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Fuzzy AHP Based New Questionnaire Process for Improving Judgments Under Agile Software Development Framework

Ms. Sangeeta Mishra [*1], Dr. Mohd. Haroon [2]

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Abstract: An efficient approach of risk assessment that uses a questionnaire to get expert replies is the fuzzy analytical hierarchy process (FAHP). However, the FAHP has significant challenges to establish a consistent judgment matrix & determination of the fuzzy membership function (MF). This study suggests a brand-new consultation procedure to address the triangular MF FAHP's prior issues. The suggested procedure includes a newly constructed questionnaire and a novel scheme to figure out the fuzzy MF. Responses of experts to the questionnaire were used to build a consistent judgment matrix and determine the membership function. For the intent of proving the proposed scheme's viability, it is used to the security assessment in agile software development. In the case study, the judgment matrix is created using both the classic and new questionnaires. The outcomes demonstrate that judgment matrix established using the proposed approach may produce a consistent judgment matrix and determine triangular fuzzy MF. The proposed questionnaire, as opposed to the standard one, may be helpful for quickly and conveniently gathering expert opinions.

Keywords: *Risk assessment; analytical hierarchy process (AHP); Triangular fuzzy membership function.*

1. Introduction

Services for the urban class are attracting a lot of attention as a result of the economy's fast growth [1-3]. Because of the huge volume of traffic, existing infrastructures, and agile environment, projects relating to sophisticated applications incur relatively significant risks [4-8]. The accompanying risks with such projects might have detrimental effects, such as a large requirement for specialized people and several project delay causes [9-11]. In such undertakings, risks are typically unavoidable; nevertheless, mitigating actions may effectively lessen the unfavorable effects. [12], [13]. For instance, [14] a fuzzy analytical hierarchy process (FAHP) was suggested for improving the assessment of public-private partnerships (PPP) projects, and it was noted that the traditional AHP is unable to resolve imprecision & uncertainty issues because decision-makers' perceptions are linked to precise numbers. The development plan advocated the employment of prospective methods for controlling risks during the stage of development in order to guarantee the successful completion of a project. For a project to be completed successfully, it is essential to identify the causes of possible risk early on [15]. The discovery of risk variables may be utilized to statistically estimate risk in advance and support project managers in mitigating various software problem types [16-17].

Risk assessment frequently makes use of the AHP [18–20]. However, the classic AHP is ineffective at managing hazy information and unclear facts in the process of making decision rules. To address these issues, the FAHP was created. It uses fuzzy logic-based algebra to describe uncertainty and maps human preferences into a score when various selection criteria are taken into account [21-23]. For instance, [24] compares the priority weight vectors for the multi-attribute decision making process in the classic AHP and FAHP. [25] Proposed a model of FAHP for the AHP's fuzzy consistent matrix to evaluate risk. [26]. FAHP that incorporates failure types and assesses the impact for risk management to enable remedial measures. [27-28] FAHP linked successfully to geographic information system application for risk analysis.

Both the AHP and FAHP are widely used in the evaluation of risk in various projects. Risk management in the software sector including 4 stages: identification of risk, assessment of risk, plan development, and monitoring of risk. [29]. By giving a qualitative and quantitative evaluation of the project risk that was detected in the earlier stage, assessment of risk significantly aids strategic decision making. [30] conducted a study on risk variables in various project kinds; they discovered 77 different types of risk factors and offered a categorization into seven groups. Using the FAHP, [31] evaluated the risk associated with the development of a software project; this aids in creating a hierarchy of risk variables. For the construction of a system of risk assessment in project development, [32] used the FAHP scheme, which offers strong assistance for decision-making agencies during the development of a project.

The interval type, triangular type, and trapezoidal type are the three main forms of FAHP procedures [33. The interval FAHP employs number of interval to convey the relative significance of a component [34-36] rather than a crisp number. Similar to this, the triangular and trapezoidal FAHPs employ the equation for the triangle or trapezoidal membership function to describe the relative significance in pairwise comparisons of the variables [24], [37]. The triangular fuzzy MF takes into account a middle value, which represents the value that is most likely to occur, and two border values, which reflect the lowest and biggest conceivable values. Developers and managers are at ease giving an estimate that includes the most probable (likely) figure and a

Ph.d., Research Scholar, Computer Science & Engineering, Integral University, Lucknow, Uttar Pradesh, India
Professor, Computer Science & Engineering,Integral University, Lucknow, Uttar Pradesh, India

possible range. In such kind of cases, the triangular FAHP is suitable to assess different types of risks factors [16].

The use of fuzzy logic algebra is constrained by the difficulty of determining its purpose and creating a consistent judgment matrix under FAHP [18], [38-40]. Several investigations are carried out to get around this restriction. As an illustration, [38] and [41] integrated fuzzy logic into AHP. [42] suggested a fuzzy AHP as a solution to the uncertainty associated with human judgment and inadequate data by converting the crisp value into a fundamental AHP matrix of fuzzy MF. [18] designed a new questionnaire and suggested a practical way to increase the judgment matrix consistency on incorporating the mechanism for ranking & sorting as an improvement to AHP schemes. However, when the number of evaluation techniques increases, such modifications to standard AHP approaches have trouble identifying consistent matrices.

