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RESEARCH ARTICLE

A Fuzzy AHP Approach to Evaluating the Fuzzy Weight of Mobile Game Application Software Quality Factors: Usability Expectations for Novice Users

Manish Mishra[1],* and Reena Dadhich[1]

[1]*Department of Computer Science & Informatics, University of Kota, India*

Abstract: Mobile games have become a popular way to pass the time, and an increasing number of new and inexperienced users are searching for enjoyable and simple-to-learn experiences. It is essential to ensure that the software of these mobile games is intuitive and of high quality in order to keep users satisfied and coming back. However, it is difficult to assess the subjective and frequently nebulous expectations of first-time users. In between the development of mobile game applications, stakeholders in the mobile game industry are continually exploring applications whose quality is measured. The deployment of this effort will be facilitated by the quantification of qualitative aspects that depend on software quality factors. Thus, it is crucial to choose the proper evaluation strategy. The evaluation is based on two parameters: fuzzy rate and fuzzy weight. The evaluation of a five-point fuzzy rating system is based on surveys or questionnaires, and it involves straightforward inputs. Fuzzy weight refers to the relative significance of software quality aspects, and it is determined by stakeholders responsible to ensure appropriate quality of mobile application, ensuring that the crisp sum is equal to one. This may be achieved when stakeholders agree on the relative significance or pairwise comparison of software quality factors and examine their relative value. This technique guarantees that the total assessment of quality converges in the correct direction. This paper presents a novel application of the fuzzy analytic hierarchy process that evaluates the appropriate fuzzy weight for software quality factors of mobile game applications, particularly for neophyte users. This will aid the mobile game application industry in formulating and evaluating fuzzy weights to reinforce the process that converts qualitative to quantitative aspects during mobile application development.

Keywords: software quality factors, mobile game, quantification, fuzzy logic, usability, novice users, FAHP

1. Introduction

Getting software that is both easy to use and of good quality is always hard in the world of mobile games, where user experience is everything and things change quickly. How well these things work together determines how well mobile games do, especially with people who have never played them before or are new to using their phones. New gamers want games that are more fun and easy to use as the industry grows. Mobile game developers have to change every part of their games and make them better than their competitors in order to meet these standards and do better than their competitors.

The quality of the mobile application as a final product is the only thing that will be able to do this, but there are two essential questions that need to be answered: what are the quality factors? Moreover, what are the criteria that are used to assess quality factors throughout the creation of the application? A method to fuzzy-based assessment is presented in this study. The evaluation model is dependent on two parameters: fuzzy rating and fuzzy weight. The survey or questionnaire that is based on the prototype of the mobile application that is currently being developed is the source of the input for fuzzy ratings on a five-scale fuzzy framework, such as VL, L, M, H, and VH. At the same time, the input source of fuzzy weight may also be taken as five scale fuzzy weights, such as VL, L, M, H, and VH; nevertheless, weight is subject to one significant restriction, which is that the total must equal one. The current literature does not take this into account. The purpose of this study is to address the research gap that exists between the current literature and assessment criteria that potential mobile application companies may use in order to evaluate the quality of applications while they are being developed and access the overall quality in the appropriate direction. In order to achieve the research objective of this study, it is essential to accurately evaluate the quality of the application or quantify its overall quality throughout the development process of a mobile application.

An implicit feature that is of tremendous value for any assessment is the ability to perform precise calculations or accurate measurements. The emphasis of this research is on this particular feature, which contributes to more accurate assessment and, as a result, converges to an adequate level of overall quality. Every time a mobile application is developed by any software or mobile application, stakeholders or investors always place a

*Corresponding author: Manish Mishra, Department of Computer Science & Informatics, University of Kota, India. Email: profrdadhich@uok.ac.in

strong emphasis on the quality of the mobile application while it is being developed. Due to the fact that quality is dependent on quality factors, the first thing that has to be done is to gather the ideal amount of quality factors according to the stakeholders, investors, and quality managers or decision makers of mobile application development companies. The next phase in the process involves quantifying the overall quality of the mobile application by considering the optimal combination of quality factors that require input for fuzzy rate and fuzzy weight. This research study focuses on the notion that the cumulative weight of quality factors must be precisely equal to one. The purpose of this component is to ensure the accuracy of fuzzy weights in all calculations related to overall quality. It also aids decision makers in correctly interpreting these calculations during the development of mobile applications.

The fuzzy analytic hierarchy process (FAHP) is the subject of this study paper. It is a new and cutting-edge way to figure out how to measure value expectations in the context of software quality factors for mobile game newbies. Traditional ways of testing usefulness do not always show how new users' needs are different and often subjective. This is especially true now that mobile game apps are always getting more involved and different.

