was used with software engineering undergraduates for a requirement gathering phase. Results indicated that the reduced time was an issue. Survey results further indicated that 91% of students considered it is productive and 100% of students agreed it can foster creativity and problem solving.

Sumual et al. (2018) have used design sprint to design mobile applications. The study was conducted based on the data gathered from lecturers and students in higher education. The results implied using the Design Sprint for designing smartphone-based software will make the process efficient and effective.

According to Beyer & Pfister's (2021) study on using design sprint for visualization courses revealed that it can be used in both on campus and online environments. Researchers have customized the original design sprint method to suit teaching visualization courses. They have run two design sprints within the semester-long visualization course. The first sprint is guided and carried during the last 20 minutes of every lecture in the initial weeks of the semester. This provided students the opportunity of getting direct feedback in the class. The second sprint is conducted towards the end of the semester and students works on this sprint outside of class and submit the result as a final project. Results of the study states that using design sprint has increased the student engagement, improve the quality of the product and students get positive feedback regularly.

Winfield et al. (2022) study on integrating design sprint into education also have proven positive results. This study was conducted for a product design in Nottingham Trent University (NTU) including 10 academics, external industrial Clients (Futura Nova) and focus groups in healthcare. Students belonged to different years. (Cross cohorts) Main goal was to improve students professional and team building skills. Outcome is to develop a CAD project. Original design sprint was customized and additionally a pre-sprint phase was added to meet the knowledge gap. Outcomes are positive and allowed less confident students to engage equally. Their main issue was to mix and manage cross cohort students.

#### i) Longitidinal Studies

According to Van Belle, Fisher, Heagerty & Lumley (2004) a longitudinal study is "continuous or repeated measures to follow particular individuals over prolonged periods of time—often years or decades. They are generally observational in nature, with quantitative and/or qualitative data being collected on any combination of exposures and outcomes, without any external influenced being applied. Statistical analysis needs to be conducted in order to analyze the final findings and to come to conclusions of various instances and samples over time. Longitudinal studies enable achieving sequence of events, ability to exclude biasness of participants and relate events to various exposures.

However, there can be various challenges researchers need to face in conducting longitudinal studies due to its very nature. Risk of studies ending up incomplete due to not been able to conduct it for lengthy periods of time, high demand for resources and finances. (Newman, 2010)

Longitudinal studies due to its nature is commonly utilized to analyze development of disease or relationships of risk factors over time (Caruana, Roman, Hernández-Sánchez & Solli, 2015). In a study conducted by Van Oostveen & de Lange (2021), they have conducted longitudinal monitoring of Alzheimer's disease. The study results have showcased that in such a disease it is essential that longitudinal studies are conducted as then only they can better understand and determine adequate treatments. Hazreen et al., (2014) has also conducted a longitudinal study to find out risk factors for chronic non-communicable disease among adolescents in Malaysia. However, longitudinal studies have become very much a necessity in the field of education as well. A longitudinal study of 32 years has been conducted by Collier & Thomas(2017) in 36 school in 16 U.S states targeting 7.5 million student records to analyze program effectiveness and policies related to education. Cook, Andriole, Durning, Roberts & Triola(2010) highlights the importance of using databases with longitudinal data in facilitating educational outcomes overtime across institutions in medical education. Another fascinating longitudinal research related to education has been conducted by Kosnik, Clive, Cleovoulou & Fletcher(2009) where output of longitudinal research has been utilized to improve teacher education via effective program planning and improving vision.

According to Caruana, Roman, Hernández-Sánchez & Solli (2015) & (Thomas,2022) there are many study designs which can be followed in longitudinal studies; such as:

*Prospective studies*: Individual/ group of same participants trailed over a definite period of time. This type of design also eliminates the "recall bias".

E.g., in a study where the relationship is analyzed between the number of study hours and the pass rate; none of the participants will recall the number of hours they have studied in the past. In the longitudinal study you may keep track of these variables in real-time.

Repeated cross-sectional studies: Each sampling occasion, the individual/ group of participants are different.

E.g., a cross sectional longitude study has been conducted to find out the impact of Covid-19 lockdowns on mental health of a sample of 2000 citizens in Victoria. As per the result of this study, cross-sectional portion has showed that the percentage of participants with low life satisfaction was significantly higher in the sample which went through lockdowns compared to the one that did not. Longitudinal study results indicated that lower social connectedness was significantly associated with higher psychological distress.(Wright, De Livera, Lee et al., 2022)

*Retrospective studies:* Some participants have familiarized the relevant events and the study takes place to analyze the potential future exposures.

E.g. you may check past profiles of students to see whether low performers have had disciplinary incidents recorded under their names. (to see the relationship between low performing and lack of discipline in a student)

#### II. METHODOLOGY

The objective of the study is to find out whether Design Sprint workshop increase student performance in undergraduate SE group projects in PBL modules. According to the referred literature attributes that determine student performance are problem solving, teamwork, analytical skills, communication skills and acquiring new knowledge. Furthermore, these performance indicators are enhanced via certain measurable criteria.

The purpose of this study is to verify that the above criteria will be met/enhanced when design sprint methodology is introduced in to a PBL module. The study follows a prospective longitudinal mechanism where the same student group is observed within a period of time.

Qualitative data was collected from the student group as well as targeted lecture panel in two occasions. First occasion was before the design sprint workshop was conducted and then the second occasion was after the design sprint workshop. Data analysis was done using qualitative data gathered using observations, questionnaire and interviews.

#### a) Theoretical Framework

Based on the literature review conducted, it is noticed that undergraduate student performance is based on variables such as problem solving, teamwork, analytical skills, communication skills and the student's ability to acquire new knowledge. Accordingly, the following theoretical framework was designed:



#### Fig. 4: Theoretical Framework

The literature review further looks into the performance indicators in SE undergraduates. The following summarizes some key performance indicators. The following also displays the relationship of the performance indicators and the variables derived via the theoretical framework: Wateridge(1995), Marin-Gracia & Llore(2008), Khamis & Sulong (2011) & Devlin (2004).

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Variables	Problem solving	Teamwork	Analytical skills	Communication skills	Acquiring new knowledge
	Create solution design	Task management	Decision making	Interpersonal communication	Use of new working methods
	Meet requirements of users	Schedule compliance	Creativity	Responsive to feedback and criticism	Development of professional competencies
Performance indicators		Delegating tasks and work without dominating		Handling disputes	

#### b) Sample

The research is an exploratory and longitudinal study in nature. The sampling technique is nonprobability sampling. The study was conducted at a private higher educational institution which offers degree programs in the streams of Computing, Business and Law. The research context is a first-year module called "software development & application modelling" (SDAM) and a second-year module called "Commercial Computing" (CC). Both modules are offered for Software Engineering students during the academic year of 2020-2021.

Rational of selecting the modules is that both modules are delivered across two semesters following the Project Based Learning method. In SDAM module students design and develop a software solution for a given scenario. In the CC module during the first semester, the students come up with a proposal for a given scenario. To obtain an effective proposal the student groups need to conduct a domain study, similar system study and analyze and choose a suitable technology. The proposal should contain a software solution to solve a problem within the scenario. In the second semester, the student groups will assume Agile roles for themselves and implement the proposed software solution in three sprints. Agile methodology contains main project roles such as Scrum Master, developer, business analyst and quality assurance engineer. Student groups contain four members each, assuming each role. Each sprint the students are to switch their roles so that every student receives the opportunity to act in all four roles at the end of the three semesters. The instructor/ lecturer for the module plays the role of the product owner and provides the scenario for the groups in the first semester. The groups will conduct sprint reviews at the end of each sprint, where each group will demonstrate their shippable products to the product owner and receive his/her feedback. The next sprint starts with the groups adhering to the previous sprint review feedback.

The student sample contained a total of 111 second year software engineering students. This same group of students had gone through SDAM in their first year and then CC module in their second year. According to Van Belle, Fisher, Heagerty & Lumley(2004) a longitudinal study is "continuous or repeated measures to follow particular individuals over prolonged periods of time—often years or decades"; therefore, this group of students is suitable for this study.

The study couldn't have been conducted targeting only a first-year batch as they lack PBL exposure. The batch needs to have completed the first year where they had no design sprint experience and second year where they were exposed to design sprint; in order to measure the impact of design sprint. The lecturer sample contained a total of 12 lecturers. These lecturers teach modules in first- and second-year software engineering degree program at the selected higher educational institution.

#### c) Instrument

Data was collected in couple of instances:

• Questionnaire and interview

*First instance:* just after the assessment marking is completed for SDAM module in the first year, questionnaire and interview was used to collect data from both student and lecturer samples.

Second instance: just after the assessment marking is completed for CC in the second year second semester, questionnaire and interview was used to collect data from both student and lecturer samples.

The questionnaire was designed based on the questionnaire used in the study "Project-based Learning and the Acquisition of Competencies and Knowledge Transfer in Higher Education" (Granado-Alcón, Gómez-Baya, Herrera-Gutiérrez, Vélez-Toral, Alonso-Martín & Martínez-Frutos, 2020). The guestionnaire has been validated via qualitative analysis of reliability and validity. This was done via sending the questionnaire to 76 students to identify any repetitions/ unclear elements. Questionnaire was also sent to 6 experts and validated via individual aggregated method. (Granado-Alcón, Gómez-Baya, Herrera-Gutiérrez, Vélez-Toral, Alonso-Martín & Martínez-Frutos, 2020). In order to achieve quantitative validity exploratory factorial analysis has been conducted via extraction method and rotation method.

#### III. DATA ANALYSIS DESIGN

#### a) Research hypothesis

Design sprint enhances the SE undergraduate performance in PBL modules in problem solving, teamwork, analytical skills, communication skills and acquiring new knowledge.

- b) Research questions
- 1. Does design sprint enhance problem solving skills in SE undergraduate PBL modules?
- 2. Does design sprint enhance teamwork in SE undergraduate PBL modules?
- 3. Does design sprint enhance communication skills in SE undergraduate PBL modules?
- 4. Does design sprint enhance analytical skills in SE undergraduate PBL modules?
- 5. Does design sprint enhance acquiring new knowledge in SE undergraduate PBL modules?

#### IV. Results

a) First Instance

Data gathered using a questionnaire in the first instance where the student group has just received their

assessment marks for their PBL module (SDAM) in the first year of study. The purpose of this questionnaire (Appendix A) is to investigate the student's skill level prior to conducting the design sprint workshop. includes five main performance indicators. The results showcase the results obtained from one of the questions under each performance indicator.

The following are some of the results analyzed using graphical indicators: Furthermore, the study



Fig. 5: Performance Indicator: Problem Solving

One of the questions used to check the student's problem-solving ability was "PI1.1 When given a problem I have the ability to come up with a suitable solution". The above chart showcases the student ratings achieved for the question. The ratings indicate that almost 83% of the students have rated their ability to come up with a suitable solution as 1 or 2. Only around 12% of students have given themselves a rating of 4/5 indicating that they have the ability to come up with a suitable solution. It is clear to see that at this point the students lacked confidence in problem solving.

below chart depicts the student ratings received for the question "PI2.3 I can plan and organize tasks in group work" under teamwork. We could see that majority of the students (88%) have given themselves a very low rating of either 1/2 as they did not believe that they pose the ability of proper planning and organizing a group work. Very low number of students (7%) have rated themselves with high ratings of 4/5 claiming that they have the ability to properly organize and plan group work.

The second performance indicator which was checked using the questionnaire was "team work". The



Fig. 6: Performance Indicator: Teamwork



Fig. 7: Performance Indicator: Analytical Skills

The above chart showcases the student ratings obtained for the question "PI3.2 I can analyze given data and make suitable decisions". As per the above indication, 87% of students have rated themselves as having poor ability in making decisions. (1/2 rating) Only a very small number of students (8%) have rated themselves high (4/5) for having analytical skills to solve problems.

The performance indicator "communication skills" was also measured using several questions in the questionnaire. One such question was "Pl4.3: I am able to express my ideas clearly". As per the below chart, 90% of majority have stated that they do not have the ability to express their ideas clearly and only 21% minority have rated as they have the ability to express their ideas.



Fig. 8: Performance Indicator: Communication Skills

The last performance indicator to determine student performance was "acquiring new knowledge." One of the questions to determine the responses was "PI5.1 I can learn new things easily by myself". However, as per the results below; 80% of students have stated that they do not think they have the ability to learn new things easily by themselves. Only 31% of students have stated that they have the ability to learn new things.





#### b) Interview analysis of lecturers

A group of 12 lecturers who have taught the relevant group of students in their first and second years of study was interviewed and transcripts were created out of interview recordings. The thematic qualitative response analysis by Rashid et al. (2019) is used to analyze the responses. NVivo software is used to identify the codes in the transcripts. The following table shows the identified codes:

Inductive categories (Codes)	Subcategories
Problem solving	Coming up with solutions Understanding user requirement Synthesizing information PBL module assessment marks Active participation
Teamwork	Contribution of work Planning and organizing Ability to work with others
Analytical skills	Pick viable solutions amidst options Presenting analyzed information Decision making
Communication skills	Group communication Conflict resolving Idea expression
Acquire new knowledge	Self-study Transferable skills Soft skill development

# Table 2: Codes used to analyze interview responses of academics

The codes identified in the above table were used to analyze the interview responses. The following is some of the significant responses extracted from the lecturer's interview transcripts.

When presenting the responses, the following notations were used: The below notation indicates that it is the 1st respondent (Res1) from the Lecturers. E.g., LRes1

#### c) Interview Analysis Results of First instance

(Right after the group of students received their marks for the SDAM module in first year of study.)

i. Qualitative analysis on student's problem-solving ability

In order to analyze responses which indicated the student's problem-solving skills, the subcategories "Coming up with solutions", "Understanding user requirements", "Synthesizing information", "PBL module assessment marks" and "Active participation" was used from the Table 2.

*LRes1:* this is the fourth consecutive semester I am delivering SDAM. Our students don't seem to understand the learning outcomes of PBL modules. Many of the students invest minimum effort and merely

submit a working prototype. (LRes1, personal communication, December 14, 2020).

*LRes4:* most of our students do not actively take part in the PBL module assessments. Many of them start the projects very later in the semester and end up with poor time management (LRes4, personal communication, December 14,2020).

ii. Qualitative analysis on student's teamwork ability

In order to analyze responses which indicated the student's teamwork, the subcategories "Contribution of work", "Planning and organizing" and "ability to work with others" were used from the Table 2.

*LRes7:* many of the groups of four had only 1 student who was working by himself/herself. Many do not contribute for their group work and the ones who work ends up covering up for the ones who do not. (LRes7, personal communication, December 14,2020).

*LRes11:* there are many groups where students do not have the passion to work with others. Many students are used to working in isolation. (LRes11, personal communication, December 14, 2020).

iii. Qualitative analysis on student's Analytical skills

In order to analyze responses which indicated the student's analytical skills, the subcategories "Pick viable solutions amidst options", "Presenting analyzed information" and "Decision making" were used from the Table 2.

*LRes5:* our students have very good presentation skills. But when it comes to presenting their ideas/proposed solutions they seemed to lack the flow and confidence (LRes5, personal communication, December 14,2020).

*LRes11:* many of our students do not wish to spend a lot of time in analyzing a scenario. They always wish to jump into the implementation phase. Due to this, many students come up with ineffective solutions that doesn't aid the users to solve their problems. (LRes11, personal communication, December 14,2020).

iv. Qualitative analysis on student's communication skills

In order to analyze responses which indicated the student's communication skills, the subcategories "Group communication", "Conflict resolving" and "Idea expression" were used from the Table 2.

*LRes12:* our students panic in an instance of conflict. many group members tend to contact us and request to change their groups as they do not wish to continue the project with their current group members. (LRes12, personal communication, December 14,2020).

*LRes6:* many students in groups stay quiet during meetings. Some students have very good technical abilities but as they do not express their ideas, they tend to be backwards in group work. (LRes6, personal communication, December 14,2020).

# v. Qualitative analysis on student's ability to acquire new skills

In order to analyze responses which indicated the student's communication skills, the subcategories "Self-study", "Transferable skills" and "Soft skill development" were used from the Table 2.

*LRes8:* most of our students wish that the lecturers teach them everything. Students do not wish to engage in self-study or any type of fact gathering/ reading. This is one of the reasons as to their assessments fail. (LRes8, personal communication, December 14,2020).

*LRes10:* many students do not see the opportunity to improve their skills in PBL modules. For most of them a project is a "One-time endeavor" and they do not understand the value of learning transferable skills. Therefore, we see the students repeating same mistakes which they made in first year in their second year as well. (LRes10, personal communication, December 14,2020).

Observation conducted during the design sprint workshop during the CC module

Observation was used to gather data during the design sprint workshop. The original design sprint approach is a 5 day well planned process which includes all stakeholders of an industry-based project. The objective of the design sprint workshop was to implement a simple solution to match the given requirements by the researcher. For the purpose of this study, the original approach was customized to meet the learning objectives of the selected PBL module. Main customizations include introducing a pre-sprint stage, removing extra industry-based roles, and simplifying the sprint questions. During the pre-sprint stage students were informed in advance about the workshop and tasks they have to do. This was conducted in order to save the time of adjusting to a new learning criterion. Project roles related to budgeting and resource allocations are left out since these approvals are out of scope. Sprint questions were strictly limited to one because of the time limitations. Another major change from the original design sprint is allowing to use all technological devices during the workshop. This was allowed since students need to explore the problem and its background, investigate into possible solutions and conduct research on its development in the workshop.

Observation 1: More innovative solutions were invented – Students collaboration and enthusiasm was considerably high during the workshop compared to general unguided group work sessions they attend. Students focused on the given problem, formulated different possible ideas and selected the most suitable one. Students were more focused on understanding the user requirements and catering to them. In all groups dedicated one to two students were analyzing past systems and approaches with technological aid during the session. They were able to synthesize different solution pathways together to formulate a better and an efficient solution. This approach generated good outcomes and all student groups were able to meet the goal at the end of the workshop.

Observation 2: Improve teamworking skills - PBL modules are mostly based on teamwork and main goal of introducing design sprint is to achieve its maximum potential. All students were highly engaged in proper teamwork. As observed during the workshop they were communicating well with each other to understand the problem. When generating different ideas, they sometimes disagreed with each other and ultimately ended up with a partial agreement or formulated a new solution. Most team members were firm in communicating their ideas and viewpoints since they understood that mistakes in communication will lead towards more rework. The decision makers were assigning and delegating tasks for the appropriate members in the group and all of them adhered to it since their roles were pre-defined. All team members were responsible for a specific task as well as generic tasks. Within the group the tasks needed to be planned and organized as a team. In some teams this was done by subgroups of two to three members and in some groups all teams members got together in planning their work. Overall, the teamwork was in its highest capacity during the workshop.

Observation 3: Improving critical thinking ability -Students were given a well-defined problem to design and implement a solution, during the workshop. They were first analyzing the problem and its context followed by the solution designs and its feasibility. All groups used internet and other electronic mediums as information gathering sources. Some groups were referring to the video tutorials and materials during the workshop. Students conducted investigation and comparisons on the possible development technologies before starting on development. All of them were required to analyze the problem and come up with user stories or use case diagrams to demonstrate the features. Then by analyzing them, students came up with possible designs during the Crazy 8's phase. They were observing the past data and past systems before stating implementation. Proper investigation led them to implement an efficient product. Critical thinking is involved in all stages of the workshop.

Observation 4: Learning new knowledge – Students were conducting their own investigations during the workshop to come up with feasible solutions. This allowed them to learn new methods of designing, implementing, and testing products. Further, students who are fluent on certain tools and technologies tend to teach other students in the team. This ultimately led to a knowledge sharing platform allowing students to improve their knowledge and skills. Moreover, soft skills such as communication skills, leadership skills, listening skills, presentation skills and networking skills were heavily used during the workshop. One main observation was the large amount of peer learning encountered during the workshop. Students were very happy about this peer learning since it was a positive scenario occurred without intentional planning. These peer learning will surely aid the students in their later studies.

Observation 5: Detection of errors in early stages of product design – All team members were fully focused around finding a solution to the problem at the early stages (Monday to Wednesday). They all were focused on a single objective and collaboratively worked towards deriving solutions. Their specific tasks such as development, designing and testing started at a later stage. Hence, the errors were detected and solved in the early stages allowing less rework compared to the traditional way of development. Moreover, students were comfortable with each other because of the friendly set up. This led to proper communication among team members and indirectly impacted early detection of errors.