In order to establish a consistent judgment matrix with a higher level of convenience and determine the triangular fuzzy logic MF, in this article a new process is proposed for triangular FAHP. The consulting process under this proposed work will then be used to assess the various risks associated with software projects.

1.1 Brief Overview Traditional AHP and its Limitation

The approach suggested on the basis of AHP [42] is typical for dealing with intricate decision-making systems. A decision-making system may be broken down into three layers: criteria, goals, and options. The importance relative to the component connected to expert views from a consultation questionnaire is then determined using pair-wise comparisons in the alternatives & criteria of each factor [42-44] [27], [19]. The decision maker's choice for an option in a pair-by-pair comparison is expressed using clear values in the standard AHP [1]. However, a quantitative number may not accurately convey a decision-maker's thoughts [45- 46]. Values based on the triangle fuzzy logic membership function are useful in capturing the interval judgments characteristics and the values having highest probability of occurrence. Additionally, traditional questionnaire consumes large time. For number of factors are n, then number of comparisons in pairwise manner has magnitude of ((n – 1)*n)/2.

1.2 Traditional Questionnaire

The usual questionnaire style is shown in Appendix I used for obtaining expert opinions to establish the relative relevance of impact variables for pairwise comparisons. In this example, each component is evaluated separately until (n-1) factor is compared to n factor. There are limitations to using the usual questionnaire to compare is completed in pair wise acquired by consistent judgment. The discrepancy is unavoidable since the judgment matrix is based on people' subjective preferences in pairwise comparisons. It is difficult to build a consistent judgment matrix in this manner. Sometimes collecting expert judgements by using these questionnaires consumes time, laborious and worse for comparing in pairs if parameters large in number. As a result, the expert sometime offer distorted responses [18].

2. Proposed Methodology

This section focuses on creating a new questionnaire for consultation that will assist analysts effectively gathering response of several experts & create a simple judgment matrix utilizing the replies of experts (Appendix I). The new questionnaire substitutes a full table with listings of all components in the 1st column and 9 scores under different columns for direct factor comparison. Nine ratings (from one being the least important to nine being the most essential) show the relative importance of each factor's contribution to the risk associated with the software project. With the aid of these minute scoring increments, specialists are better able to identify the minor variations in how heavily a risk factor influences how well a development process performs. This new survey is particularly useful for gathering expert opinions on a complex issue that involves many diverse influencing elements.

2.1. New Questionnaire

Two prerequisites must be met when utilizing the new questionnaire to gather expert opinions in order to guarantee the effectiveness of pair-wise comparisons. First, each expert must only assign integer scores for each component that range from 1 to 9. The judgment matrix is ineffective for giving all aspects in the same layer the same importance; hence experts are urged to give various values to different factors within the same layer. Analysts turn to the opinions of a second expert and give the element a sufficient score for the post-calculation if one expert chooses two variables with equivalent significance. The experts suggested assigning different ratings under various variables if there were less than nine factors in the layer. If there are between 10 and 18 criteria, experts advise giving a score that is comparable to a maximum of two factors. When there are more elements in a layer, similar criteria spread across.

2.2 Triangular Fuzzy MF based AHP

The triangular fuzzy MF, described by notation (l, m, u) as shown in Figure 1 function 'M'. The parameters l, m and u denotes minimum, most probable and the maximum value of a fuzzy MF. The M (μ) described in equation (1) [18]. This work is employing the Δ^{ar} MF based FAHP scheme to the assessment of risk. The proposed schemes may be useful for determination of the Δ^{ar} fuzzy numbers & establishing the judgment matrix consisting the Δ^{ar} MF based fuzzy values explained in the steps below).

1. Scores assigning to entire factor are summarized, it is including the scores and number of times assigned a score.
2. All scores representing value of interval having minimum and maximum score assign to entire factor.
3. The comparison in pair wise manner in two factors used to establish a judgment matrix having every element describe ratio of values of two interval under two factors.
4. A value in crisp form (concised Δ^{ar} fuzzy MF) use for replacement of ratio mentioned previously for satisfying the required judgment matrix consistency.
5. A Δ^{ar} MF of fuzzy algebra use for generating a value as a replacement of a crisp value in the judgment matrix:

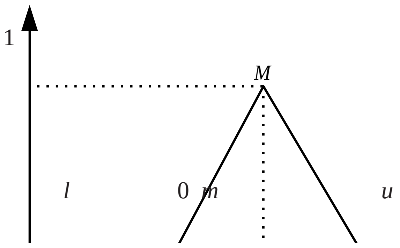
$$\mu(x|M) = \begin{cases} 0 & (x < l) \\ \dfrac{x-l}{m-l} & (l \le x \le m) \\ \dfrac{u-x}{u-m} & (m \le x \le u) \\ 0 & (x > u) \end{cases} \qquad (1)$$