In our study, we look into fuzzy weights and come up with a new framework that takes into account the questions and contradictions that happen naturally when judging the expectations of mobile gamers. The fuzzy AHP was added so that we can meet the needs of both people who use AHP in simple, clear ways and people who need to use it in more complicated, specific ways. This method is meant to give more accurate and adaptable details on how to select the most important fuzzy weight software quality factors. A lot of people will be able to understand and use the power of software quality factors if they know how to properly evaluate the fuzzy weight of quality factors.

It is important to remember that meeting standards for software quality and value is a hard problem that needs advanced methods to solve as mobile games change the way people have fun. In this way, this paper can be used as a guide for further research and as a valuable tool for game developers who want to improve the way they evaluate the quality of games and make mobile games that keep getting more and more people excited.

The purpose of this article is to establish the appropriate framework, together with the ideal amount of quality factors, for the purpose of making mobile games simple to learn for first-time players. On the other hand, it makes use of fuzzy AHP in order to determine the relative importance of each software quality factor (QF) for mobile gaming apps while they are in the process of being developed.

2. Literature Review

The term "quality" is the one that is often used in describing any form of product. Software is anything that may be considered a product; hence, it is unclear how someone can argue that software is of high quality? Numerous professionals have devoted their time and energy to researching and developing straightforward models to describe quality with the help of quality models, such as Boehm's model [1] and Dromey's model [2]. A framework for assessing software quality and developing a quality model was proposed by Maryol et al. [24]. The International Organization for Standardization (ISO) is a global organization that establishes several quality standards. One of these is the ISO 9126 standard [3]. However, each of these models is generic in nature, but they may be modified to meet the requirements of any software application, taking into account the constraints of the particular software application. These concepts offer a foundation for excellence as a foundation. The quality framework is a qualitative element of the software product, and this one is useless if we do not have a comparison analysis for the quality aspects or a technique to figure out the total quality in a numerical approach.

The use of fuzzy logic is required for any kind of quantitative or qualitative analysis. Since the evaluation process contains ambiguity, fuzzy logic is one of the greatest techniques for dealing with such situations [4].

Thus, the next important question is how to quantify the quantity attributes. The quantification of quality factors investigates a method to examine quality variables or justify overall quality while the software product is being developed. Many of the researchers are moving in this particular direction. In their study, Srivastava et al. [5] examine the application of a fuzzy multicriteria approach to quantify software quality. A method for quantifying the quality of software is proposed by Dubey and Sharma [6] using a multicriteria decision approach. Similarly, Reena and Bhavesh [7] suggest a technique for assessing the dependability of aspect-oriented software by employing fuzzy logic. Srivastava and Kumar [8] put forth the perspectives of a project manager, a developer, and a tester, and further developed the research. However, the focus of these studies remains on developing a framework to ensure the production of high-quality software products and quantifying them as desktop applications. The next significant step in the process is to transform qualitative aspects into quantitative aspects for a mobile application [9]. Nitze and Schmietendorf [10] conduct a survey to assess the perception and expectation of mobile consumers regarding software quality. Idri et al. [11] modify the ISO 9126 standard to accommodate mobile environments.

The input of the end user is critical to the determination of one of the most crucial aspects of product quality, i.e., usability. Bevan-defined usability as quality of use [12]. The issue of usability arises as a result of consumers' responses to the product, which might be positive or negative communication among customers in the future. Similar to how Ghazizadeh and Vafadar [13] concentrated on quantitative usability evaluation, this article also proposes an empirical investigation. Mobile gaming is one of the most complex domains, where considerable effort was required to ensure that mobile game applications were usable. Cui and Zhu [14] present a model for determining the most effective user interface from a variety of alternatives by analyzing user interviews and questionnaire responses and satisfying user expectations. The ease of use of a mobile gaming application is and will continue to be a key factor, particularly for first-time users and other inexperienced players. In order to have a good usability quality framework, one must ensure that the optimal amount of quality elements is present [15]. A framework for assessing the efficacy of first-time user experience (FTUE) in mobile games was introduced by Barnett et al. [16].

The evaluation procedure is determined by the relative importance of the many quality parameters. The first step toward a more effective assessment procedure will be determining the ideal value of the weights. AHP, which stands for "analytic hierarchy process," is one of the ways in which pairwise comparison is conducted to determine the relative significance or preference of items by comparing them in pairs. This is accomplished by giving numerical numbers that signify the intensity of preference. These values are often represented on a scale, such as the Saaty scale, where a value of 1 implies equal significance, but other values imply different levels of preference.

This approach helps where anyone may determine an acceptable weight by doing pair-by-pair comparisons, introduced by Saaty [17].

