

RESEARCH ARTICLE

Fuzzy inference system for corrosion engineer interview selection: Insights from Idemitsu Sdn. Bhd.

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Abstract - Recruitment is a crucial factor that organizations consider while seeking the most appropriate candidates, hence requiring a balance between equity and efficiency. This research concentrates on constructing a fuzzy inference system (FIS) appropriate for the recruitment of corrosion engineers at Idemitsu Sdn. Bhd. It is intended that the FIS be used to reduce subjectivity and complexity in assessing the candidate by utilizing fuzzy logic principles. Academic qualifications, certifications, industry experience, and skills were among the key criteria transformed into homogenized inputs for the system. MATLAB Application Designer tools were developed to translate the FIS into an operational format. MATLAB Application Designer was also used for real-time evaluation of prospects and immediately produced an acceptance or rejection decision based on its suitability score. This study demonstrates that implementing FIS provides significant benefits by making the recruitment process more objective, consistent, and efficient.

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1. Introduction

The selection of corrosion engineers is crucial in sectors where corrosion is common and costly, such as manufacturing, petrochemicals, and oil and gas. Apart from endangering the structural integrity of assets, corrosion significantly impacts operational expenses, productivity, and safety, as noted by Uhlig [1]. The petrochemical industry, which includes companies such as Idemitsu Sdn. Bhd. is especially vulnerable to these problems because of the demanding working conditions in which machinery and equipment are exposed to harsh chemicals and weather. To mitigate such difficulties, there is an immediate need for highly qualified experts who can implement efficient corrosion control measures, as stated by Kutz [2]. A corrosion engineer's position description includes managerial duties in addition to technical knowledge. These experts are responsible for selecting materials resistant to corrosion, creating maintenance schedules, and planning and organizing corrosion-prevention measures. The operational effectiveness and safety of industrial processes are directly impacted by their choices, as stated by Cicek [3]. For instance, subsea engineers need to be highly skilled in metallurgy, chemistry, and physics, in addition to having hands-on experience with corrosion prevention methods, including cathodic protection, coatings, and inhibitor use. The strategic significance of this role underscores the need for a thorough, methodical hiring process. Ineffective hiring practices in this area can lead to serious operational inefficiencies, safety risks, and higher maintenance expenses, as stated by Pletcher and Walsh [4]. The importance of the position is crucial. The current hiring procedures for corrosion engineers frequently rely on traditional methods, such as interviews and resume reviews, which are biased and subjective. These traditional methods fall short of thoroughly assessing applicants across the wide range of frequently qualitative requirements for this role, as stated by Denert [5]. It can be difficult to measure certain qualities objectively using traditional methods, such as technical knowledge, problem-solving abilities, industry experience, and adaptability, which causes irregularities and inefficiencies in the hiring process. Therefore, to overcome these drawbacks and provide a trustworthy framework for assessing applicants, a more organized, data-driven approach is desperately needed, as stated by Zadeh [6].

Establishing a fuzzy inference system (FIS) is an achievable approach to addressing this issue. Fuzzy logic is used by FIS to handle subjective and ambiguous criteria, enabling more complex evaluations of applicants' skills and qualifications, as stated by Ross [7]. FIS can assess candidates using both quantitative and qualitative criteria by using rule-based reasoning and membership functions, providing a more thorough and impartial evaluation process. This strategy supports the expanding movement in human resource management to improve decision-making by incorporating computational tools, as stated in Language T [8]. Idemitsu Sdn. Bhd. can create a uniform hiring process that reduces bias, boosts productivity, and ensures the selection of the best corrosion engineers for crucial positions by implementing FIS. Besides, FIS fits into another underlying trend in industrial recruitment: the shift towards algorithm-based selection methods. Business sectors can continue streamlining and automating, as data management tools are proving quite useful for optimizing work structures and reducing actual and potential errors, as stated by Kline [9]. The FIS model for corrosion engineer selection could be used to begin establishing the necessary framework as a pilot for Idemitsu, with the aim of utilizing similar systems for other engineering posts in the future. This change thus not only improves the hiring

