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PAPER

A Conceptual Approach of an Integrated Multi Criteria Decision Making Techniques and Deep Learning for Construction Project Managers Selection Problem

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ABSTRACT

The success of a construction project depends on several critical success factors in such a hazardous scenario characterized by COVID-19 and its consequent stress. One important factor is supervision by a competent project manager with higher emotional intelligence (EI) skills especially in these pandemic times of uncertainty. The selection of this kind of project manager is, by nature, one of the most important and, at the same time, most complicated decisions to be made due to a multi-criteria decision-making (MCDM) problem. Based on previous studies, the human emotion element is often overlooked in the decision-making process. Modern evaluation would require a multimodal dataset to evaluate a competent candidate for the position. In addition, it is identified that classical MCDM is static and unable to quantify real-time human emotion. Hence, in this study, our approach uses an integrated techniques for MCDM and deep learning to address the managers' selection problem. Accordingly, a number of techniques, such as convolutional neural networks and other variations of algorithms, will be tested and compared. The emotion in our facial emotion recognition intensities value will be forwarded to MCDM as part of the input and eventually yield a non-bias and quality decision. It is anticipated that this study will enable employers to simplify and implement an effective decision-making process by embedding EI into the decision-making process to improve the quality of their hires and source the perfect candidate for construction project managers. Therefore, this study is aligned with the national construction agenda under the Construction 4.0 Strategic Plan (2021–2025), which requires changes to be made within the construction industry in tandem with the rapid development of technology and smarter systems. It emphasizes the utilization of digital technology as well as skills and knowledge enhancement.

KEYWORDS

multi-criteria decision-making (MCDM), deep learning, project managers' selection problem, construction management

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1 INTRODUCTION

A construction project team comprises various people from multiple entities with diversified or differing purposes and interests. It can be seen that the project manager is the person in charge of managing the project [1], [6]. Developing an understanding of project managers' perspectives and lived experiences of leadership, management, decision-making, and self- and social awareness is vital to project success or failure. Project managers who develop their emotional intelligence (EI) are more self-aware, can manage their emotions and behaviors, and build genuine friendships and connections with the people around them. Although previous researchers [9], [22], [13], [15] have studied EI and project managers' role in their management style and relationship to project management's success, the study only focused on project management in general. The previous study's findings indicate that the interpersonal effect contributes positively to project output [20]. The project's overall success is influenced by eight skill components: visioning, EI, organizational skills, transformational leadership, interpersonal control, evident sincerity, quality management, and paper and contract management [3], [12], [20], [2]. Thus, construction companies can use the results as a recommendation to select project managers with the 'right' capability profile or to base their development of human resources on the key competencies for project success. One of the most important decisions in construction project management is to choose project managers. The classical MCDM technique usually measures structured data, such as opinions from experts, where the data is either a qualitative or quantitative dataset. However, classical MCDM is unable to measure unstructured data such as human emotion, which is essential for modern personnel selection in project management where it involves a mix of structured and unstructured data. To the best of the researcher's knowledge, in previous studies, there were no available tools to evaluate construction project managers using MCDM with emotion recognition.

2 LITERATURE REVIEW

2.1 Construction project manager

A construction project team is composed of individuals from different organizations or departments, each with their own goals and interests. The project manager is the person responsible for overseeing the project and ensuring that it is completed on time, within budget, and to the desired quality standard. To ensure the success of the project, it is important to understand the perspectives and experiences of project managers in terms of their leadership, decision-making, management, and self-awareness.

Project managers play a crucial role in the success or failure of a construction project, as they are responsible for overseeing all aspects of the project, from planning and design to execution and delivery. For firms, choosing the best project manager to hire is a crucial choice. Decisions made by project manager could lead to the failure of a typical project or, on the other hand, could result in an extraordinary success for initiatives facing numerous unforeseen difficulties.

