IJARnD
INTERNATIONAL JOURNAL OF ADVANCE RESEARCH AND DEVELOPMENT

(Volume2, Issue6)
Available online at www.ijarnd.com

An Integrated Approach for the Selection of Software Requirements Using Fuzzy AHP and Fuzzy Topsis Method

Mohd. Sadiq, Arashiya Afrin
[1] *Asst.Prof, Computer Engineering Section, UPFET Jamia Millia Islamia (A Central University)New Delhi-110025, INDIA*
[2] *M.tech Scholar, Department of Computer Science and Engineering Al-Falah University, (A NAAC- UGC 'A' Grade University), Dhauj, Faridabad, Haryana, INDIA E-mail: afrin47@gmail.com*

ABSTRACT

Software requirements selection (SRS) is an important research issue of the software requirements elicitation process. Different methods have been developed for the selection of software requirements by using the ant colony optimization, teaching learning-based optimization, "analytic hierarchy process" (AHP), "technique for order preference by similarity to ideal solution" (TOPSIS), etc. Based on our literature review, we identify that existing methods for SRS do not support the integrated approach based on fuzzy AHP and fuzzy TOPSIS for the selection of software requirements from the set of requirements. Therefore, to address this issue in this paper we propose an "integrated fuzzy AHP and fuzzy TOPSIS method for the selection of software requirements". Finally, the explanation of the proposed method is demonstrated with the help of a case study.

Keywords: Software Requirements Selection, AHP, TOPSIS.

1. INTRODUCTION

During software requirements elicitation process, software requirements analysts identify different types of the requirements, i.e., functional requirements (FR) and non-functional requirements (NFR) according to the need of the clients [15,9]. FR describes the functionality of the system while NFR describes the nonbehavioral aspects of the system or "*how the system is supposed to be*" [15]. Generally, FR and NFR are identified before the development of software; and testing requirements are identified at the end of the software development [16]. Based on our review, we identify that clients may have thousands of requirements; and all the requirements of the clients cannot be implemented due to the time and budget constraints [15, 16]. In this situation, group requirements elicitation technique is employed to select those requirements that would be implemented after getting the consent of the different type of the stakeholders like clients, developers, testers, etc. [17].

Selection of software requirements on the basis of several criteria creates a "*multi-criteria decision making"* (MCDM) problem [8,9,10]. Fuzzy set theory combined with MCDM methods have been extensively used to deal with uncertainty in the supplier selection decision, software requirements selection process, etc. Fuzzy based MCDM algorithms [14, 18] like fuzzy "*analytic hierarchy process*" (AHP), fuzzy "*technique for order preference by similarity to ideal solution*" (TOPSIS), fuzzy MoSCoW, i.e., Must have, Should have, Could have, and won't have, have been used for the selection of the software requirements under fuzzy environment, etc.

In recent years, integrated methods like fuzzy AHP and fuzzy TOPSIS [18, 19, 20, 21] have received much attention in the area of management science, operation research, mechanical engineering, etc. Based on our literature review, we identify that software requirements selection methods do not support that how to apply the "*integrated fuzzy AHP and fuzzy TOPSIS methods for the selection of software requirements*". Therefore, it motivates us to propose a method for the selection of software requirements using an integrated approach of fuzzy AHP and fuzzy TOPSIS. The remaining part of this paper is organized as follows: Related work based on the software requirements selection methods is given in section II. An integrated method of fuzzy AHP and fuzzy TOPSIS is presented in section III. Application of the proposed method is given in Section IV. Finally, in section V, we conclude our work and suggest future research directions in the area of software requirements selection.

2. RELATED WORK

In the literature of search based software engineering (SBSE) [3, 13], software requirements selection is referred to as "*Next Release Problem*" (NRP). In SBSE, different methods have been developed for NRP. For example, Cheng *et al.* [4] proposed an "adaptive memetic algorithm based on multi-objective optimization for software NRP". Chaves-Gonzalez *et al.* [2] proposed a multi-objective "*teaching learning-based optimization*" (TLBO) for the selection of software requirements. Multi-objective ant colony optimization was used by Sagrado et al. [12] for requirements selection. Chaves-Gonzalez and Perez-Toledano [1] solve the NRP by using differential evolution with Pareto tournament.