2.3 *Triangular FAHP*

$$F_{n\times n} = \begin{pmatrix} \frac{A_1}{A_1} & \frac{A_1}{A_2} & \frac{A_1}{A_3} & \frac{A_1}{A_4} \\ \frac{A_2}{A_1} & \frac{A_2}{A_2} & \frac{A_2}{A_3} & \frac{A_2}{A_4} \\ \frac{A_3}{A_1} & \frac{A_3}{A_2} & \frac{A_3}{A_3} & \frac{A_3}{A_4} \\ \frac{A_4}{A_1} & \frac{A_4}{A_2} & \frac{A_4}{A_3} & \frac{A_4}{A_4} \end{pmatrix} = \begin{pmatrix} 1 & \frac{1}{5} & \frac{1}{3} & 3 \\ 5 & 1 & 5 & 5 \\ 3 & \frac{1}{5} & 1 & 3 \\ \frac{1}{3} & \frac{1}{5} & \frac{1}{3} & 1 \end{pmatrix} \quad (6)$$

The calculated number using triangular fuzzy MF and the established associated judgment matrix helps to apply for assessment of the risk by following steps:

1. A judgment matrix: Fn×n consisting factor of values of interval is given in equation (2)



$$\mathbf{F}_{n\times n} = \begin{pmatrix} 1 & \cdots & P_{1n} \\ \vdots & \ddots & \vdots \\ P_{n1} & \cdots & 1 \end{pmatrix} \quad (2)$$

Fig. 1. Triangular fuzzy membership function (M).

where P1n addressing the proportion of the worth of time span factor and worth time frame factor; and P1n' addressing the P1n backwards. The worth of Fn×n might be sensible when consistency proportion (CR) is underneath edge worth of 0.1 [35], [36], [43], [48]. As the Fn×n fulfilling these necessity of consistency, all Fn×n lattice component may supplanted by a relating esteem got from three-sided fluffy MF.

2. Equation (3) defines the evaluation of the ith object's fuzzy synthetic extent, with Pi serving as the ith object's fuzzy synthetic extent; Pjfi is fluffy engineered degree of the jth element to the ith object of Fn×n with three-sided fluffy MF based esteem; furthermore, Si is amount of the worth acquired

$$P_i = S_i \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{n} P_{fi}^{j} \right]^{-1} \quad (3)$$

from three-sided MF [16].

3. The MF between the triangular numbers in P1 = (l1, m1, n1) and P2 = (l2, m2, n2) is plotted in Figure 2 based on the results of Pi.

4. The worth of) not entirely set in stone by point A, as the most elevated converge in P1 and P2 (Figure 2). The μ(d) given in condition (4)

$$\mu(d) = \begin{cases} 1 & (m_1 \geq m_2) \\ 0 & (l_2 \geq u_1) \\ \dfrac{l_2 - u_1}{(m_1 - u_1) - (m_2 - l_2)} & (\text{otherwise}) \end{cases} \quad (4)$$

On the basis of equation (4) and Fig 2, both μ (P2≥ P1) and μ(P1 ≥ P2) is evaluated [16].

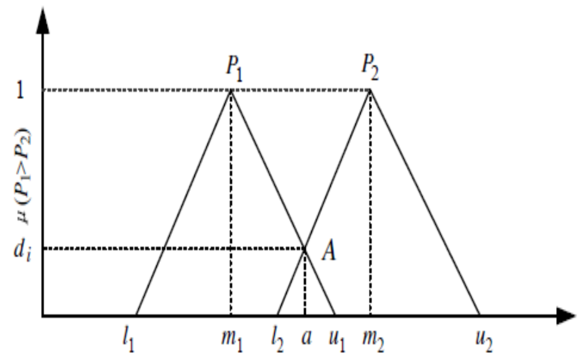


Fig. 2. Membership function between triangular numbers P_1 and P_2.

5. The normalized weight vector is determined as

w = (μ(d1)' , μ(d2)' , ……. μ(dn)')T (5)

where μ(di)' = μ(di) / ∑ni=1 μ(di), μ(di) = min [μ (Pi⩾Pk)], and and ∑ni=1 μ(di)' =1 . The weight vector w describes the rank of the influence factors in the assessment of risk.

3. Application

3.1 Hierarchical Structure

To evaluate the security risk in spry structure, purposed-driven strategy for examining and chose specialists. These specialists included scholarly teachers: programming designer with over 20 years of involvement, a chief, and clients. The expert's responses indicate the following four major risk factors: classification (A1), respectability (A2), accessibility (A3), and credibility (A4). Utilizing the input from the specialists, the distinguished elements are Iterative, Quick conveyance, Perceivability, Adaptiveness and Adaptability.

Involving these data as referenced over, a design of order for security risk evaluations laid out, as displayed in the Figure 4.In the progressive construction, the unfavorable effect on factors under layer second may causing the worry of chance in layer first [6,49,7].