The FAHP, often known as FAHP, was first presented by Buckley in 1985 as an extension of the AHP [18]. Fuzzy AHP enhances the conventional AHP methodology by using fuzzy logic. Fuzzy logic enables the incorporation of ambiguity and inexactness in the process of decision making. Fuzzy AHP employs linguistic variables and fuzzy numbers to indicate the ambiguity linked to judgments, as opposed to using precise values. In a FAHP, the pairwise comparison matrix is expanded to include fuzzy numbers. Instead of giving an exact value, decision makers have the option to articulate their judgments using language phrases such as “slightly more important” or “strongly more important,” which are then translated into fuzzy numbers.

The FAHP may be used in a wide variety of different contexts (Wu, Tzeng & Chen, 19].

Data envelopment analysis (DEA) is another quantitative technique used in the fields of operations research and management science to evaluate the effectiveness of decision-making processes. The research of Sharafi et al. [20] introduces a novel fuzzy DEA model for the purpose of selecting green suppliers. The model does this by gathering expert votes. Subsequently, the suggested models were used to choose an environmentally friendly supplier inside an automobile conglomerate. In this particular case study, a comprehensive rating of environmentally friendly providers is achieved.

Decision makers may handle uncertainty and imprecision in the decision-making process by combining fuzzy AHP with pairwise comparison. A novel approach proposed by Tavana et al. [21] to enhance the limitations of DEA by incorporating the advantages of pairwise comparisons in AHP. It also proposes many new hybrid MADM-DEA models with varying levels of computing complexity and consistency.

The determination of fuzzy weights is the primary topic of discussion in this chapter [22], with a specific emphasis placed on the fuzzy least square error approach and the fuzzy best worst approach. The purpose of this chapter is to provide readers with a better knowledge of fuzzy weight determination techniques and the possible applications of these approaches in decision-making situations that occur in the real world.

Pairwise comparison is very advantageous in complex decision-making situations that include numerous factors. It facilitates the process of making comparisons and offers a systematic method for assessing different choices. The analytic hierarchy process (AHP) is a frequently used technique for pairwise comparison. It entails the creation of a matrix to systematically assess and evaluate alternates.

This article describes a one-of-a-kind application with the support of FAHP and pairwise comparison with the goal of defining fuzzy weight of software quality factors for mobile gaming applications according to the usability expectations of novice users.

3. Fuzzy Logic

Fuzzy logic is a way of thinking about mathematics as well as a kind of logic that supports persons in forming judgments and reasoning when they are uncertain about what the future holds. Fuzzy logic is also a type of logic. In contrast to classical logic, often known as Boolean logic, which can only accept “true” or “false” values as inputs, fuzzy logic is able to take in values that are neither true nor false. It is willing to work with values in the center that represent varying degrees of truth or positions within a collection. Because of this, it is useful when working with information that is not crystal clear or precise. When it comes to the concept of variables, linguistic variables have numbers that are represented by language words or concepts, such as “low,” “medium,” and “high.” These expressions are not used to discuss specific numerical values, but rather broad or qualitative aspects of a system. You may, for instance, have a linguistic variable known as “temperature” that contains terms such as “cold,” “cool,” “warm,” and “hot” that together describe the temperature of a particular location. When there is a great deal of uncertainty and potential for making mistakes, fuzzy logic and linguistic elements are often utilized jointly to make judgments because of the tight connection between the two. This paper adopts a triangular fuzzy membership function as illustrated in Figure 1.

Figure 1
Triangular fuzzy membership function

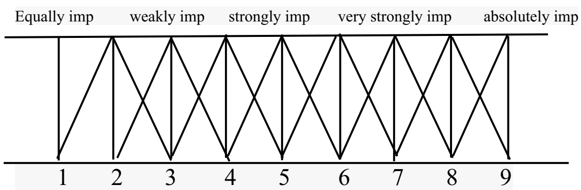


Table 1
Relationship between linguistic variable and fuzzy value as per Figure 1

Comparison (crisp)	Linguistic variable	Fuzzy value
1	Equally important	(1,1,1)
2	In between equally important and weakly importance	(1,2,3)
3	Weakly importance	(2,3,4)
4	In between weakly important and strongly importance	(3,4,5)
5	Strongly importance	(4,5,6)
6	In between strongly important and very strongly importance	(5,6,7)
7	Very strongly important	(6,7,8)
8	In between very strongly important and absolutely importance	(7,8,9)
9	Absolutely important	(8,9,9)