process but also provides an incentive to introduce better supporting technologies to achieve the company's objectives in innovation and efficiency, as stated by Rodgers et al. [10]. Additionally, integrating FIS with programs such as MATLAB can expedite data processing and help human resources (HR) managers make decisions. The system can be made user-friendly and accessible by using MATLAB's Application Designer, which offers an intuitive interface for entering candidate data and producing evaluation results, as stated by Migranov and Dobroskok [11]. Utilizing the development of a FIS specifically suited to Idemitsu Sdn. In line with Bhd.'s hiring requirements, this study seeks to address these issues and support the company's strategic objectives of sustainability, safety, and operational excellence.

Applying fuzzy logic as a decision-support tool has evolved along a gradient of task complexity and proficiency. This is because it has been proven that fuzzy systems are extremely effective at handling processes with unclear or disruptive inputs. Fuzzy systems were first used in industrial automation and control applications, as stated by Zadeh [6]. These basic applications demonstrated that fuzzy logic can handle practical problems without requiring perfect numerical models. Fuzzy systems were used in increasingly complex decision-making scenarios in fields such as finance, healthcare, and human resource management as computing power increased and more approachable development environments became accessible, as stated by Ross [7]. A decision-making system that incorporates human reasoning and involves an FIS is a critical component. Consequently, to emulate how people tackle issues, a FIS is designed to transform imprecise and ambiguous input into a clear output. The novelty of FIS is based on the principle of fuzzy logic, as introduced by Zadeh [6] as an extension of classical logic, which allows partial truth rather than complete truth or falsity, as stated by Bojadziew and Bojadziew [12]. FIS is the perfect method for managing ambiguity and uncertainty in real-world applications because it assigns different degrees of truth, unlike binary systems, where decisions are either 0 or 1. MATLAB Application Designer, a useful tool for developing graphical user interfaces (GUIs), was developed from a MATLAB-based tool. This tool can be used to input candidate data, and an assessment outcome will be produced on the spot. The major advantage of the presented MATLAB-based tool is that it provides real-time feedback. This is especially important where the assessment, for example, interviews or performance evaluations, are conducted on the spot. The GUIs of the proposed MATLAB-based tool are designed to be as simple and as easy to use as possible. There are four criteria, each consisting of an input form field and an 'Evaluate' button that performs the FIS calculation. After the evaluation is complete, the tool presents the decision as "Accept" or "Reject" based on the threshold value, and the clear score is shown. Thus, the tool is relatively simple to use and can be used even by someone who has probably never heard of fuzzy logic. This feature is important in real-world applications, since end users may be unaware of the computational models used, as stated by Bojadziew and Bojadziew [12]. There are two software programs, the MATLAB Application Designer and the Excel Integration software, that attempt to incorporate FIS into the decision-making process. The first tool, developed with MATLAB Application Designer, is easy to use, especially for people accustomed to spreadsheets. Therefore, the input data, such as skills, certifications, academic qualifications, and industry experience, are processed using fuzzy logic, incorporating triangular and trapezoidal MFs, custom formulas, and data manipulation tools in MATLAB Application Designer. MATLAB Application Designer is perfect for a straightforward, single application due to its ease of use. MATLAB Application Designer is flexible, but when dealing with large datasets or complex scenarios, it compromises computational performance. Depending on the amount of information and the complexity of the fuzzy-logic operations used in the decision-making process, performance and scalability issues may arise for the user.

The MATLAB Application Designer user interface is simple and intuitive, and its background requires only basic spreadsheet experience, making it familiar to anyone who uses it, as stated by Shaikh et al. [13]. Through entering data into cells and using formulas to derive results, the user interacts with the given system. Although it is relatively easy to understand and use for non-technical users, there is an inherent difficulty in using it and in expanding its functionality to meet the guidelines. For more comprehensive tasks, users may require a deeper understanding of the calculation formulas, and applying extensive fuzzy logic in practice can be challenging. However, in terms of user controls, forms, and buttons, MATLAB's Application Designer provides a more structured and customizable interface as stated by Srinivas et al. [14].