3.2 Judgment Matrix from Traditional Questionnaire

The CR value is greater than 0.1, it indicating that the Fn×n violates the requirement of consistency.

A judgment matrix is created beneath both levels by using a standard questionnaire with pairwise comparisons of two elements. The listing of an example related to layer 1st that was compiled by experts using the conventional questionnaire is provided in Appendix I. Based on the response of questionnaire and Equation (2), the Fn×n matrix for 1st layer is obtained by:

The word “data” is plural, not singular. The subscript for the permeability of vacuum μ0 is zero, not a lowercase letter “o.” The term for residual magnetization is “remanence”; the adjective is According to the traditional AHP [43], [45], the value of eigenvector w = (0.117, 0.585, 0.230, 0.067).The AHP scheme for solving the priority problem for maximum eigen value problem, given in equation (7)

Hence, the value of the maximum eigen value of λmaxis given by:

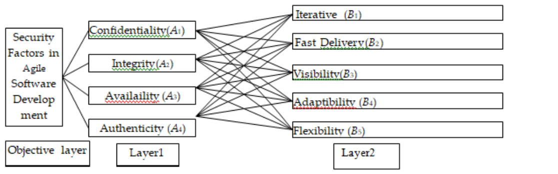


Fig. 3. Hierarchical structure for security assessment in Agile software Development.

$$Fn \times n.W = \begin{pmatrix} 1 & \frac{1}{5} & \frac{1}{3} & 3 \\ 5 & 1 & 5 & 5 \\ 3 & \frac{1}{5} & 1 & 3 \\ \frac{1}{3} & \frac{1}{5} & \frac{1}{2} & 1 \end{pmatrix} \begin{pmatrix} 0.1171 \\ 0.5850 \\ 0.2303 \\ 0.0676 \end{pmatrix} = \begin{pmatrix} 0.5137 \\ 2.6600 \\ 0.9014 \\ 0.3004 \end{pmatrix} \quad (7)$$

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{\sum_{j=1}^{n} f_{ij} w_i}{n w_i}$$

$$= \frac{1}{4}\left(\frac{0.5137}{0.1171} + \frac{2.66}{0.585} + \frac{0.9014}{0.2303} + \frac{0.3004}{0.0676}\right) = 4.3229 \quad (8)$$

The consistency index (CI) computed as [43]:

$$CI = \frac{\lambda_{\max} - n}{n-1} = \frac{4.3229 - 4}{4-1} = 0.1076 \quad (9)$$

The consistency ratio (CR) given as :

$$CR = \frac{CI}{RI} = \frac{0.1076}{0.89} = 0.2967 > 0.1 \quad (10)$$

3.3 Judgment Matrix from Proposed Consulting Process

3.3.1 Summary of Expert Viewpoints from New Questionnaire

A novel questionnaire design for assessing risk for software development in an agile environment was presented based on the hierarchy. Two sets of experts, A & B, are studied in this article as examples of the new questionnaire's efficacy. There are six specialists in each group. The old questionnaire is linked to the "A" Group first, while the new questionnaire is linked to it second.

concept to use score from one to nine for estimation of risk, and the 2 requirements in use of the new questionnaire. Each expert requested that a score be given to each component of the newly created questionnaire. A new questionnaire is being utilized to get expert opinions on each element in layers 1 through 3.An overview of responses of questionnaire from each of the experts of Similar to Group B, Group B examines the old questionnaire first before moving on to the new questionnaire. Here, the findings from the consulting in the "A" group were used to demonstrate the application of the triangular fuzzy MF with expert replies to a freshly created questionnaire. At the start of process of consultancy, the proposed new mode of questionnaire design explained to assure a detailed understanding of all experts. The explanation includes the description of all factor involved under reach layers, the group A included in Appendix II. The number of intervals for the influence factor and the periods at which the score assignment is carried out under a particular interval are decided on the basis of the tabular summary.

3.3.2 Triangular Fuzzy MF Determination:

To validate the established judgment matrix using triangular fuzzy MF, the expert responses are applied to factors A1 to A4 in layer 1 for establishing the example of determining the judgment matrix. Appendix II is describing the scores that are assigned by experts for the factor A1.Since the range of factor A1 is from one to four; hence, a number of intervals of one to four assigned initially. With respect to the A1 scores, 2 assigns for 3 times, and 1, 3 or 4 assigns one time only. In this way on comparison with1, 3, &4, the selected score for A1 is 2.For the factor A2 selected score is 7 to 9 (7 assigned thrice , 8 twice, and 9 only one time assigned), A3 = 4 to 7(both 4 and 5 assign twice), and A4=1 to 3 (1 assign thrice and 2 assign twice). Judgment matrix element expressed by ratio of two interval numbers, like A2/A1 = (7-9)/(1-4), and A4/A1 = (1-3)/(1-4).Hence, the comparison matrix in pairwise manner may express using Eq. (11).