In non-SBSE area, MCDM methods like AHP, TOPSIS, etc., have received much attention by the research community for SRS problem. Different methods have been developed for SRS problem like AHP-GORE-PSR [11], PRFGORE process [10], GOASREP [5], etc. Sadiq *at al.* [11] proposed a method for the prioritization of software requirements using AHP in goal-oriented requirements elicitation process, i.e., AHP_GORE_PSR. Sadiq and Jain [10] proposed a method for the "*prioritization of requirements using the fuzzy based approach in goal oriented requirements elicitation (PRFGORE) process*". Kaiya *et al.* [6] proposed a method called, "*attributed goal oriented requirements analysis*" (AGORA) method. In 2016, Mohammed *et al.* [7] proposed a "*fuzzy attributed goal oriented requirements analysis method*" by extending the AGORA method. Garg *et al.* [5] proposed GOASREP, i.e., "*Goal-Oriented Approach for Software Requirements Elicitation and Prioritization using AHP*".

Different methods have been developed by integrating the "*fuzzy-AHP and fuzzy-TOPSIS*" for the selection of facility location, supplier selection, auxiliary systems of ship main engines, etc. For example, Rodrigues Lima Junior et al. [23] compare "*fuzzy AHP and fuzzy TOPSIS methods for supplier selection*". Supplier selection is a "*decision process with the aim of reducing the initial set of the potential supplier to the final choices*".

In a similar study, Ertugrul and Karakasoglu [24] compare "*fuzzy AHP and fuzzy TOPSIS methods for facility location selection"*. In [24] authors compare the fuzzy AHP and fuzzy TOPSIS on the basis of the following criteria: "*favourable labour climate*", "*proximity to markets*", "*community consideration*", "*quality of life*", "*proximity to suppliers and resources"*. In their work, authors summarize the differences and similarities between "*fuzzy AHP and fuzzy TOPSIS*". As a result, they fund that fuzzy AHP contains more number of steps as compared to the fuzzy TOPSIS. There is no pairwise comparison in fuzzy TOPSIS, while in the case of fuzzy AHP there are pairwise comparisons among the FR and NFRs. Fuzzy TOPSIS method is the method which deals with the rank reversal problem while in the case of less attention is given to the fuzzy AHP.

Both fuzzy AHP and fuzzy TOPSIS deal with the linguistic variables. Both the methods produce the same results. Therefore, in the proposed method for the computation of the weights of NFR we apply the fuzzy AHP and for the computation of ranking values of the FR, we apply the fuzzy TOPSIS method.

Torfi et al. [25] propose a "*fuzzy MCDM approach to evaluating the alternative options with respect to the user's preference orders*". They use fuzzy AHP to compute the criteria and fuzzy TOPSIS to rank the alternatives. In literature, less attention is given to the integrated methods of fuzzy AHP and fuzzy TOPSIS for the selection of software requirements. Therefore, to address this issue, we proposed an integrated method of fuzzy AHP and fuzzy TOPSIS for the selection of software requirements.

3. PROPOSED METHOD

In this section, we propose an integrated fuzzy AHP and fuzzy TOPSIS method for the selection of software requirements. The block diagram of the proposed method is given in Fig. 1. Proposed method includes the following steps:

Step 1: Elicitation of non-functional requirements
Step 2: Construct PCM for NFRs
Step 3: Apply extent fuzzy AHP
Step 4: Compute weight of NFRs
Step 5: Elicitation of FR using goal-oriented requirements elicitation technique
Step 6: Assignment of rating to the FRs with respect to NFRs
Step 7: Compute aggregate fuzzy rating for the FRs
Step 8: Compute the fuzzy decision matrix for FRs
Step 9: Normalize the fuzzy decision matrix
Step 10: Compute the weighted normalized matrix
Step 11: Compute the distance of each FR from FPIS and FNIS
Step 12: Compute the closeness coefficient (cc) of each FR Selection of FRs.

The explanations of the above steps are given below:

Step 1: Elicitation of non-functional requirements

Elicitation is an important process of requirements engineering which is used to identify the need for the stakeholders. The objective of this step is to identify the non-functional requirements. These requirements are used as criteria for the selection of functional requirements (FR) [10].

Step 2: Construct PCM for NFRs

Pair wise comparison matrix (PCM) is constructed after evaluating the NFR by different decision makers. Since each DM have a different opinion for the same set of requirements. Therefore, different PCM would be constructed by the DMs.