2. Methodology

2.1 Criteria Definition and Input Ranges

The selection criteria for candidates for the Corrosion Engineer position were defined comprehensively in accordance with the requirements of Idemitsu Sdn. Bhd. and the requirements of the industry. A total of four key evaluation criteria were identified: academic qualifications, certifications, industry experience, and skills. Idemitsu helped to provide a clear, systematic, and fully factual approach to the examination of candidates and their compliance with organizational activity objectives and legal requirements. The academic qualification criterion required a minimum qualification of a degree in Mechanical Engineering before they could be considered for the position. This ensured that candidates had the minimum technical competency required for the opportunity. Academic qualifications were divided into three categories: Diploma, Degree, and Master's. Those candidates with a higher level of education, especially a Master's Degree, were rated higher because of the engineering knowledge associated with such qualifications.

The skills criterion assessed the candidate based on their experience working as a qualified corrosion engineer in accordance with Regulation 2014 P.U (A) 96/2014, which is a requirement set by the Department of Occupational Safety and Health Malaysia. Additionally, the candidate is expected to understand maintenance and reliability standards, as well as the rules and regulations in the petrochemical, oil and gas, and power plant industries. Furthermore, they have awareness of working and maintenance/reliability of static and mechanically equipped items, mechanical knowledge, and proficiency in inspection/corrosion aspects, which apply to petrochemical, chemical, and refinery plants. Skills are divided into three groups: Low, for candidates who do not have a high level of technical skills and can handle only one

technical skill; Medium, for those who can handle up to two or three technical skills; and High, for those who can competently solve technical problems associated with corrosion. The skills assessment also had the purpose of ensuring that the candidates were able to fulfil the duties of an engineer later. Certifications are part of the assessment and demonstrate success in following best practices and technical proficiency. The company focused on certifications such as Corrosion and Materials Certification API 571, as well as other certifications such as API 580-581, API 510, API 570, or API 653. The Department of Occupational Safety and Health Malaysia has mandated these API certifications. Candidates with only one certification were classified as Low; those with two or three relevant certifications were rated Medium; and those with more than three certifications received a High rating. This criterion ensured that only suitably qualified candidates for corrosion management were selected based on their technical qualifications.

The industry experience criterion analysed the applicability and penetration of the candidate’s employment history. This criterion was divided into three categories, which are Low, Medium, and High. Low-output activity was defined as candidates with no job experience and with experience outside the petrochemical, oil and gas, or power plant industries. Those with work experience in a related field, such as the oil and gas industry or power plants, were considered Medium. Candidates with experience in the petrochemical industry, particularly in maintenance, reliability, or corrosion engineering, were rated High. Such a categorization enabled the system to match individuals with past experiences in executing similar responsibilities. However, incorporating these criteria into the Fuzzy Inference System made the evaluation process easier, clearer, and more in line with the requirements of Idemitsu Sdn. Bhd. In the process of designing the ranges and categories for each criterion, the company actively participated to ensure that the system would embody appropriate ranges and categories that accommodate their operations and regulations. This structure enabled the firm to recruit efficiently and systematically, customised to the organisational needs. Due to confidentiality, the candidates' resumes and the names of the companies' experts involved in this study cannot be included in this journal paper. Instead, permission has been granted to use and discuss adjusted values derived from the candidates' data, subject to consultation with the Idemitsu Human Resource Manager.

2.2 Development of FIS

The FIS model is validated by applying historical recruitment data and feedback from specialists to meet organizational requirements. Validation entails using the FIS to process previous candidate profile data in order to benchmark its results against eventual hiring decisions. The four categories of membership functions and rule weights are examined with Human Resources Managers and current corrosion engineers at Idemitsu through review sessions to reflect real job requirements. Following this approach makes the FIS model accurate, feasible, and in line with revised industry benchmarks after cycles of testing. FIS is designed to select corrosion engineers, which involves assessing academic qualifications, certifications, industry experience, and skills. These inputs can give the organisation assurance that the overall fitness of candidates for the available positions has been evaluated in detail. The output is classified simply into two classes, which are reject or accept for the candidates, which enhances the decision-making accuracy as well as minimizes bias. Figure 1 shows the flowchart of the fuzzy model.

