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The nature and practices of the use of Machine Learning and Deep Learning Frameworks to assist Software Project Management: A Developing Country Context

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Abstract: - The study conducted a comprehensive analysis of literature and interviews related to the use of ML and DL in SPM, identifying challenges and gaps in the field. The study adopts a qualitative research design, gathering data through semi-structured interviews with project managers involved in SPM using ML and DL frameworks. The collected data is analysed using thematic analysis to capture the participants' subjective experiences, perceptions, and opinions. The findings suggest that while the use of AI techniques for SPM has been gaining attention, it is still in its infancy, with limited research and practice in developing countries. The study also emphasizes the unique challenges faced by developing countries in SPM, including limited resources, diverse stakeholders, cultural differences, and rapid changes. It suggests that ML and DL frameworks can offer advantages in enhancing the productivity, innovation, and competitiveness of software projects in these contexts. However, the study acknowledges that there are limitations to these AI techniques for SPM, and further research is needed to address these limitations. The study bridge the gap between theory and practice by offering practical insights for project managers and recommendations for future research in utilizing ML and DL frameworks to assist SPM.

Keywords: Machine Learning, Deep Learning, Project Managers, Software, Artificial Intelligence

1 INTRODUCTION

Software project management (SPM) process is crucial for effectively planning, executing, monitoring, and controlling software projects within specified constraints. In recent times, the application of Machine Learning (ML) and Deep Learning (DL) frameworks to support SPM has gained significant attention (Obaidi et al., 2022; Vusumuzi & Mfowabo, 2022; Sheoraj and Sungkur, 2022). Artificial intelligence (AI) is an emerging technology that has the potential to enhance SPM by providing intelligent and automated solutions for various SPM tasks (Mishra et al., 2023; Vusumuzi & Mfowabo, 2022; Karenkamp et al., 2020; Dam et al., 2019). The use of ML and DL for SPM has been gaining attention in recent years, as evidenced by the increasing number of publications on this topic. A bibliometric analysis by Vusumuzi and Mfowabo (2022) revealed that the number of publications on AI in project management research increased from 12 in 2010 to 144 in 2019. Some of the research areas that have evolved through research included AI applications for project scheduling, risk management, resource allocation, quality management, and stakeholder management (Mishra et al., 2023; Vusumuzi & Mfowabo, 2022; Karenkamp et al., 2020; Dam et al., 2019), etc. However, the use of ML and DL for SPM is still in its infancy, as many challenges and gaps need to be addressed. For example, Mishra et al. (2023) proposed a research agenda for the application of AI/ML in intelligent project management (IPM), which is defined as “the application of AI/ML techniques to augment human capabilities in managing projects”.

A study by Obaidi et al. (2022), it is highlighted the importance of understanding the impact and implications of ML and DL frameworks in different contexts and environments. The study envisaged that developing countries face unique challenges in SPM, such as limited resources, diverse stakeholders, cultural differences, and rapid changes. Vusumuzi and Mfowabo (2022) add that there is a lack of studies that investigate the human factors and behavioural aspects of using AI for project management, such as the trust, acceptance, resistance, and collaboration between project managers, developers, clients, and users. Reliability, interpretability, and scalability of ML and DL models must introduce new sources of uncertainty and complexity in SPM which requires a closer look. An attempt by Sheoraj and Sungkur (2022) to use AI to develop a framework to prevent employees from missing project deadlines in software projects, but they only applied their framework to one case study of a global human capital management software company, and did not evaluate its applicability or

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effectiveness in other software projects or contexts. There is a need to explore the current state of the art and practice of using ML and DL frameworks to assist SPM, particularly in developing countries.

A recent study by Kumar and Srinivas (2023) proposed a hybrid optimization and machine learning technique for software effort estimation based on analogy, but they did not compare their technique with other existing methods or evaluate its generalizability across different software projects, domains and contexts. The use of ML and DL frameworks to assist SPM in developing countries and project managers may offer some advantages, such as enhancing the productivity, innovation, and competitiveness of software projects. However, it may also entail some disadvantages, such as increasing the dependency, vulnerability, and inequality of software projects. Therefore, it is important to investigate the experiences, nature and practices of the use of ML and DL frameworks to assist SPM in developing countries (Sheoraj & Sungkur, 2022). Developing countries and software project managers may face many challenges and opportunities in the use of ML/DL for SPM, such as limited resources, diverse stakeholders, cultural differences, and rapid changes and therefore, their experiences and practices with the use of these AI will be beneficial to software developers in their design and continuous use of these frameworks.