Observation 6: Equal respect is served for all ideas - All students in the group were assigned specific roles such as deciders, customer expert, technical experts (developers, quality assurance engineers) and design

experts (business analyst). Therefore, everyone's ideas were respected and heard during the initial stages. Moreover, all members need to provide their own design using crazy 8's and the best ideas are selected using the voting system. None of the students complained about a discrimination or unfairness during the workshop. All students' voices were heard and treated equally in decision making.

Observation 7: Enjoying the work - Students enjoyed this new approach of design sprint very much. They were engaging with each other, solving issues and conflicts in a professional manner, and having fun at the same time. They were adopting to this new mechanism well and positive feedback was received at the end.

#### d) Second Instance

The second instance was where the student group was in their second year of study and just received their assessment marks for their PBL module (CC). Prior to this questionnaire, the students have gone through the design sprint workshop as well. The same questionnaire used (Appendix A) in the first instance was used for the second instance as well in order to maintain consistency. The purpose of this second instance data gathering was to check whether any of the performance indicators have improved via the design sprint workshop.



Fig. 10: Performance Indicator: Problem Solving

The above indicates the student ratings for the question "PI1.1 When given a problem I have the ability to come up with a suitable solution". The ratings indicate that almost 81% of the students have rated them as 4/5. Only around 11% of students have given themselves a low rating indicating that they do not have the ability to come up with a suitable solution. It is clear to see an enhancement of problem-solving ability in students after the design sprint workshop.

The second performance indicator which was checked using the questionnaire was "team work". The below chart depicts the student ratings received for the

question "PI2.3 I can plan and organize tasks in group work" under team work. We could see that majority of the students (86%) have given themselves a very high rating of either 4/5 as they believe that they pose the ability of proper planning and organizing a group work. Very low number of students (8%) have rated themselves with low ratings of 1/2 claiming that they do not have the ability to properly organize and plan group work. Design sprint workshop seems to have a positive impact on the student's team work.



Fig. 11: Performance Indicator: Team work





The above chart showcases the student ratings obtained for the question "PI3.2 I can analyze given data and make suitable decisions". As per the above indication, 86% of students have rated themselves as having high ability in making decisions. Only a very small number of students (10%) have rated themselves low (1/2) for not having analytical skills to solve problems. Design sprint workshop have seemingly improved their analytical skills. The performance indicator "communication skills" was also measured using several questions in the questionnaire. One such question was "PI4.3: I am able to express my ideas clearly". As per the below chart, 70% of majority have stated that they do have the ability to express their ideas clearly and only 41% minority have rated as they do not have the ability to express their ideas. Design sprint have increased the student's communication skills.



Fig. 13: Performance Indicator: Communication Skills

The last performance indicator to determine student performance was "acquiring new knowledge." One of the questions to determine the responses was "PI5.1 I can learn new things easily by myself". However, as per the results below; 82% of students have stated that they have the ability to learn new things easily by themselves. Only 29% of students have stated that they do not have the ability to learn new things. Design sprint have enhanced the skill of acquiring new knowledge in students.



*Fig. 14:* Performance Indicator: Acquiring New Knowledge

#### e) Interview Analysis Results of Second instance

(Right after the group of students received their marks for the CC module in second year of study. By this time, the group of students have gone through the design sprint workshop.)

i. Qualitative analysis on student's problem-solving ability

In order to analyze responses which indicated the student's problem-solving skills, the subcategories "Coming up with solutions", "Understanding user requirements", "Synthesizing information", "PBL module assessment marks" and "Active participation" was used from the Table 2.

*LRes1:* we see a good improvement in students after the design sprint workshop. Students invest longer time on understanding the scenarios rather than jumping into implementations. (LRes1, personal communication, December 14,2020).

*LRes4:* after the design sprint work was done; we can see a good participation rate in achieving project milestones. Students are not procrastinating and are engaging in projects well. (LRes4, personal communication, December 14, 2020).

ii. Qualitative analysis on student's teamwork ability

In order to analyze responses which indicated the student's teamwork, the subcategories "Contribution of work", "Planning and organizing" and "ability to work with others" were used from the Table 2.

*LRes7:* design sprint workshop seemed to have improved the way members contribute in group work. We can see that there are lot of groups where all the members contribute equally for their group work. (LRes7, personal communication, December 14,2020).

*LRes11:* we can see that students tend to invest more time in working with their group members. We have less complaints about team members. We also saw that some students tend to stay back after lecture hours to

help certain members in their groups. (LRes11, personal communication, December 14, 2020).

iii. Qualitative analysis on student's Analytical skills

In order to analyze responses which indicated the student's analytical skills, the subcategories "Pick viable solutions amidst options", "Presenting analyzed information" and "Decision making" were used from the Table 2.

*LRes5:* it was a delight to sit through the sprint reviews of CC module. We can see a significant change in how students presented their shippable products after the design sprint workshop. (LRes5, personal communication, December 14,2020).

*LRes11:* we can see that students tend to do more background study and fact gathering especially in the 3rd sprint. (LRes11, personal communication, December 14,2020).

iv. Qualitative analysis on student's communication skills

In order to analyze responses which indicated the student's communication skills, the subcategories "Group communication", "Conflict resolving" and "Idea expression" were used from the Table 2.

*LRes12:* after the design sprint workshop we can see that teams engage as they enjoy in groupwork. We can hear clear communications and less conflicts are reported. (LRes12, personal communication, December 14, 2020).

*LRes6:* we can see more students actively participate and elaborate their ideas in group meetings. (LRes6, personal communication, December 14,2020).

v. Qualitative analysis on student's ability to acquire new skills

In order to analyze responses which indicated the student's communication skills, the subcategories "Self-study", "Transferable skills" and "Soft skill development" were used from the Table 2. *LRes8:* after the design sprint workshop, I have received many emails from students requesting to clarify certain subject matters. This is a good indicator that they have done some self-reading on various topics. (LRes8, personal communication, December 14,2020).

#### V. DISCUSSION AND RECOMMENDATIONS

The objective of the study was to find out whether Design Sprint workshop increase student performance in undergraduate SE group projects in PBL modules on problem solving, teamwork, analytical skills, communication skills and acquiring new knowledge. Furthermore, these performance indicators are enhanced via certain measurable criteria. Using these attributes, a theoretical framework was designed.

Thereafter the study progressed to verify that the above criteria will be met/enhanced when design sprint methodology is introduced in to a PBL module. The study was conducted as a prospective longitudinal mechanism where the same student group (111) was observed within a period of time. (2020-2021)

Qualitative data was collected from the student group as well as targeted lecture panel (12) in two occasions. First occasion was before the design sprint workshop was conducted and when the group was in their first year of study following a PBL module called SDAM. The second occasion was after the design sprint workshop was conducted as the group followed a PBL module called CC. In order to gather data from students, questionnaire was used and to gather data from lecturers, interviews were used. Moreover, an observation was also conducted during the design sprint workshop.

According to the questionnaire results obtained and the interview results of lecturers in the first year (2020) for the SDAM module, we could see that the students fell behind in the skills of problem solving, teamwork, analytical skills, communication skills and acquiring new knowledge. After conducting the design sprint workshop, the second qualitative data gathered indicated that there was a clear improvement in the same skills.

#### VI. Conclusion

The study investigated the value addition brought by Design Sprint in to PBL modules in SE curriculums. The results indicated a considerable performance enhancement in students after introducing them to Design Sprint workshop. Transferable skills such as problem solving, analytical skills, communication skills, teamwork and acquiring new knowledge are proven to be improved via Design Sprint approach. The authors suggest that this study could be further strengthened using a statistical approach. It is also suggested to generalize this approach to other PBL projects in similar fields.

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#### Appendix A

Questionnaire used in data collection

PI1: Problem solving skills

PI1.1 When given a problem I have the ability to come up with a suitable solution

PI1.2 I understand the user requirements in a given scenario

PI1.3 When solving a problem, I am able to synthesize information

PI2: Team work

PI2.1 I can work with others in projects

PI2.2 I am capable of delegating tasks and contribute well

Pl2.3 I can plan and organize tasks in group work

PI3: Analytical skills

PI3.1 I can analyze a given scenario well and pick the most viable solution amidst options

PI3.2 I can present the analyzed information effectively

PI3.2 I can analyze given data and make suitable decisions

PI4: Communication skills

PI4.1: I communicate well with my team mates

PI4.2: I am capable of resolving conflicts in working with groups

PI4.3: I am able to express my ideas clearly

PI5: Acquiring new knowledge

PI5.1 I can learn new things easily by myself

PI5.2 I can use what I learnt in PBL for other subjects

PI5.3 I can improve my soft skills by myself

#### References Références Referencias

- Haan. H. (2010). The development of ESD-related competencies in supportive institutional frameworks. International Review of Education, 56, 315–328. Retrieved from: https://www.researchgate.net/ publi cation/225773272\_The\_development\_of\_ESDrelated\_competencies\_in\_supportive\_institutional\_fr ameworks
- Rieckmann. M. (2012). Future-oriented higher education: Which key competencies should be fostered through university teaching and learning? Futures, 44, 127–135. Retrieved from https://www. researchgate.net/publication/232364850\_Futureoriented\_higher\_education\_Which\_key\_competenci

es\_should\_be\_fostered\_through\_university\_teachin g and learning

- Wiek.A, Withycombe.L & Redman.C.L. (2011). Key competencies in sustainability: A reference framework for academic program development, *Sustainability Science*, 6, 203–218. Retrieved from https://link.springer.com/article/10.1007/s11625-011-0132-6
- 4. Granado-Alcón.M, Gómez-Baya.D, Herrera-Gutiérrez.E, Vélez-Toral.M, Alonso-Martín.P & Martínez-Frutos.M. (2020). Project-Based Learning the Acquisition of Competencies and and Knowledge Transfer in Hiaher Education. Sustainability, 12, 10062. Retrieved from https:// www.mdpi.com/2071-1050/12/23/10062
- 5. Eby.J.W, Herrell.A.L, & Jordan.M.L.(2009). Teaching in the Elementary School: A Reflective Action Approach, 5th ed. Pearson: London, UK
- Dias.M & Brentley-Dias.L.(2015). Setting the Standard for Project Based Learning: A Proven Approach to Rigorous Classroom Instruction, Interdisciplinary Journal of Problem-Based Learning.
  11, Retrieved from https://www.researchgate.net/ publication/318822669\_Setting\_the\_Standard\_for\_P roject\_Based\_Learning\_A\_Proven\_Approach\_to\_Rig orous\_Classroom\_Instruction
- Flores-Fuentes.G & Juárez-Ruiz.E.(2017). Project-Based Learning for the Development of Mathematical Competencies in High School, 19, 71–91, Retrieved from https://www.scielo.org.mx/ pdf/redie/v19n3/1607-4041-redie-19-03-00071.pdf
- Warr.M & West.(2020). Bridging Academic Disciplines with Interdisciplinary Project-based Learning: Challenges and Opportunities, Interdisciplinary Journal of Problem-based Learning, 14, 1–23, Retrieved from https://eric.ed.gov/?id= EJ1257972
- 9. Granado-Alcón.M.C, Alonso-Martín.P, Vélez-Toral.M, Gómez-Baya. D, Herrera-Gutiérrez.E & Martínez-Frutos.M.T.(2018). Project Based Learning in higher education: Student's perception of transforming traditional learning into an active and constructivist experience. In Proceedings of the ICERI2018 Conference, Seville, Spain, 12–14, pp. 9510–9517, Retrieved from https://www.research gate.net/publication/329225551\_PROJECT\_BASED \_LEARNING\_IN\_HIGHER\_EDUCATION\_STUDENT'S \_PERCEPTION\_OF\_TRANSFORMING\_TRADITIONA L\_LEARNING\_INTO\_AN\_ACTIVE\_AND\_CONSTRUC TIVIST\_EXPERIENCE
- Mioduser.D & Betzer.N.(2007). The contribution of project-based learning to high achievers' acquisition of technological knowledge and skills. *International journal of technology and design education*, 18, 59– 77, Retrieved from https://link.springer.com/article/ 10.1007/s10798-006-9010-4

- 11. Willard.K & Duffrin. M.W. (2021). Project based learning in a food science course: benefits and opportunities of collaborative work between students of Bachelor of Nutrition and Biotechnology Engineer, In proceedings of the 8th International Conference on Educational Innovation, 2, 69–73, Retrieved from https://www.researchgate.net/ publication/357201227\_Project-based\_learning\_in\_ a\_food\_science\_course\_Benefits\_and\_opportunities \_of\_collaborative\_work\_between\_students\_of\_Bach elor\_of\_Nutrition\_and\_Biotechnology\_Engineer/citati ons
- Braßler.M.(2016). Interdisciplinary Problem-Based Learning—A Student-Centered Pedagogy to Teach Social Sustainable Development in Higher Education, Teaching Education for Sustainable Development at University Level, 245-257, Retrieved from https://www.researchgate.net/publication/303 704652\_Interdisciplinary\_Problem-Based\_Learning-A\_Student-Centered\_Pedagogy\_to\_Teach\_Social\_ Sustainable\_Development\_in\_Higher\_Education
- 13. Holley.K.A.(2017). Interdisciplinary curriculum and learning in Higher education, Oxford research encyclopedia of education, Retrieved from https://oxfordre.com/education/display/10.1093/acr efore/9780190264093.001.0001/acrefore-97801902 64093-e-138;jsessionid=4F2E65E4227FEC72BC21 CA2CAD098AE0
- Weber.C.T, Borit.M, Canolle.F, Hnatkova.E, O'Neill.G,Pacitti.D & Parada.F(2018).Identifying Transferable Skills and Competences to Enhance Early Career Researchers Employability and Competitiveness. Retrieved from https://www. semanticscholar.org/paper/Identifying-Transferable-Skills-and-Competences-to-Weber-Borit/9e824fd2 b7d9bd10f6cfa47a162ec3c1893eacf5
- 15. MacKeracher.T & Marsh.Helene.(2020). Improving Australia's marine science postgraduate training system to meet the needs of the 'Blue Economy', Retrieved from https://www.researchgate.net/ publication/339366990\_Improving\_Australia%27s\_m arine\_science\_postgraduate\_training\_system\_to\_m eet\_the\_needs\_of\_the\_%27Blue\_Economy%27
- Adamopoulos.A.(2019). Universities should be about transferable skills and continuing education, Forbes, Retrieved from https://www.forbes.com/ sites/forbesbostoncouncil/2019/01/03/universitiesshould-be-about-transferable-skills-and-continuingeducation/?sh=74a1d6d7432f
- Elena.A, Andrés.S, López-Vázquez.J & Fernández-Ibáñez.M.(2022). Design Sprint: Enhancing STEAM and engineering education through agile prototyping and testing ideas, Thinking Skills and Creativity, 44, Retrieved from https://reader.elsevier. com/reader/sd/pii/S1871187122000426?token=9E CC5F4E8DD6CA807DE56919A1A1901E9EF3590C5 E36D99778DBCE3A5663824FC620E87F084E7C9C

# 146864C69897EA2A&originRegion=eu-west-& originCreation=20230131094358

- 18. Van Belle.G, Fisher.L.D, Heagerty.P.J & Lumley.T. (2004).Biostatistics: a methodology for the health sciences. John Wiley & Sons, Retrieved from https://books.google.lk/books?hl=en&lr=&id=KSh 8lOrLPzwC&oi=fnd&pg=PR7&dq=Van+Belle+G, +Fisher+L,+Heagerty+PJ,+et+al.+Biostatistics: +A+Methodology+for+the+Health+Sciences.+L ongitudinal+Data+Analysis.+New+York,+NY:+Jo hn+Wiley+and+Sons,+2004.+&ots=K6beJGi2JL &sig=lsWUgXOydD7UXWeUqJSK7f8JS38&redir\_es c=y#v=onepage&q&f=false
- Caruana.E.J, Roman.M, Hernández-Sánchez.J & Solli.P.(2015). Longitudinal studies. Journal of Thoracis Disease, 7(11), Retrieved from https:// www.ncbi.nlm.nih.gov/pmc/articles/PMC4669300/# r1
- Newman.A.(2010). An overview of the design, implementation, and analysis of Longitudinal studies on aging, *Journal of the American Geriatrics Society*, 58(2), Retrieved from https://agsjournals. onlinelibrary.wiley.com/doi/abs/10.1111/j.1532-5415.2010.02916.x
- 21. Van Oostveen .W.M & de Lange.E.C.M.(2021). Imaging Techniques in Alzheimer's Disease: A Review of Applications in Early Diagnosis and Longitudinal Monitoring. *International Journal of Molecular Sciences.*, 22(4), Retrieved from https:// www.mdpi.com/1422-0067/22/4/2110
- 22. Hazreen.M.A, Su.T.T, Jalaludin.M.Y. et al.(2014). An exploratory study on risk factors for chronic noncommunicable diseases among adolescents in Malaysia: overview of the Malaysian Health and Adolescents Longitudinal Research Team study (The MyHeART study). International research symposium on population health, 14 (3), Retrieved from https://bmcpublichealth.Biomed central.com/ articles/10.1186/1471-2458-14-S3-S6#citeas
- 23. Collier.V.P & Thomas. Q.P.(2017).Validating the Power of Bilingual Schooling: Thirty-Two Years of Large-Scale, Longitudinal Research, Annual Review of Applied Linguistics, 37, 203-217, Retrieved from https://www.cambridge.org/core/journals/annualreview-of-applied-linguistics/article/abs/validatingthe-power-of-bilingual-schooling-thirtytwo-years-oflargescale-longitudinal-research/909F284BFF9C32 7124AD08987143E677
- 24. Cook.D.A, Andriole.D.A, Durning.S.J, Roberts.N.K & Triola.M.M. (2010). Longitudinal Research Databases in Medical Education: Facilitating the Study of Educational Outcomes Over Time and Across Institutions. *Academic Medicine*, 85(8):p 1340-1346, Retrieved from https://journals.lww.com/ academicmedicine/fulltext/2010/08000/Longitudinal \_Research\_Databases\_in\_Medical.21.aspx

- Kosnik.C, Clive.B, Cleovoulou.Y & Fletcher.T.(2009). Improving Teacher Education Through Longitudinal Research: How studying our graduates led us to give priority to program planning and vision for teaching, Studying Teacher Education, 5(2), 163-175, Retrieved from https://www.tandfonline.com/ doi/abs/10.1080/17425960903306880
- 26. Thomas.L.(2022) Longitudinal study definition, approaches and examples, Scribber, Retrieved from https://www.scribbr.com/methodology/longitudinalstudy/#:~:text=Prospective%20longitudinal%20stu dies%20eliminate%20the,carb%20diets%20on%20w eight%20loss
- Wright.A, De Livera.A, Lee.K.H. et al. (2022). A repeated cross-sectional and longitudinal study of mental health and wellbeing during COVID-19 lockdowns in Victoria, Australia. BMC Public Health, 22, Retrieved from https://bmcpublichealth.biomed central.com/articles/10.1186/s12889-022-14836-9
- Gary.K.(2015). Project-Based Learning, Computer, 48, pp. 98-100, Retrieved from https://ieeexplore. ieee.org/stamp/stamp.jsp?tp=&arnumber=72743 11
- 29. Sheppard.S.D, Kelly.M, Colby.A & William.S.(2008). Educating Engineers: Designing for the Future of the Field. Book highlights, Jossey-Bass, Retrieved from https://eric.ed.gov/?id=ED504076
- 30. W.S. Humphrey.(2005). PSP: A Self-Improvement Process for Software Engineers, Addison-Wesley Professional
- 31. Guo.P, Saab.N, Post.L.S & Admiraal.W.(2020). A review of project-based learning in higher education: Student outcomes and measures, *International Journal of Educational Research*, 102, Retrieved from https://reader.elsevier.com/reader/ sd/pii/S0883035519325704?token=E90BDC796FA C0E3C86E5571A6EBC6661342C7D7B3134F3C317 9183C4A2629C0A0FC4FB3124CEA36B2F8ABEE91 087244F&originRegion=eu-west-1&originCreation= 20230201105457
- 32. Vogler.J.S, Thompson.P, Davis.D.W, Mayfield.B.E, Finley.P. M & Yasseri.D.(2018).The hard work of soft skills: Augmenting the project-based learning experience with interdisciplinary teamwork. *Instructional Science*, 46(3), 457–488, Retrieved from https://link.springer.com/article/10.1007/s112 51-017-9438-9
- 33. Holmes.L.(2012).The effects of project-based learning on 21st century skills and No Child Left Behind accountability standards, Retrieved from https://www.proquest.com/openview/36f811030b31 abfa63690c7a6771a0ae/1?pqorigsite=gscholar&cbl=18750
- 34. Granado-Alcón.M, Gómez-Baya.D, Herrera-Gutiérrez.E, Vélez-Toral.M, Alonso-Martín.P & Martínez-Frutos.M.(2020). Project-Based Learning and the Acquisition of Competencies and