Table 1.Triangular fuzzy judgment matrix of layer1 for objective layer

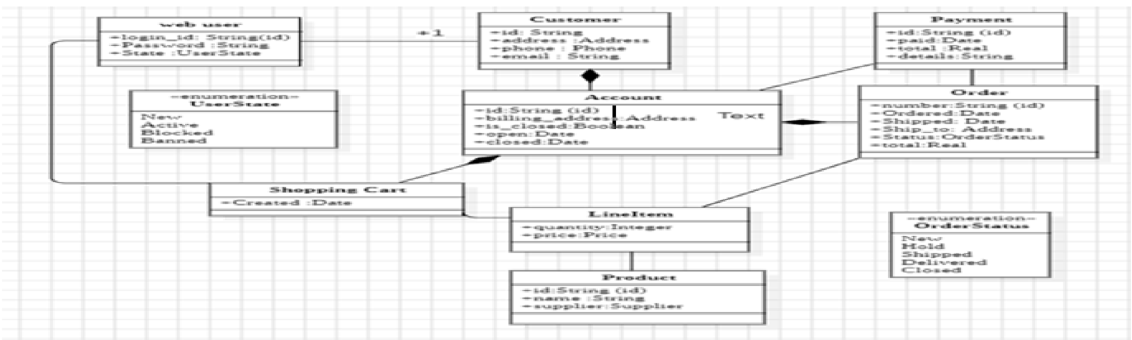


Fig. 4. Online Banking System: (a) class; and (b) attributes

Factor	A_1	A_2	A_3	A_4	Sum of triangular fuzzy numbers(S_i)	Fuzzy synthetic extent(P_i)
A_1	(1,1,1)	(0.2,0.33,1)	(0.25,0.5,1)	(0.33,1,1)	(1.78,2.83,4)	(0.051,0.142,0.35)
A_2	(1,3,5)	(1,1,1)	(1,2,4)	(1,3,5)	(4,9,15)	(0.116,0.45,1.313)
A_3	(1,2,4)	(0.2,0.33,1)	(1,1,1)	(1,2,4)	(3.2,5.33,10)	(0.092,0.267,0.875)
A_4	(1,1,3)	(0.2,0.33,1)	(0.25,0.5,1)	(1,1,1)	(2.45,2.83,6)	(0.071,0.142,0.525)

Table 2.Triangular fuzzy judgment matrix of layer2 for factor A1 in layer1

Factor	B_1	B_2	B_3	B_4	B_5	Sum of triangular Fuzzy numbers(S_i)	Fuzzy synthetic extent(P_i)
B_1	(1,1,1)	(1,1,1)	(1,2,4)	(1,3,5)	(1,3,5)	(5,10,17)	(0.096,0.306,0.791)
B_2	(1,1,1)	(1,1,1)	(1,1,1)	(1,2,4)	(1,2,4)	(5,7,11)	(0.096,0.214,0.512)
B_3	(0.25,0.5,1)	(1,1,1)	(1,1,1)	(1,3,5)	(3,5,7)	(6.25,10.5,15)	(0.119,0.321,0.698)
B_4	(0.25,0.5,1)	(0.2,0.33,1)	(0.2,0.33,1)	(1,1,1)	(1,1,1)	(2.65,3.16,5)	(0.051,0.097,0.233)
B_5	(0.2,0.33,1)	(0.25,0.5,1)	(0.14,0.2,0.33)	(1,1,1)	(1,1,1)	(2.59,2.03,4.33)	(0.049,0.062,0.201)

$$\begin{pmatrix} \frac{A_1}{A_1} & \frac{A_1}{A_2} & \frac{A_1}{A_3} & \frac{A_1}{A_4} \\ \frac{A_2}{A_1} & \frac{A_2}{A_2} & \frac{A_2}{A_3} & \frac{A_2}{A_4} \\ \frac{A_3}{A_1} & \frac{A_3}{A_2} & \frac{A_3}{A_3} & \frac{A_3}{A_4} \\ \frac{A_4}{A_1} & \frac{A_4}{A_2} & \frac{A_4}{A_3} & \frac{A_4}{A_4} \end{pmatrix} = \begin{pmatrix} 1 & \frac{1-4}{7-9} & \frac{1-4}{4-7} & \frac{1-4}{1-3} \\ \frac{7-9}{1-4} & 1 & \frac{7-9}{4-7} & \frac{7-9}{1-3} \\ \frac{4-7}{1-4} & \frac{4-7}{7-9} & 1 & \frac{4-7}{1-3} \\ \frac{1-3}{1-4} & \frac{1-3}{7-7} & \frac{1-3}{4-7} & 1 \end{pmatrix}$$

$$= \begin{pmatrix} 1 & 0.33' & 0.5' & 1' \\ 3' & 1 & 2' & 3' \\ 2' & 0.33' & 1 & 2' \\ 1' & 0.33' & 0.5' & 1 \end{pmatrix}$$

columns of Table 1. First layer consist of 4 indices, & these index indicates the criteria for establishing judgment matrices in three-sided fluffy MF under the subsequent layer. In this manner second layer comprise of four three-sided fluffy judgment framework. Likewise, third layer comprise of five three-sided fluffy judgment grid related to every basis in second layer. One of the three-sided fluffy judgment grids is recorded in table 2 related to second layer under standards A1 in first layer. The other three-sided fluffy MF based judgment frameworks might be depicted in comparative way. As indicated by these judgment frameworks utilizing three-sided fluffy MF, the weight vector of the impact of elements is acquired for positioning the gamble.