Considering that the use of ML/DL for SPM is at its nascent stages in developing countries, a qualitative approach that enables a rich and detailed analysis of the nature and practices of ML and DL frameworks in SPM has been used (Stahl, 2014). The study seeks to provide a comprehensive overview of the current state of the art and practice in this field, as well as offer recommendations for future research and practice. The outcomes of this study are expected to include the experiences of experts in the use of ML/DL for SPM, as well as a set of recommendations for future research and practice in this domain. Mishra et al. (2023) proposed a research agenda on the application of AI/ML in intelligent project management, but they did not consider the experiences of users or experts. While previous research has proposed a research agenda in this area, there is a lack of study understanding of the nature and practices of the use of these ML/DL frameworks. By conducting a comprehensive analysis of the views, opinions and practices of experts in this field, this study seeks to provide valuable insights and recommendations for future research and practice in utilizing ML and DL frameworks in SPM

2 SOFTWARE PROJECT MANAGEMENT AND THE USE OF ARTIFICIAL INTELLIGENCE FRAMEWORK

Software project management (SPM) is the process of planning, organizing, executing, monitoring, and controlling software projects, to deliver high-quality software products within the specified time, budget, and scope constraints (Sheoraj & Sungkur, 2022). SPM is a complex and challenging task, as it involves dealing with various uncertainties, risks, dependencies, and human factors that can affect the software project outcomes (Mishra et al., 2023). Therefore, SPM requires effective methods and tools to support the software project team in making informed decisions, solving problems, and managing risks.

Karenkamp, Rebstadt, and Thomas (2020) explored the applications of AI in classical software engineering. They discussed how AI techniques, including code analysis, defect prediction, and automated testing, can enhance traditional software development processes by improving efficiency and accuracy. In a study by Relich and Muszyński (2014), it was investigated the use of intelligent systems for planning and scheduling product development projects. By leveraging expert systems and optimization algorithms, project managers can make informed decisions regarding resource allocation, task sequencing, and risk assessment. Kunnathur (2020) delved into the topic of applying artificial intelligence techniques in project management. The study covered areas such as project planning, risk management, and resource allocation. Integrating AI tools into project management practices can enhance decision-making processes and improve overall project outcomes. These studies collectively highlight the potential benefits of incorporating AI into software project management processes—from code analysis to resource allocation.

2.1 Artificial Intelligence

The One of the specific areas where AI can be applied for SPM is software effort estimation (SEE), which is the process of predicting the amount of effort required to develop a software product or system (de Barcelos Tronto

et al., 2008). SEE is an important task for SPM, as it affects the planning and allocation of resources, time, and budget for software projects. However, SEE is also a difficult task, as it depends on various factors such as the size, complexity, functionality, quality, and reliability of the software product or system; the skills, experience, and productivity of the software developers; the tools, methods, and processes used for software development; etc. (Kumar & Srinivasan 2023). Several methods and models have been proposed for SEE in the literature. These can be broadly classified into two categories: algorithmic models and analogy-based models (Lessmann et al., 2008). Algorithmic models are based on mathematical formulas or equations that relate software effort to one or more software attributes or metrics. Examples of algorithmic models include COCOMO (Constructive Cost Model), SLIM (Software Life Cycle Management), FP (Function Point), etc (Chandrasekaran & Kumar, 2012; Lessmann et al., 2008). Analogy-based models are based on finding similar historical projects or cases from a database or repository and using their effort values to estimate the effort for a new project or case. Examples of analogy-based models include CBR (Case-Based Reasoning), ABE (Analogy-Based Estimation) (Benala & Bandarupalli, 2016; Lessmann et al., 2008).

2.2 Machine Learning

Karenkamp, Rebstadt, and Thomas (2020) conducted a comprehensive review of papers on the application of Machine Learning (ML) in software project management. The findings of the study suggest that studies are contributing to project risk assessment using ML. Their findings suggest that ML-based project risk assessment is more successful in minimizing project losses, increasing the likelihood of success, and improving software fault prediction accuracy. Skinner (2022), discusses how AI, including ML, will transform project management. They envision a future where CEOs can monitor project status, benefits, team morale, and stakeholder buy-in through smartphone apps. AI-driven self-adjustments and real-time decision support enable successful project outcomes. Additionally, understanding the machine learning lifecycle is crucial for incorporating ML into software development processes. This lifecycle maps ML activities to traditional software development stages, ensuring seamless integration.

