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"Personnel Selection in Multimedia Projects: A case of Designer Selection"

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Abstract
The Multimedia industry is expanding quickly, and it is now crucial to employ an agile strategy when choosing designers for project managers. As various projects have specific requirements and managers are responsible for several projects simultaneously, selecting the most suitable designer requires a structured procedure. This research adopts the Bellman-Zadeh technique to identify freelance designers for Multimedia projects. The suggested approach is utilized in two case studies, one involving the use of objective data to select a designer and the other using subjective judgment to select designers with prior experience working with project managers. The findings show that our proposed technique effectively identifies the ideal candidate by considering the project's needs.
Keywords:
"Fuzzy Logic; MCDM; Bellman-Zadeh Method; Multimedia; Project Management; Personnel Selection Problem; Executive Information Systems"

1. Introduction

As new technologies continue to arise, particularly in the IT and Digital Media industry, companies are facing a growing need for specialized expertise. Their current workforce may not possess the necessary skills to fill these gaps. To address this issue, companies can hire new experts with the necessary skills. It is crucial first to identify the specific areas where expertise is lacking. To do this, an individual's existing knowledge and skills must be evaluated in relation to the job requirements. Companies determine which specific expertise is needed to address the identified gaps within the company[1]. However, it seems inconceivable to maintain large and expensive permanent human resources.

While the economy shifts towards a focus on knowledge, organizations increasingly need to prioritize their human resources. Employees are key strategic assets that drive performance and help organizations achieve their goals. As such, it's crucial for organizations to invest in proper management and development of their staff in order to optimize their performance[2].

Multimedia project management is a complex and challenging task, requiring coordination of multiple types of media, effective resource management, and ensuring quality and meeting client expectations. Finding the appropriate person for the required task is one of the most challenging problems in any project. Traditional project management methods may not be well suited to handle this challenge, especially when the decision-making process is complex and uncertain.

One solution to addressing the problem of human resource management in projects is to use freelancers. Freelancers are independent contractors not committed to a long-term employment contract with a company. They can be hired on a project-by-project basis, which allows companies to fill specific skill gaps without the need to maintain a full-time employee[3]. This can be especially useful in multimedia projects, where the need for particular expertise may be temporary or intermittent. Assigning them to freelancers with the necessary competencies is crucial to successfully outsourcing tasks. Utilizing freelancers can be an effective solution if the effort of managing them is considered [4].

While using freelancers can be a useful solution for addressing the problem of human resource management in projects, it is not without its drawbacks. A significant degree of variability exists among freelancers in terms of time required to complete a task, salary expectations, and the quality of their work. These variations can have a substantial impact on the outcome of multimedia projects that involve creative elements. Such variability necessitates a thorough evaluation of the freelancers before engaging them in a project to ensure that the project's objectives are met as intended.

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Given the aforementioned variability in freelancers' capabilities and the constraints present in each project in terms of time, budget, and quality expectations, it can be challenging for managers to effectively match freelancers to specific projects—making decisions in conditions of uncertainty. This highlights the need for a systematic approach to evaluating and selecting freelancers to ensure that the most suitable individuals are chosen for the task and that the project's objectives are met satisfactorily.

Decision support systems (DSS) are computer-based systems that support decision-making activities by providing data, modeling, analytical tools, and knowledge-based systems. They can be used to assist managers in making decisions by providing relevant information and suggestions, but the final decision is always left to the human decision-maker[5].

Accordingly, the use of Decision Support Systems (DSS) has become a business necessity as well as an opportunity for companies to gain a competitive advantage by utilizing them[6].

A DSS can be used to assist in the selection of freelancers (in our case, Graphic Designers) for multimedia projects by providing a set of data and analytical tools that can help managers evaluate the freelancers' suitability for the project. The system takes into account the project's constraints, including time, budget, and quality expectations, as well as the freelancers' work speed (speed), salary, and skill so that it provides suggestions on the best freelancers based on the data and knowledge.

Fuzzy decision support systems (FDSS) are a type of decision support system that uses fuzzy logic to handle imprecise or uncertain information[7]. Fuzzy logic is a mathematical method that allows reasoning with vague or imprecise information, such as natural language expressions like "high," "medium," or "low[8]."