3.3.3 Weight Vector from Triangular FAHP

Using the TFJM associated to first layer, for illustrating the determination of the Δar MF of fuzzy algebra results, the value of A2/A1=3' is considered as the example. For A2/A1=(7 – 9)/(1 – 4), the smallest value is 7/4=1.75, and the highest is 9/1 =9. Hence, the A2/A1 value vary from 1.75 to 9.According to the rule of Saaty, the judgment matrix element varies from 1 to 9 or its reciprocal. In this way, A2/A1 applied using 2, 3, 4, 5, 6, 7, 8, and 9 in the calculations. Under this calculation the triangular fuzzy MF evaluation, if A2/A1 equal to 2, 3, 4, 5, 6, 7, 8, and 9, , the judgment matrix satisfies the requirement of consistency. Consideration of different scores, A1 is selected as 2, and A2 is as 7. Hence, the A2/A1 is taken as 3.5. Since odd number is used generally for expressing the relative significance in a comparison based on pairwise manner [44] [1], the A2/A1 is taken to be 3. Hence, the resultant triangular fuzzy MF based response indicates the value 3rd= (1, 3, 5) for representing A2/A1. The value of A1/A2 is inverse of A2/A1. Similarly the other fuzzy MF based resultant value is determined using this approach.

3.3.4 Establishment of Fuzzy Judgment Matrix

On the basis of triangular fuzzy MF approach, the triangular fuzzy judgment matrix is established for first layer as an objective layer, indicating under the left five the values of Si and Pi obtained by Equation (3), as shown given in two columns in right half of Table 1. The triangular MF response for every Pi is displayed in Figure 2, and the likelihood degree μ(d) is determined by Condition 4. After estimation of the of μ(d) for every Pi, the standardized loads of the elements in first layer is

Table 3.Weights of factors in layer 2 to factors A1 −A4 in layer 1

acquired from Condition 5 as w = (0.155; 0.362; 0.291; 0.192). In a similar approach the TFM and the weights of third layer for

Factor	A_1 0.156	A_2 0.361	A_3 0.289	A_4 0.194	Synthesized weights
B_1	0.340	0.339	0.329	0.326	0.3337
B_2	0.213	0.276	0.271	0.271	0.2638
B_3	0.252	0.188	0.189	0.204	0.2014
B_4	0.092	0.081	0.103	0.091	0.0910
B_5	0.103	0.116	0.106	0.108	0.1095

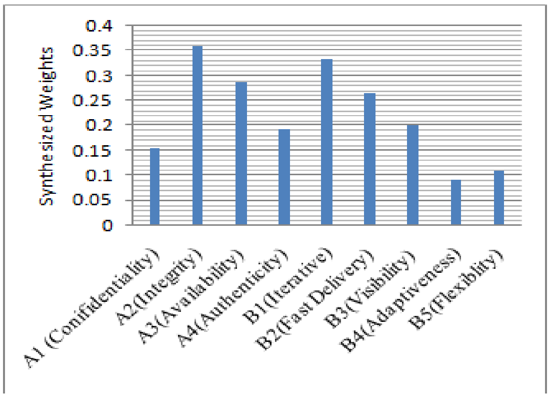


Fig. 5. Synthesized weights for ranking risks in security assessment in agile software development.

the B1 to B5 criteria in 2nd layer are obtained.

4. Results

Figure 5 shows the weights that were synthesized for utilizing triangular FAHP to evaluate risk variables for assessing security risk in agile software development. The second layer's B1 bears the biggest weight, as seen in Figure 5, which is related to it. Therefore, iterativeness is a major factor in the security risk associated with agile software development. The biggest security risk in an agile development environment is integrity (A2). The ranking's findings demonstrate that these two aspects warrant further consideration. Results are used to verify the correctness of the security risk rank computation under the conditions of agile software development.

5. Discussion

When employing the typical comparison in a paired fashion with the AHP technique, it may be challenging to construct a consistent evaluation matrix [18]; [24]. [18] according to two viewpoints: (1) the conflicting examination grid, and (2) the unpredictable pairwise correlation approach used to make the judgment framework. The new survey that is being recommended gives its all to wipe out consistency through test calculations [24][49].A complex issue with a few contributing perspectives requires a lot of chance to separate the well-qualifier's viewpoints [25] and brings about conflicting suppositions [38] [41] [43]; [25]. Consequently, a decrease in the specialists' functioning hours is important to resolve the issue of consistency. The proposed survey in this article has been demonstrated to be helpful in eliminating how much time counselled specialists should spend working. The time expected by specialists to finish the two polls is kept to explore the effect of the meeting request on the time expected to finish the regular and new surveys. The foundation of the specialists and the time expected to finish the surveys are likewise framed in Supplement III. It demonstrates that experts in group A completed the new questionnaire in less time than experts in group B. According to the findings, obtaining expert opinions with the new questionnaire takes less time than with the conventional questionnaire. The changed survey lessens time by around half. The new poll is valuable in get-together expansive information on all components under a few levels on a solitary page. In contrast, the conventional questionnaire occupies three pages.