2.3 Deep Learning

Deep learning, a subset of AI, involves neural networks with multiple layers (deep neural networks). These networks can learn complex patterns from data, making them suitable for tasks like code analysis and defect prediction in software development. Relich and Muszyński (2014) investigated the use of intelligent systems for planning and scheduling product development projects. Although they didn't explicitly mention deep learning, the concept aligns with the idea of using neural networks to optimize project schedules. Deep learning models can learn intricate relationships from historical project data and assist in resource allocation, task sequencing, and risk assessment. While their study primarily focused on AI, it indirectly sheds light on deep learning (Karenkamp, Rebstadt and Thomas, 2020). These studies collectively emphasize that deep learning, as part of AI, has the potential to revolutionize software project management by improving efficiency, risk assessment, and overall success.

Embracing AI/ML/DL in software project management offers opportunities for efficiency gains and better decision-making. It is indicated that Organizations should explore integrating ML/DL techniques into project management tools. These models could analyze historical data, predict risks, and optimize resource allocation. Also, the use of these intelligent frameworks will provide continuous learning to project managers. Project managers should stay updated on AI advancements to leverage new tools effectively.

3 RESEARCH SETTING AND METHODOLOGY

This study is part of a larger research project that critically examines the drivers and barriers in the adoption of ML/DL frameworks for software project management in a developing country. This current study focuses on the experiences and practices of ML/DL use for SPM.

3.1 Methodology

This study adopts an interpretive approach to explore the nature and practices of the use of machine learning and deep learning frameworks to assist software project management in a developing country context. The study

aims to understand how these frameworks are applied, what benefits and challenges they bring, and what factors influence their adoption and effectiveness. The study attempts to understand these phenomena through the meanings project managers assign to the use of ML/DL for SPM (Stahl, 2014). The study follows a qualitative research design, as it seeks to capture the subjective experiences, perceptions, and opinions of the participants who are involved in software project management using machine learning and deep learning frameworks (Boateng, 2020, pg. 123; Myers, 2013; Walsham, 2006).

3.2 Data Collection

The data collection method for this study is semi-structured interviews with open-ended questions (Jamshed, 2014). This vehicle is the basis for the interpretive investigation. The interviews are designed to elicit the participants' knowledge about machine learning and deep learning frameworks, the techniques and tools they use, the outcomes and impacts they achieve, and the difficulties and barriers they face.

The study targets software project managers and developers who are into software projects. These persons were selected using snowball sampling, based on referrals from other experts in the field. The participant's profiles are presented in Table 1 below. They were selected using purposive sampling (Miles et al., 2014), to ensure that they have relevant experience and knowledge about the topic of interest, and can provide "information-rich" data for the analysis (Boateng, 2020, pg. 123). Data collection took place in September 2023, transcribed and used for the data analysis.

Table 1: Interviewee Profile

No. of Interviewees	Organisation	Unit
3	Kwame Nkrumah University of Science and Technology (KNUST)	University Information Technology Services (UITS)
1	CEQA Food and Beverages Limited. (Pizzaman Chickenman)	Software Development Unit
2	Ghana National Sports Authority (NSA)	Software Development Unit
1	AIVESLab LBG	Information Systems Unit
2	Radio Entertainment Limited	Information Technology Unit
3	Obitech Ghana Limited	Information Systems Unit

4 ANALYSIS

Based on the semi-structured interviews with 12 participants from six organisations in Ghana that have heard or used machine learning and deep learning frameworks for software project management. The participants included five software project managers, three information system analysts and four software developers, who had varying levels of experience and expertise in using ML and DL frameworks.

The interviews were transcribed and analysed using thematic analysis, following the steps proposed by Braun and Clarke (2006). The study presents analysis on the four main themes that emerged from the data: (1) the current state of the art and practice of using ML and DL frameworks for SPM in Ghana; (2) the most common and effective ML and DL frameworks for SPM tasks; (3) the benefits and challenges of using ML and DL frameworks for SPM in Ghana; and (4) the recommendations for future research and practice on the use of ML and DL frameworks for SPM in developing countries.