Table 1. Linguistic variables, values, and types of membership function input candidate data for evaluation

	Linguistic Variables	Linguistic Values	Value	Explanation
Inputs	Academic Qualification	Diploma	0	The candidate is a Diploma holder
		Degree	1	The candidate is a Degree holder
		Master	2	The candidate is a Master's holder
	Certification	Low	1	The candidate has only 1 certification
		Medium	2	The candidate has 2 or 3 certifications
		High	3, 4, 5	The candidate has 3, 4, or 5 certifications
	Industry Experience	Low	0	The candidate has no job experience and has experience only in the petrochemical, oil and gas, or power plant industry
		Medium	1	The candidate has working experience in a related field, such as the oil and gas industry or power plants
		High	2	The candidate has experience working in the petrochemical industry
	Industry Experience	Low	1	The candidate has only 1 experience
Medium		2	The candidate has 2 experiences	
High		3, 4, 5	The candidate has 3, 4, or 5 experiences	
Output	Result	Reject	Below 5	The result is rejected if the result is below 5
		Accept	Above 7	The result is accepted if the result is above 7

2.3 Fuzzy System

Both continuous trapezoidal and discrete triangular membership functions are employed to achieve flexibility and accuracy. Trapezoidal membership functions are used for broader value ranges, such as ‘Low’ or ‘High’ certification levels, while triangular membership functions provide more precise boundaries for intermediate levels like ‘Medium.’ However, for distinct classifications such as academic qualifications, crisp data is used to ensure clear and accurate comparisons without ambiguity. A detailed explanation of how ratings are assigned to each candidate based on the selected input parameters is provided. These values correspond to four main factors: academic qualifications, certifications, industry experience, and skills. Each of these factors plays a crucial role in determining a candidate’s eligibility and is evaluated using the fuzzy system. Table 1 presents the Linguistic Variables, Values, and Types of Membership Functions used for the evaluation of input candidate data. The following section outlines how HR managers can assign values to each criterion.

2.4 Implementation

Taking into consideration that MATLAB’s Fuzzy Toolbox was used for creating the FIS for selecting corrosion engineers at Idemitsu Sdn. Bhd. There are four input variables, which are academic qualification, certification, industry experience, and skills, that have been described qualitatively with trapezoidal and triangular membership functions. The output, in the form of a decision (“Accept” or “Reject”), was also assigned to fuzzy categories. A fuzzy rule base containing 81 rules was developed and combined with the input and output variables. Fuzzification converted crisp inputs into fuzzy sets, and the inference engine applied the rules to calculate fuzzy outputs. The final decision was defuzzified using the centroid approach, yielding a crisp value of 2.2593, which was categorised in the Reject category.