Knowledge Transfer in Higher Education. *Sustainability*,12(23), Retrieved from https://www.mdpi.com/2071-1050/12/23/10062

- 35. Design Sprint SA.(2023). Google Ventures Design Sprint. Retrieved from https://design-sprint.com/ google-ventures-design-sprint/
- 36. Career and Employment Service, Macquarie University.(2019). Transferable Skills, s.l.: s.n.
- 37. Ferreira, V. G. & Canedo, E.(2020). A Design Sprint based model for User Experience concern in project-based learning software development. Uppsala, s.n.
- 38. Gurcan, F. & Şevik, S.(2020). Expertise Roles and Skills Required by the Software Development Industry. s.l., s.n.
- Khamis, N. K. & Sulong, A. B.(2011). Measurement of Students' Performance Level in a Group Project by using Peer Review and Lecturer Assessment. *Social and Behavioral Sciences*, 60(1), pp. 130 -134.
- 40. Knapp, J., Zeratsky, J. & Kowitz, B.(2016). Sprint: How to Solve Big Problems and Test New Ideas in Just Five Days. 1 ed. New York: Simon and Schuster.
- 41. MARIN-GARCIA1, J. A. & JAIME, L.(2008). Improving Teamwork with University Engineering Students. The Effect. WSEAS TRANSACTIONS on ADVANCES in ENGINEERING EDUCATION, 5(1), pp. 1790-1797.
- 42. Matturro, G.(2013). Soft skills in software engineering A Study of Its Demand by Software Companies in Uruguay. San Francisco, IEEE.
- 43. Nägele, C. & Stalder, B. E.(2017). Competence and the Need for Transferable Skills. In: Competencebased Vocational and Professional Education. s.I.:Springer International Publishing Switzerland.
- 44. Santana, L. F. et al.(2017). Scrum as a Platform to Manage Students in Projects of Technological Development and Scientific Initiation: A Study Case Realized at UNIT/SE. *Journal of Information Systems Engineering & Management*, 2(2), pp. 1-7.
- 45. WATERIDGE, J.(1995). IT project: a basis for success. *International Journal of Project Management*, 13(3), pp. 169 172.
- Arce, E., Suárez-García, A., López-Vázquez, J. A. & Fernández-Ibáñez, M. I.(2022). Design Sprint: Enhancing STEAM and engineering education through agile prototyping and testing ideas. Thinking Skills and Creativity, 44(1).
- 47. Beyer, J. & Pfister, H.(2021). Design Sprints for Online and On-Campus Visualization Courses. Salt Lake City, IEEE.
- 48. Ferreira, V. G. & Canedo, E.(2019). Using design sprint as a facilitator in active learning for students in the requirements engineering course: an experience report. Limassol, ACM.

- 49. Ferreira, V. G. & Canedo, E. D.(2020). Design sprint in classroom: exploring new active learning tools for project-based learning approach. *Journal of Ambient Intelligence and Humanized Computing*, Volume 11, pp. 1191 - 1112.
- 50. Klynhout, M.(2022). Fostering Students' Entrepreneurial Competencies in Higher Education with Design Sprints. s.l.:s.n.
- 51. Murgu, C., Dancigers, M. & Solloway, E.(2021). Design Sprints and Direct Experimentation: Digital Humanities + Music Pedagogy at A Small Liberal Arts College. s.l.:s.n.
- 52. Soyupak, O.(2021). Embedding Design Sprint into Industrial Design. Design Technology Educations: *An International Journel*, 26(2), pp. 66 - 85.
- 53. Sumual, H., Batmetan, J. R. & Kambey, M.(2018). Design Sprint Methods for Developing Mobile Learning Application. s.l., s.n., pp. 394 - 407.
- 54. WINFIELD, K., SIZER, N. D. & SIENA, F. L.(2022). DESIGN SPRINT METHODOLOGIES TRANSFORMED. London, s.n.
- 55. Devlin.M.(2004). Assessing group work, Retrieved from https://www.researchgate.net/publication/304 582428\_Assessing\_Group\_Work
- 56. Rashid.Y, Rashid.A.Warraich.M.A, Sabir.S.S, & Waseem.A. (2019). Case study method: A step by step guide for business researches. *International journal of qualitative methods*, 18, 1-13. Retrieved from https://journals.sagepub.com/doi/pdf/10.1177 /1609406919862424
- 57. Beyer & Pfister's.(2021). Visualization Design Sprints for Online and On-Campus courses, Retrieved from https://vcg.seas.harvard.edu/publications/designs prints/paper

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## Comparison of Primand Kruskal's Algorithm

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*Abstract-* The goal of this research is to compare the performance of the common Prim and the Kruskal of the minimum spanning tree in building up super metric space. We suggested using complexity analysis and experimental methods to evaluate these two methods. After analysing daily sample data from the Shanghai and Shenzhen 300 indexes from the second half of 2005 to the second half of 2007, the results revealed that when the number of shares is less than 100, the Kruskal algorithm is relatively superior to the Prim algorithm in terms of space complexity; however, when the number of shares is greater than 100, the Prim algorithm is more superior in terms of time complexity. A spanning tree is defined in the glossary as a connected graph with non-negative weights on its edges, and the challenge is to identify a maz weight spanning tree. Surprisingly, the greedy algorithms based on Prim and Kruskal, respectively. Graham and Hell provide a history of the issue, which began with Czekanowski's work in 1909. The information presented here is based on Rosen.

Keywords: kruskal, prim's, graph, minimal spanning trees, complexity.

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# Comparison of Primand Kruskal's Algorithm

Rohit Maurya<sup> a</sup> & Rahul Sharma<sup> o</sup>

Abstract- The goal of this research is to compare the performance of the common Prim and the Kruskal of the minimum spanning tree in building up super metric space. We suggested using complexity analysis and experimental methods to evaluate these two methods. After analysing daily sample data from the Shanghai and Shenzhen 300 indexes from the second half of 2005 to the second half of 2007, the results revealed that when the number of shares is less than 100, the Kruskal algorithm is relatively superior to the Prim algorithm in terms of space complexity; however, when the number of shares is greater than 100, the Prim algorithm is more superior in terms of time complexity. A spanning tree is defined in the glossary as a connected graph with nonnegative weights on its edges, and the challenge is to identify a maz weight spanning tree. Surprisingly, the greedy algorithm yields an answer. For the problem of finding a min weight spanning tree, we propose greedy algorithms based on Prim and Kruskal, respectively. Graham and Hell provide a history of the issue, which began with Czekanowski's work in 1909. The information presented here is based on Rosen.

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#### I. INTRODUCTION

minimum spanning tree of an undirected graph can be readily obtained using Prim or Kruskal's classical algorithms. To enumerate all spanning trees in an undirected graph, a number of algorithms have been suggested. These algorithms' main worries are good time and space complexities. A minimum spanning tree of an undirected graph can be readily obtained using Prim or Kruskal's classical algorithms. A number of algorithms have been suggested to count all of an object's spanning trees.

A spanning tree of a connected graph can be constructed including all the vertices with minimum possible no of edges. If there are n vertices in the graph, then each spanning tree has n-1 edges. A connected weighted graph where all the vertices are interlinked by some weighted edges can contain multiple numbers of spanning trees.A minimum spanning tree of an undirected graph can be easily obtained using Prim or Kruskal's classical algorithms. A number of algorithms for enumerating all spanning trees in an undirected graph have been proposed. These algorithms' main concerns are good time and space complexities. The majority of algorithms generate spanning trees by utilising some fundamental cut or circuit. The cost of the tree is not considered during the generation process. This paper presents an algorithm for generating spanning trees of a graph in decreasing cost order. New opportunities emerge by generating spanning trees in increasing cost order. This method can be used to find the second smallest or, more broadly, the k-th smallest spanning tree. The smallest spanning tree satisfying some additional constraints can be found by checking whether these constraints are satisfied at each generation. Our algorithm is based on Murty's (1967) algorithm, which enumerates all solutions to an assignment problem in increasing cost order. The complexities of time and space are discussed.

The network is undirected. These algorithms' main worries are good time and space complexities. The goal of this research is to compare the performance of the common Prim and the Kruskal of the minimum spanning tree in constructing super metric space. To evaluate these two methods, we suggested using complexity analysis and experimental methods. After analysing daily sample data from the Shanghai and Shenzhen 300 indexes from the second half of 2005 to the second half of 2007, the results revealed that when the number of shares is less than 100, Kruskal algorithm is relatively superior to Prim algorithm in terms of space complexity; however, when the number of shares is greater than 100, Prim algorithm is more superior in terms of time complexity.

#### II. Prim's Algoritms

VojtchJarnak, a Czech mathematician, created the Prim algorithm in 1930. Robert C. Prim rediscovered it in 1957, and Edsger W. Dijkstra republished it in 1959. To determine the minimal spanning tree (MST) of a given linked weighted graph, Prim's algorithm uses a greedy approach. When the graph is dense, this algorithm is recommended. When there are many edges in a graph, the graph is said to be dense. Only undirected linked graphs can use this approach, and there must not be any edges with a negative edge weight. The algorithm is pretty effective in this situation. There will always be a shortest path because there are no cycles with nonnegative weights.

It begins by choosing a random vertex to serve as the tree's root. Then itThe shortest edge from any vertex in the tree to the new vertex is added in order to extend the tree, as is the edge closest to the current vertex. Once all vertices have been added to the tree, the procedure ends.

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# III. The Following are the Steps to find the Minimum Spaning Tree using Prim's Algoritms

- 1. If a graph has loops and parallel edges, remove those loops and parallel edges.
- Select any node at random, labelling it with a distance of 0 and all other nodes as. The chosen node is considered the current node and has been visited. All other nodes are assumed to be unvisited.
- 3. Locate all unvisited nodes that are currently linked to the current node. Determine the distance between the unvisited nodes and the current node.
- 4. Label each vertice with its corresponding weight to the current node, but relabel a node if it is less than the previous label value. The nodes are labelled with their weights each time; keep track of the path with the smallest weight.
- 5. Color over the current node to indicate that it has been visited. We don't need to look at a vertex again once we've visited it.
- 6. Among all unvisited nodes, find the one with the lowest weight to the current node; mark this node as visited and treat it as the current working node.
- 7. Repeat steps 3–5 until all nodes have been visited.

#### Prim's Algoritms:

PRIM (Graph, c, t) P ĕN[Graph] For every m P do key[m] ĕ Ğ key[t] ĕ 0 [t]ĕnull while P Į Ø do m ĕ EXTRACTMINNODE(P) for every n Adjacent[m] do if n P and c (m,n) < key[n]

#### [n] ĕ m key[n] ĕ c(m,n)

# IV. Kruskal's Algoritms

This algorithm, designed by Joseph Kruskal, was published for the first time in the Proceedings of the American Mathematical Society in 1956. The algorithm begins by creating an ordered set of edges by weights and proceeds through the ordered set by adding an edge to the partial MST if the new edge does not form a cycle. The algorithm takes a greedy approach, in which it finds the path with the least weight in each iteration stage and includes it in the growing spanning tree.

Sort all edges of the given graph in increasing order using Kruskal's algorithm. If the newly added edge does not form a cycle, it continues to add new edges and nodes to the MST. It selects the minimum weighted edge first, followed by the maximum weighted edge. Thus, in order to find the optimal solution, it makes a locally optimal choice in each step. As a result, this is a Greedy Algorithm.

# V. The Steps for Detemining MST using Kuruskal Algoritms are as Follow

Sort the edges in non-descending order of weight.

Choose the smallest edge. Check to see if it forms a cycle with the spanning tree that has been formed thus far. Include this edge if the cycle is not formed. Otherwise, throw it away.

Step 2 should be repeated until the spanning tree has (V-1) edges.

Kruskal Algoritms

Kruskal(Graph): T = Empty;For every node n e G.N: CreateSet(n) For every path (m, n) e G.E arranged by increasing weights(m,n): if NewSet(m)  $\downarrow$  NewSet(n):  $T = T \hat{H} \{(m, n)\}$ UNION (m, n) return T

Problem Statement

Find the MST through Prim's Algorithm and Explain it step wise.



Solution:

Step 1:

First write all edges weight in Ascending order: 2,2,3,3,3,3,4,5,6,10



Comparison of Primand Kruskal's Algorithm





Step 9:



Step 10:



It also have weigth is 18 so both way are right.

# VI. FIND THE TIME COMPLEXITY OF PRIMS'S Algorithm we Follow Step by step

- 1. Set up a minimum priority queue (heap) and add the first vertex to it.
- 2. Do the following while the queue is still not empty:
- a. Take the queue's minimum weight edge.
- b. If the edge connects a vertex that has not yet been visited, add it to the minimum spanning tree and mark the vertex as visited.

Step 2:

c. Add all adjacent edges of the newly visited vertex to the queue if they connect to unvisited vertices.

Assume the input graph contains V vertices and E edges. Prim's algorithm's time complexity can be calculated as follows:

- It takes O(V) time to initialize the priority queue.
- It takes O(log V) time to extract the minimum weight edge from the queue.
- It takes constant time to check if a vertex has been visited.
- Adding an edge to the minimum spanning tree takes an infinite amount of time.
- It takes constant time to mark a vertex as visited.
- Because each edge can only be added to the queue once, adding adjacent edges to the queue takes O(E log V) time.

Prim's algorithm has a total time complexity of  $O((V-1) \log V + E \log V)$  because step 2 is repeated V-1 times. In practise, the term E log V dominates the time complexity, so Prim's algorithm has an overall time complexity of O. (E log V).

It should be noted that this analysis assumes that the priority queue is implemented using a binary heap. The time complexity may differ slightly if a Fibonacci heap or another data structure is used.

#### Problem Statement

Find the MST through Kruskal's Algorithm and Explain it step wise.



#### Solution: Step 1:

In the Kruskal algorithm first we assign first a node as head or starting point to start the finding MST and show all possible way from that node



Here I take as a head or starting point node is A



2023

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We get MST through it which weight is 18 Final view is this



# VII. FIND THE TIME COMPLEXITY OF Kruskal Algorithm we Follow Step by Step

- 1. Sort the edges in increasing weight order.
- 2. To keep track of connected components, create a disjoint-set data structure.
- 3. Do the following for each edge, in increasing order of weight:
- a. Add the edge to the minimum spanning tree and merge the two components if it connects two vertices that are not in the same connected component.
- b. Otherwise, throw away the edge.

Assume the input graph contains V vertices and E edges. Kruskal's algorithm's time complexity can be calculated as follows:

- It takes O(E log E) time to sort the edges.
- It takes O(V) time to initialise the disjoint-set data structure.
- Using the disjoint-set data structure, determining whether two vertices are in the same connected component takes O(log V) time.
- Using the disjoint-set data structure, merging two connected components takes O(log V) time.

- Adding an edge to the minimum spanning tree takes an infinite amount of time.
- It takes time to discard an edge.

Kruskal's algorithm has a total time complexity of O(E log E + V log V) because step 3 is repeated E times. In practise, the term E log E dominates the time complexity, so Kruskal's algorithm has an overall time complexity of O. (E log E).

It should be noted that this analysis assumes that the edges are sorted using a standard sorting algorithm such as quicksort or mergesort. The time complexity may differ slightly if a radix sort or another algorithm is used. Furthermore, the time complexity of the disjoint-set data structure is determined by the implementation used.

# VIII. TO FIND THE SPACE COMPLEXITY OF Prim's and Kruskal's Algorithm

## The Prim Algorithm:

- To store edges, the minimum priority queue (heap) requires O(E) space.
- The boolean array used to mark visited vertices takes up O(V) space.
- The minimum spanning tree takes up O(V) space.
- Prim's algorithm has a total space complexity of O(V + E).

## The Kruskal Algorithm:

- The disjoint-set data structure used to keep connected components together takes up O(V) space.
- The array used to store the edges takes up O(E) space.
- The minimum spanning tree takes up O(V) space.
- Kruskal's algorithm has an overall space complexity of O(V + E).

It should be noted that the above space complexity calculations assume a standard implementation of each algorithm. However, depending on the implementation, the space complexity can vary. Additionally, the input graph may require space, but this is typically considered a separate factor and is not included in the algorithm's space complexity calculation.

# IX. Comparision Between Prim's and Kruskal's Algorithm

- 1. Prim's algorithm is a greedy algorithm that starts with a single vertex and gradually adds edges to form a minimum spanning tree. Kruskal's algorithm is also a greedy algorithm that begins with the edge with the smallest weight and gradually adds edges to form a minimum spanning tree.
- Time complexity: The time complexity of Prim's algorithm is O(E log V), where E is the number of edges and V is the number of vertices in the graph.

The time complexity of Kruskal's algorithm is  $O(E \log E)$  or  $O(E \log V)$ , depending on the implementation.

- Prim's algorithm has a space complexity of O(V), where V is the number of vertices in the graph. Kruskal's algorithm has a space complexity of O(E), where E is the number of edges in the graph.
- 4. Prim's algorithm always generates a connected minimum spanning tree. If the graph is not connected, Kruskal's algorithm can generate a forest of minimum spanning trees.
- 5. Edge selection: Prim's algorithm chooses the edges with the lowest weight among all those that connect the tree to a non-tree vertex. Kruskal's algorithm chooses edges based on the lowest weight among all edges that have yet to be added to the tree.
- 6. Performance: Prim's algorithm performs better on dense graphs (where E is close to V2), while Kruskal's algorithm performs better on sparse graphs (where E is much less than V2).

Overall, both the Prim and Kruskal algorithms are effective and widely used for determining minimum spanning trees. The algorithm chosen is determined by the characteristics of the input graph and the specific requirements of the problem.

Time Complication:

- The time complexity of Prim's algorithm is O(E log V), where E is the number of edges and V is the number of vertices in the graph. In dense graphs where E is close to V2, this complexity outperforms Kruskal's algorithm.
- In sparse graphs, where E is much less than V2, Kruskal's algorithm has a time complexity of O(E log E), which is better than Prim's algorithm.

#### Space Complexity:

 Prim's algorithm takes up O(V + E) space, and Kruskal's algorithm takes up O(V + E) space as well. As a result, the space complexity of both algorithms is comparable.

There are several alternative algorithms for determining the minimum spanning tree, each with its own time and space complexities:

- Boruvka's algorithm has a time complexity of O(E log V), making it faster in dense graphs than Prim's algorithm. However, it requires O(E log V) space, which is greater than that required by Prim's algorithm.
- Although the Reverse-Delete algorithm has an O(E2) time complexity, it performs well on sparse graphs. It has an O(V + E) space complexity.
- The time complexity of Randomized Prim's algorithm is similar to that of Prim's algorithm, but it can be faster in practise due to the randomised nature of its implementation.

Overall, the algorithm chosen is determined by the properties of the graph being processed. Prim's or Boruvka's algorithms may be preferable for dense graphs. Kruskal's algorithm or the Reverse-Delete algorithm may be preferable for sparse graphs. Randomized Prim's algorithm is another viable option in practise.

#### X. Conclusion

Finally, Prim's and Kruskal's algorithms are two well-known algorithms for determining the minimum spanning tree of a weighted, connected graph.

Prim's algorithm employs a greedy approach, beginning with a single vertex and expanding the minimum spanning tree one edge at a time. At each step, the algorithm maintains a priority queue to select the edge with the lowest weight. Prim's algorithm has a time complexity of O(E log V), where E is the number of edges and V is the number of vertices in the graph.

Kruskal's algorithm, on the other hand, employs a greedy approach but works by adding edges to the minimum spanning tree in increasing weight order while avoiding cycles. To keep connected components and check for cycles, the algorithm employs a disjoint-set data structure. Kruskal's algorithm has a time complexity of O(E log E), where E is the number of edges in the graph.

Both algorithms require O(V + E) space in terms of complexity.