4.1 ML and DL Frameworks in Early days for SPM in Developing Countries

The first theme revealed that the use of ML and DL frameworks for SPM in Ghana is still in its infancy, as most organisations are still experimenting with different frameworks and techniques, and have not yet established a standard or best practice for their application. The participants reported that they mainly use ML and DL frameworks for tasks such as requirements analysis, software testing, defect prediction, and risk management, but they also mentioned other potential applications such as software design, code generation, code review, and

software maintenance. The participants expressed their interest and enthusiasm in learning more about ML and DL frameworks, and their willingness to adopt them for their SPM activities. For example, a software project manager who was asked about how the practice or use of ML / DL frameworks for SPM has had this to say;

"*We heard about these frameworks not long ago, I am still learning how to use ML and DL frameworks for my software projects. I have heard of some frameworks like TensorFlow and PyTorch, but not sure if they are the best ones for my needs. I will also want to explore other frameworks that can help me with other aspects of SPM, such as design, code generation, or maintenance. I think that ML and DL frameworks have a lot of potential to improve our SPM processes and outcomes*."

4.2 Identified ML and DL Frameworks for SPM

The most common and effective ML and DL frameworks that the participants use or have used for their SPM tasks are presented in this section of the study. The participants mentioned several frameworks, such as TensorFlow, PyTorch, Scikit-learn, Keras, XGBoost, and Apache Spark. They also shared their experiences and opinions on the strengths and weaknesses of each framework, as well as the criteria they use to select a suitable framework for their specific SPM task. Some of the criteria included the availability of documentation, tutorials, and community support, the ease of installation, integration, and deployment, the compatibility with different programming languages and platforms, the performance, scalability, and reliability of the framework, and the features, functionalities, and flexibility of the framework. For example, one participant said:

"*I use TensorFlow for my requirements analysis and defect prediction tasks because it has a lot of documentation, tutorials, and support from the online community. It is also easy to install, integrate, and deploy on different platforms and languages. It has a high performance, scalability, and reliability for our large-scale and complex software projects. It also has many features and functionalities that we can use or customize for our specific needs*."

4.3 Benefits and Challenges of using ML and DL for SPM

This section explored the benefits and challenges of using ML and DL frameworks for SPM in Ghana. The participants highlighted several benefits that they have gained or expect to gain from using ML and DL frameworks even in these early days. They expressed that these frameworks improve the quality, efficiency, productivity, and innovation of their software projects, enhancing their decision-making, problem-solving, and risk management skills, increasing their competitive advantage, customer satisfaction, and market share, and advancing their professional development, career opportunities, and reputation.

However, they also faced several challenges that hindered or limited their use of ML and DL frameworks, such as the lack of adequate infrastructure, resources, funding, and support from their organisations or stakeholders, the lack of sufficient data, data quality, data security, data privacy, data ethics issues related to their software projects or domains, the lack of skilled personnel, training, and education on ML and DL frameworks, the difficulty of finding or adapting suitable frameworks or models for their specific. SPM tasks or contexts, the complexity and uncertainty of ML and DL frameworks, their outcomes and impacts, and the resistance or scepticism from some of their colleagues, clients, or users regarding the use of ML and DL frameworks.

When asked about the benefits and the challenges of using ML and DL for SPM, an information system analyst had this to say;

"*I have seen some benefits from using ML and DL frameworks, such as improving the quality and efficiency of our software testing, predicting defects more accurately, and managing risks more effectively. I also think that using ML and DL frameworks can help us to innovate and create new solutions for our customers, and to enhance our reputation and career prospects in the software industry*".

Another participant indicated that;

"*I face many challenges using these frameworks. There is a lack of infrastructure, resources, funding, and support from our organization or stakeholders, the lack of data, data quality, data security, data privacy, data ethics standards and practices, the lack of training, education, and skills on ML and DL frameworks, the*

difficulty of finding or adapting suitable frameworks or models for our SPM tasks or contexts the complexity and uncertainty of ML and DL frameworks, and their outcomes and impacts, and the resistance or scepticism from some of our colleagues, clients, or users regarding the use of ML and DL frameworks."