Step 3: Apply extent fuzzy AHP
In this step, we apply the extent fuzzy AHP to compute the weights of the NFRs, proposed by Chang [26].

Step 4: Compute weight of NFRs
Here, we compute the weights of NFRs using extent fuzzy AHP [26].

Step 5: Elicitation of FR using goal oriented requirements elicitation technique

After computing the weight of NFRs, we elicit the functional requirements (FR) using goal oriented requirements elicitation technique (GORET). In GORET, the high-level objective is refined and decomposed in such a way so that an AND/OR graph can be constructed [10].

Step 6: Assignment of rating to the FRs with respect to NFRs

In this step, DM evaluates the rating of FR with respect to NFRs. During the evaluation process, DM use the linguistic variables like low, very low, high, very high, etc. Steps from 7 to 12 are based on fuzzy TOPSIS method, as discussed in Hwang and Yoon [27] and [22]. These steps are explained in the case study, i.e., in section IV.

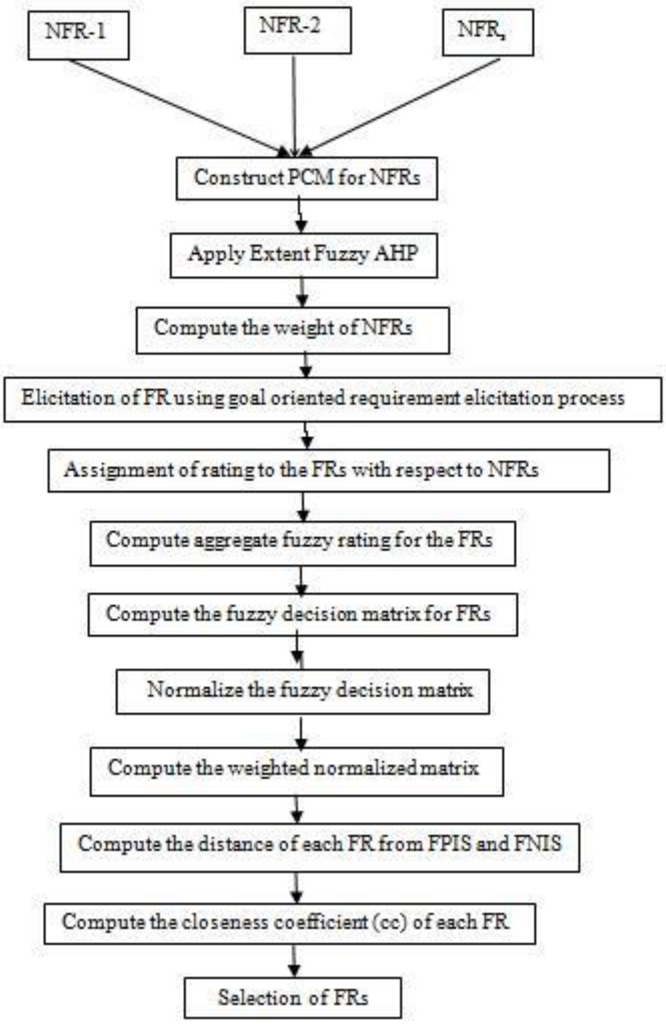

Fig. 1: An Integrated fuzzy AHP and fuzzy TOPSIS method for Software Requirements Selection

4. CASE STUDY

In this section, we have applied the proposed method on Institute Examination System (IES).

Step 1: In our study, we have identified three NFRs, i.e., security, reliability, and economy. Then we construct the PCM for these given NFRs.
Step 2: PCM is constructed by four decision makers for the three NFR. This PCM are given below:

Table 1: PCM by DM1

NFR	NFR1	NFR2	NFR3
NFR1	1	7	5
NFR2	1/7	1	5
NFR3	1/5	1/5	1

Table 2: PCM by DM2

NFR	NFR1	NFR2	NFR3
NFR1	1	5	5
NFR2	1/5	1	7
NFR3	1/5	1/7	1

Table 3: PCM by DM3

NFR	NFR1	NFR2	NFR3
NFR1	1	1/5	7
NFR2	5	1	5
NFR3	1/7	1/5	1

Table 4: PCM by DM4

NFR	NFR1	NFR2	NFR3
NFR1	1	1	5
NFR2	1	1	1
NFR3	1/5	1	1

Step 3: Apply extent fuzzy AHP
In the proposed method, we use the extent fuzzy AHP proposed by Chang in 1996. The detailed description of the extent fuzzy AHP is given in [26].