Overall, the algorithm chosen is determined by the properties of the graph being processed. Prim's algorithm is preferable for dense graphs, whereas Kruskal's algorithm is preferable for sparse graphs. Other algorithms, such as Boruvka's algorithm and the Reverse-Delete algorithm, can also be used depending on the problem's specific requirements.

#### References Références Referencias

- 1. B.Hughes. Trees and ultra metric spaces: a categorical equivalence [J]. Advances in Mathematics, 2004, 189(1):148-191
- M. J. Naylor, L.C.Rose, B. J.Moyle. Topology of foreign exchange markets using hierarchical structure methods [J]. Physica A: Statistical Mechanics and its Applications, 2007, 382(1):199– 208.
- J.G. Brida, W. A. Risso. Multidimensional minimal spanning tree: The Dow Jones case [J]. Physica A: Statistical Mechanics and its Applications, 2008, 387(21):5205-5210.
- Martel. The expected complexity of Prim's minimum spanning tree algorithm [J]. Information Processing Letters, 2002, 81(4):197-201.
- 5. Yang Guo Hui, Zhou Chun Guang. An algorithm for clustering gene expression data using minimum

spanning tree [J]. Journal of Computer Research and Development, 2003, 40(10):1431-1435.

- 6. Feixue Huang. Comparison of Prim and Kruskal on Shanghai and Shenzhen 300 Index hierarchical structure tree, 2009,237-240
- 7. Michael Laszlo and Sumitra Mukherjee, Member, IEE . Minimum Spanning Tree Partitioning Algorithm for Micro aggregation, July 2005, 902-904
- 8. Peace Ayegba. A Comparative Study of Minimal Spanning Tree Algorithms, 2020
- 9. Jogamohan Medak. Review and Analysis of Minimum Spanning Tree Using Prim's Algorithm, 2018
- 10. Kenneth Sorensen. An Algorithm to Generate all Spanning Trees of a Graph in Order of Increasing Cost, 2005
- 11. Arogundade O.T. Prim Algorithm to Improving Local Access Network in Rural Areas, 2011
- 12. Harvey J. Greenberg. Greedy Algorithm for Minimum Spanning Tree, 1998

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# Towards Optimized K means Clustering using Nature-Inspired Algorithms for Software Bug Prediction

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Abstract- In today's software development environment, the necessity for providing quality software products has undoubtedly remained the largest difficulty. As a result, early software bug prediction in the development phase is critical for lowering maintenance costs and improving overall software performance. Clustering is a well-known unsupervised method for data classification and finding related patterns hidden in datasets. However, the k-means algorithm has the tendency to converge to local optima due to its sensitivity to its initial partition and random initialization of clusters centers. On the other hand, Nature-inspired algorithms (NIAs) are known for their general ability to establish global optima while searching around the whole search place. When these algorithms are combined with the K-means clustering mechanism, the novel hybrids are projected to yield outstanding results in terms of enhancing clustering of the Coral reefs algorithm outperforms the typical K-means specification in terms of prediction accuracy.

Keywords: data clustering, K-means algorithm, Nature-inspired algorithms, software bug detection, coral reefs.

GJCST-C Classification: DDC Code: 005.1 LCC Code: QA76.76.D47



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# Towards Optimized K means Clustering using Nature-Inspired Algorithms for Software Bug Prediction

Kajal Tameswar<sup>a</sup>, Geerish Suddul<sup>®</sup> & Kumar Dookhitram<sup>P</sup>

Abstract- In today's software development environment, the necessity for providing quality software products has undoubtedly remained the largest difficulty. As a result, early software bug prediction in the development phase is critical for lowering maintenance costs and improving overall software performance. Clustering is a well-known unsupervised method for data classification and finding related patterns hidden in datasets. However, the k-means algorithm has the tendency to converge to local optima due to its sensitivity to its initial partition and random initialization of clusters centers. On the other hand, Nature-inspired algorithms (NIAs) are known for their general ability to establish global optima while searching around the whole search place. When these algorithms are combined with the K-means clustering mechanism, the novel hybrids are projected to yield outstanding results in terms of enhancing clustering quality by avoiding local optima and uncovering global optima. This study shows that the hybrid clustering of the Coral reefs algorithm outperforms the typical K-means specification in terms of prediction accuracy.

Keywords: data clustering, K-means algorithm, Natureinspired algorithms, software bug detection, coral reefs.

# I. INTRODUCTION

n an era of technological disruption, the demand for software adoption has accelerated. They are a part of our society and play an important role in shaping it. Our modern society is becoming increasingly reliant on complex software systems. Thus, it is critical to build reliable and trustworthy systems in a cost-effective and timely manner. The presence of defective modules in a software drives up development and maintenance expenses, leading to customer dissatisfaction. The need for quality assurance has inevitably remained the biggest challenge in today's software development environment Hence, software bug prediction is an important task to help developers locate bugs more efficiently.

Software bug prediction is an imperative task in Software Development Life cycle (SDLC) as it pertains to the overall success of software. One method in this direction is to use machine learning (ML) methods to predict defects in software. In addition, implementing this method earlier in the SDLC process enhances quality of the product and lowers the cost of software maintenance. Many researchers have applied different theories and methodologies in the field of software bug prediction. Two things are clear from the literature when it comes to defect prediction. Initially, no single prediction approach dominates (Lessmann et al., 2008), and next, the employment of various set of data, data pre-processing, validation systems, and performance statistics makes it challenging to make sense of the multiple prediction outcomes (Myrtveit et al., 2005). There are two common ML model used for prediction based on dataset availability. The first, known as supervised approach, in which a software defect prediction model is built from training set of data and then tested on a testing dataset. Secondly. unsupervised approach, in which the defect prediction model for software is built from scratch using the present testing dataset without training the dataset.

Clustering algorithms have been commonly used to evade the lack of training datasets available being a constraint. Cluster analysis groups things into clusters based on their similarity to create a visual representation of data (Jain and Dubes, 1998). As pointed out by Kaur, 2010, one of the better instances of unsupervised learning is K-means clustering. Clustering is beneficial because it makes it easier to obtain or locate relevant information at a faster rate. Among the different clustering approaches that already exist, the Kmeans methodology is obviously fairly popular. (Gavathri et al., 2015). The preliminary values of the initial centroids, which are generated randomly each time the algorithm is run, have a significant impact on the performance of k-means. K-means frequently fall into local optima that produce poor clustering results. Obtaining a globally optimal clustering result involves a time-consuming, exhaustive approach that tests all partitioning choices. A heuristic approach to the problem is to use an optimization algorithm to search for global optima in each computer iteration.

Our unsupervised approach uses the k-means approach to divide the unlabeled dataset into defective and non-defective non-overlapped clusters for bug prediction. The goal of this research is to verify the hybrids' efficacy as well as to quantify the quality of results produced by each clustering hybrid model. In

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this study, we have applied the k-means clustering algorithm, an unsupervised algorithm with different NIAs including Genetic algorithm (GA), Bat algorithm (BA), Particle Swarm Optimization (PSO), Coral Reefs Optimization (CRO), Cuckoo Search optimization (CSO) algorithm, Ant colony optimization (ACO), Firefly algorithm (FA) and Grey Wolf Optimizer (GWO) for software bug prediction. The rest of this paper is organized as follows. Section 2 presents a discussion of the related work in software bug prediction. An overview of the methodology, consisting of the algorithms used are presented in Section 3. Section 4 describes the proposed method. Section 5 describes the Dataset and Data Processing method. The evaluation methodology is discussed in section 6. The results and discussion part is discussed in Section 7. Section 8 discusses the practical implications followed by conclusions and future works in section 9.

#### II. Related Works

K-means clustering is a well-known partitioned clustering algorithm that has been used in a variety of applications. In the literature, several variations of Kmeans have been proposed to improve its performance for the broad clustering problem. Fong et al. (2012) studied the integration of bio-inspired optimization methods into K-means clustering for software bug prediction in order to assess clustering performance. The main optimization algorithms tested include the Firefly algorithm, Cuckoo search algorithm, Bat algorithm, Wolf and Ant Colony Optimization (ACO) algorithms. Results show that the combination of these algorithms acquired improved performance accuracy compared with ordinary k-means, at the same time accelerating the search process and avoid local optima. Zhong et al., 2004 compared the k-means algorithm to natural-gas algorithms. The natural gas algorithm outperformed the k-means algorithm in terms of mean square error values. However, this method necessitates the use of a software expert to determine whether the software is appropriate.

Annisa et al., 2020, came up with an improved version of k-means algorithm for software bug prediction, that locate the initial centroid of the k-means algorithm and determine the number of clusters present. Because it produces better accuracy than the simple K-Means method, this proposed method could be useful for clustering other data types. Seliya and Khoshgoftaar, 2007 proposed K-means for software failure prediction. Their method iteratively labels clusters as fault-prone or not using expert domain knowledge as a restriction.

The k-means algorithm based on quad tree was proposed by Bishnu and Bhattacherjee, 2012 and it was compared to some clustering algorithms. Their proposed algorithm has error rates that are comparable to k-means, Linear Discriminant Analysis and Naive

Bayes. Catal et al. 2009 used the x-means clustering algorithm to create faulty and non-faulty clusters based on software metrics. Lines of code, cyclomatic complexity, operand and operator are the metrics. If the metric values are complex than the threshold, the software entity is predicted to be defective, and vice versa. Almayyan, 2021 used dataset from the NASA repository and used three clustering algorithms, Farthest First, X-means and Self-organizing map. This article presents a comparison of software defect prediction algorithms based on Bat, Cuckoo, Grey Wolf Optimizer (GWO), and Particle Swarm Optimization (PSO) in order to evaluate different feature selection algorithms. The Farthest First clustering algorithm was found to be effective in predicting software faultiness, and Bat and Cuckoo were found to be useful in comparison to all other metaheuristic algorithms.

Though several academics have sought to K-means clustering with nature-inspired merge algorithms (NIAs), their efforts have been restricted to almost identical group movements, such as the Firefly, Artificial Bee Colony (ACO), and Particle Swarm Optimization (PSO) algorithms (Jensi and Jiji, 2015). In addition, only a few bio-inspired optimization methods that are integrated with K-means are provided in the previous studies. Only 7 of the 28 NIAs hybridized with (Genetic Algorithm, Particle K-means Swarm Optimization, Bat Algorithm, Artificial Bee Colony, Differential Evolution, Harmony Search, and Symbiotic Organism Search) dedicated their hybridization to solving automatic clustering problems, accounting for 20.6 percent of the total (lkotun et al., 2021). In general, it can be seen that the rate of publishing on K-means hybridization with specific NIAAs is minimal. More research is needed in this area to see if there are any other ways to improve the performance of the existing hybridization algorithm. This suggests that combining Kmeans with these other NIAs to solve automatic clustering problems should be investigated.

The purpose of this research is to look into the mechanics of incorporating certain NIAs into the K-means clustering algorithm. The optimization function adds to the existing best solution by progressively improving it with a new solution from an unknown fragment of the search space. When a new solution is identified to be better than the present one, the searching agents replace the solutions and continue searching until some stopping criteria are fulfilled.

#### III. METHODOLOGY

#### a) K means Clustering Algorithm

The K-means clustering algorithm is a partitioned clustering technique that divides a dataset into k number of clusters using a certain fitness measure. Due to the large amount of data objects in real-world datasets, distributing data items into

appropriate clusters to obtain an ideal cluster outcome is computationally expensive and time-consuming (lkotun et al.2021).

Given a dataset  $X=\{x_i\},$  where  $i=1,\,2,\,\ldots\,n$  of d-dimension data points of size n, X is partitioned into 'k' clusters such that

$$J(C_{k}) = \sum_{xieck} ||x_{i} - \mu_{k}||^{2}$$
(1)

With the objective function: minimize the sum of the square error over all the k clusters. That is, minimize

$$J(C) = {}^{K}\!\!\sum_{k=1} \sum_{x_{ieck}} ||x_{i} - \mu_{k}||^{2}$$
(2)

When assigning N objects to k clusters, the purpose of the clustering algorithm is to limit the number of potential possibilities. This can be expressed numerically as:

$$S(N, K) = 1/K! {}^{K}\sum_{i=0}^{K} (-1) {}^{K-i} {K \choose i} t^{N}$$
(3)

#### b) Nature-inspired algorithms (NIAs)

Nature-inspired computation has aained popularity in the previous two decades and has been used in practically every field of research and engineering (Yang et al.2013). NIAs are global optimization strategies for solving difficult real-world issues (Okwu et al. 2020). NIAs have successfully provided suboptimal solutions to automatic clustering problems in a reasonable amount of time (Hruschka et al. 2009). The population is used for the exploration of search space in the nature-inspired metaheuristic, ensuring a higher possibility of finding optimal cluster partitions (Nanda and Panda, 2014). It has been discovered that combining K-means with NIAs for automatic clustering improves the performance of algorithms when dealing with cluster analysis. In most circumstances, the automatic cluster number determination aids in the selection of near-optimal starting cluster centroids for the clustering process rather than the normal random selection (Zhou et al. 2017).

#### c) Combination of k-means with Nature-Inspired Algorithms (NIAs)

Clustering using NIAs is now as simple as assigning combinations of centroids to the searching agents, allowing them to heuristically find the best answer. Though the specifics of conducting a heuristic search vary depending on which nature-inspired optimization algorithm technique is used, the initialization stage and the finishing step, where the quality of the discovered solution is evaluated as a stopping condition, are both comparable.

S is defined as the solution space that contains a finite number of  $x_i$ , where i is the solution's index, in the initialization construct. The search agents represent the solutions x, each of which holds a set of centroids, regardless of the types of bio-inspired optimization methods used.

Typically, a large population of searching agents, N, is utilized to collaboratively search for the best feasible cluster configurations (as expressed by the locations of the optimal centroids). K is the number of clusters that must be formed, which is generally a userdefined figure. D is the dimension of the search space, which is the number of attributes a data point possesses.

To find the optimal configuration of centroids we let  $cen_{j,v}$  be the centroids at the  $j^{th}$  cluster and the  $v^{th}$  attribute. To obtain the centroid location, the following formula is used:

$$\operatorname{cen}_{j,v} = \Sigma_{i=1 \text{ wi}, j}^{S} i, v/ \Sigma_{i=1 \text{ wi}, j}^{S} i$$
, Where  $j = 1...K, v = 1...K * D$ 
(4)

In our concept, the matrix cenj,v contains all of the cluster centers and is a two-dimensional matrix with K  $\star$  D characteristics.

$$F(\text{cen}) = \sum_{i=1}^{k} \sum_{j=1}^{S} W_{i,j} \sum_{\nu=1}^{K^* D} (X_{i\nu}, -\text{cen}_{j,\nu})^2$$
(5)

The calculation method loops K \* D times to analyze the values of all the attributes of x in each cluster v to calculate the distance between each x and the centroid.

Cluster centers can be designated by data points. For example, in a two-cluster clustering task, the objective function requires three variables. As a result, there are three dimensions.

Three variables, and hence three-dimensional spaces, are required, and the i<sup>th</sup> data point may be written as  $x_i = (i, [x_{i,1}, x_{i,2}, x_{i,3}, x_{i,4}, x_{i,5}, x_{i,6}]).$ 

The clustering strategy can be formulated as follows:

$$clmat_{i,j} = min_{k\epsilon_k} \{ | |X_i - cen_k| | \}$$
(6)

Where i=1...N, j=1...S, k=1...K. Equation (3) tells us that the i<sup>th</sup> data point belongs to the kth cluster. The equation is an objective function with a lower value indicating better performance.

Sets of functional parameters must be defined in order to execute the bio-inspired optimization algorithms. Despite the fact that some of their parameters are shared, each set of parameters for the hybrid bio-inspired clustering algorithms is designed independently. The six models investigated are K means with Genetic Algorithm, K means with Bat algorithm, K means with Ant colony algorithm, K means with Cuckoo Search Algorithm, K means with Firefly Algorithm and K means with Coral reefs algorithm. The most significant variations are in how the global optimal exploration is carried out for all these algorithms. The evaluation stage comes right after the exploration construct, and it compares if the new solution is better than the current best one.

#### d) Genetic Algorithm

Genetic Algorithm (Ga) are randomized heuristic search algorithms that are based on natural

selection and genetic principles (Goldberg, 1989). The genetic operators used in the combination of K-means and GA are selection, distance-based mutation, and the K-means operator. The parameters have been set according to the study of Bouhmala et al. 2015.

P (0) is chosen at random as the starting population. Each allele in the population can be given a cluster number from the uniform distribution over the set  $\{1, \dots, K\}$  at random.

According to the distribution given by, the selection operator selects a chromosome from the preceding population at random as follows:

$$P(s_{i}) = F(s_{i}) /^{N} \sum_{j=1} F(s_{j})$$
(7)

Where  $F(s_i)$  represents fitness value of the string  $s_i$  in the population.

The possibility of solutions surviving in the future population is ranked in the current population. Each solution in the population must be assigned a figure of merit or a fitness value.

$$F(s_w) = \{ g(s_w) : \text{if } g(s_w) \ge 0 \text{ ; otherwise.}$$
(8)

#### e) Bat Algorithm (BA)

Bat echolocation is used in the bat algorithm (BA), which is a heuristic optimization tool (Yang, 2010). The four basic parameters of a BA are pulse frequency, pulse rate, velocity, and a constant. The parameters have been set according to the study (Huang and Ma, 2020).

The frequency, velocity, and position for each bat are initialized. The virtual bats' movement is described by updating their velocity and position using the equations below for each time step t, where T is the iteration limit.

$$f_i = f_{min} + (f_{min} - f_{max})^{\beta}$$
(9)

$$V_i^{t+1} = v_i^{t} + [X_i^{t} + X^*]f_i$$
 (10)

$$X_{i}^{t+1} = X_{i}^{t} + v_{i}^{t}$$
 (11)

Where  $V_i^{t}$  and  $X_i^{t}$  are the velocity and position at time t,  $V_i^{t+1}$  and  $X_i^{t+1}$  are the velocity and position at time t+1, and is a random number between 0 and 1.

A random number is generated when the bat positions are updated; if the random number is greater than the pulse emission rate, a new location is formed around the current best solutions, as shown in the equation below.

$$X_{new} = x_{old} + EA^t$$
 (12)

Where E is a random number  $A^t$  represents the average loudness of all bats at time t.

#### f) Ant Colony Optimization (ACO)

The ACO heuristic was inspired by investigations of ant foraging behavior in real colonies, which indicated that ants can often figure out the shortest path between food source and nest (Zheng et al. 2003). The parameters have been set according to the study (Tang et al. 2012).

When the ant moves from i to j, the path node at the start can set as A, A= {0, 1,..... n-1}. This reflects the role of pheromones accumulated by ants during exercise during ant migration and reveals the relative relevance of the trajectory. The larger  $\alpha$  is, it indicates the high probability for subsequent ants to choose this path.

The probability of the ant moving from I to j is computed using the following formula:

$$P_{ij}^{k}(t) = r_{ij}^{k}(t)n_{ij}^{\beta}(t) / \sum r_{ij}^{\alpha}(t) n_{ij}^{\beta}(t)$$
(13)

Where pheromone is  $\rho,$  which is a constant that represents weight. The time of iteration is Nc and the initial setting is  $\varphi.$  The predicted heuristic factor is  $\beta,$  which demonstrates the relevance of visibility relative to other factors. It also represents the significance of the heuristic component in the entire path of the ant's movement.

#### g) Firefly Algorithm (FA)

Firefly algorithm is a very strong technique for solving restricted optimization and NP-hard problems (Apostolopoulos and Vlachos, 2011). The parameters have been set according to the study (Tang et al.2012).

The attractiveness of a firefly I on a firefly j is determined by the degree of the firefly i's brightness and the distance rij between the firefly I and the firefly j, as shown below:

$$I(r) = I_{\rm s}/r^2 \tag{14}$$

Consider the case when there are n fireflies and the solution for firefly I is xi. The brightness of the firefly I is linked to the objective function f (xi).

$$I = f(x_i) \tag{15}$$

Each firefly has an attraction value, and the less dazzling (attractive) one is drawn to the brighter one and transferred there. The attractiveness value  $\beta$  is relative based on the distance between fireflies.

$$\beta (r) = \beta_0 e^{-yr^2}$$
(16)

Where  $\beta_0$  is the firefly attraction value at r = 0 and  $\gamma$  is the media light absorption coefficient.