2.2 The criteria of project manager's selection

The project concepts are taken into account when choosing a project manager with respect to that role's requirements. This idea includes common project management responsibilities and connects them to the abilities needed to be a successful project leader. Screening qualified individuals is one method used in the evaluation of human resources [18]. In the field of human resource management, there are numerous studies that have been completed and published that are conducted using interviews, written assignments, tests, assessments, technical competency, and personality assessments [4], [5]. For selecting a project manager, we can take into account professional expertise, social intelligence, management skills, and stakeholder engagement as essential considerations.

A study was carried out by [21] to ascertain how firms are actually employing competence data and to offer insights into successful real-world practices. "A description tool that describes the information, talents, capabilities, and behaviors required to work successfully in an organization," according to the definition of competences [5]. In the setting of an industrial nation construction systems (IBS) construction project in Malaysia, [7] conducted research on the preliminary information pertaining to the competence of the project manager. Among a list of skills that multiple project managers should have, [14] suggested interrelationship administration, multitasking, contemporaneous team leadership, and managerial staff of the interproject process. Examples of eligibility criteria for management are shown in the following Table 1 [19].

Table 1. Criteria and sub criteria for selection of a project manager

Project Manager criteria and sub-criteria			
1. General Management	1.1	Knowledge	Judgment, Integrity, Self-confidence, Flexibility, Initiative, Perseverance, thinking skills, organizational awareness…
	1.2	Legal Skills	Owning general knowledge about legal rules and laws adjusted by government
	1.3	Communication	To shape others' understanding in ways that capture interest, inform and gain support.
	1.4	Social awareness	PM emotional behaviors could an important key reach successfulness
	1.5	Action management	To achieve expected results through the successful and timely completion of activities and delivery of Products and services.
	1.6	Financial Management	Ability to keep financial flows under control and perceive the concepts of finance
2. Project Management	2.1	Integration	To co-ordinate the diverse components of the project by quality project planning, execution and change control to achieve required balance of time, cost and quality.
	2.2	Report	To distribute quality project information.
	2.3	Risk	To identify and control risk.
	2.4	Scope	To create quality product by including only the required work and to control scope changes.
	2.5	Human resource	To employ quality leadership to achieve quality teamwork.
	2.6	Procurement	To ensure quality service or product acquisition.
	2.7	Time	To ensure timely completion of the project
	2.8	Quality	To ensure that the product will satisfy the requirements
	2.9	Cost	To ensure that the project is completed within allotted budgets.
3.project Management	3.1	Associated resume	The result of previous activities in the PETROLEUM project leadership, Cost, Time, scope….
	3.2	Multiple project* management	Organizational experience, inter pendency management, multitasking, simultaneous team management, management of inter-project possess
	3.3	Technical skills	Own enough general knowledge about technical staff like reading plans, designing software and etc.
	3.4	Availability for the project	On of the most important role of a project manager is to be accessible to make decision in the project duration

Yet, there are a few problems with the assessment of the choice of project leader. Employability is not solely determined by a candidate's credentials or IQ level. Employers seek candidates with a suitable personality who can blend in well with the team in addition to their expertise. Employers have various active cognitive processes while interviewing candidates. Despite knowing it, we are gauging their reactions, demeanor, and communication skills. Their empathy is being evaluated by the employer. Creativity and psychological equilibrium should be considered essential characteristics for choosing managers, according to [16].