Step 4: Compute weight of NFRs
We apply the extent fizzy AHP to compute the weight of NFRs. These weights are used as criteria for the selection of software requirements. After applying the extent fuzzy AHP by considering PCM; and as result we have computed weighted vectors for the NFRs, i.e., (0.517, 0.458, 0.024)

Step 5: In this step, we have elicited FR using goal oriented requirements elicitation technique (GORET). After applying GORET, we have identified 16 FR for IES:
FR1: Upload examination related activities; FR2: Upload examination schedule; FR3: Generate list of students attendance; FR4: Upload the list of the evaluated marks; FR5: Generate Mark-sheet; FR6: Maintenance of the

Website; FR7: Clearance certificate for the students; FR8: Online fee payment; FR9: Generate the bank receipt of

Student fee; FR10: Acceptance of examination form; FR11: Generate examination form and submission; FR12: Generate the list of reappearing students; FR13: Generate the seating plan; FR14: Generate the hall ticket; FR15:
Download the hall ticket; FR16: Entry of external and internal marks

Step 6: In this step, we first define the triangular fuzzy numbers for the different linguistic variables used in our study. Following linguistic variables are used for the assignment of the rating to the FRs, i.e., very weak (VW) = (2, 2, 4), weak (W) = (2, 4, 6), medium (M) = (4, 6, 8), Strong (S) = (6, 8, 10), and very strong (VS) = (8, 10, 10). In Table 5, we present the results after evaluation of the FR on the basis of the NFRs by four DM.

Table 5: Evaluation of the FR on the basis of NFRs by 4 DM (Decision Makers)

DM	**FRs**	**NFRs**		
		NFR1	NFR2	NFR3
DM1	FR1	VW	S	W
DM2		W	VS	M
DM3		M	M	S
DM4		S	S	VS
DM1	FR2	VM	W	W
DM2		W	S	M
DM3		S	VS	S
DM4		M	M	VS
DM1	FR3	S	W	M
DM2		M	M	W
DM3		VS	VS	S
DM4		S	S	VS
DM1	FR4	S	M	W
DM2		VS	S	M
DM3		S	S	S
DM4		M	VS	S
DM1	FR5	S	M	W
DM2		S	S	M
DM3		VS	S	S
DM4		S	VS	S
DM1	FR6	S	S	W
DM2		M	S	S
DM3		M	M	VW
DM4		W	W	M
DM1	FR7	S	S	W
DM2		M	VW	M
DM3		S	W	S
DM4		W	S	M
DM1	FR8	W	S	S
DM2		M	W	S
DM3		W	M	M
DM4		S	S	W
DM1	FR9	S	VW	W
DM2		M	VW	S
DM3		S	M	S
DM4		W	S	M

DM1	FR10	S	S	W
DM2		M	M	S
DM3		S	S	M
DM4		S	W	S
DM1	FR11	S	W	W
DM2		S	S	VS
DM3		VS	S	S
DM4		M	VS	W
DM1	FR12	W	M	W
DM2		VW	S	VS
DM3		S	S	S
DM4		S	M	M
DM1	FR13	S	VS	W
DM2		VS	S	VS
DM3		W	M	S
DM4		S	VM	VM
DM1	FR14	S	S	W
DM2		S	VS	S
DM3		VS	W	VS
DM4		W	S	M
DM1	FR15	S	S	S
DM2		S	VS	M
DM3		VS	S	VS
DM4		W	VW	S
DM1	FR16	S	W	M
DM2		VS	S	S
DM3		M	S	S
DM4		W	W	W

Step 7 and 8: After computing the aggregate fuzzy rating of the FR on the basis of the results of Table 5, we generate the fuzzy decision matrix, as shown in Table 6.

Step 9 and 10: Now we normalize the Tables 6, and after normalization the results are shown in Table 7. The weighted normalized matrix is given in Table 8.