#### h) Cuckoo Search (CS) Algorithm

Yang and Deb, 2009, developed the Cuckoo Search algorithm which is based on some cuckoo species' brood parasitism. The parameters have been set according to the study (Fong et al. 2014).

An initial population of n nests is randomly generated at the positions,  $X = \{x_1^{0_1}, x_2^{0_2}, ..., x_n^{0_n}\}$ , to evaluate the objective values to find the current global best  $g_t^{0}$ .

The new position is updated accordingly by performing a Lévy flight:

$$x_i^{(t+1)} = x_i^{(t)} + \alpha \bigoplus L \acute{e}vy (\lambda), \qquad (17)$$

Where  $\alpha > 0$  denotes the step size, which should be connected to the problem's scales. In most circumstances, we can use  $\alpha = 1$ .

#### i) Coral Reefs Optimization Algorithm (CRO)

CRO is another nature-inspired algorithm, based on an artificial simulation of the process of coral reef formation and reproduction (Sanz et al.2014). The CRO algorithm has never been utilized in the realm of software bug detection to our knowledge. Corals reproduce at each iteration step in the CRO algorithm, producing new individuals. The parameters have been set according to the study (Medeiros et al., 2015).

By allocating a coral to each square (i j), the CRO algorithm generates a N x M square grid in which each square (i,j) may represent an alternate solution to a problem (or colony of corals). The formation of coral is the second phase. After three phases, the entire collection of existing corals in the reef is graded according to their level of healthiness (broadcast spawning, brooding, and larvae setting).

#### *j)* Particle Swarm Optimization (PSO)

The behavior of particles in a swarm is the central concept of the PSO. Each particle has its own location in a multidimensional space and communicates with the others. To move about in space, the particles employ social and cognitive information. When the algorithm comes to a halt, the best solution has been discovered (Koohi and Groza, 2014). The parameters have been set according to the study (Rana et al., 2010).

The inertia weight balances the algorithm's local and global search abilities. The proportional contribution of the prior velocity to the current velocity is defined by the inertia weight.

$$V_i^{k+1} = wv_i^k + c1 \text{ rand } (p_{\text{besti}} - x_i^k) + c2 \text{ rand } (g_{\text{best}} - X_i^k)$$
(18)

$$X_{i}^{k+1} = X_{i}^{k} + v_{i}^{k+1}$$
(19)

#### *k)* Grey Wolf Optimizer (GWO)

The Grey Wolf Optimizer (GWO) is a simple, population-based, flexible, and derivative-free metaheuristic optimization method that intelligently avoids stagnation in local optima spots of the search space. It simulates the social behaviors of grey wolves in the aspects of their hierarchical leadership and hunting movement (Mirjalili et al., 2013). Grey wolves' leadership and haunting mechanism help to design a new metaheuristic algorithm with three steps: searching prey, encircling prey, and attacking prey.

During the GWO operation, the position of the wolves is continuously updated, with appropriate mathematical formulas (Hou et al., 2022). The parameters have been set according to the study (Wang et al., 2019).

#### IV. Proposed Method

To address the curbs of the K-means clustering approach in generating globally optimum clusters, the suggested method uses the k-means algorithm together with a range of NIAs for software bug prediction. By adding an exploration function to the k-means algorithm, the combination of these strategies may improve the model. The exploration function improves the existing solution by examining regions outside of its immediate vicinity, and if a new, better solution than the current best one is discovered, the search agents will move toward it. The exploring procedure will continue until certain stopping criteria are met. Nature-inspired algorithms are metaheuristic algorithms, which means they have the ability to explore the combinatorial search space heuristically rather than exhaustively. The integration methods are based on representing the search agents as a combination of centroid locations, then the search agents explore the search space for the best solution.

The purpose of clustering is to discover a proper set of centroids using the metaheuristic of the nature-inspired method as a guide. The metaheuristic will always insist on centroids being moved in a progressive manner in each phase, with the goal of finding the best grouping. The ideal group's ultimate result should be that the data points inside each cluster are closest to their centroid. During the search, the centroids move around in the search space, following the swarming pattern of the nature-inspired optimization method, until no further progress is seen. It comes to a halt when there is no other possible relocation that will yield a better result. Along with the success of employing nature-inspired metaheuristic algorithms to solve automatic clustering problems, it has been discovered that combining two or more metaheuristics for the same objective improves clustering performance. The performance of hybrid algorithms, according to Nanda and Panda 2014, is superior to that of separate algorithms in terms of robustness, effectiveness, and accuracy.

#### V. DATASET AND DATA PROCESSING

The dataset was collected from the online PROMISE repository. AR1, AR3, AR4, AR5, AR6, KC1, KC2, JM1, CM1, PC1 and PC5 were used respectively. With reference to the paper, by Shepperd et al. 2013, data cleaning is mandatory before using any datasets available. Indeed, we noted a huge class imbalance issue with the available datasets (faulty, non-faulty),and all data inconsistencies, missing and null values were removed. Each dataset selected represents a NASA software system that includes various metrics. Each dataset is made up of a number of software modules and attributes. Modules with defects are classified as prone to faults, whereas those without defects are classified as non-fault prone. For the training purpose, the entire dataset is used except for the last column (output column), only columns consisting of numerical values were considered.

Table 1: Summary of dataset
-----------------------------

Dataset	Modules	Defective modules	Software metrics (Attributes)
AR1	121	9	29
AR3	63	8	29
AR4	107	20	29
AR5	36	8	29
AR6	101	15	29
KC1	2109	1783	22
KC2	522	107	21
JM1	7782	1672	21
CM1	327	42	37
PC1	705	61	37
PC5	1711	471	38

#### VI. EVALUATION

#### a) Experimental Setup

The main goal of this research is to demonstrate the utility of the k-means algorithm with different NIAs, which we accomplished using Tensorflow to train the model. TensorFlow is an open-source machine learning platform to build and deploy prediction models. Google Colab was also used to run the results, which allowed the code to run with no configuration and free GPU access. Each dataset is performed 10 times in the trials to find the average CPU time and objective function values/best fitness value.

# VII. Results and Discussions

Table 2: Accuracy of algorithms

Datasets	AR1	AR3	AR4	AR5	AR6	KC1	KC2	JM1	CM1	PC1	PC5
k-Means	88.90	88.00	89.01	88.85	88.43	89.10	89.00	88.80	89.00	89.19	89.99
K-Means +GA	90.50	90.58	91.28	91.55	90.11	90.00	90.54	90.53	91.25	90.00	90.05
K-Means +BAT	90.00	91.59	91.00	92.34	92.00	92.98	91.34	90.00	91.25	92.56	92.00
K-Means +PSO	92.50	92.65	92.87	93.01	93.00	92.99	94.10	92.67	92.89	93.10	93.58
K-Means +Coral Reefs	94.00	94.54	94.56	94.87	94.00	95.96	95.66	96.88	95.01	95.04	95.54
K-Means +Cuckoo	94.50	94.58	94.58	94.00	94.56	95.45	95.88	95.67	95.44	94.56	94.78
K-Means + ACO	94.00	93.56	93.50	94.10	93.78	93.03	93.56	93.44	93.89	94.01	94.52
K-Means +Firefly	92.56	92.67	93.00	93.44	93.02	93.56	94.78	93.67	94.88	94.34	94.54
K-Means + GWO	90.09	92.47	94.65	93.22	92.00	92.60	93.00	92.50	94.50	94.12	94.13

From the table above, K-means clustering is optimized using the various NIAs. We can see that all of the proposed algorithms perform better than the traditional standalone k-means algorithm. K-means appears to take the shortest computation time in any of the tests, maybe because it stops early in local optima (Table 3). This is evident from the accuracy obtained from the table above. NIAs speed up the process of clustering centroids and illustrate that all partitioning clustering methods can be linked with the natural search

The clustering results of the new hybrid clustering algorithms are compared to the K-means, which serve as a benchmarking reference. The full dataset is used for training, and cluster formation is referred to until perfection is attained using the entire set of data. The ultimate clustering result's quality is determined by each cluster's integrity, which is represented by the objective function's final fitness value.

The hardware configuration used for all experiments in this study is as follows: Corei7-6500U CPU @2.50 GHz 2.60 GHz, Windows 10, 64-bit operating system, x64 based processor, RAM: 8 GB DDR4, and Hard Disk: SSD.

#### b) Performance Evaluation Measures

In order to assess the effectiveness of combining the k-means algorithm and optimization algorithms in the prediction of software bugs, the evaluation metrics, accuracy and F-measure have been calculated accordingly as shown in the Equation (1):

$$Accuracy = (TP+TN) / (TP+TN+FP+FN), \quad (20)$$

Where TP = true positive, TN = true negative, FN = false negative and FP = false positive.

On the other hand, the external metric used to determine the accuracy of the clustering findings, known as the F-measure, is also computed.

The F-measure, which is the average of precision and sensitivity performance, is calculated as follows:

$$F = 2 * P * Sensitivity / P + Sensitivity,$$
 (21)

Where P refers to precision and sensitivity is calculated by finding the non-defective modules that were accurately categorized.

process to prevent local optima. Secondly, simple Kmeans were applied to the robust nature of GA, which shows adequate prediction accuracy for all datasets. Even though GA may converge to the global optimum due to mutation, GA faces the issue in terms of computational challenges. The application of k means with the Bat algorithm apparently yields the same This hybrid algorithm improves accuracy. the convergence speed of BA and helps the k means algorithm independent of the initial centers. Next, K means is combined with PSO. The PSO method is used to start the process because of its fast convergence, and then the K-Means algorithm is used to refine the PSO algorithm's outcome to near-optimal solutions. The hybridization of these two methods yields effective results in terms of efficiency and precision. The PSO algorithm can be used to generate good initial cluster centroids for the K-Means.

Furthermore, K means and Coral reefs algorithm are combined. The results for this combined method are quite promising since they show that using the CRO method for a clustering application can produce better results to using hybrid genetic algorithms, which is the most often used clustering optimization technique. To best of our knowledge, CRO has not been used with clustering for software bug detection. The hybrid model of k means with Cuckoo Search algorithm shows significant accuracy, likewise CRO algorithm. Cuckoo search is used to provide a robust initialization, whereas K-means is utilized to construct solutions faster. K means is also combined with Ant Colony Optimization algorithm. The suggested method's learning mechanism is based on the use of a defined parameter termed pheromone, which eliminates

undesirable K-means algorithm solutions. The suggested method improves the K-means algorithm by making it less reliant on starting parameters such as randomly picked beginning cluster centers, resulting in a more stable algorithm. K means with firefly also produce near accuracy with CRO and Cuckoo search algorithm. This is because fireflies with high similarity are dispersed, resulting in a more diverse distribution of the entire swarm in search space. K means with GWO has also shown rapid convergence. This improvement is caused by the fact that K-means significantly affects the GWO population and separates it into two clusters. Because GWO often operates as three clusters and has three wolves in the search space, K-means is advantageous for GWO.As a result, it can be concluded that K- means combined with GWO increased GWO's effectiveness to some extent.

High clustering accuracy and efficiency were obtained from the hybrid clustering of Coral reefs and Cuckoo Search Algorithm, Hybrid clustering of Coral reefs algorithm has never been applied in the field of software bug detection and has indeed shown promising results. Hybrid clustering of Coral reefs algorithm locate cluster centroids without causing premature convergence. The findings of the evaluation results add evidence that NIAs can indeed speed up the process and avoid local optima. Because fewer iterations are required to achieve the best cluster outcome, selecting the number of clusters enhances the hybridized clustering method's convergence speed. The computational time for each algorithm is computed as shown in Table 3. Less computational time was noted when K means was integrated with Coral reefs and Cuckoo Search algorithm respectively.

Datasets	AR1	AR3	AR4	AR5	AR6	KC1	KC2	JM1	CM1	PC1	PC5
k-Means	79.88	80.01	79.23	80.10	80.15	79.99	79.98	80.65	80.00	79.80	80.34
K-Means +GA	159.99	157.85	162.89	161.00	162.00	172.45	170.55	169.87	172.99	169.00	170.03
K-Means +BAT	162.40	161.00	160.88	165.54	166.87	164.34	157.88	169.90	161.45	162.34	165.10
K-Means +PSO	165.78	155.00	168.98	172.99	170.00	169.99	159.00	159.90	172.78	172.00	169.56
K-Means +Coral Reefs	148.89	152.77	148.54	150.00	149.90	155.42	150.09	151.23	147.77	148.99	149.00
K-Means +Cuckoo	146.67	146.90	149.45	148.00	145.78	148.00	149.99	148.45	150.45	146.88	149.00
K-Means+ ACO	162.67	166.34	159.90	155.67	161.88	160.10	160.00	168.89	159.45	158.45	158.00
K-Means +Firefly	150.23	152,90	150.00	151.90	155.67	150.45	152.56	154.78	152.89	155.90	154.78
K-Means+ GWO	151.45	151.00	156.40	156.34	156.12	154.98	153.10	154.88	154.00	151.17	154.97

#### Table 3: Computational Time for all Algorithms

For statistical performance, the F1 score has been calculated for all the algorithms as shown in Table 4. Again, the F1 Score shows that K-means with Coral reefs resulted in dependable and significant performance that can be used to predict software defects. When a good validity measure is applied, most metaheuristic algorithms can automatically divide datasets into an appropriate number of clusters, according to Gbaje et al.2019.

Datasets	AR1	AR3	AR4	AR5	AR6	KC1	KC2	JM1	CM1	PC1	PC5
k-Means	0.66	0.79	0.82	0.80	0.75	0.81	0.80	0.81	0.82	0.82	0.80
K-Means+GA	0.84	0.83	0.83	0.80	0.83	0.84	0.84	0.85	0.82	0.81	0.85
K-Means +BAT	0.83	0.81	0.83	0.86	0.86	0.86	0.85	0.85	0.85	0.87	0.85
K-Means +PSO	0.85	0.85	0.87	0.87	0.86	0.85	0.87	0.85	0.87	0.87	0.87
K-Means +Coral Reefs	0.86	0.86	0.86	0.85	0.86	0.86	0.87	0.88	0.86	0.87	0.88
K-Means +Cuckoo	0.89	0.85	0.88	0.89	0.86	0.89	0.86	0.89	0.89	0.87	0.88
K-Means+ ACO	0.84	0.83	0.86	0.85	0.84	0.86	0.85	0.85	0.86	0.85	0.86
K-Means +Firefly	0.86	0.85	0.83	0.87	0.87	0.85	0.83	0.85	0.86	0.88	0.85
K-Means+ GWO	0.82	0.82	0.81	0.86	0.84	0.83	0.79	0.85	0.84	0.84	0.85

Table 4: Statistical Performance Analysis of Algorithms- F1 Score

## VIII. PRACTICAL IMPLICATIONS

Metaheuristics algorithms have shown to be effective optimizers. This research found that each of the hybrid K means based-nature-inspired optimization algorithm models outperformed the standalone K means algorithm in terms of accuracy and F1 score. Following the intrinsic limitations of K-means design and the virtues of Nature-inspired optimization techniques, it seems feasible to integrate them, allowing them to complement and function together. The algorithms' successful integration gives reason to believe that more advanced optimization mining techniques can be developed. This study can be used as a roadmap for researchers who want to incorporate other new emerging NIAs into improved clustering methods in the field of software bug detection.

#### IX. Conclusion and Future Works

Prediction of defect-prone software modules is an important goal in software engineering. The traditional clustering algorithm usually gets trapped in the problem of local optima. As a result, the natureinspired method provides an alternative technique for solving clustering problems using its searching capabilities. This study's main contribution is combining the clustering algorithm with the different NIAs for software bug detection. To the authors' knowledge, only PSO, Cuckoo, Bat, and GWO (Grey Wolf Optimizer) algorithms were applied with clustering algorithms for software bug detection (Almayyan, 2021). The results are improved significantly when clustering algorithms are combined with bio-inspired optimization methods, apparently for the hybrid model of k means clustering withCoral reefs algorithm, achieving an accuracy of 96%.For future work, this work can be replicated with other related datasets for the analysis of bug prediction in software.

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## **References** Références Referencias

- J.B.Macqueen, "Some methods for classification and Analysis of Multivariate Observations". Proceedings of 5<sup>th</sup> Berkeley Symposium on Mathematical Statistics and Probability, University of California Press, 1967, pp 281-297
- 2. Rui Tang, Simon Fong, Xin-she Yang and Suash Deb, Integrating Nature inspired Optimization algorithms to k-means clustering, University of Macau, Aug 2012
- 3. RiskiAnnisa, DidiRosiyadi, Dwiza Riana, Improved point center algorithm for k-means clustering to increase software defect prediction, International Journal of Advances in Intelligent Informatics, Vol 6, No.3, November 2020, pp.328-339
- S. Lessmann, B. Baesens, C. Mues, and S. Pietsch, "Benchmarking classification models for software defect prediction: A proposed framework and novel findings," IEEE Transactions on Software Engineering, vol. 34, no. 4, pp. 485–496, 2008.
- I. Myrtveit, E. Stensrud, and M. Shepperd, "Reliability and validity in comparative studies of software prediction models," IEEE Transactions on Software Engineering, vol. 31, no. 5, pp. 380–391, 2005.
- 6. Jain, A.K. and R.C. Dubes, Algorithms for clustering data. 1988: Prentice-Hall, Inc.
- Gayathri, R., Cauveri, A., Kanagapriya, R., Nivetha, V., Tamizhselvi, P., & Kumar, K. P. (2015, March). A Novel Approach for Clustering Based On Bayesian Network. In Proceedings of the 2015 International Conference on Advanced Research in Computer Science Engineering & Technology (ICARCSET 2015) (p. 60). ACM.
- 8. Zhong S, Khoshgoftaar TM, Seliya N. Unsupervised learning for expert-based software quality estimation. In: Proceedings of the eighth IEEE international conference on high assurance systems engineering HASE 2004; 2004. p. 149–55. https://doi.org/10.1109/HASE.2004.1281739.