2.3 Tools for managers selection: multi-criteria decision making techniques and deep learning

Several strategies for people's evaluation and choice have been put forth, all with the same overarching objective: to guarantee the caliber and accuracy of the employee's choice for a particular role. The selection of an impartial evaluation method that is both valid and dependable is crucial [8]. This is a crucial matter because the evaluation processes prospective employees go through also affect them [17]. The parameters against which alternative applicants will be evaluated and ranked must be set prior to starting the human selection procedure. For that reason, several authors have thus far put forth various sets of standards. During the COVID-19 period, people mostly rely on technology or a remote working environment with access to video conferencing to communicate. The selection of personnel or managers can also be done remotely by analyzing video submitted by the prospective candidate, or an interview session can be assessed in real time. The performance during the Q&A session can be analyzed in terms of facial expression and emotions. Performance during testing and interview sessions is vital to be integrated as a criteria for the best project managers and personnel. Based on Table 2, the classical managers' selection problem used multi-criteria decision making (MCDM) to be used in the selection process. To the researcher's best knowledge, facial emotion recognition (FER) has been overlooked to be integrated in the selection process with the existing MCDM technique. In the past, academicians and researchers have paid close attention to MCDM techniques for analyzing, rating, and ranking alternatives across a variety of industries. Numerous recent studies have looked at the use of MCDM modeling techniques in decision-making procedures, particularly in the construction sector. The following Table 2 lists the previous work that has been done for the managers' selection problem with the method used.

Table 2. Application for managers' selection and the methods used

Citation	Application	Method
(Zavadskas et al., 2008a)	Construction Project manager selection	Complex Proportional Assessment of alternatives with Grey relations (COPRAS-G)
(Zhao et al., 2009)	Selection of a Project Manager	Fuzzy Comprehensive Evaluation
(Xing and Zhang, 2006)	Construction Project manager selection	Fuzzy Analytical Hierarchy Process
(Rashidi et al., 2011)	Construction Project manager selection	Neurofuzzy Genetic System
(Shahhosseini and Sebt, 2011)	Selection construction project manager	Fuzzy AHP; Adaptive Neuro-Fuzzy Inference System (ANFIS)
(Gilan et al., 2012)	Project manager selection	Computing with words
(Afshari et al., 2012)	Project manager selection	Fuzzy Simple Additive Weighting method
(Zavadskas et al., 2012)		AHP, ARAS
(Afshari et al., 2013)	Project manager selection	Fuzzy Integral
(Torfi and Rashidi, 2011)	Selection of Project Managers in Construction Firms	AHP and Fuzzy TOPSIS

(Continued)

Table 2. Application for managers' selection and the methods used *(Continued)*

Citation	Application	Method
(Hadad et al., 2013)	Project manager selection	Data Envelopment Analysis
(Jazebi and Rashidi, 2013)	selecting project managers in construction firms	Fuzzy curves method
(Varajão and Cruz-Cunha, 2013)	Project manager selection	AHP, ICB
(Sadeghi et al., 2014)	Evaluating Project Managers	TOPSIS technique
(Mohammadi et al., 2014)	Project manager selection	Cybernetic ANP, QFD
(Keren et al., 2014)	Selecting a Project Manager	AHP and DEA Methods
(Dodangeh et al., 2014)	Selecting a Project Manager	Fuzzy MCDM
(Reza Afshari, 2015)	Selection of construction project manager	Delphi and fuzzy linguistic
(Chaghooshi et al., 2015)	Project manager selection	Fuzzy DEMATEL, Fuzzy VIKOR
(Cassar and Martin, 2016)	Choose a Project Manager	CLOUD theory
(Sadatrasool et al., 2016)	Project manager selection	VIKOR and PCA-TOPSIS method

Based on the above Table 2, the classical MCDM method is unable to capture unstructured data, particularly human emotion. Thus, an improved MCDM technique is required with the integration of deep learning techniques in the field of artificial intelligence. Deep learning has the potential to quantify human emotion during the selection process.

A hierarchy can be used to describe the deep learning model's learning experience. An image's features are extracted using a number of hidden layers. These hidden layers are stacked one on top of the other from the input to the output layer. The lowest layer of hidden layers often acquires the ability to recognize edges, forms, and areas and then combines them to create curves and angles. These corners and contours, in turn, help to create the abstract object sections of the image in the following layer. Filters that the model automatically learns finish this learning experience. The image is finally classified using a classification method in the output nodes to provide the final classifier [11].