4.3 Recommendations

Participants recommend that in the future, several measures and actions could be taken to address the challenges they faced or to enhance the benefits they gained from using ML and DL frameworks. Some of these actions included improving the infrastructure, resources, funding, and support for using ML and DL frameworks, developing or acquiring more data, data quality, data security, data privacy, data ethics standards and practices, providing more training, education, and awareness on ML and DL frameworks, creating or sharing more frameworks, models, tools, and best practices for SPM tasks or domains, simplifying or explaining more clearly the workings, outcomes, and impacts of ML and DL frameworks, and building more trust, confidence, and acceptance among colleagues, clients, or users regarding the use of ML and DL frameworks. A participant indicated the below;

"*I recommend that more research and practice should be done on the use of ML and DL frameworks for SPM in developing countries. We need more infrastructure, resources, funding, and support from our organisations or stakeholders to use ML and DL frameworks effectively. We need more training, education, and awareness on ML and DL frameworks, and how they can help us with our SPM tasks or domains. We need more frameworks, models, tools, and best practices that are suitable for our specific SPM tasks or contexts. We also need to simplify or explain more clearly how ML and DL frameworks work, what outcomes and impacts they have, and how we can trust and accept them.*"

The analysis concludes that the use of ML and DL frameworks for SPM in Ghana is at its nascent stage but challenging endeavour that requires more research and practice to realise its full potential.

5 DISCUSSION, CONCLUSIONS, & FUTURE RESARCH DIRECTIONS

The use of ML and DL frameworks for SPM in Ghana is still in its early stages, but there is a high level of interest and enthusiasm among the software project managers and developers to learn more and adopt them for their SPM activities. This result is in par with a literature survey that indicated that there has been an increasing interest in AI-assisted project management since the beginning of Industry 4.0 (Taboada et al., 2023). The potential of AI to revolutionize project management has been a concern of researchers, practitioners and the scientific community. For instance, Kucharska and Dudek-Dyduch (2014) introduced an ML method for determining intelligent cooperation at IT project realization. Studies further showed that "ML and DL techniques are suited for effort estimation, and ML-based analytics are suited for backlog item identification, backlog item refinement, and risk mitigation" (Dam et al., 2019). It is perceived that there is no one-size-fits-all solution for choosing the best ML and DL framework for SPM tasks, as different frameworks have different strengths and weaknesses, and the selection depends on various factors such as the availability of resources, the nature and complexity of the software project, and the preferences and expertise of the software project team.

The use of ML and DL frameworks for SPM in Ghana can bring many benefits, such as improving the quality, efficiency, productivity, and innovation of the software projects, enhancing the decision-making, problem-solving, and risk management skills of the software project team, and increasing the competitiveness and reputation of the software organisations in the global market. Also, Taboada et al. (2023) indicated that "project management would benefit from artificial intelligence to achieve project goals by improving project performance, and consequently, reaching higher sustainable success". Combining AI systems into Common Data Environments can help project team members in finding and tracking documents efficiently. Also, a study by Kowalski et al (2012) adds that AI could be beneficial for future projects by gathering knowledge from past projects by automating data management.

The use of ML and DL frameworks for SPM in Ghana also faces many challenges, such as the lack of adequate infrastructure, data, and skills, the high cost and complexity of implementing and maintaining the frameworks, the ethical and legal issues related to data privacy and security, and the resistance to change and trust issues among the software project stakeholders. The lack of evidence of AI adoption for project managers is an

indication that there exist some challenges. Taboada et al. (2023) purported that AI design, standardization and implementation in project-based firms are challenges yet to be attended to.

This current study suggests that software organisations in Ghana should invest more in developing their infrastructure, data, and skills to support the use of ML and DL frameworks for SPM. They should also seek external funding, collaboration, and guidance from other organisations or institutions that have more experience and expertise in using ML and DL frameworks for SPM. The software project managers and developers should explore different ML and DL frameworks for their SPM tasks, and evaluate them based on their specific needs and criteria. They should also keep themselves updated with the latest developments and trends in ML and DL frameworks for SPM, and learn from best practices and lessons learned from other successful cases. The software project team should communicate clearly and frequently with the software project stakeholders about the benefits and challenges of using ML and DL frameworks for SPM. They should also address any concerns or questions that may arise from the stakeholders, such as how the frameworks work, how they affect the software project outcomes, how they ensure data privacy and security, and how they handle any errors or uncertainties that may occur.

Further studies need to focus more empirical studies on the use of ML and DL frameworks for SPM in developing countries, especially in Africa. Such studies can provide more insights into the most common and effective frameworks. There is a need for more comparative studies on the use of different ML and DL frameworks for different SPM tasks. Such studies can provide more evidence on the strengths and weaknesses of each framework, as well as the criteria and methods for selecting a suitable framework for a specific SPM task. There is a need for more evaluative studies on the impact of using ML and DL frameworks for SPM on various aspects of software project performance.

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