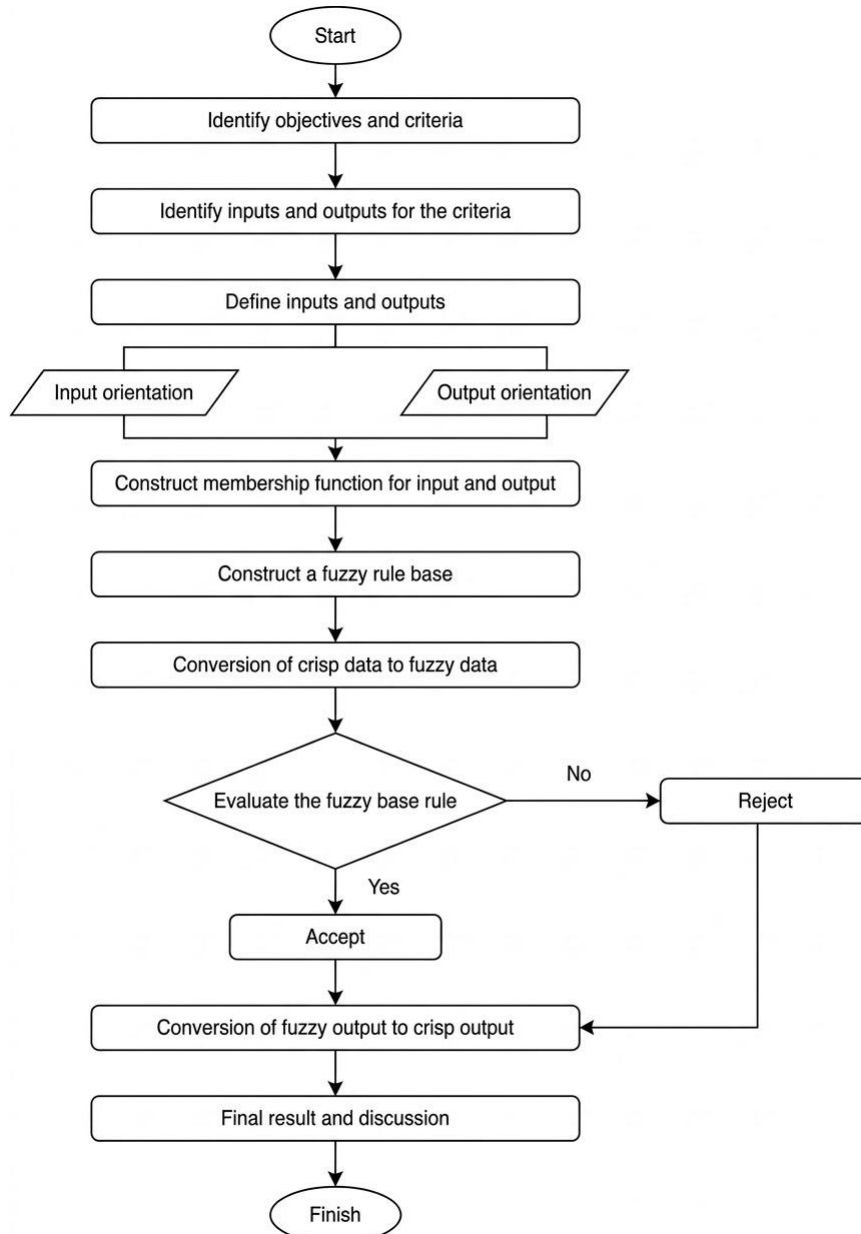


Figure 1. Flowchart of fuzzy model

3. Results and Discussion

The findings of this study were obtained using MATLAB App Designer, which uses an FIS to assess the candidates. The MATLAB App Designer application allows HR Managers to enter candidate data, and the predefined fuzzy rules and membership functions of the system will process it. These systems output a decision based on the input variables, including academic qualifications, certifications, industry experience, and skills. Additionally, MATLAB with Application Designer was used, which provided a friendly, graphical interface for HR Managers to modify inputs via sliders and observe the effect on the decision in real time. In this study, candidate assessment relies on quantized metrics for academic qualifications, certifications, skills, and industry experience. Level of education is measured as Diploma (0), Degree (1), and Master's (2). Certifications are evaluated on a scale of Low, Medium, and High. A Low certification level (value 1) corresponds to candidates holding only one certification. Medium (values 2 or 3) represents candidates with 2 or 3 certifications. Highly assigned values of 4 or 5 indicate a greater number of certifications. In this evaluation, the input variable certification is equivalent to skills, as both represent the candidate's qualifications and expertise in the relevant domain. Industry experience is also assessed on a scale of Low, Medium, and High. Candidates with Low experience (valued at 0) have either no relevant job experience or experience unrelated to the petrochemical, oil and gas, or power plant industries. Medium, with a value of 1, indicates some relevant experience in related fields such as oil and gas or power plants. High, assigned a value of 2, indicates substantial experience in specialized fields such as the petrochemical industry. The output result in the class shows “Reject” for candidates who got a score below 5, and “Accept” for candidates who got a score above 7. Table 2 shows the results from the FIS based on the candidate's resume. Based on the results, only 3 candidates can proceed to the next stage, an interview with the human resources department. Table 3 compares the results of an FIS implemented with MATLAB's Fuzzy Logic Toolbox with those obtained by manual calculation. The purpose of this comparison is to ensure that the fuzzy model developed in MATLAB accurately replicates the manual inference process, verifying the correctness of the system. Both methods evaluate candidate eligibility based on specific input criteria, such as academic qualifications, certifications, industry experience, and skills.