Facial expressions are significant components of human communication that aid in our understanding of others' intents, according to a deep learning application. Typically, people use facial expressions and verbal tones to infer other people's emotional states, such as happiness, sorrow, and rage [10]. According to [10], only one-third of interpersonal language is verbal, and two-thirds is nonverbal. Facial expressions are one of the primary information carriers in verbal relationships among a number of nonverbal cues because they convey emotional significance. Convolutional neural networks are among the methods used in deep learning most frequently. The following subsection describes MCDM and deep learning techniques.

Multi-Criteria Decision Making. Multi-criteria decision-making is a decision-making approach that helps in selecting the best option from multiple alternatives based on different criteria or factors. In MCDM, decisions can be made under two different circumstances: surety and uncertainty. Under the surety circumstance, it is assumed that all relevant information about the decision problem is known, and each decision has a known deterministic relationship with the associated outcome. This means that the decision-maker is confident in their understanding of the decision-making context and the consequences of their actions. However, in real-world scenarios, decision-making contexts often involve uncertainty. Uncertainty can be brought about by incomplete knowledge of the decision-making context or by vagueness or perception in the presentation of the semantic significance of events, phenomena, or assertions. This can make it challenging to determine the best course of action.

In MCDM, decision-making under uncertainty can be further separated into two categories: stochastic and fuzzy decision-making. Stochastic decision-making involves the use of probability theory to model uncertainty, while fuzzy decision-making involves the use of fuzzy set theory to represent imprecise or vague information. Therefore, when dealing with decision-making under uncertainty, it is important to carefully consider the type of uncertainty involved to determine the best MCDM approach to use. By doing so, decision-makers can make informed decisions that take into account the uncertain nature of their decision-making context.

In general, MCDM addresses a set of conflicting criteria. Several non-commensurable and competing criteria, variable units of measurement across the requirements, and the existence of alternatives that differ greatly are only a few of the distinctive features of MCDM analysis. Reviewing the various MCDM in an effort to evaluate and empirically validate the many methods for incorporating MCDM into circumstances involving collective decision-making in order to handle ambiguity. Based on the decision-target maker's preference structure, MODM and MADM difficulties can be further classified into two types. (i) Regardless of the number of decision-makers actually participating, the issue is alluded to as autonomous choice-making if there is just one goal-preference structure (ii). On the other side, the issue of group decision-making arises when individuals (activist organisation) have various goal-preference frameworks. Figure 1 illustrates the steps of developing a general MCDM model.