Table 6: Fuzzy decision matrix

FR	NFRs		
	NFR1	NFR2	NFR3
FR1	(2,5,10)	(4,4,10)	(2,7,10)
FR2	(2,5,10)	(2,7.5,10)	(2,7,10)
FR3	(4,8,10)	(2,7,10)	(2,7,10)
FR4	(4,8,10)	(4,7,10)	(2,6.5,10)
FR5	(2,9,10)	(4,8,10)	(2,6.5,10)
FR6	(2,6,10)	(2,6.5,10)	(2,5,10)
FR7	(2,6.5,10)	(2,5.5,10)	(2,6,10)
FR8	(2,5.5,10)	(2,6.5,10)	(2,6.5,10)
FR9	(2,6.5,10)	(2,4.5,10)	(2,6.5,10)

FR10	(4,7.5,10)	(2,6.5,10)	(2,5.5,10)
FR11	(4,8,10)	(2,7.5,10)	(2,6.5,10)
FR12	(2,5.5,10)	(4,8,10)	(2,7,10)
FR13	(2,7.5,10)	(2,6.5,10)	(2,6,10)
FR14	(2,7.5,10)	(2,7.5,10)	(2,7,10)
FR15	(2,8,10)	(2,8,10)	(4,9,10)
FR16	(2,7,10)	(2,6,10)	(2,7,10)

Table 7: Normalized fuzzy decision matrix with criteria

FRs	NFRs		
	NFR1	NFR2	NFR3
FR1	(0.2,0.5,1.0)	(0.4,0.4,1.0)	(0.2,0.7,1.0)
FR2	(0.2,0.5,1.0)	(0.2,0.75,1.0)	(0.2,0.7,1.0)
FR3	(0.4,0.8,1.0)	(0.2,0.7,1.0)	(0.2,0.7,1.0)
FR4	(0.4,0.8,1.0)	(0.4,0.7,1.0)	(0.2,0.65,1.0)
FR5	(0.2,0.9,1.0)	(0.4,0.7,1.0)	(0.2,0.65,1.0)
FR6	(0.2,0.6,1.0)	(0.2,0.65,1.0)	(0.2,0.5,1.0)
FR7	(0.2,0.65,1.0)	(0.2,0.55,1.0)	(0.2,0.6,1.0)
FR8	(0.2,0.55,1.0)	(0.2,0.65,1.0)	(0.2,0.65,1.0)
FR9	(0.2,0.65,1.0)	(0.2,0.45,1.0)	(0.2,0.65,1.0)
FR10	(0.4,0.75,1.0)	(0.2,0.65,1.0)	(0.2,0.55,1.0)
FR11	(0.4,0.8,1.0)	(0.2,0.75,1.0)	(0.2,0.65,1.0)
FR12	(0.2,0.55,1.0)	(0.4,0.8,1.0)	(0.2,0.7,1.0)

FR13	(0.2,0.75,1.0)	(0.2,0.65,1.0)	(0.2,0.6,1.0)
FR14	(0.2,0.75,1.0)	(0.2,0.75,1.0)	(0.2,0.7,1.0)
FR15	(0.2,0.8,1.0)	(0.2,0.8,1.0)	(0.4,0.9,1.0)
FR16	(0.2,0.7,1.0)	(0.2,0.6,1.0)	(0.2,0.7,1.0)
Criteria	**0.517**	**0.458**	**0.024**

Table 8: Weighted Normalized fuzzy decision matrix

FRs	NFRs		
	NFR1	NFR2	NFR3
FR1	(0.103,0.258,0.517)	(0.183, 0.183,0.458)	(0.004,0.016,0.024)
FR2	(0.103,0.258, 0.517)	(0.091,0.343, 0.458)	(0.004,0.016,0.024)
FR3	(0.206,0.413, 0.517)	(0.091,0.320, 0.458)	(0.004,0.016,0.024)
FR4	(0.206,0.413, 0.517)	(0.183,0.320, 0.458)	(0.004,0.015,0.024)
FR5	(0.103,0.465, 0.517)	(0.183,0.320, 0.458)	(0.004,0.015,0.024)
FR6	(0.103,0.310, 0.517)	(0.091,0.297, 0.458)	(0.004,0.012,0.024)
FR7	(0.103,0.336, 0.517)	(0.091,0.251, 0.458)	(0.004,0.014,0.024)
FR8	(0.103,0.284, 0.517)	(0.091,0.297, 0.458)	(0.004,0.015,0.024)
FR9	(0.103,0.336, 0.517)	(0.091,0.206, 0.458)	(0.004,0.015,0.024)
FR10	(0.206,0.387, 0.517)	(0.091,0.297, 0.458))	(0.004,0.013,0.024)
FR11	(0.206,0.413, 0.517)	(0.091,0.343, 0.458)	(0.004,0.015,0.024)
FR12	(0.103,0.284,	(0.183,0.413,	(0.004,0.016,0.02