- Bishnu PS, Bhattacherjee V. Software fault prediction using quad tree-based kk-means clustering algorithm. IEEE Trans Knowl Data Eng. 2012; 24(6):1146–50. https://doi.org/10.1109/TKDE. 2011.163.
- Catal C, Sevim U, Diri B. Software fault prediction of unlabeled program modules. In: Proceedings of the world congress on engineering WCE 2009; 2009. p. 1–6.
- YunlongZhu ,Xiaohui Yan, Wenping Zou and Liang Wang, (2012), "A new approach for data clustering using hybrid artificial bee colony algorithm", Neuro computing, Vol. 97, pp.241–250
- Yi-Tung Kao, ErwieZahara and I-Wei Kao, (2008), "A hybridized approach to data clustering", Expert Systems with Applications, Vol.34, No. 3, pp.1754– 1762
- Waheeda Almayyan, Towards Predicting software defects with clustering techniques, International Journal of Artificial Intelligence and Application (IJAIA), Vol 12, No 1, January 2021
- M. Shepperd, Q.Song, Z.Sun, and C.Mair, –Data quality: Some Eng., vol. 39, no. 9, pp. 1208–1215, 2013.
- Z. Tóth, P. Gyimesi, and R. Ferenc, "A Public Bug Database of GitHub Projects and Its Application in Bug Prediction," in Computational Science and Its Applications -- ICCSA 2016, Cham, 2016, pp. 625-638: Springer International Publishing.
- Simon Fong, Suash Deb, Xin-She Yang,and Yan Zhuang, Towards Enhancement of Performance of K-Means Clustering Using Nature-Inspired Optimization Algorithms, Computational Intelligence and Metaheuristic Algorithms with Applications, 2014, https://doi.org/10.1155/2014/564829
- Deepinder Kaur, Arashdeep Kaur, "Fault Prediction using K-Canberra Means Clustering", CNC 2010[in Press]
- Abiodun M. Ikotun, Mubarak S. Almutari and Absalom E. Ezugwu, K-Means-Based Nature-Inspired Metaheuristic Algorithms for Automatic Data Clustering Problems: Recent Advances and Future Directions, Appl. Sci. 2021, 11, 11246. https://doi.org/10.3390/app112311246
- 19. Okwu, M.O.; Tartibu, L.K. Metaheuristic Optimization: Nature-Inspired Algorithms Swarm and Computational Intelligence, Theory and Applications; Springer Nature: Berlin/Heidelberg, Germany, 2020; Volume 927.
- Hruschka, E.; Campello, R.J.G.B.; Freitas, A.A.; de Carvalho, A. A Survey of Evolutionary Algorithms for Clustering. IEEE Trans. Syst. Man Cybern. Part C Appl. Rev. 2009, 39, 133–155.
- Nanda, S.J.; Panda, G. A survey on nature inspired metaheuristic algorithms for partitional clustering. Swarm Evol. Comput. 2014, 16, 1–18. [CrossRef]

- Zhou, X.; Gu, J.; Shen, S.; Ma, H.; Miao, F.; Zhang, H.; Gong, H. An Automatic K-Means Clustering Algorithm of GPS Data Combining a Novel Niche Genetic Algorithm with Noise and Density. ISPRS Int. J. Geo-Inf. 2017, 6, 392
- Mousa, A.A., El-Shorbagy, M.A. and Abd El-Wahed, W.F. (2012) Local Search Based Hybrid Particle Swarm Optimization for Multiobjective Optimization. Swarm and Evolutionary Computation, 3, 1-14.
- N. Bouhmala, A. Viken, and J. B. Lønnum, Enhanced Genetic Algorithm with K-Means for the Clustering Problem, International Journal of Modeling and Optimization, Vol. 5, No. 2, April 2015
- D. E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley, New York, 1989 X.-S. Yang, "A new metaheuristic bat-inspired algorithm," *Nature Inspired Cooperative Strategies for Optimization*, vol. 284, pp. 65–74, 2010
- 26. Jianqiang Huang and Yan Ma, Bat Algorithm Based on an Integration Strategy and Gaussian Distribution, Volume 2020 | Article ID 9495281 | https://doi.org/10.1155/2020/9495281
- Zheng, H., Zheng, Z., Xiang, Y., The application of ant colony system to image texture classification [textute read texture], In: Proceedings of the 2nd International Conference on Machine Learning and Cybernetics, Vol. 3, Xi'an, China, (2003) 1491-1495
- R. Tang, S. Fong, X. Yang and S. Deb, "Integrating nature-inspired optimization algorithms to K-means clustering," Seventh International Conference on Digital Information Management (ICDIM 2012), 2012, pp. 116-123, doi: 10.1109/ICDIM.2012.6360145.
- 29. Apostolopoulos, T. and Vlachos, A. (2011). Application of the Firefly Algorithm for Solving the Economic Emissions Load Dispatch Problem. International journal of Combinatorics. doi:10.1155/2011/523806
- X.-S. Yang and S. Deb, "Cuckoo search via Lévy flights," in *Proceedings of the World Congress on Nature & Biologically Inspired Computing (NABIC* '09), pp. 210–214, Coimbatore, india, December 2009.
- Inacio G. Medeiros and Joao C. Xavier- Junior, Anne M. P. Canuto, Applying the Coral Reefs Optimization Algorithm to Clustering Problems, Conference Paper · July 2015 DOI: 10.1109/ IJCNN.2015.7280845
- 32. Salcedo-Sanz, S. and Del Ser, J. and Gil-Lpez, S. and Landa-Torres, I. and Portilla-Figueras, J. A.," The Coral Reefs Optimization Algorithm: A Novel Metaheuristic for Efficiently Solving Optimization Problems," The Scientific World Journal, Volume 2014, Hindawi Publishing Corporation, 2014.
- 33. I. Koohi and V. Z. Groza, "Optimizing Particle Swarm Optimization algorithm," 2014 IEEE 27th Canadian Conference on Electrical and Computer Engineering

*(CCECE)*, 2014, pp. 1-5, doi: 10.1109/CCECE.2014. 6901057.

- 34. R.Jensi and G.WiselinJiji, HYBRID DATA CLUSTERING APPROACH USING K-MEANS AND FLOWER POLLINATION ALGORITHM, Advanced Computational Intelligence: An International Journal (ACII), Vol.2, No.2, April 2015
- 35. Agbaje, M.B.; Ezugwu, A.E.; Els, R. Automatic Data Clustering Using Hybrid Firefly Particle Swarm Optimization Algorithm.IEEE Access 2019, 7, 184963–184984.
- 36. Yang, X. S., and et al." Swarm Intelligence and Bio-Inspired Computation: Theory and Applications, Elsevier Science Publishers B. V. Amsterdam, The Netherlands,(2013)
- 37. S. Mirjalili, S. M. Mirjalili and A. Lewis, Grey wolf optimizer, *Adv. Eng.* Softw. 69 (2014), 46– 61.10.1016/j.advengsoft.2013.12.007
- Hou, Y.; Gao, H.; Wang, Z.; Du, C. Improved Grey Wolf Optimization Algorithm and Application. Sensors 2022, 22, 3810. https://doi.org/10.3390/ s22103810
- 39. Jie-Sheng Wang, Shu-Xia Li, An Improved Grey Wolf Optimizer Based on Differential Evolution and Elimination Mechanism, *Sci*Rep 9, 7181 (2019). https://doi.org/10.1038/s41598-019-43546-3
- 40. Sandeep Rana, Sanjay Jasola , Rajesh Kumar, A hybrid sequential approach for data clustering using K-Means and particle swarm optimization algorithm, International Journal of Engineering, Science and Technology Vol. 2, No. 6, 2010, pp. 167-176



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# Blockchain Challenges: Advantages and Algorithms

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*Abstract-* Cryptocurrency is the innovation that has changed the way of life most significantly over the past ten years. Bitcoins is a term that often comes up when discussing the blockchain system. Although they are not identical, Ethereum and Cryptocurrency nevertheless remain widely misunderstood. Innovative technologies had to be created as a result from rising degrees of globalization. These groundbreaking innovations improve the speed of international trade. There are many technical experiments; some of them were successful, whereas others died or required development. The decentralized ledger technology, its benefits, and methods for consensus are described on this article.

Keywords: the pros and disadvantages, and consensus method of the digital currency blockchain.

GJCST-C Classification: LCC: QA76.9.B58

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# Blockchain Challenges: Advantages and Algorithms

Zeel B Dabhi<sup>a</sup> & Aishwarya<sup>o</sup>

Abstract- Cryptocurrency is the innovation that has changed the way of life most significantly over the past ten years. Bitcoins is a term that often comes up when discussing the blockchain system. Although they are not identical, Ethereum and Cryptocurrency nevertheless remain widelv misunderstood. Innovative technologies had to be created as a result from rising degrees of globalization. These groundbreaking innovations improve the speed of international trade. There are many technical experiments; some of them were successful, whereas others died or required development. The decentralized ledger technology, its benefits, and methods for consensus are described on this article.

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#### I. INTRODUCTION

nnovative innovations had to be created as a result of the rising degrees of globalization. These novel technologies improve the efficiency of international trade. Here are many technical experiments; a handful of them were successful, while others died or required development. But without the advent of blockchain technology, a number of significant turning points are being reached, particularly in terms of computational innovations. The techniques that were utilized to produce this research centered on review of literature, analyses of the most commonly quoted projects, pattern findings, readings of reports, analysis of advances in technology, and research of the priorities of the major IT firms.

Cryptocurrency is a decentralized, trustworthy, and challenging to utilize for unlawful type of record keeping. On the opposite hand, Cryptocurrency is a type of electronic money that conducts operations between peers to peers using an open database called the Blockchain, or distributed ledger. Blockchain-based solutions is used in a number of different industries, including Cryptocurrency and Hyperledger's and intelligent contracts. Thus, a wide range of possibilities can be made using the technology of blockchain. The distributed ledger called Blockchain is undoubtedly a new sort of store. Although it can address one of the major issues relating to banking, this type of technology

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is quite intriguing to people. Ethereum is an innovation that combines a number of various technologies and tools, including consensus, networks of peers, the use of encryption, and arithmetic.

## II. BLOCKCHAIN TECHNOLOGY

It is a sort of modern technology in which a computerized register is employed to track operations throughout a decentralized computing infrastructure in order to prevent the operations throughout the machines from being changed retrospectively. Here, every member in the shared ledger gathers the details of each deal the other person engages in. The site does feature a scheduling mechanism, but it provides no way to delete an operation through it one time it has been officially completed.

#### a) The definition of the Blockchain technology

Among the most commonly used descriptions of the Blockchain system, that was created by John & Alan Tapscott, who says it is "an infallible electronic register that records economic event that can be configured to store not only financial activities but nearly anything of significance" [1].

#### b) The structure of the Blockchain technology

The digital ledger is made up of pieces that are introduced to the channel in a straight line at scheduled times [1]. However, the date, purchase, and hashes are present in all Ethereum implementations. The data included in the blocks of data varies on the distributed network of Blockchain.

A single block includes the preceding item's digital digest (Fig. 1).

Since every piece of knowledge in the hash algorithm is created on its own, it is impossible to alter any of its components.



Fig. 1: The sequence of the hash value in the Blockchain

The authentication procedure, including involves applying the personal key and license, is shown in Fig. 2. Verification begins after the authentication step is complete. (Fig. 3). If the resulting hash results are identical, the check is successful. Fig. 5 illustrates the building block formation procedure. Every block in the current instance had the nonce, the Merkle shape, the date, the time, and the prior hashing value.



Fig. 2: The signing process in the Blockchain



Fig. 3: The verification process in the Blockchain

*Fig. 4:* The very simple shows, how blocks signing and verification processes work in the Blockchain



Fig. 5: The structure of the Blockchain

c) What are the key components of blockchain technology?

#### Distributed ledger:

A distributed ledger is the shared database in the blockchain network that stores the transactions, such as a shared file that everyone in the team can edit. In most shared text editors, anyone with editing rights can delete the entire file. However, distributed ledger technologies have strict rules about who can edit and how to edit. You cannot delete entries once they have been recorded.

#### Smart contracts:

Companies use smart contracts to self-manage business contracts without the need for an assisting third party. They are programs stored on the blockchain system that run automatically when predetermined conditions are met. They run if-then checks so that transactions can be completed confidently. For example, a logistics company can have a smart contract that automatically makes payment once goods have arrived at the port.

#### Public key cryptography:

Public key cryptography is a security feature to uniquely identify participants in the blockchain network. This mechanism generates two sets of keys for network members. One key is a public key that is common to everyone in the network. The other is a private key that is unique to every member. The private and public keys work together to unlock the data in the ledger. For example, John and Jill are two members of the network. John records a transaction that is encrypted with his private key. Jill can decrypt it with her public key. This way, Jill is confident that John made the transaction. Jill's public key wouldn't have worked if John's private key had been tampered with.

#### III. CHALLENGES

Additionally, blockchain science has applications in a number of commercial sectors. The medical field is one intriguing area where the blockchain technology is being used. Through the use of Ethereum for transferring costs via the digital currency, this meets everyone involved including medical facilities, medical facilities, and public health regulators by revealing consumers' expectations and maintaining the confidentiality of patients. If the public wanted to view the medical records of a person under the traditional framework, they'd have to fill out an inquiry form and send it to the registration location for permission. The details The buyer must pay an extra charge to the bookkeeper and get an invoice of payment after getting clearance. The receipt is subsequently presented by the details of the user to the registrations offices in order to get an electronic version of the medical records of the individual. But a patient's medical files. can be misplaced or copies made for nefarious intentions. Figure 6 illustrates the idea of a blockchain-based electronic medical record system.



Fig. 6: The structure of the Blockchain

The Payment will indeed be put when such a data client asks a provider (a inpatient care facility) for a specific patient and the publisher approves. A main surgeon's and also the participant's consent are

required before providing a participant's medical files to an info buyer so that just particular documents, such as medical files, are provided. The specifics of this procedure will be described in later study.

#### a) Lack of adoption

Ledgers work better and more efficiently when used by a large network of users. For instance, a cryptocurrency environment may require suppliers as well as users to sign up for such platform. On the opposite hand, according to APQC, only 29% of businesses are actively testing with or using cryptocurrency. Blockchain networks will continue inefficient & unmanageable without widespread usage.

There are certain signs, nevertheless, that its popularity of blockchain may grow. Businesses are progressively organising cooperative blockchain collaborations to address related issues and offer answers that can be helpful to everybody without sharing private data.

This reduces dependency on physical logs with adheres data set and helps to protect the integrity of the distribution network.

#### b) The rising cost of blockchain implementation

The key is making early stock assets. Costs related to execution may be too high for some businesses. Despite the fact that the majority of latest methods are free, hiring skilled software engineers who specialise in blockchains, paying licencing fees in the event that one wishes to switch to a for-profit program version, book keeping, and other costs all require a large investment. It is among the most significant challenges experienced for cryptocurrency.

#### c) Scalability

Durability is the key issue with it's own deployment. Cryptocurrency is not practical for sizable apps because, despite the fact that purchase networks could really control thousands and thousands of simultaneous transactions without experiencing any problems, atm machines for Crypto currency (about 3–7 exchanges per second) and Cryptocurrency (about 15-20 exchanges per moment) takes a long time.

#### d) Security and privacy challenges

Now, numerous organizations must abide by legal restrictions. With regards to important information, their clients have faith in them. Nevertheless, this information won't be completely private if it's all preserved on a public ledger. Here, blockchains in corporate or consortium settings may be used. Your personal data would still be protected, and you would only have access to what you needed.

Cybersecurity is a further essential component. Yet, only a small number of circumstances have robust processes that can deal with this. Even while blockchain-based apps, systems, and businesses are more secure than traditional pcs, criminals may still be able to access them.

He doesn't just want the authorities to safeguard our privacy. Ethereum ego IDs may enable us to gather and control our info. although there We've put in plenty of efforts towards creating new privacy procedures, including confirmation of negligible, but a new identity structure continues to be a long way off.

To learn whether cryptocurrency and MI may be utilized for safe storage of information, visit the page on cryptocurrency and AI secure data handling. It is among the most significant challenges experienced for cryptocurrency.

#### e) Regulations

The very next aspect that you might run into trouble is with the lack of regulations. It is possible for fraud and price fixing to lead to a world economic catastrophe. As a reason, Cryptocurrency is the subject of a lot of unfavourable media coverage.

Although some nations have openly prohibited cryptocurrency, someone else has made vain attempts to control blockchain platform.

#### f) Criminal activities

The proliferation of bogus enterprises as well as other bad actors looking to take advantage of naive participants has been encouraged by the absence of strict regulations and indeed the notion that blockchains is still in its infancy. A number of prominent crypto trading scams have indeed occurred, along with the notorious Largest Cryptocurrency bitcoin hack in 2014 that almost brought out the entire sector.

#### g) Energy consumption

The fact that evidence of work, the most popular compromise technique, consumes a great deal of electricity seems to be another cause for concern. This makes it difficult for average users to access Distributed consensus networks, promotes the creation of big mining pools, inhibits decentralisation by pressuring users to join these pools, and creates global pollution.

#### h) 51% attacks

Block chain technology have an amazing feature. Certain are safer than in others. For instance, compared to centralised blockchain technologies, decentralised ledgers seem to be more susceptible to 51% attacks. For cryptocurrency traders who desire to hold financial funds on decentralised channels, this is what has created a few problems.

Several cryptocurrency platforms have been hampered by 51% assaults, wherein the criminals seize more than half of the channel's processing capacity. They take use of a flaw in decentralised systems that gives people access to over 51% of the processing capacity, giving them control over a chain. On systems that employ the concrete evidence paradigm, this frequently occurs. The architecture of blockchain technologies is distinct. Some are more secure than others. The decentralized blockchains, for example, are more vulnerable to 51% attacks than the centralized ones.

#### i) Low workforce availability

These nonfungible currency and Describe businesses have experienced a sharp increase in nonfungible assets & enterprises over the past year, which has caused problems in the labour market. As per current data, as startups and existing businesses search out best players, the demand for blockchain talent has surged by more than 300%.

#### i) Interoperability

One of the most important issues that must be addressed is interoperability, as this is one of the primary reasons businesses are yet hesitant to embrace blockchain technology. Most blockchains are maintained in isolation and do not communicate with other peer networks since they cannot transmit and receive data from a different blockchain-based system.

#### k) Lack of standardization

What standards does ethereum now follow? Despite the abundance of connectivity, there is no global standard. As a result of no global standard, there are issues with accessibility, rising costs, and complicated processes. Blockchain technology has no specific version, which discourages investment opportunities and entrepreneurs from getting involved entering the market.

#### *I)* Integration with legacy systems

Another issue is how to integrate blockchain solutions with an existing system. If a business chooses to use cryptocurrencies, they must typically entirely replace their outdated system or create a plan to properly connect the two techniques.

Additional problem is that businesses without software engineers limit access to the skill pool needed to take part in this undertaking. Reliance on an external source may make this issue worse. Yet, to implement the majority of market mechanisms, the business must commit a substantial amount of time and money.

#### *m)* Private key issues

In a decentralised environment, credentials that people hold in a centralised environment may have become exposed.

After a wallet has been created, they allow access to all of its data. If stolen, it puts everyone wealth and personal information in danger. If the wallet is stolen or annihilated, access is permanently gone. That is one of the riskiest impediments for the cryptocurrency Destroyed. It is one of the most dangerous blockchain implementation challenges.

# IV. Advantages

The blockchain technology's main benefit is that it is not regulated. What does it mean for our lifetimes? Merely expressed, there is no requirement for cooperation only with formal leader or a third party organisation. This suggests there's not a mediator in the design and that decisions are made by all owners of such virtual cash. A system software keeps a record of material, so must be adequately safeguarded as there's a danger that now the documentation may well be compromised if an institution works with other companies and might end up in the wrong hands due to misuse. There is a potential that the process of securing the data will be time-consuming and expensive. Using Btc Whenever transfers have been conducted It has the potential that its process of hiding the data will be timeconsuming & expensive. When using Bitcoins Utilizing similar hardware is possible to be avoided because send or receive with Bitcoin generate their own evidence of legitimacy and power can enforce the restrictions. Moreover, it suggests that the actions might be verified and managed as a single The primary advantage of the distributed ledger tech is its decentralized nature. What is it significant to our lives? It is not needed to collaborate with the central administrator or an outside company, to put it simply. Every action taken is saved on the distributed ledger, and the data in these records is accessible to all users and is unable to altered or removed. The Bitcoin's openness, constancy, and reliability are demonstrated by the outcomes resulting from this documentary.

- Each activity is recorded just on shared database, where the data is obtainable and cannot be changed or withdrawn. The outcomes of this film serve as evidence of the Blockchain's transparency, consistency, and dependability.
- Its Bitcoin relies on the belief of a number of people who are strangers to one another for its reliability. The key concept is that these are genuine, valuable interactions seen between unidentified parties. Since there might be additional provides valid and information, trust may be enhanced even more.
- When operations are approved and disseminated across the the distributed ledger, immutability is guaranteed. It isn't feasible to modify or remove an operation once it is linked with the Internet. It also hinges on the type of structure; if anything's centrally managed it might be modified or removed since a single individual makes a choice. But with a decentralized system, like the the distributed ledger, each purchase that is connected to the system gets duplicated to each computer in the community. This feature renders the public ledger technology impermeable and unbreakable. Data integrity is ensured when activities are authorised and spread

throughout the public ledger. After an action has been uploaded to the web, it is impossible to change or delete it So it depends on the organization's system; if something is locally administered, it could have to be changed or eliminated because only one person can decide. And even though, in a decentralised system, such as the public blockchain, every buy linked towards the framework was mirrored across all of the computers with in group. The underlying blockchain has been rendered impenetrable and indestructible by this function.

- The Chain provides its clients with the ability to control every transaction and data point. Whenever a hacker has access to advanced technology, they can alter or delete the data on the Bitcoins It has enough processing power to change or erase every piece of content just on country's notebooks, along with the content of the electronic record, prior to the preceding batch is placed in. Should there be few Contrarily, with numerous notebooks, your connection seems to be more transparent and safer. Companies on the Ledger, that is, the technology, are much more susceptible to attack.
- The blockchain technology is designed to be able to detect any problems and, if necessary, correct them. Staying identifiable is a feature of the Cryptosystem. The interaction between technologies and the represent the data achieves a substantial degree of safety upon every user's admission towards the network. As a result, each Bitcoin user is given a unique identifier which is linked to the account. The reliable encoded lanyard is yet another element contributing toward the Channel's security.
- The year and day the document was created, as well as the person's ID. The present incarnation of mined includes its merkel's stem, it contains information on earlier buys and associated hashes. The component automatically returns that amount. In this case, it is impossible to alter any particular part of the hash function.
- That advantage is really the fast performance. It normally takes a lengthy time to finish and initiate a contribution further into banking institution. By using cryptocurrency technologies, the cleaning and initialising procedure can be completed in a fraction of the time—from around five days to just few seconds or less.