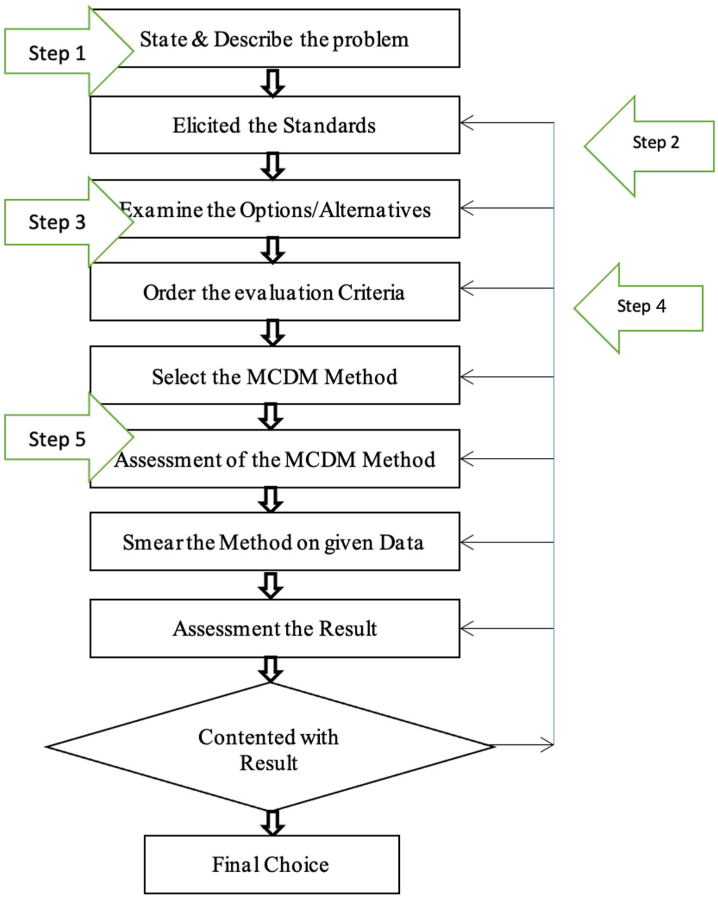

Fig. 1. Overview of generic MCDM approach

Multi-criteria decision-making consists of a number of connected steps that happen one after another. The generic MCDM model, as depicted in Figure 1, a flow diagram showing the processes that are basically present in all MCDM solutions, is presented next. Each phase is then elaborated in detail.

Step 1: Declare and describe the issue area. The problem identification step addresses aspects of the decision-making problem under discussion, such as specifying the variety of choices, qualities, and restrictions, etc. The decision-making problem's documentation serves as the foundation for selecting the best MCDM strategies, which will then be applied to the issue at hand.

Step 2: Identify the standards. It is crucial to choose the appropriate evaluation criteria because they have a significant impact on how the MCDM technique selection process turns out. Nevertheless, using all of the criteria at once is not the optimal course of action since, as the number of criteria increases, more data becomes necessary and the processing cost increases. As aspects of an MCDM framework and as input data for a decision problem for method selection, the evaluation metrics will be applied as described.

Step 3: Examine the options. A choice is dominated if another choice outperforms it in one or more criteria and is on par with it in the other ones. The dominant technique, which does not call for any attribute changes or assumptions, eliminates the dominant MCDM methods. The processes involved in the sieve of supremacy are as follows: Compare the first two choices and, if one is controlled by the other, remove the dominant one. Then, compare the remaining two alternatives and, again, discard any dominant ones. Finally, present the fourth alternative and continue this process until the final alternative has been compared. Unconscionable or impractical attribute values may be present in a set of non-dominated options. The connective technique, in which the decision-maker establishes the cut-off figures he or she will tolerate for each of the qualities, is used to eliminate the unsatisfactory possibilities. The cut-off values will be used to eliminate any alternatives with attribute values that are worse. In order to eliminate the options, it is crucial to use the cut-off values that the decision-maker provides. The candidate MCDM approaches for further selection still include those that can perform a feasibility review.

Step 4: Choose your preferred standards for assessment. The expectation is that numerous MCDM approaches will still be available when the initial screening stage is finished; otherwise, the decision-making problem can be solved by selecting the sole remaining option. The criteria are prioritized through this stage. It will assist us in determining which factors are most important, which in turn will have the biggest influence on our ultimate decision, and conversely.

Step 5: Choose MCDM as your selection procedure. This stage involves choosing one of the multivariate techniques from the pool of currently popular methods. We can choose sophisticated techniques for complex situations. It is vital to research the method's advantages and disadvantages before making a final decision.

In terms of MCDM approaches, there are a lot of different techniques. This variety has both strong points and drawbacks. Variety makes it easier to choose the best solution from a large pool of possibilities for a particular problem, but because these techniques are so widely varied, making the right choice is more difficult. Each method has its own benefits and disadvantages. Early on in the development of MCDM, applying methods based on the problems was not taken into consideration, but it is now obvious that the results of dissimilarities may produce less than ideal outcomes, the improper implementation of useful models may result in their discarding (which results in time and financial losses), and eventually it may deter potential users from using MCDM techniques to solve real-world problems. The weighted sum model (WSM) is the oldest and arguably the most popular technique. The analytical hierarchical process (AHP) is capable of handling more challenging issues, while thevtechnique for order of preference by similarity to ideal (TOPSIS) is one of the other extensively employed methods.