Table 2. Result based on the candidate's resume

Candidates	Input Variables				Outputs Variable	
	Academic Qualification	Certification	Industry Experience	Skills	Result	
1	0	1	0	1	2.23	Reject
2	1	2	2	3	8.76	Accept
3	2	3	1	5	8.76	Accept
4	1	4	2	1	2.23	Reject
5	2	5	1	4	8.76	Accept

Table 3. Comparison of FIS with manual calculation

Candidates	FIS implemented with Fuzzy Logic Toolbox	Manual Calculation
1	2.23 = eligible	2.2593 = eligible
2	8.76 = eligible	8.7333 = eligible
3	8.76 = eligible	8.7333 = eligible
4	2.23 = eligible	2.2593 = eligible
5	8.76 = eligible	8.7333 = eligible

Figure 2 shows an interface in the MATLAB Application Designer. This interface can help HR Managers make their decision on selecting corrosion engineers with the help of FIS. The interface is simple and user-friendly, allowing the HR team to enter candidate information based on key selection criteria: academic qualifications, certifications, industry experience, and skills. The fields in the application are labelled with names, and the user enters numeric values corresponding to the candidate's attributes. Subsequently, for certification and skills, the HR manager can assign values based on the candidate's profile. Despite that, for academic qualification, the HR Manager can give values of 0 for a Diploma, 1 for a Degree, and 2 for a Master's. Furthermore, for industry experience, HR Managers can assign values of 0 (no working experience), 1 (worked in a similar industry), or 2 (worked in the petrochemical industry). To calculate the result, the user enters all values and clicks the Evaluate button on the right side of the application window. The features of the Result Field, where the FIS produces a numerical value as the output of the equation. This application also helps segregate the results into clear Reject and Accept forms. For instance, the result value in the displayed case is 2.234, which belongs to the Reject range. This is made even clearer by the complementary red “Reject” label, so the HR manager can easily evaluate the results without needing to decode the numerical value. Using this tool, the HR manager can reduce decision-making obstacles and decide by applying the FIS to quantify a candidate's membership values against predefined rules and functions. This integration rationalizes the process, reduces subjective influences, and provides a consistent, effective means of assessing candidates.