	0.517)	0.458)	4)
FR13	(0.103,0.387, 0.517)	(0.091,0.336, 0.458)	(0.004,0.014,0.024)
FR14	(0.103,0.387, 0.517)	(0.091,0.387, 0.458)	(0.004,0.016,0.024)
FR15	(0.103,0.413, 0.517)	((0.091,0.413, 0.458)	(0.009,0.021,0.024)
FR16	(0.103,0.361, 0.517)	(0.091,0.274, 0.458)	(0.004,0.016,0.024)

Step 11: In this step, we compute the distance of each FR from FPIS and FNIS; and the results are shown in Table 9 and Table 10, respectively.

Table 9: Distance between FRi (i= 1,2,…,16) and FR* with respect to NFRs

Distance	NFR1	NFR2	NFR3	Sum
D_1^* =d(FR1, FR^*)	0.281	0.223	0.012	**0.516**
D_2^* =d(FR2, FR^*)	0.281	0.221	0.012	**0.514**
D_3^* =d(FR3, FR^*)	0.279	0.225	0.012	**0.516**
D_4^* =d(FR4, FR^*)	0.279	0.306	0.012	**0.597**
D_5^* =d(FR5, FR^*)	0.240	0.306	0.012	**0.588**
D_6^* =d(FR6, FR^*)	0.266	0.230	0.023	**0.513**
D_7^* =d(FR7, FR^*)	0.260	0.240	0.022	**0.522**
D_8^* =d(FR8, FR^*)	0.273	0.230	0.012	**0.515**
D_9^* =d(FR9, FR^*)	0.204	0.254	0.012	**0.47**
D_{10}^* =d(FR10, FR^*)	0.192	0.230	0.022	**0.444**
D_{11}^* =d(FR11, FR^*)	0.187	0.221	0.012	**0.42**
D_{12}^* =d(FR12, FR^*)	0.273	0.158	0.012	**0.443**
D_{13}^* =d(FR13,	0.248	0.221	0.022	**0.491**

FR*)				
D_{14}^* =d(FR14, FR*)	0.248	0.214	0.012	**0.474**
D_{15}^* =d(FR15, FR*)	0.244	0.212	0.000135	**0.456**
D_{16}^* =d(FR16, FR*)	0.254	0.234	0.012	**0.5**

Table 10: Distance between FRi (**i=** 1,2,…,16) and FR$^-$ with respect to NFRs

Distance	NFR1	NFR2	NFR3	Sum
D_1^-=d(FR1, FR*)	0.254	0.223	0.013	**0.49**
D_2^-=d(FR2, FR*)	0.254	0.256	0.013	**0.523**
D_3^-=d(FR3, FR*)	0.337	0.248	0.013	**0.598**
D_4^-=d(FR4, FR*)	0.337	0.254	0.013	**0.604**
D_5^-=d(FR5, FR*)	0.316	0.254	0.013	**0.583**
D_6^-=d(FR6, FR*)	0.266	0.242	0.000100	**0.508**
D_7^-=d(FR7, FR*)	0.273	0.230	0.012	**0.515**
D_8^-=d(FR8, FR*)	0.260	0.242	0.013	**0.515**
D_9^-=d(FR9, FR*)	0.273	0.221	0.013	**0.507**
D_{10}^-=d(FR10, FR*)	0.294	0.242	0.012	**0.548**
D_{11}^-=d(FR11, FR*)	0.337	0.221	0.013	**0.606**
D_{12}^-=d(FR12, FR*)	0.260	0.256	0.013	**0.559**
D_{13}^-=d(FR13, FR*)	0.289	0.252	0.012	**0.553**
D_{14}^-=d(FR14, FR*)	0.289	0.272	0.013	**0.574**
D_{15}^-=d(FR15, FR*)	0.298	0.281	0.015	**0.594**
D_{16}^-=d(FR16, FR*)	0.281	0.236	0.013	**0.53**

Step 12: In this step, we compute the closeness coefficient (cc) of each FR; and the results are shown in Table 11.