2.4 Deep learning

Deep learning is becoming an increasingly popular approach to solving complex problems. One of the reasons for this is that it is a universal approach to learning, which means it can be applied in practically any application area, making it a ubiquitous knowledge tool. Another reason for the popularity of deep learning is that it is robust, which means it does not require the creation of features in advance. Instead, it automatically learns the qualities that are most suited for the task at hand, making the data resistant to natural changes.

Deep learning is also known for its ability to generalize, meaning the same methodology can be used in more situations or with various types of data. This strategy is often referred to as transfer learning, and it is useful when there is not enough information available to resolve the issue. In fact, many publications have been produced on the basis of this idea.

Lastly, the deep learning method is highly scalable, which means it can be scaled up very quickly. Microsoft proposed a network called ResNet in a study published in 2015, which has 1202 layers and is frequently used at the level of supercomputers. The Lawrence Livermore National Laboratory (LLNL) is currently making significant efforts to create foundations for systems like these that can be put into use. Overall, deep learning is a powerful tool that offers many benefits, including its universality, robustness, generalization, and scalability.

3 RESEARCH FRAMEWORK

The new framework for integrated MCDM and deep learning for manager selection problems and the new deep learning model with an MCDM approach will enhance the understanding and application of these techniques in construction project management. Additionally, the new set of criteria for personnel and manager selection and the new tools developed in this research will assist decision-making processes for construction managers, ultimately leading to better project outcomes.

The following illustrates our framework (see Figure 2), where the intensity of emotion value from deep learning (facial emotion recognition) will be the input to MCDM evaluation.