The perspectives of experts from group B are summarized for the purpose of validating the performance of the triangular fuzzy MF approach. The A1 factor's score ranges from 1 to 4, and two is scored four times. Accordingly, factor A1 is chosen as to 2. In comparable manner, factor A2 is chosen as 7, A3 as 4, and A4 as 1. The three-sided fluffy MF worth still up in the air to be 3, which is reliable with Condition 11 (bunch A specialists perspectives. In any case, the recommended technique just eliminates the time specialists spend finishing up surveys, not on the general measure of time expected to give the gamble evaluation discoveries. The recommended procedure, which succeeds using the regular survey, decreases the time expected to accumulate master decisions enormously, assists with examination to decide three-sided fluffy MF reply, and lays out a reliable judgment lattice. This new questionnaire can be easily modified to evaluate the security of various projects. The two general circumstances are still obvious, despite how the proposed survey was adjusted for different conditions. Every part was first given a whole number score somewhere in the range of 1 and 9. Second, elements in the same layer are given ratings that are as distinct as possible. The ability to post-process expert responses for efficient pairwise comparisons within the same layer to create a consistent judgment matrix is made possible by the two requirements. At the point when specialists offer a number score to a part to imply the degree of importance that the element postures to risk, they are in a roundabout way contrasting two variables inside a similar layer. The new questionnaire-based calculation takes into account the effects of additional layers. The effects of the components in the lower layer (for example, layer 2) to the higher layer (for example, layer 1) are thought about while working out the degree (Pi) in the three-sided FAHP, for instance.

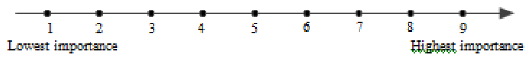
6. Conclusions

This study helps create a consistent judgment matrix on the FAHP platform by proposing a novel consulting procedure based on a triangular fuzzy MF-based scheme. The suggested approach is effectively used in the context for agile software development to identify security threats. A novel questionnaire with nine scores that represent the relative importance of a factor assessment is used in the suggested consultation procedure.

The proposed consulting process employs a new questionnaire with nine scores to express the relative importance of assessment

(1) factor 2	(2) factor 3	(3) factor 4	(*i*) ……	(*n*-1) factor *n*
O Extremely	O Extremely	O Extremely	O Extremely	O Extremely
O Very strong	O Very strong	O Very strong	O Very strong	O Very strong
O Strong	O Strong	O Strong	O Strong	O Strong
O Moderate	O Moderate	O Moderate	O Moderate	O Moderate
O Equal	Equal	Equal	Equal	Equal
O Moderate	Moderate	Moderate	Moderate	Moderate
O Strong	Strong	Strong	Strong	Strong
O O Very strong	Very strong	Very strong	Very strong	Very strong
Extremely	Extremely	Extremely	Extremely	Extremely

Fig. 6. Traditional questionnaire for pairwise comparisons in AHP



Factor	Influence of the factor on the risk of tunnel construction								
	1	2	3	4	5	6	7	8	9
Layer 1									
Factor 1									
Factor 2									
……									
Factor *i*									
Layer 2									
Factor 1									
Factor 2									
……									
Factor *j*									
……									
Layer *n*									
Factor 1									
Factor 2									
……									
Factor *m*									

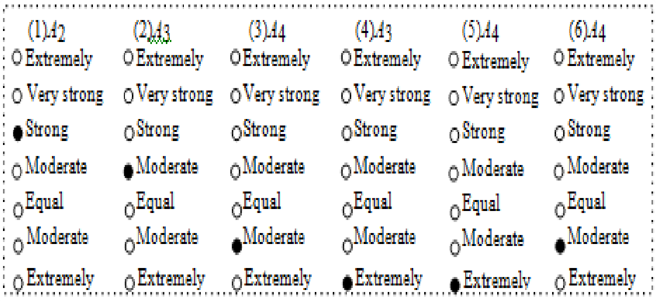
Note: The general requirements are assigning only a score from 1 to 9 to a factor and eliminating the number of times that the same score is repeatedly assigned to different factors in the same layer. If the number of factors in a layer does not exceed 9,a score is suggested to be assigned to no more than one factor in this layer. If the number of factors in a layer is between 10 and 18, the same score is encouraged to be assigned to no more than two factors in this layer. Please place a check [] for any rating that you consider to be appropriate for each factor.