Table 2
Relationship between crisp value & inverse fuzzy value

Comparison (crisp)	Fuzzy value (Inverse)	Simplified fuzzy value
1/1	$(1,1,1)^{-1}$	(1,1,1)
1/2	$(1,2,3)^{-1}$	$\left(\frac{1}{3},\frac{1}{2},\frac{1}{1}\right)$
1/3	$(2,3,4)^{-1}$	$\left(\frac{1}{4},\frac{1}{3},\frac{1}{2}\right)$
1/4	$(3,4,5)^{-1}$	$\left(\frac{1}{5},\frac{1}{4},\frac{1}{3}\right)$
1/5	$(4,5,6)^{-1}$	$\left(\frac{1}{6},\frac{1}{5},\frac{1}{4}\right)$
1/6	$(5,6,7)^{-1}$	$\left(\frac{1}{7},\frac{1}{6},\frac{1}{5}\right)$
1/7	$(6,7,8)^{-1}$	$\left(\frac{1}{8},\frac{1}{7},\frac{1}{6}\right)$
1/8	$(7,8,9)^{-1}$	$\left(\frac{1}{9},\frac{1}{8},\frac{1}{7}\right)$
1/9	$(8,9,9)^{-1}$	$\left(\frac{1}{9},\frac{1}{9},\frac{1}{8}\right)$

4. Fuzzy AHP

The regular AHP is enhanced with the FAHP, which adds fuzzy reasoning to the normal AHP in order to assist individuals in making choices when they are at a loss for what to do. AHP stands for "analytical hierarchy process," and it is a method for making decisions that guide you through looking at a list of possibilities and ranking them based on a variety of criteria. Thomas L. Saaty was the one who first came up with the concept in the 1970s. The AHP is expanded upon by the fuzzy AHP method, which enables users to make choices based on less-than-perfect conclusions and unknowns. People who make judgments in the real world do not always have crystal clear and accurate figures to compare, and there could be some ambiguity. Words and phrases such as "very important," "somewhat important," and "not important" are employed in fuzzy logic to demonstrate these confusing conclusions.

5. Research Methodology

5.1. Research design

A model of evaluation that is fuzzy based is shown in this study. In order to do this, we use ISO 9126 as our point of departure. Learn-ability, attractiveness, and operability are the three quality factors that need to be extracted from ISO 9126. Simplicity, error and recovery, and user satisfaction are the other three qualities that have to be taken into consideration. Therefore, our proposed model consists of a total of six distinct quality factors as illustrated in Table 1.

This research adopts the strategy that is presented to do a pair-wise comparison among all of the quality parameters, the justification for this method is that first to find out the relative significance between each of them being taken into consideration. Therefore, this study creates a pair-wise matrix; but, prior to this, it is important to determine the relative value of each quality element when seen in a pair-wise fashion as illustrated in Table 2. Uncertainty surrounds the nature of weight. The triangular fuzzy function is considered in this study.

Table 3
Quality factors to access usability

Characteristic	Quality factors
Usability	Learn-ability Simplicity Attractiveness Operability Error and recovery User satisfaction

5.2. Proposed model

This paper adopts the algorithm discussed by Nădăban et al. ([23], P-826). The following steps will explain the proposed model.

Step 1. Design the usability framework for mobile game applications.
Step 2. Decide pair-wise priorities (crisp value) among software quality factors of usability.
Step 3. Replace crisp value with corresponding fuzzy values as per linguistic variable.
Step 4. Calculate fuzzy geometric mean (FGM) for all quality factors (QF).
Step 5. Calculate normalized fuzzy weight (NFW) from FGM for all quality factors (QF).
Step 6. Convert NFW into corresponding crisp values and validate with the sum of all quality factors (QF).

5.3. Data analysis and validation

This study uses five criteria as linguistic variables: equally imp, weakly imp, strongly imp, very strongly imp, and absolutely imp. Each of these criteria maps to a fuzzy value according to the triangle fuzzy function. The data source for fuzzy weight is determined by assessing the degree of relative significance among all quality factors in a pair-wise manner, as described in step 1 of Section 6 (Case Study).

The fuzzy value of the data that has to be acquired, which is reliant on the data values, is shown in Table 2. These data were organized in the form of a pairwise matrix so that each pair of QF could be compared to one another in a pairwise way. The validation of the data is shown by the fact that this matrix converges to a normalized pair-wise matrix, in which the sum of the crisp sums of each QF is considered to be one.

6. Case Study

Suppose there is a mobile development organization "ABC" whose stakeholders evaluate fuzzy weight for six quality factors QF1 to QF6. The following steps along with numeric values illustrate it. Quality factors for usability expectation as per novice users for mobile game applications are illustrated in Table 3:

Table 4
Quality factors QF1 to QF6

	Quality factors
QF1	Learn-ability
QF2	Simplicity
QF3	Attractiveness
QF4	Operability
QF5	Error and recovery
QF6	User satisfaction

Step 1: Design a pair-wise comparison framework matrix for each pair of quality factors. Stakeholders and investors mutually agreed upon the following criteria imposed upon six quality factors as illustrated in Table 4:

1. Learn-ability is 4 times more important (in between weakly imp and strongly imp) than simplicity.
2. Learn-ability is 7 times more important (very strongly imp) than attractiveness.
3. Learn-ability is 6 times more important (in between weakly imp and strongly imp) than error and recovery.
4. Learn-ability is 3 times more important (weakly imp) than operability.
5. Learn-ability is 8 times more important (in between v strong imp and absolutely imp) than user satisfaction.
6. Simplicity is 5 times more important (strongly imp) than attractiveness.
7. Simplicity is 3 times more important (weakly imp) than error and recovery.
8. Simplicity is 7 times more important (very strongly imp) than user satisfaction.
9. Operability is 2 times more important (in between equally imp and weakly imp) than simplicity.
10. Error and recovery are 2 times more important (in between equally imp and weakly imp) than attractiveness.
11. Operability is 6 times more important (in between strongly imp and very strongly imp) than attractiveness.
12. Attractiveness is 3 times more important (strongly imp) than user satisfaction.
13. Operability is 4 times more important (in between weakly imp and strongly imp) than error and recovery.
14. Error and recovery is 5 times more important (strongly imp) than user satisfaction.
15. Operability is 7 times more important (very strongly imp) than user satisfaction.

Table 5
Pair-wise comparison matrix

	QF1	QF2	QF3	QF4	QF5	QF6
QF1	1	4	7	6	3	8
QF2	1/4	1	5	3	1/2	7
QF3	1/7	1/5	1	1/2	1/6	3
QF4	1/6	1/3	2	1	1/4	5
QF5	1/3	2	6	4	1	7
QF6	1/8	1/7	1/3	1/5	1/7	1

Step 2. Replace fuzzy value with crisp value as per Tables 2 and 5 and calculate FGM for each QF as illustrated in Table 6.

Computation of FGM for quality factor QF1:

$$\left((1*3*6*5*2*7)^{1/6}, (1*4*7*6*3*8)^{1/6}, (1*5*8*7*4*9)^{1/6}\right) = (3.37, 4.10, 4.79)$$

Similarly calculated for other quality factors.

Step 3. Computation of NFW for each quality factor as illustrated in Table 7.

Computation of NFW for quality factor QF1:

$$(3.37, 4.10, 4.79) * \left(\frac{1}{11.36}, \frac{1}{9.25}, \frac{1}{7.37}\right) = (0.297, 0.443, 0.649)$$

Similarly calculated for other quality factors.

Table 7
Computation of normalized fuzzy weight (NFW) for each quality factor

	FGM	NFW
QF1	(3.37,4.10,4.79)	(0.297,0.443,0.649)
QF2	(1.22,1.55,2.03)	(0.107,0.168,0.275)
QF3	(0.34,0.43,0.56)	(0.029,0.046,0.076)
QF4	(0.55,0.71,0.92)	(0.048,0.077,0.125)
QF5	(1.69,2.23,2.79)	(0.149,0.241,0.379)
QF6	(0.2,0.23,0.27)	(0.018,0.025,0.037)

Step 4. Computation of crisp weight for each quality factor and verify with its sum which is 1.06 (nearly equal to 1). Hence, NFW for each quality factor can be used for computation of usability expectations of mobile games for novice users. Crisp weight also justifies overall relative importance in between quality factors as illustrated in Table 8.

Thus, the mobile app development company "ABC" has a mathematically sound method of calculating fuzzy weights.

Table 8
Verification with crisp weight (Sum = 1) and priorities of quality factors

	NFW	Crisp weight	Priority
QF1	(0.297,0.443,0.649)	0.463	1st
QF2	(0.107,0.168,0.275)	0.183	3rd
QF3	(0.029,0.046,0.076)	0.050	5th
QF4	(0.048,0.077,0.125)	0.083	4th
QF5	(0.149,0.241,0.379)	0.256	2nd
QF6	(0.018,0.025,0.037)	0.027	6th

Table 6
Computation of fuzzy geometric mean (FGM) for each quality factor

	QF1	QF2	QF3	QF4	QF5	QF6	FGM
QF1	(1,1,1)	(3,4,5)	(6,7,8)	(5,6,7)	(2,3,4)	(7,8,9)	(3.37,4.10,4.79)
QF2	(1/5,1/4,1/3)	(1,1,1)	(4,5,6)	(2,3,4)	(1/3,1/2,1)	(6,7,8)	(1.22,1.55,2.03)
QF3	(1/8,1/7,1/6)	(1/6,1/5,1/4)	(1,1,1)	(1/3,1/2,1)	(1/7,1/6,1/5)	(2,3,4)	(0.34,0.43,0.56)
QF4	(1/7,1/6,1/5)	(1/4,1/3,1/2)	(1,2,3)	(1,1,1)	(1/5,1/4,1/3)	(4,5,6)	(0.55,0.71,0.92)
QF5	(1/4,1/3,1/2)	(1,2,3)	(5,6,7)	(3,4,5)	(1,1,1)	(6,7,8)	(1.69,2.23,2.79)
QF6	(1/9,1/8,1/7)	(1/8,1/7,1/6)	(1/4,1/3,1/2)	(1/6,1/5,1/4)	(1/8,1/7,1/6)	(1,1,1)	(0.2,0.23,0.27)

6.1. Results and discussion

The results that were acquired inside this part have two points of view. The first point is that the total of the crisp weight of all quality factors equals 1.06, which is considered to be one, and this is what validates the data. The other is the order of priority among the quality factors in comparison to the crisp weight, which may be placed in accordance with the order of priority as shown in Table 8.