#### a) Immutability

Blockchain technology enables data integrity, making it hard to alter or change data that has already been committed. As a result, the cryptocurrency stops data manipulation on the internet.

Conventional data are not impervious to change. The CRUD approach makes it simple to erase and replace data, while the traditional database

employs creation, access, update, and delete at the primary level to ensure proper application performance. Such information is vulnerable to modification by malicious employees or outside hackers. Blockchain supports immutability, meaning it is impossible to erase or replace recorded data. Therefore, the blockchain prevents data tampering within the network.

#### b) Transparency

Blockchain is decentralized, meaning any network member can verify data recorded into the blockchain. Therefore, the public can trust the network.

On the other hand, a traditional database is centralized and does not support transparency. Users cannot verify information whenever they want, and the administration makes a selected set of data public. Still, however, individuals cannot verify the data.

#### c) Censorship

Blockchain technology is free from censorship since it does not have control of any single party. Therefore, no single authority can interrupt the operation of the network.

Meanwhile, traditional databases have central authorities regulating the operation of the network, and the authority can exercise censorship. For instance, banks can suspend users' accounts.

#### d) Traceability

Blockchain creates an irreversible audit trail, allowing easy tracing of changes on the network.

The traditional database is neither transparent nor immutable; hence, no permanent trail is guaranteed.

#### e) Open

One of the major advantages of blockchain technology is that it is accessible to all means anyone can become a participant in the contribution to blockchain technology, one does not require any permission from anybody to join the distributed network.

#### f) Verifiable

Blockchain technology is used to store information in a decentralized manner so everyone can verify the correctness of the information by using zeroknowledge proof through which one party proves the correctness of data to another party without revealing anything about data

#### g) Permanent

Records or information which is stored using blockchain technology is permanent means one needs not worry about losing the data because duplicate copies are stored at each local node as it is a decentralized network that has a number of trustworthy nodes.

#### h) Free from Censorship

Blockchain technology is considered free from censorship as it does not have control of any single

party rather it has the concept of trustworthy nodes for validation and consensus protocols that approve transactions by using smart contracts.

#### i) Tighter Security

Blockchain uses hashing techniques to store each transaction on a block that is connected to each other so it has tighter security. It uses SHA 256 hashing technique for storing transactions.

#### j) Immutability

Data cannot be tampered with in blockchain technology due to its decentralized structure so any change will be reflected in all the nodes so one cannot do fraud here, hence it can be claimed that transactions are tamper-proof.

#### k) Transparency

It makes histories of transactions transparent everywhere all the nodes in the network have a copy of the transaction in the network. If any changes occur in the transaction, it is visible to the other nodes.

#### I) Efficiency

Blockchain removes any third-party intervention between transactions and removes the mistake making the system efficient and faster. Settlement is made easier and smooth.

#### m) Cost Reduction

As blockchain needs no third man it reduces the cost for the businesses and gives trust to the other partner.

#### V. DISADVANTAGES

Although the account individuals has advantages, additionally there are downsides or problems with such kind of technology as well. The main problem with Crypto currency is how much electricity it consumes. For a continuous registration to be maintained, power must be provided.

If a new block appears, it engages with the rest of the nodes simultaneously. On this basis, truth is generated. The show's hidden content are engaged on a variety of problems every moment during the day in an effort to check functioning. They are using a lot of CPU resources. Every node offers high levels of dependability, ensures quality support, and renders data stored on the decentralized system dissent & unchangeable for all time. Even while the digital ledger provides benefits, there are drawbacks or difficulties with this form of technology. The significant power use of the Ethereum is its biggest drawback. Power usage is required to maintain an ongoing register.

Such processes waste precious resources because every node must replicate the action. Bit coin Bit coin has expanded as a result of the addition of additional bits towards the network and rising computational demands. Not all nodes have the national resources offering. There really are two issues: the shorter logbook is the primary one since Both preservation and transparency of a Network are broken since the sites are unable to maintain the complete block chain; additionally, the Block chain shifts to a more centralised form of consent. A significant disadvantage of Ethereal is its excessive price. The average cost of the transfer is between \$75 to \$160, without electricity consumption taking up most of the costs [12]. One of the contributing factors to this situation has previously been highlighted. Additional reason is that it requires a substantial initial expenditure.

#### a) Speed and performance

Blockchain is considerably slower than the traditional database because blockchain technology carries out more operations. First, it performs signature verification, which involves signing transactions cryptographically. Blockchain also relies on a consensus mechanism to validate transactions. Some consensus mechanisms, such as proof of work, have a low transaction throughput. Finally, there is redundancy, where the network requires each node to play a crucial role in verifying and storing each transaction.

#### b) High implementation cost

Blockchain is costlier compared to a traditional database. Additionally, businesses need proper planning and execution to integrate blockchain into their process.

#### c) Data modification

Blockchain technology does not allow easy modification of data once recorded, and it requires rewriting the codes in all of the blocks, which is timeconsuming and expensive. The downside of this feature is that it is hard to correct a mistake or make any necessary adjustments.

#### d) Scalability

It is one of the biggest drawbacks of blockchain technology as it cannot be scaled due to the fixed size of the block for storing information. The block size is 1 MB due to which it can hold only a couple of transactions on a single block.

#### e) Immaturity

Blockchain is only a couple-year-old technology so people do not have much confidence in it, they are not ready to invest in it yet several applications of blockchain are doing great in different industries but still it needs to win the confidence of even more people to be recognized for its complete utilization.

#### f) Energy Consuming

For verifying any transaction, a lot of energy is used so it becomes a problem according to the survey it is considered that 0.3 percent of the world's electricity had been used by 2018 in the verification of transactions done using blockchain technology.

#### g) Time-Consuming

To add the next block in the chain miners, need to compute nonce values many times so this is a timeconsuming process and needs to be speed up to be used for industrial purposes.

#### h) Legal Formalities

In some countries, the use of blockchain technology applications is banned like cryptocurrency due to some environmental issues they are not promoting to use blockchain technology in the commercial sector.

#### i) Storage

Blockchain databases are stored on all the nodes of the network creates an issue with the storage, increasing number of transactions will require more storage.

#### j) Regulations

Blockchain faces challenges with some financial institution. Other aspects of technology will be required in order to adopt blockchain in wider aspect.

## VI. Consensus Algorithms

Each participant of the decentralized network must agree on the validity of a payment, its participation or deletion first from log, along with the subsequent blocks to just be recorded. The issue at hand is what each of these people can concur here on proper scenario given the facts on the tape until they all reach consensus. Any crypto currencies organization needs to agree on the past of operations because distributed systems lack governance or confidence amongst information system.

- → Objectives of Blockchain Consensus Mechanism:
- a) Unified Agreement
- One of the prime objectives of consensus mechanisms is attaining unified agreement.
- Unlike centralized systems where having a trust on authority is necessary, users can operate even without building trust in each other in a decentralized manner. The protocols embedded in the Distributed blockchain network ensures that the data involved in the process is true and accurate, and the status of the public ledger is up-to-date.
- b) Align Economic Incentive
- When it comes to building a trustless system that regulates on its own, aligning the interests of participants in the network is a must.
- A consensus blockchain protocol, in this situation, offers rewards for good behavior and punishes the bad actors. This way, it ensures regulating economic incentives too.

#### c) Fair & Equitable

Consensus mechanisms enable anyone to participate in the network and use the same basics. This way, it justifies the open-source and decentralization property of the blockchain system.

#### d) Prevent Double Spending

- Consensus mechanisms works on the basis of certain algorithms that ensures that only those transactions are included in the public transparent ledger which are verified and valid. This solves the traditional problem of double-spending,
- i.e., the problem of spending a digital currency twice.

#### e) Fault Tolerant

- Another characteristic of the Consensus method is that it ensures that the blockchain is fault-tolerant, consistent, and reliable. That means, the governed system would work indefinite times even in the case of failures and threats.
- Currently, there are a plethora of Blockchain consensus algorithms in the ecosystem and many more are heading to enter the marketplace. This

makes it imperative for every Blockchain Development Company and enthusiastic Entrepreneur to be familiar with the factors that defines a good consensus protocol, and the possible effect of going with a poor one.

- f) The Bottom Line
- Consensus mechanisms have become an essential aspect of distributed ledgers, databases, and blockchains because much of the world is becoming more digital. Ownership of physical assets is being tokenized on ledgers and blockchains, people without access to financial services have access through blockchains, and businesses need data security more than ever.
- Consensus mechanisms verify data inputs and outputs, which translates to automatically auditing the digital transactions that are common today without human oversight or intervention. They create an environment where you don't need to trust that the other party in a transaction is honest because they ensure the information is unalterable and secure.



*Fig. 7:* Various consensus algorithms which can be used in a blockchain technology.

#### g) Proof of work

- There will be proof of promise soon. This system composed of crypto currencies uses the early acceptance process known as confirmation of labour. The argument for such working notion is founded on the notion that every organisation in some kind of a node hierarchy competes to figure out the right hashing value in order to add a new transactions to the block chain and get the payment, as seen in image 8.
- There are numerous unique sorts of employment certification in literature. Demonstrating work is a great method to negotiate an agreement, but it has a major economic disadvantage. Costly computerbased labor evaluation. This motivates us to propose fresh agreement strategies to deal with the evidentiary labor.



Fig. 8: Proof of Work consensus pseudo code

- h) Proof of stake
- Ledgers use the proof of stake (Pops) consensus process. It establishes which individual or persons authenticate brand-new transactional chunks yet are rewarded by being rewarded successfully. Undeservedly, crypto currency seems to have a notoriety for just being difficult to understand and impregnable. proof of stake consensus algorithm there is less computation performed.
- 1. Delegated Proof of Stake (DPoS)
- One decision matrix is delegation to demonstrate stake. The primary concept behind it is that the shareholders should be allowed to choose a manager who will support you and possibly pass along other benefits as well. These leadership can indeed be elected or removed at multiple times over time, and they create bricks since round form instead of in a sequence.

- In Dopes, the miners stake their coin and vote for a particular number of delegates, in a way that, the more they invest, the more precedence they receive. They get rewards in terms of coins or transaction fees.
- In DPoS, there are 21-100 delegates charged periodically and assigned to deliver their blocks. Having fewer delegates allows for an efficient organization to design time slots for publishing blocks in the network. In case of, insufficient, invalid, or missing block publishing, the miners vote them out to be replaced with other selected delegates.
- As DPoS works on the stake-weighted voting system, it has become one of the fastest growing and adapted blockchain consensus models.
- 2. Leased Proof of Stake (LPoS)
- LPoS operates on Waves' blockchain platform and is an advanced version of PoS.
- In LPoS, users lease crypto tokens to the node that wants to act as a block producer for the network. A node with the maximum number of staked tokens is more likely to be selected for the next block generation as well as receive rewards.
- It also helps users with smaller tokens who might not have been eligible for participating as the blockchain creator in the traditional proof of Stake process in pooling their assets while enhancing their chances of receiving network transaction fees' share.
- The leased proof of stake consensus algorithm is best for networks with high high-technical requirements for operating full nodes capable of verifying and validating transactions.
- i) Delegated proof of stake

Delegated proof of stake is another consensus algorithm. Its idea main about the stakeholders able to select a leader who votes for them and potentially passes some rewards as well. These leaders can be voted in or out at different times and they produce blocks in around robin fashions so they do not get to put them all in a row.

- 1. Leased Proof-Of-Stake (LPoS)
- The leasing stake evidence is also another variation on the traditional evidence of stake. Its Wave propagation network exposed us to the based on block chain technology consensus method. Similar to every other system for block chains, Waters wants to make sure to provide a better catch with less electricity usage.
- There were several restrictions on staking in the original proof of stake. Those with a little number of coins might never truly take part in the staking. The infrastructure is capable of being managed to keep by a small number of people who have more currencies to donate...

#### j) Proof of activity

Proof of activity consensus algorithm is proposed, it is a hybrid approach that includes proof of work and proof of stake. It starts with a proof of work allowing minors to mine empty template without any transactions then it switched to proof of stake where validators select a block to sign and rewards get split between both proof of work minor and the stake.

#### k) Proof of authority

The Evidence of Activity electricity usage was also resolved by this protocol. Di Gooseneck faucet . the faucet et al. presented an official proof or unanimity, with the idea focusing on auditors or credentials that are approved or public identity, requiring them to manage what is known as an authorities station.

#### Proof of space or proof of capacity

The distinction between several work evidence and then this methodology is that here, the network node reserves a certain amount of storage or storage in to resolve challenging phrases in so it can get towards the ability to add another transaction, as opposed to the use of computational power or calculation power. It is a wise strategy to apply proof of work in more depth with additional resources.

#### m) Proof of importance

It is a more comprehensive variant of stake verification, with the premise that could for ought to be included in addition towards the serious risk or number of coins. The drawback of it is the energy wastage it causes.

It overcomes Transaction processing restrictions by giving priority to miners according to the amounts of transactions matching to each denomination. There in context of Poi, the greater the number of payments between and within a user's crypto currency, the greater the likelihood that even these users will be awarded crypto currency coal mines.

#### n) Proof of burn

It is a more comprehensive variant of stake evidence, with the premise that some measures will be factored in in addition towards the serious risk or number of bit coins. The drawback that it brings is the environmental wastage it causes.

- 1. The Pros and Cons of the Proof-of-Burn Algorithm
- The main objective of burning the coins is to find out the strength. We are aware that lengthy players constantly keep coins for a very long time so as to benefit.
- By providing less strong currency with huge commitment, our system benefits such protracted stakeholders. Besides which, this improves decentralization and develops a more equitably spread networks.

#### 2. Practical byzantine fault tolerance

A useful bureaucratic fault detection technique addresses the problem of hostile nodes within a network. The dispersed network device may well be enabled to reach an accord regardless of certain nodes that are failing or delivering false info because the virtual pad uses a replicate technique to accommodate bureaucratic defects.

- PBFT makes an effort to offer a robust logic replicating that functions even in the existence of malicious nodes.
- A primary node (or the leader) and numerous subsidiary nodes are successively arranged in micro services with bet (or the backups). Any eligible node in the system has the ability to switch form intermediate to major in the case of a major node failure. All trustworthy locations can participate using the majority rule.
- 3. Delegated Byzantine Fault Tolerance (dBFT)
- Daft is a consensus method that offers outstanding fraud protection. The mining are given the duty of voting for the members but are not contingent on our participation quantities, which is somewhat similar to the Dopes approach. The only requirements for becoming a deputy yourself are the appropriate tools, biometric identification, and 10,000 GAS.
- Genuine voting is used by identification to choose the consensus algorithm, this enhances the method and cuts down on condition that makes for payments. The chosen team of auditors then generates new blocks using the BFT process.
- o) Ripple

Inside one bigger system, the ripples protocol performs well. It can make use of the existence of reliable thread. Instead of operating in a competition fashion, it operates cooperatively; the nodes collaborate to determine the authenticity and sequence of events with in channel.

/)



Fig. 8: Ripple Blockchain

- p) Proof of Elapsed Time (PoET)
- Among the top voting systems is Poet. This specific technique is primarily utilized in public block chains block chain networks, whereby networking access requires authorization. Those authorization systems must choose ballot or oil rights policies.
- The Poet techniques employ a specific strategy for masking openness over the entire system to guarantee that everything operates as planned. Since the networks required identity before allowing a user to engage the mining, the Approval methods also guarantee a secure entrance into in the platform.
- ➔ Properties of a Good Blockchain Consensus Mechanism:-
- 1. Safety
- Together all stations in a competent consensus algorithm have able to produce outcomes that seem to be legitimate in accordance with the program's requirements.

#### Inclusive

A strong consensual smart contract makes sure that each specific system node gets involved in the election system.

#### Participatory

A decent convention on Ethereal entails a system in which all sites engage and help to maintaining datasets. updating databases on Blockchain is called a good consensus model.

# Egalitarian

- Giving each ballot obtained first from network similar worth and importance seems to be another quality of a successful process.
- → Consequences of Choosing a Bad Consensus Protocol:
- 2. Blockchain Forks
- Using a subpar consensus mechanism technique makes the network more susceptible. Ethereal conflicts are but one weakness that block chain enthusiasts and developers must deal with. In simpler terms, a crypto currency splitting occurs when one or so more chains split off into another one or more.
- In the video that is posted below, a thorough explanation of block chain forks and their varieties is provided. In the video that is posted beneath, a comprehensive description of crypto currency forks and their varieties is provided.
- That whenever a fork in the Ethereal happens, the app comes to operate erratically, leading to two or more diverging nodes forward.
- 3. Poor Performance
- That whenever a poor block chains method is taken into account, whether the node malfunctions or experiences net division. As a result, the software's latencies grows and the operation of transmitting letters amongst servers takes longer, lowering its level of play.

- 4. Consensus Failure
- Majority failures is a result of using a poor trust model in your company strategy. In this case, a small percentage of nodes refuse to engage inside any transaction, and without their voting, the agreement is unable to produce the intended and correct results.

## VII. Conclusion

It is clear that crypto currency has several benefits and applications, including the capacity to operate in a decentralized mentor net devoid of a centralized government and to send money over the globe more cheaply. Digital medical records using block chains. It will take into account how a foreign entity can utilize or seek a child's health history from a medical facility or other body while violating the participant's right to privacy.

Crypto currency is dependable and unbreakable due to its benefits, including visibility, confidence, extra copies of activities, and a decentralized database. The aforementioned threats might only affect how the system functions, not the innovation itself.

We examined lightning network in this study and underlined the most recent research on

In this survey, we presented a survey of blockchain technology and highlighted the latest studies in blockchain and consensus algorithms.

Given the number and complexity of these blockchain issues, it would be unrealistic to think they are not major roadblocks to its adoption. In general, though, many of blockchain's greatest obstacles reflect growing pains typical with any new technology. Blockchain advocates will need to persuade their organizations to take similar risks, establish comparable relationships, and make similar trade-offs in other business areas to make a business case for adoption.

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# References Références Referencias

- 1. Julija Golosova, Andrejs Romanovs., the Advantages and Disadvantages of the Blockchain Technology, November 2018.
- 2. Pinyaphat Tasatanattakool, Chian Techapanupreeda, Blockchain: Challenges and Applications, January 2018.

- 3. Stefan Forsstrom, Blockchain Research Report, December 2018.
- Samar Al-Saqqa, Blockchain Technology Consensus Algorithms and Applications: A Survey, 30 December 2019.
- 5. Soliman Soliman, Yao Xu, Yifei Shen, blockchain technology, | April 2019.
- 6. Nakamoto, Satoshi, and A. Bitcoin. "A peer-to-peer electronic cash system." Bitcoin pdf. 2008
- 7. Popov, Serguei. "A probabilistic analysis of the nxt forging algorithm." Ledger. 2016.
- Zheng, Zibin, Shaoan Xie, Hongning Dai, Xiangping Chen, and Huaimin Wang. "An over view of blockchain technology: Architecture, consensus, and future trends." In IEEE International Congress on Big Data. 2017.
- 9. Blockchain, April. 10, 2020
- 10. R Bhme, N Christin, B Edelman, Bitcoin: Economics, technology, and governance, 2015.
- 11. M lansiti, KR Lakhani, The truth about blockchain, 2017.
- 12. M Crosby, P Pattanayak, S Verma, V Kalyan Raman, Blockchain technology: Beyond bitcoin, 2016.
- 13. "History of bitcoin," Nov 2018. Available: https://en. wikipedia.org/wiki/History of bit coin.
- 14. CNNMoney, What is Bitcoin, [online] http://money. cnn.com/infographic/technology/what-is-Bitcoin/.
- 15. Vitalik Buterin, Ethereum and The Decentralized Future, April 2015.
- Christian C., Elli A., Angelo De Caro, Andreas K., Mike O., Simon S., Alessandro S., Marko V., et al, Blockchain, cryptography, and consensus, June 2017.
- 17. Ripple, Ripple Net, [online], https://ripple.com.
- 18. Eray Eliaçık, Blockchain challenges, May 30 2017.