Fig 7. New questionnaire for security assessment in agile software development

The old questionnaire does not meet the need for consistency, but the judgment matrix linked to the new questionnaire does. In compared to the conventional method, the new questionnaire's consultation procedure collects expert viewpoints more conveniently and quickly. The validity and effectiveness of the suggested approach for risk assessment are demonstrated by a risk analysis of the security assessment in agile software development. Using the new questionnaire, collecting expert opinions is simple. The outcomes of a new consultation procedure utilizing a triangular FAHP enable informed decision-making for enhancing the management of security threats. The typical questionnaire, shown in Figure 6, has two drawbacks. First off, gathering expert judgments takes time and is laborious when there are several elements operating on multiple levels.

When a hierarchy of risk assessment has numerous layers, the overall number of pair wise comparisons rises. An expert needs the layer's score to be assigned n times for each of the layer's n factors. Experts' subjective assessments usually lead to inconsistency, which results in a flawed judgment matrix. The updated survey is depicted in Figure 7. The new questionnaire makes it simple to get expert opinions about the effect of various factors on security risk. The new survey includes several elements from many tiers. Figure 8 shows an illustration of layer 1 information obtained from an expert using the conventional questionnaire.

Fig. 8. Viewpoints in layer 1 collected from experts using traditional questionnaire



Appendix I. Consulting Qustionnaire

Fig. 6 indicates the traditional questionnaire, which has two limi- tations. First, collecting expert judgments with the traditional ques- tionnaire is tedious and time-consuming when many factors exist in different layers.

Appendix II. Responses from Experts in Group A

Appendix II. Responses from Experts in Group A

Layer	Factor	Influenceoffactoronsecurity riskassessment in agile software development								
		1	2	3	4	5	6	7	8	9
Layer1	A1 (Confidentiality)	I	III	I	I	–	–	–	–	–
	A2(Integrity)	–	–	–	–	–	–	III	II	I
	A3(Availability)	–	–	–	II	II	I	I	–	–
	A4(Authenticity)	III	II	I	–	–	–	–	–	–
Layer2	B1(Iterative)	–	–	–	–	–	II	I	II	I
	B2(Fast Delivery)	–	–	–	–	I	III	I	I	–
	B3(Visibility)	–	III	II	I	–	–	–	–	–
	B4(Adaptive)	III	I	II	–	–	–	–	–	–
	B5(Flexibility)	III	II	I	–	–	–	–	–	–

Appendix III. Expert Background and Time Required to Complete Traditional and New Questionnaires

Expert	Occupation	Work experience (year)	[minutes (')/seconds(")] Traditional(T_m)	New(N_m)	Efficient ratio (%)	Preference on questionnaire
Group A: Traditional questionnaire first and new questionnaire second						
A1	Professor	35	9'42"	4'30"	46.39	New questionnaire
A2	Professor	32	16'	9'	56.25	New questionnaire
A3	Professor	30	10'	5'	50	New questionnaire
A4	Developer	20	9'	5'	55.56	New questionnaire
A5	Owner/manager	9	9'	4'	44.44	New questionnaire
A6	Client	7	10'	4'	40	New questionnaire
Group B: New questionnaire first and traditional questionnaire second						
B1	Developer	36	5'25"	3'30"	64.81	New questionnaire
B2	Developer	33	5'40"	2'10"	38.23	New questionnaire
B3	Developer	27	6'10"	3'30"	56.76	New questionnaire
B4	Client	20	8'58"	5'16"	58.73	New questionnaire
B5	Client	18	6'19"	3'34"	56.46	New questionnaire
B6	Client	17	3'58"	2'40"	67.22	New questionnaire
B7	Developer	15	5'40"	2'13"	39.12	New questionnaire
B8	Developer	13	4'31"	2'42"	59.79	New questionnaire

Note: Efficient ratio ð%Þ¼ N_m=T_m.

Appendix IV. Responses from Experts in Group B

Layer	Factor	Influenceoffactorsecurity risk assessment in agile software development								
		1	2	3	4	5	6	7	8	9
Layer1	A1 (Confidentiality)	I	IV	I	II	–	–	–	–	–
	A2(Integrity)	–	–	–	–	–	I	IV	II	I
	A3(Availability)	–	–	–	IV	II	II	–	–	–
	A4(Authenticity)	IV	III	I	–	–	–	–	–	–
Layer2	B1(Iterative)	–	–	–	–	I	–	II	IV	I
	B2(Fast Delivery)	–	–	–	I	I	IV	II	–	–
	B3(Visibility)	–	III	II	I	II	–	–	–	–
	B4(Adaptive)	III	II	II	I	–	–	–	–	–
	B5(Flexibility)	III	I	II	II	–	–	–	–	–

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Author contributions

Ms. Sangeeta Mishra: Conceptualization, Methodology, Software, Field study **Dr. Mohd. Haroon:** Data curation, Writing-Original draft preparation, Software, Validation., Field study **Mr. Anurag Banoudha:** Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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