The results that have been validated guarantee that there is a significant link between the mathematical theoretical framework and the results that have been seen. The results that have been validated additionally guarantee that there is a significant association between the theoretical framework and its practical application.

6.2. A practical approach

The result that was acquired in this study was applied by the decision makers as an allocation of fuzzy weight, as illustrated in Table 9. The information presented here offers a concept of the distribution of fuzzy weights on a scale of five, according to the decision maker, and one feasible combination is illustrated in Table 10.

Table 9
Relative distance in six quality factors

	Relative distance
QF1-QF5	0.207
QF5-QF2	0.073
QF2-QF4	0.1
QF4-QF3	0.033
QF3-QF6	0.023

Table 10
Allocation of five-scale fuzzy weight as per relative distance by decision maker of the mobile industry

	Crisp weight	Priority	Fuzzy weight
QF1	0.463	1st	VH
QF2	0.183	3rd	H
QF3	0.050	5th	M
QF4	0.083	4th	M
QF5	0.256	2nd	H
QF6	0.027	6th	M

This paper adopts five-scale of triangular fuzzy weight and triangular fuzzy rate as illustrated in Table 11.

Table 11
Fuzzy weight and fuzzy rate

Criteria	Fuzzy weight	Fuzzy rating
VL (Very low)	(0.0,0.0,0.25)	(0.0,0.1,0.3)
L (Low)	(0.0,0.25,0.50)	(0.1,0.3,0.5)
M (Medium)	(0.25,0.50,0.75)	(0.3,0.5,0.7)
H (High)	(0.50,0.75,1.0)	(0.5,0.7,0.9)
VH (Very high)	(0.75,1.0,1.0)	(0.7,0.9,1.0)

Evaluation of fuzzy rating as feedback obtained by end user. One of the possible outcomes is illustrated in Table 12.

Table 12
Allocation of five-scale fuzzy weight as per relative distance by decision maker of the mobile industry

	Fuzzy weight	Fuzzy rate
QF1	(0.75,1.0,1.0)	(0.7,0.9,1.0)
QF2	(0.50,0.75,1.0)	(0.5,0.7,0.9)
QF3	(0.25,0.50,0.75)	(0.7,0.9,1.0)
QF4	(0.25,0.50,0.75)	(0.5,0.7,0.9)
QF5	(0.50,0.75,1.0)	(0.7,0.9,1.0)
QF6	(0.25,0.50,0.75)	(0.5,0.7,0.9)

The overall fuzzy rating of overall quality (fuzzy) is obtained with the help of fuzzy multiplication and fuzzy addition is illustrated in Table 13.

Table 13
Evaluation of overall fuzzy rating or overall quality in fuzzy term as per novice users

	Fuzzy weight	Fuzzy rate	Overall rating
QF1	(0.75,1.0,1.0)	(0.7,0.9,1.0)	(0.525,0.9,1.0)
QF2	(0.50,0.75,1.0)	(0.5,0.7,0.9)	(0.25,0.525,0.9)
QF3	(0.25,0.50,0.75)	(0.7,0.9,1.0)	(0.175,0.45,0.75)
QF4	(0.25,0.50,0.75)	(0.5,0.7,0.9)	(0.125,0.35,0.675)
QF5	(0.50,0.75,1.0)	(0.7,0.9,1.0)	(0.35,0.675,1.0)
QF6	(0.25,0.50,0.75)	(0.5,0.7,0.9)	(0.125,0.35,0.675)

Overall fuzzy rating obtained as (0.525, 0.9, 1.0), when defuzzify with the help of the centroid method, overall crisp quality obtained as 0.8083 or 80.83%.

6.3. MATLAB simulation

MATLAB was used to provide a visual representation of the overall quality. Two of the inputs are fuzzy weight and fuzzy rate, both of which are implemented by triangle fuzzy membership and are depicted in Figures 2 and 3, respectively. The output function is an overall fuzzy rating for beginner users, which is implemented as a triangular fuzzy membership function and is illustrated in Figure 4. Figure 5 is an illustration of the control surface graph in MATLAB, which was used to verify the data acquired, which showed that the overall crisp quality was attained as 0.8024, which is equivalent to 80.24%. The purpose of this practical example is to demonstrate how the priority of fuzzy weight plays a significant part in an effort to attain overall correct quality.