5. CONCLUSIONS AND FUTURE WORK

In this paper, we proposed a method for the selection of software requirements using fuzzy AHP and fuzzy TOPSIS. Proposed method includes 12 steps, i.e., elicitation of non-functional requirements, construct PCM for NFRs, apply extent fuzzy AHP, compute weight of NFRs, elicitation of FR using goal oriented requirements elicitation technique, assignment of rating to the FRs with respect to NFRs, compute aggregate fuzzy rating for the FRs, compute the fuzzy decision matrix for FRs, normalize the fuzzy decision matrix, compute the weighted normalized matrix, compute the distance of each FR from FPIS and FNIS, and compute the closeness coefficient (cc) of each FR Selection of FRs. We have applied proposed method for the selection of the requirements of Institute Examination Systems. In our study, we have identified 16 FR for IES. On the basis of our study, we identify that FR11 has the highest priority and FR1 has the lowest priority. In future, we will implement all the steps of the proposed method; and will apply it on some other real life applications like Railway Reservation System, ATM system, etc.

Table 11: Closeness coefficients (CC) of FRs and their ranking values

FR	D_i^*	D_i^-	$D_i^* + D_i^-$	$= \frac{-}{*+\ -}$	Ranking values
FR1	0.516	0.49	1.006	0.487	**16**
FR2	0.514	0.523	1.037	0.504	**11**
FR3	0.516	0.598	1.114	0.536	**6**
FR4	0.597	0.604	1.201	0.502	**12**
FR5	0.588	0.583	1.141	0.510	**10**
FR6	0.513	0.508	1.021	0.497	**14**
FR7	0.522	0.515	1.037	0.496	**15**
FR8	0.515	0.515	1.03	0.5	**13**
FR9	0.47	0.507	0.977	0.518	**8**
FR10	0.444	0.548	0.992	0.552	**4**
FR11	0.42	0.606	1.026	0.590	**1**
FR12	0.443	0.559	1.002	0.557	**3**
FR13	0.491	0.553	1.024	0.520	**7**
FR14	0.474	0.574	1.048	0.547	**5**
FR15	0.456	0.594	1.05	0.565	**2**
FR16	0.5	0.53	1.03	0.514	**9**