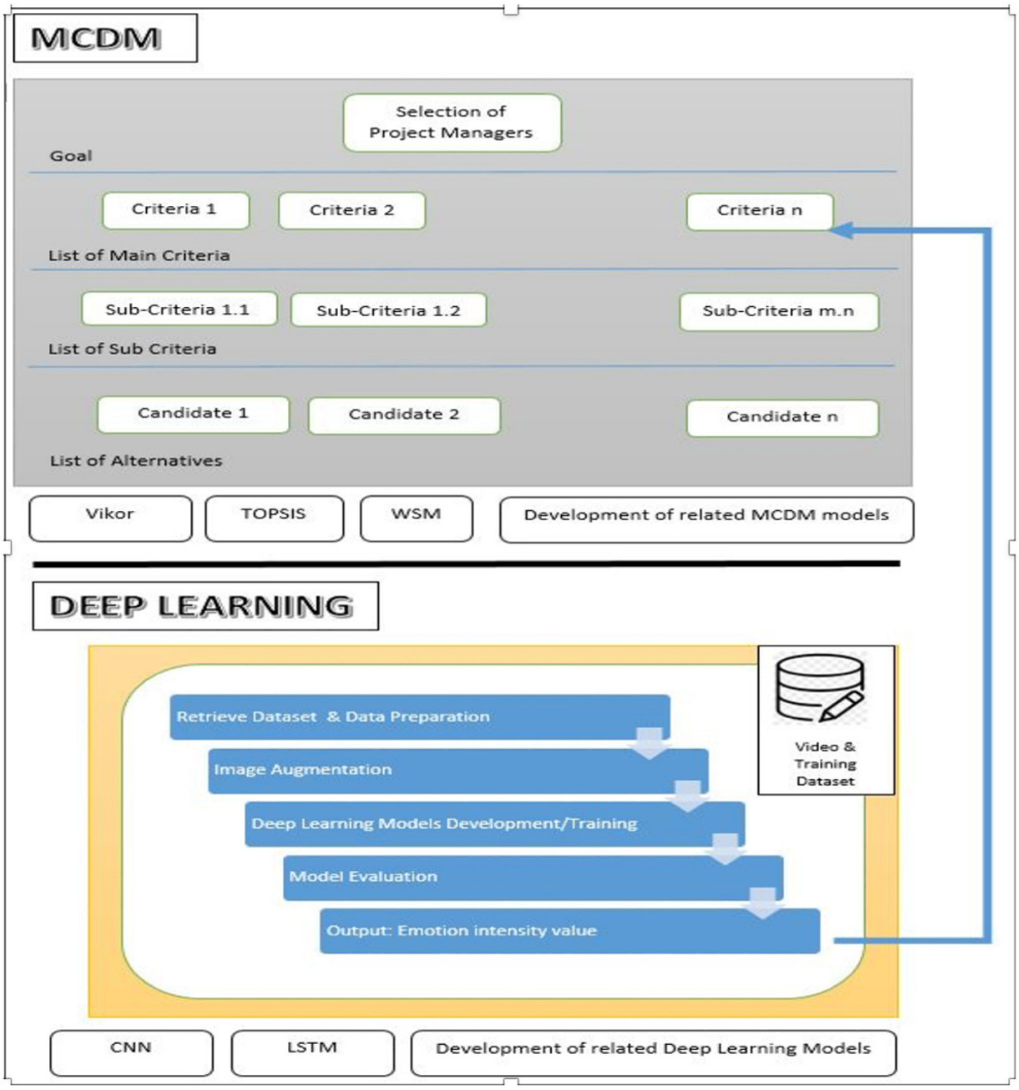

Fig. 2. Proposed framework for an integrated deep learning and MCDM for addressing selection of project manager

4 RESEARCH METHODOLOGY

The research methodology includes several key steps. First, a comprehensive literature review will be conducted to establish a strong theoretical foundation. Secondly, criteria for the selection of construction project managers will be determined through expert interviews and qualitative data analysis. Thirdly, a deep learning model will be developed using tools such as Python, OpenCV, and Keras. The model will be trained and tested using datasets such as the fer-2013 dataset on Kaggle and real-time or recorded video data. Data preparation and image augmentation techniques will be applied to improve the quality of the dataset. The developed models will be trained, evaluated, and experimented with to produce emotion intensity values.

Fourthly, MCDM techniques will be developed, and new criteria such as emotional intelligence and emotion intensity will be added to the decision hierarchy. Sensitivity analysis and experimentation will be conducted to select the best MCDM technique. Finally, the proposed model will be validated with experts and presented in a project write-up.

5 DISCUSSION AND CONCLUSION

The proposed framework integrates deep learning with MCDM to provide a comprehensive approach to personnel selection in construction projects. Specifically, the framework uses facial emotion recognition to capture the intensity of emotions expressed by candidates, which is then used as input to the MCDM evaluation. This approach is expected to contribute to the body of knowledge by introducing a new framework and deep learning model with an MCDM approach for personnel selection problems.

One of the major strengths of this framework is its ability to capture emotional cues that may be overlooked by traditional selection methods. Emotions can play a significant role in job performance and team dynamics, particularly in high-stress construction environments. By incorporating emotional intensity values into the decision-making process, the framework provides a more holistic and nuanced approach to personnel selection.

Moreover, the proposed framework contributes to the industry by providing a new set of criteria for construction managers to consider when selecting personnel. The inclusion of emotional intelligence and emotion intensity in the decision hierarchy reflects a growing recognition of the importance of soft skills in project success. The tools developed in this framework could help construction managers make more informed decisions about personnel selection, ultimately improving project outcomes.

However, there are also potential limitations and challenges associated with the proposed framework. For instance, the accuracy and reliability of facial emotion recognition technology may vary depending on factors such as lighting, facial expressions, and camera quality. Additionally, there may be concerns around privacy and data security when collecting and processing facial recognition data.

Overall, the proposed framework has the potential to improve personnel selection processes in the construction industry by incorporating emotional cues and providing a more comprehensive approach to decision-making. Further research and development may be needed to address the challenges and limitations of this approach, but it represents a promising direction for future work.

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