Figure 2
Triangular fuzzy membership function (fuzzy weight) as input

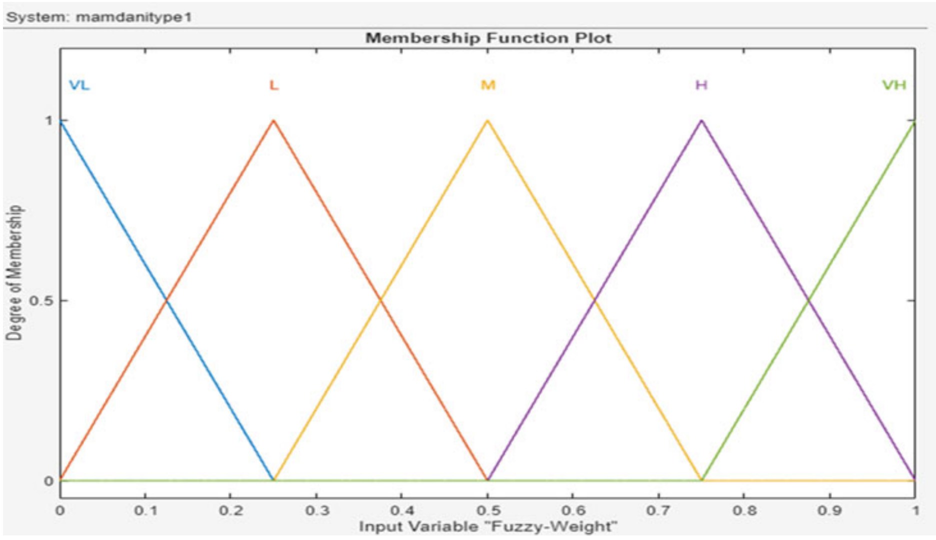


Figure 3
Triangular fuzzy membership function (fuzzy rate) as input

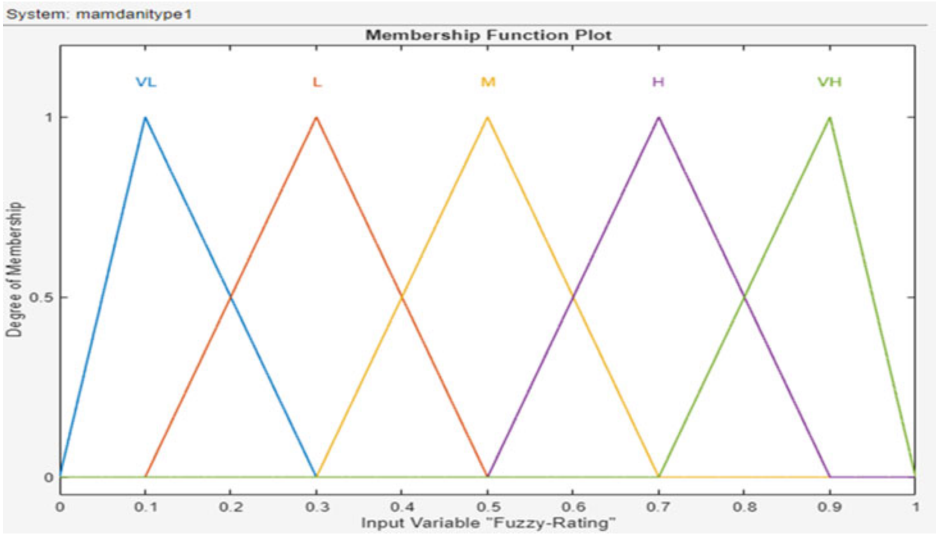


Figure 4
Triangular fuzzy membership function (overall fuzzy rating for novice user) as output