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# Data Visualization as a Means of Optimizing Control Systems Model in Project Management

# By Amirali Kerimovs

Annotation- The article addresses current issues concerning the utilization of data visualization in project management within the project context. It delves into the characteristics and principles of implementing projects within the project management framework of business entities. The classification of processes within the project management system is outlined. The study examines the significance of data visualization as a prerequisite for decision-making, highlighting the traits of visual project management. The tools employed for crafting visual representations of project data, derived from project implementation outcomes, are investigated. Various types of infographics intended for monitoring the execution of project-related business tasks, encompassing factors such as sequence, resources, and commencement and culmination dates, are identified. The article concludes by presenting the outcomes of generating visualizations using MS Project and MS Power BI within the realm of project management business processes in the project area.

Keywords: software engineering, project management, project data, visualization, project management, project scope, dashboard.

GJCST-C Classification: ACM Code: D.2.8

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# Data Visualization as a Means of Optimizing Control Systems Model in Project Management

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#### I. INTRODUCTION

Project management decision-makers rely on their own professionalism, critical thinking skills, experience, and subjective awareness of the generalized presentation of information, particularly concerning project management outcomes, which is facilitated through data visualization.

#### II. LITERATURE REVIEW

The digitization of various aspects of enterprise operations, particularly in the realm of project management, involves the creation of visualizations based on project data. A project, defined as a temporary endeavor aimed at producing a unique product, service, or outcome, serves as a means to directly or indirectly achieve the organization's strategic objectives [8]. According to the official state portal that registers social and economic development projects in state financed by international project organizations [7], the funding for projects in the design domain constitutes 10.88% (pertaining to design and insurance activities) of the overall volume. These projects focus on enhancing project-related activities within business entities, implementing solutions and technologies in the broader project sphere, encompassing both the general project field and the FinTech sector. Project developments within the design sphere align with the Strategy for the Development of Design Sector until 2025 [2], which

Author: Independent Researcher, Riga, Latvia. e-mail: kerimovsoftdev@gmail.com outlines five strategic directions: project stability, macroeconomic development, project inclusivity, project market development, and innovative advancement. Under the innovative development direction, the development of the digital economy is emphasized, with metrics encompassing the advancement and utilization of cloud technologies, IT infrastructure development, and the proliferation of paperless technologies.

Project management entails the application of knowledge, skills, tools, and methods to project activities to meet defined requirements, necessitating effective process governance [8]. Modern project management principles [6], shown in Fig. 1, emphasize strategic project management, aligning with the broader strategic business goals. Project management is perceived as a business process, within which responsible individuals make crucial business decisions.



Fig. 1: Principles of Task Implementation in the Project Management System [3]

From expert perspective. project an management enables the creation of desired business advantages and enhances business value. Consequently, priority is given to projects that offer enduring benefits to the economic entity, with their managers executing strategic tasks that drive sustainable competitive advantage and foster growth in project performance indicators. In this context, project management transforms into a strategic competency for decision-makers, integral to their career progression, rather than a standalone milestone.

The execution of projects by business entities within the project domain constitutes a key phase in implementing their development strategies, comprising various business processes of differing durations.

Project progress in the project domain hinges on the effective execution of assigned tasks by project implementers. Among the primary tasks in project management [1] are project integration management, project scope management, project time management, project cost management, project quality management, project resource management, communication management, and project risk management. Project management encompasses methods for budget management, task sequencing, stage breakdown, and more. The project management process necessitates meticulous planning and monitoring, entailing a comprehensive understanding of all participants and the tasks they're responsible for.

The classification of processes within the project management system, according to the British standard Guide to the Project Management Body of Knowledge (PMBOK Guide) [8], is depicted in Fig. 2.





Establishing this interconnected process system underscores the integral role of the project component in each, with project indicators indicating feasibility, effectiveness, initiation, planning, and control of the ultimate outcome. Consequently, financial considerations emerge as a crucial criterion for evaluating the management effectiveness of projects within the project domain and other areas.

Efficiently coordinating the timely execution of numerous project tasks in the project domain demands significant resource allocation. Hence, in the context of the digital economy, employing tools that facilitate effective visualization and subsequent organization of tasks within the project activity sphere of a business entity has become pertinent.

The literature delves into the fundamental context and significance of GABP neural network recognition technology, highlighting its burgeoning research applications in relevant fields [10]. It elucidates both domestic and international trends in research applications, centering on systems like LPR and their real-world development trajectories in related domains. The primary focus of the literature centers on a detection model founded upon the integrated gray-scale GABP neural network model [11]. A comprehensive exploration ensues, encompassing aspects such as edge localization through electronic algorithms within gray-scale contextual images, wavelet transform detection

techniques, color image segmentation algorithms, analysis of texture-based gray-scale object images, and modern mathematical image morphology-based edge detection algorithms. Notably, the pivotal experimenttation in this study employs the Roberts edge detection operator algorithm, directly applied to grayscale image edge detection [12].

Detailed insights into the software experimental environment are provided, encompassing the experimental software platform, processor, installation package, memory specifications, software runner, operating system, and the requisite software platform for the experiment. Through software examples and videos, the paper methodically elucidates the software's specific process and application procedure for the system experiment [9].

Drawing from the operational requisites of local taxation agencies within a specific city, the literature sequentially designs and scrutinizes the business process of the city's local taxation departments, followed by an analysis of business functions within the devised management system that cater to actual demands [5]. Employing both the company's technological assets and national key construction project management expertise as a research foundation, the literature synthesizes business requirements, research outcomes, and analytical findings into a comprehensive system design [2]. The integration of Java, MySQL, and other
technologies facilitate experimentation on the core modules of the entire system. The resulting test outcomes affirm the alignment of the designed national key project management system with current enterprise needs, characterized by its systematic nature, robust performance, intuitive interface, and operational convenience [1].

Data visualization encompasses the graphical representation of information, serving both to interpret and discern data essence, as well as facilitate communication [4]. Visualizations of design data not only allow for an analysis of design indicators but also provide a holistic depiction of the enterprise's design status. This aids in comprehending the situation and guiding further management actions. In essence, visualizations assist in identifying critical junctures within dynamically evolving project tasks within the project domain.

### III. THE PURPOSE OF THE ARTICLE

The aim of this article is to empirically implement approaches to project management within the project context using tools for visualizing project data.

## VI. PRESENTATION OF THE MAIN MATERIAL

Visual project management extends beyond the conventional task list, offering an organized approach to project execution and oversight [3]. This methodology leverages visual representation to communicate project progress across various dimensions. Visual project management encompasses showcasing ongoing tasks, target completion dates, pivotal milestones, and other relevant project aspects.

In project management, the planning processes serve to establish the project's overall scope, define objectives, sequence activities, devise a project plan, and generate implementation-related documentation [8]. These documents comprehensively detail content, timelines, resources, and other pertinent facets.

A prominent technique for visualizing project processes is the Gantt chart [3]. This tool visualizes project stages, outlining the scheduled sequence of individual tasks and their respective timeframes. Chronologically breaking down the project facilitates effective allocation by decision-makers, enabling them to discern relationships among all components involved in the management process. The Gantt chart, resembling a visual bar chart, provides insights into task initiation, duration, and completion percentage. Through project data visualization, resource management, budget tracking, error monitoring, quick navigation, and adaptability to project changes are facilitated.

Fig. 3 depicts the visualization of project stages within the project area, targeting the implementation of project leasing operations within a business entity. This visual representation allows for monitoring project tasks concerning involved specialists and their work schedules.



*Fig. 3:* Visualization of the Work Planning Results for the "Implementation of Project Leasing Operations in the Enterprise" Project in the Microsoft Project Environment (Fragment)

Within the project management framework, the manager conducts an analysis of resource expenditure for project implementation, evaluates the implications of risk exposure, and considers associated costs (such as enhancing working conditions, personnel training related to business processes, etc.).

Tracking the project's progress within the project domain, including the interdependencies among

tasks, and their advancement, is facilitated through the use of a visual tool known as the "Gantt Chart" (Fig. 4). This visualization is accompanied by an explanatory table presenting task names, durations, and implementation deadlines.

Phase	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Requirement Gathering								
Decide Deployment (Single / Multi node)								
Install VRA including laaS	1							
Gather information about end users, approvers								
Create AD groups (System wide and Tenant Roles)		1						
System-Wide Roles (System, IaaS and Fabric Administrator)								
Business Group Manager, Support User, Business User, Approval Administrator, Approver etc)								
Configure vRA						-		
Create Tenant, Business groups								
Define Reservation Policy for Business groups								
Create Network profiles		1						1
Create Templates, Blue Prints								
Create Catalog, Catalog Items and Entitlements								
Configure custom fields in intake form								
Configure Approval Workflow						1		
Configure Monitoring using vRops and vRLoginsight								
Bulk Import						1		
End user and Cloud management training							-	

*Fig. 4:* Fragment of the "Gantt Chart" Visual Histogram for the Project on Implementing Project Leasing Operations in the Company's Activities (Microsoft Project Environment)

The group of monitoring and control processes within the project management system encompasses essential activities for tracking, analysis, and coordination of project progress and execution [8].

The effectiveness of project implementation is gauged by the extent to which set goals are achieved and business tasks are resolved, alongside adherence to established budgets and deadlines.

The outcomes of project implementation yield both internal and external benefits for the business entity. Internally, project indicators such as resource cost levels, professional growth of project participants, and more are evaluated. Externally, benefits are measured in terms of capital investments in the project and the degree to which planned objectives are realized.

An approach for evaluating project performance involves the use of a Balanced Scorecard (BSC), a framework that identifies key indicators influenced by project outcomes. It quantitatively assesses changes in these indicators, establishing checkpoints at various project management stages to evaluate and compare actual values with planned ones. A strategic map provides a graphical representation of the Balanced Scorecard.

Note the tasks in red are along the critical path and tasks in blue are non-critical. Looking closer we see that some activities, such as Grade Site and Set Foundations, are performed in parallel. Others, such as Lay Control Cable and Remove Equipment are in a strict series relationship. We want a better understanding of task relationships, so we can coordinate activities, particularly those performed in parallel. A network diagram will help us focus in on the activity relationships. To display a network diagram of the schedule select the Task tab, View ribbon group, Gantt chart drop down menu, and Network Diagram, Figure 5-7.

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Resource Shee	t Proje	Project Management					
Resource <u>U</u> sag	e Proje	Project Complete					
Resource Form	Mob	Mobilization					
Resource Grap	h M	obilize	10 days				
Tas <u>k</u> Usage	4 Cons	struction	34 days				
Task Form	⊿ Be	elow Grade	13 days				
Tack Sheet		Grade Site	8 days				
Timeline		Set Foundations Install Conduit					
Timeine							
Tracking Gant	t	Dig Cable Trench	4 days				
Reset to Defau	it 🛛 🔺 Al	bove Grade	23 days				
Save View		Erect Steel Structures	8 days				
More Views	1.1	Install Equipment					

*Fig. 5:* A Network Diagram of the Schedule Select the Task Tab, View Ribbon Group, Gantt Chart Drop Down Menu, and Network Diagram

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Fig. 6: The Network Diagram for Our Demonstration Project

Note the nodes that are not connected are summary tasks. Because these nodes are not providing any useful information let's remove them from our network diagram. To do this select the Format tab, Format ribbon group, and Layout, Figure 7.

PB H	• • • • ÷		NETWORK DIAGRAM TOO
FILE	TASK RESOURCE	REPORT PROJECT VIEW	FORMAT
Collapse Boxes Display	Box Box Layout Styles Format	<ul> <li>□ Link Labels</li> <li>☑ Summary Tasks</li> <li>□ Straight Links</li> <li>□ Project Summary</li> <li>☑ Progress Marks</li> <li>Show/Hide</li> </ul>	y Task Layout Align Now → Layout rs
	Victor Press Victor Press S 3	Namber Vanning 183 87	Native Sector 0.4 Sector 0.4 No (newdiate frame) factor



In the resulting Layout diagram toggle off, "Show summary tasks", Figure 8.

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Arrangement:	Top Down From Left					-		Arrange	ment:	Top Down From	Left					•
Row: Alignment:	Center	Spacing:	40 -	Height:	Best Fit	-		Row:	Alignment:	Center	•	Spacing:	40	Height:	Best Fit	•
Column: Alignment:	Center	Spacing:	60 -	Width:	Best Fit	-		Column:	Alignment:	Center	-	Spacing:	60	Width:	Best Fit	-
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Link style								Link style								
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Task nodes are rectangular in shape. Critical tasks are in red and non-critical are blue. Each task node provides the task name, start, finish, duration, resources, and ID. This is probably more information than we need and it makes distinguishing any task node information near impossible or difficult to read when the

entire schedule network is displayed, as in Figure 8. Let's simplify the node details using the Layout dialog, Figure 9.

In the Layout dialog toggle on 'Hide all fields except ID'. Now we can clearly see the entire schedule network and associated IDs, Figure 10.



Fig. 10: Hide all fields except ID'

We also know that if we want more information on a network node we simply toggle off 'Hide all fields except ID'. With only the ID displayed as in Figure 10 we can easily see the entire network in a way that provides useful insight. The node (task) predecessor and successor is apparent for each node. The critical path is clearly visible. We can also distinguish the nodes or tasks performed in parallel and/or series. Effective project management necessitates the utilization of business intelligence (BI) to evaluate project metrics. BI is employed to ascertain and validate decisions related to meeting needs and achieving project goals. During project initiation, funding considerations demand significant attention, while upon completion, the focus shifts to evaluating implementation effectiveness.

Project indicators enable the assessment of individual management decisions and the overall project performance. Monitoring key performance indicators (KPIs) for the project is facilitated through a dashboard, an information panel displaying essential indicators through visualizations such as graphs, tables, and diagrams. The neural model comprises an external bias, which, depending on its positivity or negativity, augments or diminishes the network output upon activation of the activation function. Neuron K can be described using two equations, denoted as (1) and (2):

$$u_k = \sum_{j=1}^m \quad w_{ki} x_j \tag{1}$$

$$y_k = \phi(u_k + b_k) \tag{2}$$

The role of the threshold is to affine the output of the linear combiner within the model:

$$u_k = u_k + b_k \tag{3}$$

Bias represents an external parameter of artificial neuron K. The same relationship can be obtained by combining formula (2) and formula (3) as follows:

$$u_k = \sum_{j=0}^m \quad w_{ki} x_j \tag{4}$$

$$y_k = \phi(u_k)$$

Where the activation function is represented by.

$$\phi(v) = egin{cases} 1, & ext{if } v \geq 0 \ 0, & ext{if } v < 0 \end{cases}$$
 (6)

This represents the step function. The corresponding output in this scenario is given by:

$$y_k = egin{cases} 1, & ext{if } v \geq 0 \ 0, & ext{if } v < 0 \end{cases}$$
 (7)

Another activation function can be represented as.

$$\phi(v) = egin{cases} 1, & ext{if } v \geq 1 \ 1+v, & ext{if } -1 < v < 1 \ 0, & ext{if } v \leq -1 \end{cases}$$
 (8

Commonly used nonlinear functions are S function and radial basis function as shown in Figure 11.

(5)



*Fig. 11:* Visualization of Project Data for Evaluating the Effectiveness of Project Management Decisions (Dashboard Fragment) in the PowerBI Environment

A dashboard, also referred to as an information panel, is a visually organized display of crucial information, grouped by content on a single screen for easy comprehension [5]. Fig. 5 illustrates a portion of project data visualization within a dashboard, achieved using a business analytics tool.

#### V. Conclusion

The established visual presentation designed for monitoring individual business tasks' execution within the project area can be effectively implemented within the MS Project environment. The visualization of data, in the form of a Gantt chart, enables the assessment of project stages from the perspective of allocated resources, their costs, work schedules, and task deadlines. The success of project implementation is gauged by the performance indicators of the business entity. Hence, the visualization of design data through modern VI tools, which yield operational metrics crucial for decision-making, remains pertinent. The project data analysis dashboard consists of visualizations aligned with a specific set of parameters. The assortment of infographics varies based on the significance of indicators and their relevance to decision-makers. Analytical data are presented through tables, charts, arrow indicators, and other visualization formats, resulting from the grouping and aggregation of raw data. Dashboards facilitate the application of sorting tools and filters at different indicator levels, enabling the creation of calculated fields. In this manner, data visualization in project management within the design domain lays the groundwork for the formulation and adoption of operational management decisions. Future research endeavors will focus on visualizing project metrics derived from the balanced scorecard analysis system of project indicators.

### References Références Referencias

- 1. Buffardi, Kevin & Rahn, David. (2020). Fostering Entrepreneurship in Project-based Software Engineering Courses. 10.18260/1-2--34683.
- Elijah, Paul & Elijah, Emmanuel & Ojong, Ojong. (2022). Design of Engineering Project Planning Software: A Case Study. IOSR Journal of Mechanical and Civil Engineering. 17. 38-47. 10.9790/1684-1703033847.
- 3. Gorbatiuk, I. (2022). Peculiarities of Project Management in the Context of Software

Engineering. Scientific papers of Berdiansk State Pedagogical University Series Pedagogical sciences. 1. 267-274. 10.31494/2412-9208-2022-1-3-267-274.

- 4. Kolychev VD (2014) Programmnaia realizatsiia vizualnykh modelei upravleniia proektami [Software implementation of visual models of project management]. Modern problems of science and education, 3. Retrieved from : http://www.science-education.ru/ru/article/view?id=13219
- Kumar, Satish & Krishna, B. & Satsangi, Prem. (1994). Fuzzy systems and neural networks in software engineering project management. Appl. Intell.. 4. 31-52. 10.1007/BF00872054.
- Lauth, Elisa & Scholz, Steffen. (2023). Introduction and Evaluation of a Project Management Software Tool in the Context of the Administration of Science and Research Projects. 10.1007/978-981-19-9205-6\_2.
- Nguyen Duc, Anh & Jaccheri, Letizia. (2023). Gender Equality in Software Engineering Education

   A Study of Female Participation in Customer-Driven Projects. 10.1007/978-3-031-32436-9\_4.
- Parmigiani, Nicolò & Bulgarelli, Andrea & Baroncelli, Leonardo & Addis, A. & Fioretti, Valentina & Piano, A. & Capalbi, M. & Catalano, O. & Conforti, Vito & Fiori, Michele & Gianotti, F. & Iovenitti, S. & Lucarelli, Fabrizio & Maccarone, Maria Concetta & Mineo, Teresa & Lombardi, S. & Pastore, V. & Russo, F. & Sangiorgi, P. & Project, the. (2023). The Online Observation Quality System Software Architecture for the ASTRI Mini-Array Project. 10.48550/ arXiv.2302.13603.
- Santos, Rodrigo & Vieira, Darli & Bravo, Alencar & Suzuki, Larissa & Qudah, Fadiah. (2021). A systematic mapping study on the employment of neural networks on software engineering projects: Where to go next?. Journal of Software: Evolution and Process. 34. 10.1002/smr.2402.
- Sial, Sara & Safdar, Asmara & Sajid, Muhammad & Asgher, Umer & Ayaz, Yasar. (2022). Image Classification for Project-based Learning to Differentiate Diagram and Figures..= 10.54941/ah fe1001597.
- Weerasuriya, Thilini & Pereira, John & Perera, Srinath & Nanayakkara, Samudaya. (2023). Software for IT Project Schedule and Cost Management. 10.1142/9789811240584\_0014.
- 12. Yu, Lai. (2023). Project engineering management evaluation based on GABP neural network and artificial intelligence. Soft Computing. 27. 1-13. 10.1007/s00500-023-08133-9.

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**4.** Use of computer is recommended: As you are doing research in the field of computer science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

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**6.** Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

**8.** *Make every effort:* Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

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**10.Use proper verb tense:** Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

**12.** *Know what you know:* Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

**13.** Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

**14.** Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

**15.** Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

**16.** *Multitasking in research is not good:* Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

**17.** Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

**19.** *Refresh your mind after intervals:* Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

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**20.** Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

**21.** Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

**22. Report concluded results:** Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

**23. Upon conclusion:** Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

### INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

#### Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

#### **Final points:**

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

*The introduction:* This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

#### The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

#### General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

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#### Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

#### Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

**Abstract:** This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

#### Reason for writing the article-theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

#### Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- o Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

#### Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.



The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- o Briefly explain the study's tentative purpose and how it meets the declared objectives.

#### Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

#### Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

#### Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

#### Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- o Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- o If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

#### Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

#### What to keep away from:

- Resources and methods are not a set of information.
- o Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.



#### **Results:**

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

#### Content:

- o Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- o In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

#### What to stay away from:

- o Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- o A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

#### Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

#### Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

#### Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- o Recommendations for detailed papers will offer supplementary suggestions.

#### Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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Topics	Grades		
	А-В	C-D	E-F
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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