In our case, FDSS can be used to assist in the selection of freelancers for multimedia projects. Given that the selection process can be complex and uncertain. There are many factors to consider, such as freelancers' qualifications, skills, previous work experience, time, budget, and quality expectations. These factors can have different levels of importance and can be expressed in a fuzzy manner. For example, the time required to complete a project can be "tight," "medium," or "loose." By using FDSS, the system can take into account the imprecision and uncertainty that is inherent in the selection process and provide a more comprehensive evaluation of freelancers. FDSS allows the use of linguistic variables to express the preferences of the decision maker and the criteria of the selection process naturally and intuitively. This makes the system more user-friendly and easy to understand for the managers.

1.1. Multi-criteria decision-making method for personnel selection

Multimedia project management is a complex and challenging field that involves high uncertainty, timing, cost, and resource management. This includes finding and hiring (long-term or short-term) the right team members with the necessary skills and expertise, managing and motivating the team throughout the project, and ensuring that the project stays on track and within budget. Additionally, multimedia projects often require specialized skills and expertise that may be difficult to satisfy, making it challenging to assemble a team with the right mix of talents. Furthermore, the high-pressure, deadline-driven nature of multimedia projects can make it difficult to manage and maintain a cohesive and productive team. These challenges can make it difficult for project managers to ensure that multimedia projects are completed on time, within budget, and with the expected quality[9]. The personnel selection problem requires innovative approaches to become effective. Accordingly, the personnel selection problem is researched in many literature sources.

The utilization of multi-criteria decision-making (MCDM) methods has been established to address complex issues, as many real-world problems have more than one decision criterion. The objective of MCDM is to establish overall preferences among alternative options. Depending on the objective, MCDM methods can be employed for comparing and ranking alternatives or for making a final decision[10].

Güngör et al. in Ref. [11] tried to design a multi-criteria decision-making (FAHP) model based on fuzzy set theory to select the most suited person; then, they applied six methods of fuzzy numbers distance specification. In Ref. [12], Mammadova and Jabrayilova proposed a fuzzy multi-criterial model to address the personnel selection problem. In Ref. [13], Tugrul created a decision-making mechanism for personnel selection using the intuitionistic fuzzy-based TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method. Kabak et al. [10] synthesized Fuzzy TOPSIS and Fuzzy ANP methods to develop a more accurate personnel selection methodology. Next, the proposed model is tested on a sniper selection as an example of personnel selection. Jasemi et al. in Ref. [14] presented a novel fuzzy ELECTRE (Elimination and Choice Translating Reality) approach and compared the results with the TOPSIS method. The proposed method is illustrated by a real numerical example, and the results are compared with those of a similar (TOPSIS-based) method. It has been demonstrated that the new approach utilizing ELECTRE is superior, particularly as it accounts for various states of the alternatives, while the TOPSIS method only considers their simple ranking. Maghsoodi et al. in Ref. [15] Considered the problem of personnel selection as a big-data problem and developed and extended a novel W-CLUS-MCDA (CLUSter analysis for improving Multiple Criteria Decision Analysis) approaches combined with the Best-Worst method. Paudel et al. [16] explained how the Bellman-Zadeh method of decision-making can be used in order to select the best person from a set of people. In Ref. [17], Gottwald et al. discussed the process of selecting Ph.D. candidates at the University of Pardubice and how they used a combination of Entropy and ARAD methods to establish the importance of different criteria. In Ref. [18] Karsak presents a fuzzy multiple objective programming approach for personnel selection. Then, explains the method by an example.

In conclusion, the problem of personnel selection has been widely studied in recent years, with a focus on the use of multi-criteria decision-making (MCDM) methods. Several MCDM methods have been proposed, such as the Fuzzy Analytic Hierarchy Process (FAHP), the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and Fuzzy ELECTRE. These methods have been applied to various personnel selection problems and have been shown to be effective in determining overall preferences among alternative options. All these studies demonstrate the effectiveness of MCDM methods in solving complex personnel selection problems. Considering the fact that multimedia has great potential for fuzzy MCDM due to its conditions of uncertainty, it is necessary to incorporate fuzzy MCDM theory in the decision-making process. This paper utilizes the Bellman-Zadeh method as an MCDM method for personnel selection.