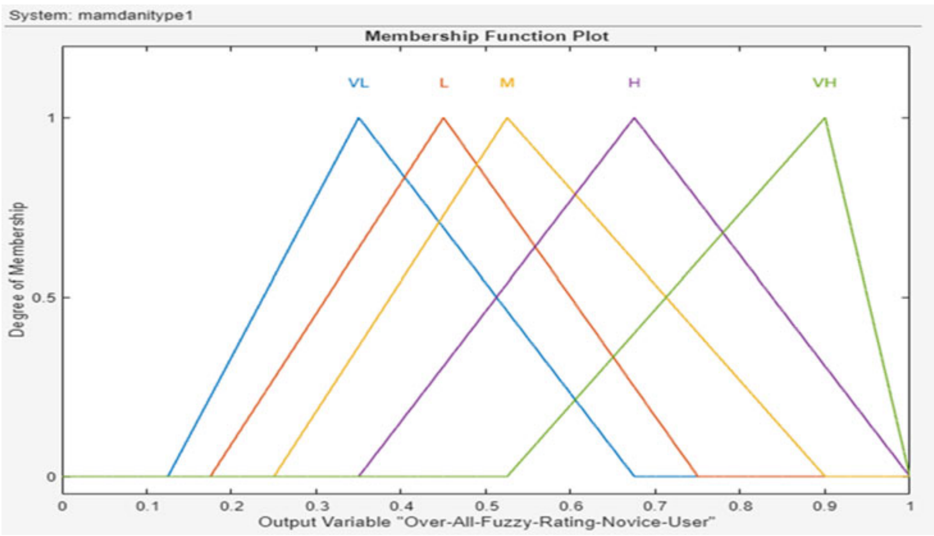
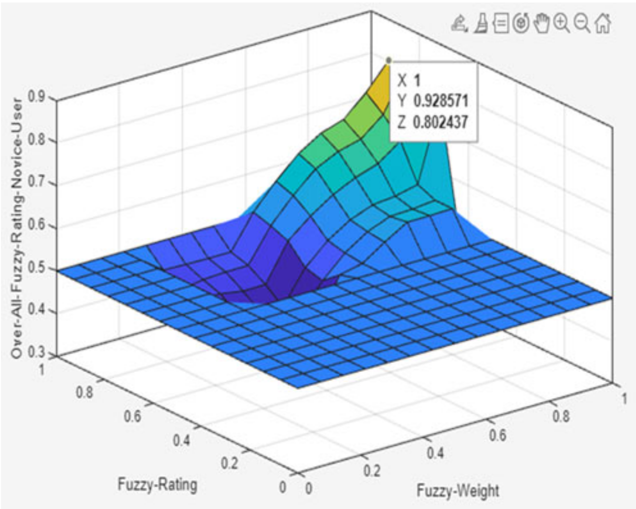


Figure 5
Control surface



7. Conclusion and Future Scope

This research study presents an innovative, effective, and novel technique for evaluating fuzzy weight for software quality criteria for mobile gaming applications based on the perspective of beginner users. This method assists stakeholders in mobile application organizations in achieving their aim of correct evaluation. The findings indicate appropriate verification, with the help of this validation; the technique that was chosen for this investigation was directed in the appropriate direction. This will also guarantee that the software industry evaluates the numerical value of the quality of mobile applications throughout the development process with more precision or accuracy and will thus take a few steps forward in the direction of an accurate assessment of the overall quality of mobile applications. Existing studies will benefit from this addition of a new dimension, especially those mobile applications that place a significant emphasis on accuracy or precision with their features. The present body of literature does not take into account the fact that crisp sum is one while assessing fuzzy weight; without a doubt, this will establish a new standard within the existing body of literature.

This research makes use of both the fuzzy set theory and the AHP to describe how new users' perspectives on the software quality elements in mobile games are inherently uncertain and imprecise. The use of FAHP is one of the most effective methods for accomplishing this goal. Users and the mobile game industry as a whole both stand to benefit from this development. The use of automation may allow for this mathematical model to be developed to a higher degree. The FAHP is a useful tool for tackling difficult decision-making issues that include a number of criteria and potential solutions. It is likely to predict that there will be an increase in the need for advanced decision-support technologies such as fuzzy AHP as decision-making challenges get more complicated. For better judgment, fuzzy AHP may be used with Artificial Intelligence and Machine Learning algorithms. It may help optimize machine learning processes by aiding in feature selection, model assessment, and adjusting machine learning parameters.

Recommendation

The use of quantitative data ensures that decisions are made on an objective basis. It is helpful in determining which areas need work, ranking the importance of additions or updates, and improving the efficiency of the development process. The software development company will be able to set clear and quantitative success measures with the assistance of this. This makes it possible to establish concrete objectives and monitor progress over the course of time. Quantitative data may also assist in the more efficient allocation of available resources. You may direct your efforts to the areas that deliver the best return on investment if you measure the effect of the different additions or modifications you implement.

Organizations may employ techniques like surveys, user analytics, user testing, and feedback-gathering tools in order to translate qualitative features into quantitative data. All of these approaches are responsible for assessing fuzzy ratings. The significance of fuzzy weight is contingent on the stakeholders and investors coming to a consensus. Therefore, the correctness of the computation is dependent on the value of the fuzzy weight. The use of fuzzy AHP helps to assure accuracy. This will give an appropriate foundation for the achievement of correct assessment. Therefore, it is recommended to all those enterprises, who produce mobile applications, that this framework approaches toward adequate computation. This will guarantee that app development organizations are able to give a comprehensive knowledge of their app's performance and user happiness via reliable quantitative data. As a result, it will be possible to enhance trust among investors and stakeholders.

It is possible for the researchers to use this method in order to determine various sets of weights according to the various perspectives held by stakeholders of the mobile gaming company. Subsequently, they will determine which prototype governs to have a more qualitative aspect by calculating the overall quality of various alternatives of the prototype of the mobile game application while mobile application development is taking place.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data available on request from the corresponding author upon reasonable request.

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