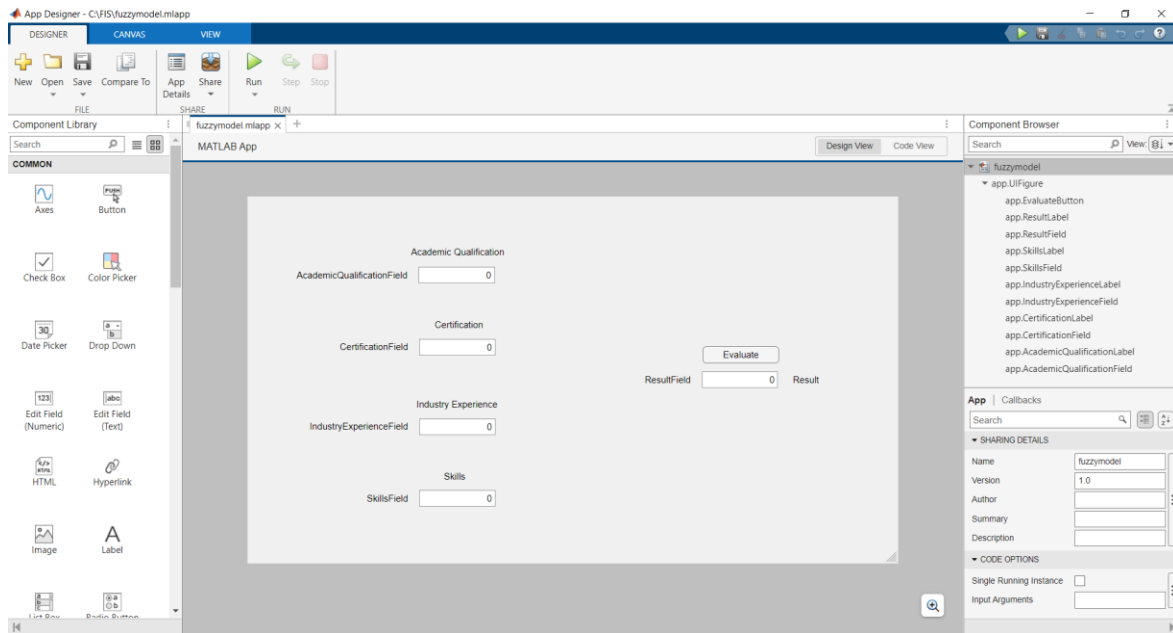


Figure 2. FIS integration in MATLAB application designer

4. Conclusions

This study effectively developed and implemented an FIS to assist Idemitsu Sdn. Bhd.'s corrosion engineer hiring process. The system established a consistent, accessible, and unbiased selection process by assessing applicants based on their academic qualifications, certifications, industry experience, and skills. The FIS provided a strong framework for selecting the best candidates for interview while successfully addressing the subjectivities and uncertainties present in conventional human evaluations. The MATLAB Application Designer of the developed tools was essential to operationalizing the FIS. An interactive, real-time platform for assessing individual candidates was developed using MATLAB App Designer, which instantly displayed acceptance or rejection results. Beyond its useful applications, the study offers additional insights. This study offers a methodological basis for future research examining computational decision-making in HR and other fields by demonstrating the potential of fuzzy logic in hiring. It emphasizes the crucial role of data-driven, well-structured models in improving the efficacy and efficiency of organizations. The results of this study highlight the revolutionary potential of fuzzy logic systems in tackling difficult decision-making problems. Organizations may reduce the risks of subjective bias and inefficiency by using FIS to make better-informed decisions. This study paves the way for future innovation in organizational decision-making systems by establishing a standard for incorporating cutting-edge computational techniques into HR procedures.

To automate the development of fuzzy rules and membership functions, future research should concentrate on integrating machine learning algorithms into the FIS. This would improve the system's adaptability across various roles and industries and reduce the need for expert input. Additionally, usability and efficiency could be improved by adding automated decision-making capabilities to Excel and by enhancing the MATLAB App Designer to support batch processing. Long-term research to assess the FIS's performance in real-world settings and across various organizational contexts would also yield valuable insights.

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Declaration of Competing Interest

The authors declare no conflict of interest.

CRedit Authorship Contribution Statement

Nur Intan Syafinaz Ahmad (Writing – original draft)

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Nur Syamilah Arifin (Writing – review & editing)

Wan Munirah Wan Mohamad (Writing – review & editing)

Ahmad Khudzairi Khalid (Resources; Software)
 Nur Saadah Ahmad (Data curation)
 Yuanita FD Sidabutar (Supervision)

Availability of the Data and Materials

The data used to support the findings of this study are included within the article.

Ethical Declarations

No artificial intelligence tools were used in the preparation of this manuscript. All content was developed manually by the authors. This study did not involve human participants or animals. Ethical approval was therefore not required.

Generative Artificial Intelligence Declarations

The authors claim that artificially intelligent-assisted technologies, such as generative AI, were not used to generate content, ideas, or theories. We have just utilised AI to enhance readability and refine the language. This was used with extreme human control and oversight. The authors take full responsibility for reviewing and approving the content.

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