In this paper, in section 2, the fuzzy sets are introduced, and The Bellman-Zadeh method is presented. The application of the Bellman-Zadeh method for personnel selection is demonstrated in sections 3 and 4. Finally, the conclusions are provided in Section 5.

2. Methodology

In this section, we explain the techniques that are utilized to tackle the personnel selection problem. We use the Bellman-Zadeh method, a widely used approach in MCDM that aims to find the optimal solution from a set of alternatives to identify the most appropriate designer.

2.1. Fuzzy Sets

In the classical set theory, an element belongs or does not belong to a set. There may be situations where it is unclear whether an element belongs to a set or maybe an element partially belongs to a set. For these situations, fuzzy set theory is a useful tool.

A fuzzy set is represented by a membership function that assigns a membership value between 0 and 1 to each element in the set. Thus, As an element's membership function value approaches to 1, its belonging to the set increases[19].

Let U be the set of all objects (universal set), and let X be a subset of U, denoted as $X \subseteq U$ (X is included in U). A fuzzy set[20] A is a collection of order pairs (x, μ_X); $\mu_X(x)$ is the membership function, therefore $\mu_X(x) \in [0, 1], x \in U$. The fuzzy set A is represented as

$$A = \{(x, \mu_A(x)) | x \in A, \mu_A(x) \in [0,1]\} \tag{1}$$

So, if $\mu_X(x) = 1$ means x is fully included in the set X, and when $\mu_X(x) = 0$ means x is unincluded in the set X.

A *trapezoidal fuzzy number*[20] with a membership function is defined on R by three crisp values. Let a, b, c, d be four crisp values that $a \leqslant b \leqslant c \leqslant d$. Accordingly, $\boldsymbol{A} = (a, b, c, d)$ is a *trapezoidal* fuzzy number with the membership function $\mu_A(x)$, where $[a, d]$ is the supporting interval and the interval $[b, c]$ is the peak, defined on R by

$$A \equiv \mu_A(x) = \begin{cases} \dfrac{x-a}{b-a}, & for\ a \le x \le b, \\ 1, & for\ b \le x \le c, \\ \dfrac{d-x}{d-c}, & for\ c \le x \le d, \\ 0, & Otherwise \end{cases} \tag{2}$$

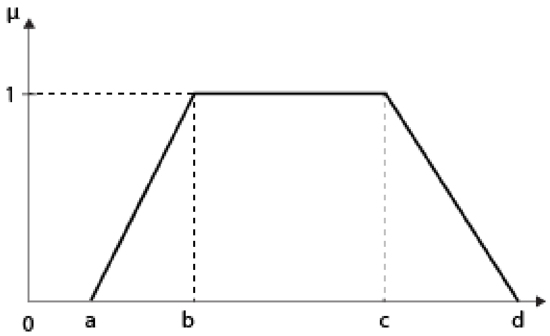

Figure. 1. trapezoidal fuzzy number

For example, consider a set of integers that indicates people's age, so we define a fuzzy set *Y* that includes people who are considered *young*. We define a membership function that assigns a degree of membership based on their age. So, we can define a trapezoidal fuzzy number *Y = (15, 25, 30, 40)* as a membership function of set *Y*:

$$Y \equiv \mu_Y(x) = \begin{cases} \frac{x-10}{20-10}, & for\ 10 \leq x \leq 20, \\ 1, & for\ 20 \leq x \leq 30, \\ \frac{x-40}{30-40}, & for\ 30 \leq x \leq 40, \\ 0, & otherwise \end{cases} \tag{3}$$

If someone is 20 years old, their degree of membership in the "young" fuzzy set would be (15 - 10)/(20 - 10) = 0.5.