6. REFERENCES

[1]. Chaves-Gonzalez J. M. and Perez-Toledano M. A., “Differential Evolution with Pareto Tournament for the Multi-objective Next Release Problem”, Applied Mathematics and Computation. 252, pp. 1-13, 2015.
[2]. Chaves-Gonzalez J.M., Perez-Toledano M. A., and Navasa A.,“Software Requirements Optimization using a Multi-objective Swarm Intelligence Evolutionary Algorithm”, Knowledge-Based Systems, Vol. 83, pp. 105-115, 2015.
[3]. Chaves-Gonzalez J.M., Perez-Toledano M. A., and Navasa A.,“Software Requirements Optimization using a Multi-objective Swarm Intelligence Evolutionary Algorithm”, Knowledge-Based Systems, Vol. 83, pp. 105-115, 2015.
[4]. Cheng X. Huang Y., Cai X., and Wei O.,“An Adaptive Memetic Algorithm based on Multi-objective Optimization for Software Next Release Problem”, GECCO,2014.
[5]. Garg N., Sadiq M., and Agarwal P., “GOASREP: Goal Oriented Approach for Software Requirements Elicitation and Prioritization using Analytic Hierarchy Process”, 5th International Conference on Frontiers in Intelligent Computing Theory and Applications, Springer, 2016.
[6]. Kaiya H., Horai H, and Saeki M., “AGORA: Attributed Goal-oriented Requirements Analysis Method”, IEEE Joint International Conference on Requirements Engineering, 2002.
[7]. Mohammad C. W., Shahid M, and Husain S. Z., “FAGOSRA: Fuzzy Attributed Goal-Oriented Software Requirements Analysis Method”, 9th International Conference on Contemporary Computing, pp. 11-13, (2016).
[8]. Saaty T. L.,“Decision Making with the Analytic Hierarchy Process”, International Journal of Services Sciences, Vol. 1, No.1, 2008.
[9]. Sadiq M, Ahmad J., Asim M, Qureshi A, Suman R., “ More on Elicitation of Software requirements and prioritization using AHP”, IEEE International Conference on Data Storage and Data Engineering, pp. 232-236, Bangalore, India, February 2010.
[10]. Sadiq M. and Jain S K.,“ Applying Fuzzy Preference Relation for Requirements Prioritization in Goal Oriented Requirements Elicitation Process”, International Journal of Systems Assurance Engineering and Maintenance**,** Springer, Vol. 5 (4), pp. 711-723, 2014.
[11]. Sadiq M., Hassan T, and Nazneen S.,“AHP_GORE_PSR: Applying Analytic Hierarchy Process in Goal Oriented Requirements Elicitation Method for the Prioritization of Software Requirements”, 3rd IEEE International Conference on Computational Intelligence and Communication Technology (CICT), Organized by ABES College, February 9-10, 2017.
[12]. Sagrado J. D., Aguila I M., and Orellana F.J.,“Multi-objective Ant Colony Optimization for Requirements Selection”.Empirical Software Engineering, Vol. 20, Issue 3, pp. 577-610, 2015.
[13]. Pitangueira A. M., Macial R. S. P., and Barros M, “Software Requirements Selection and Prioritization using SBSE Approaches A Systematic Review and Mapping of the Literature”, Journal of Systems and Software, 103, pp. 267-280, 2015.
[14]. Behzadian M. Otaghsara S. K., Yazdani M. and Ignatius J, “Review: A State of the –art-Survey of TOPSIS Applications”, Expert Systems with Applications, 39 (17), pp. 13051-13069, 2012.
[15]. Sadiq M. and Jain S K, “A Fuzzy Based Approach for the Selection of Goals in Goal-Oriented Requirements Elicitation Process”, International Journal of Systems Assurance Engineering and Maintenance, Springer, Vol. 6, Issue 2, pp. 157-164, June 2015.
[16]. Mohd. Sadiq and Neha, “Elicitation of Testing Requirements from the Selected Set of Software’s Functional Requirements using Fuzzy Based Approach”, International Conference on Computational Intelligence and Data Mining (ICCIDM-2016), Springer, December 10-11, 2016, Organized by KIIT University, Bhubaneswar, Odisha, India.
[17]. Pacheco C. and Garcia I., “A Systematic Literature Review of Stakeholder Identification Methods in Requirements Elicitation”, Journal of Systems and Software, Vol. 85, Issue 9, pp. 2171-2181, 2012.
[18]. Prakash C. and Barua M.K., “Integration of AHP-TOPSIS method for Prioritising the Solutions of Reverse Logistics Adoption to Overcome its barriers under fuzzy Environment”, Journal of Manufacturing Systems, Vol. 37, pp. 599-615, 2015.
[19]. Vinodh S, Prasanna M., and Prakash N. H., “Integrated Fuzzy AHP-TOPSIS for Selecting the Best Plastic Recycling Method: A Case Study”, Applied Mathematical Modelling, Vol. 38, pp. 4662-4672, 2014.
[20]. Alarcin F, Balin A, and Demirel H., “Fuzzy AHP and Fuzzy TOPSIS Integrated Hybrid Method for Auxiliary Systems of Ship Main Engines, Journal of Marine Engineering and Technology, Vol. 13, 2014.
[21]. Komlan G, “Integrating AHP-TOPSIS Approach on Prioritizing Self-Service Technology (SST) Decision Making in Financial Institute (TOGO), British Journal of Mathematics and Computer Science, Vol. 16, No. 3, pp. 1-22, 2016.
[22]. Chen CT, “Extensions of the TOPSIS for Group Decision Making under Fuzzy Environment”, Fuzzy Sets and System, Vol. 114, pp. 1-9.
[23]. Rodrigues Lima Junior F, Osiro L, and Carpinetti L.C.R., “A Comparison between Fuzzy AHP and Fuzzy TOPSIS Methods to Supplier Selection, Applied Soft Computing, Vol. 21, pp. 194-209, 2014.

[24]. Ertugrul I and Karakasoglu N, "Comparison of Fuzzy AHP and Fuzzy TOPSIS Methods for Facility Location Selection", International Journal of Advanced Manufacturing Technology, Vol. 39, pp. 783-795, 2008.
[25]. Torfi F, Farahani R.Z., and Rezapour S, "Fuzzy AHP to Determine the Relative Weights of Evaluation Criteria and Fuzzy TOPSIS to Rank the Alternatives", Applied Soft Computing-Elsevier, Vol. 10, pp. 520-528, 2010.
[26]. Chang DY, "Applications of the Extent Analysis Method on Fuzzy AHP", European Journal of Operations Research, Vol. 95, pp. 649-655, 1996.
[27]. Hwang CL and Yoon K, "Multiple Attributes Decision Making Methods and Applications", Springer, 1981.