The *intersection* between fuzzy sets *A* and *B*, whose membership functions are μ_A and μ_B, denoted by $A \cap B$. The membership function for this intersection is defined as

$$\mu_{A\cap B}(x) = \min\{\mu_A(x), \mu_B(x)\}\ \ for\ x \in U, \tag{4}$$

In short,

$$\mu_{A\cap B}(x) = \mu_A(x) \wedge \mu_B(x). \tag{5}$$

The *union* between fuzzy sets *A* and *B*, whose membership functions are μ_A and μ_B, denoted by $A \cup B$. The membership function for this union is defined as

$$\mu_{A\cup B}(x) = \max\{\mu_A(x), \mu_B(x)\}\ \ for\ x \in U, \tag{6}$$

In short,

$$\mu_{A\cup B}(x) = \mu_A(x) \vee \mu_B(x) \tag{7}$$

2.2. Bellman-Zadeh Method

Decision-making is a problem-solving process that involves choosing the most appropriate action from various available options to achieve a particular goal. It is a pervasive and challenging activity. Considering real-world complexities, such as uncertainty, subjectivity, and linguistics, decision-making is a fuzzy process.
Choosing from the available options is a crucial part of decision-making; the *goals* need to be achieved, and the *constraints* need to be met[20].

Linguistic variables [21] are variables whose values are words or sentences. For example, Age is a linguistic variable; its values can be linguistic rather than numerical— young, not young, more or less young, rather young, old, not very old and not very young, etc., rather than 20, 21, 32.

For example, consider a multimedia company that wants to hire a graphic designer. They require graphic designers to satisfy some specific criteria, such as: "The required salary by designers should be more or less low," which is a constraint (meaning that we have constraints on salaries), where "low" is a linguistic value, and the required salary is a linguistic variable. Similarly, an example of a fuzzy goal is: "The quality of designers must be rather high," where "high" is a linguistic value for the quality that is a linguistic variable. The underlined words make the process fuzzy.

Fuzzy goals and constraints can be represented as fuzzy sets in the space of alternatives[22]. If we are provided with a fuzzy goal *G*, and a fuzzy constraint *C*, in a set of alternatives *X*, then the intersection of *G* and *C* forms a fuzzy decision set, D.
According to Bellman-Zadeh[22], the decision is a fuzzy set *D* with membership function $\mu_D(x)$, which is the intersection of *G* and *C*,

$$D = G \cap C = C \cap G \tag{8}$$

And

$$\mu_D = \mu_G \vee \mu_C \tag{9}$$

Fig.1. depicts the relation between G, C, and D.

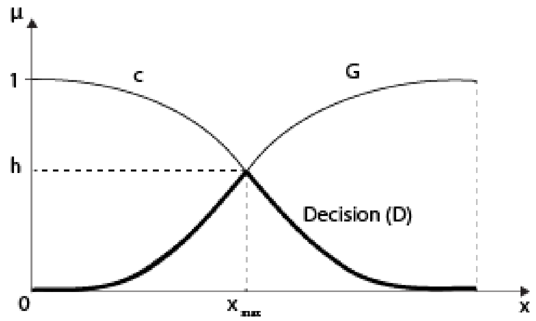

Figure. 2. Fuzzy goal *G*, constraint *C*, decision *D*, max decision x_{max}

In Fig2, the X_{max} has the highest degree of membership in the set *D*, which “adequately represents” the fuzzy set *D* [20]:

$$x_{max} = \{x|\max(\mu_D(x)) = \max(\min(\mu_G(x), \mu_C(x)\} \tag{10}$$

In general, for *n* goals G_1, G_2, G_3, · · · , G_n and *m* constraints C_1, C_2, C_3, · · · , *Cm*, the result decision is the intersection of given goals and constraints:

$$D = G_1 \cap G_2 \cap \ldots \cap G_n \cap C_1 \cap C_2 \cap \ldots \cap C_m \tag{11}$$

And the membership function is:

$$\mu_D = \mu_{G_1} \wedge \mu_{G_2} \wedge \ldots \wedge \mu_{G_n} \wedge \mu_{C_1} \wedge \mu_{C_2} \wedge \ldots \wedge \mu_{C_m} \tag{12}$$

Accordingly, the maximizing decision is given by

$$x_{max} = \{x|\mu_D(x) \text{ } is \text{ } max\} \tag{13}$$

3. Using the Bellman-Zadeh Method for Selecting Freelance Graphic Designers Using Gathered Data

The art directors of a company are searching for a freelance graphic designer for a specific multimedia project and have shortlisted five new candidates (A, B, C, D, and E) with no prior experience with the company. The company requires the candidates to fulfill specific criteria, such as work speed (in days), expected salary (in dollars for one particular project), quality of work (rated on a scale of 0 to 1), and work experience (in years), which are viewed as goals and constraints. Given their agile work style and concurrent projects, the managers provide a project brief to the candidates and request their input on requirements (for example, how many days it's going to take you to complete this project?), as well as their portfolios to evaluate their work quality and assign a rating between 0 and 1. Ultimately, the managers compile the candidates' information in Table 1 for further analysis.

Table 1. Candidate's features

Candidates	Work Speed (WS)	Desired Salary (DS)	Quality (Q)	Experience (E)
A	5	200$	0.3	5
B	9	350$	0.5	4
C	8	600$	0.6	5
D	9	700$	0.8	3
E	7	750$	0.9	3

For each project, the company has the goal to pay a low salary, finish the project as soon as possible, deliver high-quality work to their customers, and work with highly experienced designers. The company uses the collected data in table.1 to define goals and constraints.

The project managers for a particular multimedia project require a designer with these attributes:

> "*The main objective of this project is to select a senior designer who possesses a moderate level of artistic ability while simultaneously taking into account the restricted money to pay and time to meet the project deadline.*"

The selection team translates the message in the fuzzy linguistic variable, in which the candidate should be highly experienced (G_1), high quality(G_2), modest in requiring salary(C_1), and rather fast in finishing the work (C_2). So, quality and reliability are regarded as goals (G_1 and G_2), and required salary and work speed as constraints C_1, C_2.

Using the candidate's attributes, they construct fuzzy linguistic sets G_1, G_2, C_1, and C_2 on the set of potential candidates. They define *high quality* and *high experience* as goals G_1 and G_2, and *work speed* and *desired salary* as constraints C_1 and C_2.

$$G_1 = \{(x_1, a_1), \dots, (x_5, a_5)\} \tag{14}$$

$$G_2 = \{(x_1, a_1), \dots, (x_5, a_5)\},$$

$$C_1 = \{(x_1, b_1), \dots, (x_5, b_5)\}$$

$$C_2 = \{(x_1, b_1), \dots, (x_5, b_5)\}$$

The Decision formula (11) gives

$$D = G_1 \cap G_2 \cap C_1 \cap C_2 \tag{15}$$

Which, with formula (12), produces

$$D = \{(x_1, \mu_1), \dots, (x_5, \mu_5)\} \tag{16}$$

Where:

$$\mu_k = \min(a_{k1}, \dots, a_{kn}, b_{k1}, \dots, b_{km}), \quad k = 1, \dots, 5. \tag{17}$$

Where k is the number of alternatives (in this case, k = 5), n is the number of Goals (n = 2), and m is the number of Constraints (m = 2).

High, Moderate, Rather Fast, and Modesty are linguistic values that the selection team described separately for Highly Experienced, Moderate Quality, Rather Fast Work Speed, and Requiring Modest Salary, using part of the trapezoidal numbers:

$$G_1 \equiv \mu_{Highly\ Experienced}(x) = \begin{cases} 0, & x < 2 \\ \dfrac{x-2}{4-2}, & 2 \le x \le 4 \\ 1, & x > 4 \end{cases} \tag{14}$$

$$G_2 \equiv \mu_{Moderate\ Quality}(x) = \begin{cases} 0, & x < 0.2 \\ \dfrac{x-0.2}{0.4-0.2}, & 0.2 \le x \le 0.5 \\ 1, & x > 0.4 \end{cases}$$

$$C_1 \equiv \mu_{Rather\ Fast\ WorkSpeed}(x) = \begin{cases} 1, & 1 \le x < 5 \\ \dfrac{10-x}{10-5}, & 5 \le x \le 10 \\ 0, & x > 10 \end{cases}$$

$$C_2 \equiv \mu_{Modest}(x) = \begin{cases} 1, & 0 \le x < 300 \\ \dfrac{800-x}{800-300}, & 300 \le x \le 800 \\ 0, & x > 800 \end{cases}$$

The membership values will become:

Table 2. Candidate's degree of suitability for the project

Candidates	Rather Fast Work Speed	Modest	Moderate Quality	Highly Experienced
A	1	1	0.5	1
B	0.2	0.9	1	1
C	0.4	0.4	1	1
D	0.2	0.2	1	0.5
E	0.6	0.1	1	0.5

The fuzzy sets corresponding to the data obtained in Work Speed, Desired Salary, Quality, and Experience are:

$$G_1 = \{(A, 1), (B, 1), (C, 1), (D, 0.5), (E, 0.5)\} \quad (20)$$

$$G_2 = \{(A, 0.5), (B, 1), (C, 1), (D, 1), (E, 1)\}$$

$$C_1 = \{(A, 1), (B, 0.2), (C, 0.4), (D, 0.2), (E, 0.6)\}$$

$$C_2 = \{(A, 1), (B, 0.9), (C, 0.4), (D, 0.2), (E, 0.1)\}$$

Using the Bellman-Zadeh method and formula (15), we have the following:

$$D = \{(A, 0.5), (B, 0.2), (C, 0.4), (D, 0.2), (E, 0.1)\} \quad (20)$$

Candidate *A* has the largest membership grade of 0.5 among others; he is the best candidate for the project.

4. Using the Bellman-Zadeh Method for Selecting Freelance Graphic Designers Using Subjective Judgment

Assume that a company's art directors seek a freelance graphic designer. They have identified five potential candidates (A, B, C, D, and E) whom they have worked with and are acquainted with their qualities. The selection team desires candidates to possess certain characteristics, including *work speed*, *desired salary*, *quality of work*, and *reliability*, considered as goals and constraints. The company has previously worked with these candidates and is already familiar with them, so they specify fuzzy linguistic values based on the project's requirements using subjective judgment.

The project manager requires a designer with these attributes:

> "*The priority for this project is to secure a reliable designer with a strong artistic ability while also considering the limited budget available.*"

The selection team translates the message in the fuzzy linguistic variable, in which quality(G_1) reliability(G_2) should be "High," required salary(C_1) should be "Modest," and there is no constraint regarding the work speed. So, high quality and high reliability are regarded as goals (G_1 and G_2), modest salary is constraint C_1.

Table 2. Candidate's suitability for the project

Candidates	Ability to Finish Fast	Readiness to Accept a Modest Salary (C_1)	Quality (G_1)	Reliability (G_2)
A	High	Rather Low	Moderate	Moderate
B	Rather High	High	Low	High
C	Rather Low	Moderate	Very Low	Moderate
D	Moderate	Very High	Moderate	Very High
E	Low	Very Low	Very High	Rather High

The candidate with the highest membership grade from the formula (18) among $\mu_1, \ldots, \mu_p$ will be considered the best candidate for the project. The team constructs the following fuzzy sets on the set of alternatives.

Thus, we have:

G_1 = {(A, "Moderate"), (B, "Low"), (C, "Very Low"), (D, "Moderate"), (E, "Very High")},

G_2 = {(A, "Moderate"), (B, "High"), (C, "Moderate"), (D, "Very High"), (E, "High")},

C = {(A, "Rather Low"), (B, "High"), (C, "Moderate"), (D, "Very High"), (E, "Very Low")}, Here G_1 represents *acquiring a high quality of work*, G_2 is *reliability*, and C gives the *readiness of the candidates to accept a rather Low salary*.

Considering that we are using linguistic values for grades given to candidates, and we can compare these linguistic values to each other (Very Low < Low < Rather Low < Moderate < Rather High < High < Very High), there is no need for *defuzzification.* So, using formula (15), we have:

$$D = \{(A,\text{"Rather Low"}), (B,\text{"Low"}), (C,\text{"Very Low"}), (D,\text{"Moderate"}), (E,\text{"Very Low"})\} \quad (20)$$

Candidate D has the largest membership grade, "Moderate," among others, so he is the best candidate for the project.

5. Conclusion

In conclusion, this paper has presented a methodology for addressing the problem of personnel selection in the context of hiring freelance graphic designers for a multimedia project. The Bellman-Zadeh method was used as the decision-making framework. The results indicate that the proposed methodology can effectively handle the uncertainty and fuzziness in the personnel selection problem and provide a reliable solution for selecting the best candidate for the project. It could be recommended for similar projects. Furthermore, future research may involve the application of the proposed methodology to other domains or the combination of this approach with other decision-making methods to improve its performance further.

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