

Generating large dataset for software requirements prioritization and selection under fuzzy environment

Mohd. Nazim[‡]

Department of Computer Science and Engineering

School of Engineering Sciences and Technology

Jamia Hamdard 110062

New Delhi

India

Mohd. Arif[†]

Chaudhary Wali Mohammad[§]

Department of Applied Sciences and Humanities

Computer Science and Technology Research Group

Faculty of Engineering and Technology

Jamia Millia Islamia (A Central University)

New Delhi 110025

India

Mohd. Sadiq^{*}

Department of Computer Engineering

Jamia Millia Islamia (A Central University)

New Delhi 110025

India

Abstract

Requirements elicitation is a key sub-process of requirements engineering in which various types of software requirements such as functional and non-functional requirements, testing requirements etc., are identified according to the needs of the stakeholders. After the completion of the requirements elicitation process, there may be a large set of requirements and practically it is not possible to implement all requirements due to budget, time and

[‡] E-mail: naztech1983@gmail.com

[†] E-mail: mohd.arif.jmi@gmail.com

[§] E-mail: cmohammad@jmi.ac.in

^{*} E-mail: sadiq.jmi@gmail.com, msadiq@jmi.ac.in (Corresponding Author)

other constraints of an organization. Under this situation, software developers select the highest ranked software requirements from the list of the elicited software requirements for different releases of software so that a successful software product can be developed. The selection of software requirements for different releases is a difficult task because it requires the participation of various stakeholders. In the field of science and engineering, datasets play an important role during experimental work. Based on our review, we found that in the literature of software engineering less attention is given on the generation of the datasets particularly in the domain of software requirements prioritization and selection (SRPS). Therefore, to address this issue, in this paper we present a four-step method for generating the dataset for SRPS research, i.e. (a) identification of stakeholders, (b) elicitation of software requirements using the goal-oriented concept, (c) formation of decision maker committee and (d) evaluation of the functional requirements and non-functional requirements by decision makers under fuzzy environment. The proposed method has been applied to generate the dataset for the requirements of an institute examination system.

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1. Introduction

Requirements Engineering (RE) is a process of identifying the Software Requirements (SRs) as per the need of different types of stakeholders like users, customers etc. [1]. Sadiq and Jain [2] classified the RE into five sub-processes as: (a) “requirements elicitation”, (b) “requirements modeling”, (c) “requirements analysis”, (d) “requirements verification and validation” and (e) “requirements management”. Among these, requirements elicitation is a key sub-process that is used to know the stakeholders’ needs so that different types of requirements for a system can be identified [1, 2]. In this sub-process, the elicited requirements are evaluated by different decision makers based on different criteria so that a selected list of the SRs based on their priorities can be identified for modeling, analysis and implementation of the system. Various types of SRs are identified after the requirements elicitation process such as Functional Requirements (FRs), Non-Functional Requirements (NFRs), testing requirements etc. [2, 3]. In real-life applications, we have seen that a single technique for eliciting SRs is inappropriate for identifying the requirements [4]. So different techniques have been developed to identify the requirements, i.e. (a) traditional techniques, which include interview, questionnaire, analysis of the existing methods etc., (b) group elicitation method and (c) idea generation method, (d) goal oriented method [2, 5].

Software requirements prioritization and selection (SRPS) is an important step in the requirements elicitation process in which different stakeholders are invited during the elicitation and selection process of SRs [6]. During SRPS processes, stakeholders may use different types of data for the evaluation of the software requirements like crisp numbers, fuzzy numbers and rough numbers [6, 7]. For example, in attributed goal oriented requirements analysis method [5] the crisp values were used for the analysis of the SRs. Sadiq et. al. [8] used triangular fuzzy numbers (TFNs) for the selection of FRs on the basis of NFRs. Misaghian and Motameni [9] suggested a tensor decomposition-based strategy for prioritizing SRs. They invited five decision-makers during the SRPS process. Rough numbers have also been used during the SRPS process [7]. SRs are evaluated by different decision makers which are treated as a single unit during the computational process. In these studies, small and medium datasets have been considered during the experimental work. A dataset can be defined as a *“combination of distinct sets of information that is treated as a single unit during experimental work”* [10].

Different types of the datasets are available in the literature of the science, engineering and management. For example, in image forensic science, different types of the datasets are available to check the authenticity of the digital images [11]. Similarly, in the field of software engineering, there are different types of the datasets for the analysis of the methods or techniques in the following research areas like software cost estimation, requirements tracing, PRedictOr models in software engineering, QoS data for numerical computation library, Eclipse bug data, software defect prediction, predicting successful re-use, bug prediction dataset etc.; but no such datasets are available for the analysis of the SRs during SRPS process [12, 13]. Therefore, it motivates us to generate a dataset for SRPS research. On the basis of our literature review, we found that very little importance is given to generating the dataset based on the SRs which is used as an input in the SRPS processes. Keeping in view the importance of the datasets which are used in the SRPS process, in our previous work [14], we proposed a method for the generation of the datasets for the SRPS research. The objective of this paper is to extend our previous work [14] by generating the dataset for large set of the software requirements. A system having less than fifteen requirements is called the small set of requirements. In case of the large dataset, a system may have more than fifty requirements [15].

The remaining part of this paper is organized as follows: Section 2 presents the four steps process to generate the dataset for the SRPS process.

Section 3 presents the selected list of the datasets from the literature of the SRPS. The generation of the dataset for the large set of the requirements of an institute examination system (IES) is explained in Section 4. The conclusion and future work are discussed in Section 5.

2. A method to generate a dataset for SRPS research

The aim of this section is to discuss the steps for the generation of the dataset for SRPS research. The steps for generating the dataset for SRPS research are given below:

Step 1: Identification of stakeholders.

Step 2: Elicitation of software requirements using the goal-oriented concept.

Step 3: Formation of decision maker committee.

Step 4: Evaluation of the functional requirements and non-functional requirements by decision makers under fuzzy environment.

Step 1: Identification of stakeholders

The aim of this step is to identify different types of the stakeholders according to the need of the project. The stakeholders are identified based on their roles and responsibility.

Step 2: Elicitation of software requirements using goal-oriented concept

In goal oriented method, the goals of the stakeholders are decomposed and refined until the software requirements are identified. The process of decomposition and refinement are modeled by an AND/OR graph. In this graph, the high level objective (G) of an organization is placed at level zero of an AND/OR graph. The high level objective is refined and decomposed into sub-goals, i.e., $SG_1, SG_2, SG_3, \dots, SG_n$. The process of decomposition and the refinement of these sub-goals into sub-sub-goals will continue until the responsibility of the goals which are at the last level of an AND/OR graph is assigned to some agent or system [3].

Step 3: Formation of decision makers committee

The objective of this step is to form the committee of decision makers for the evaluation of the software requirements that have been identified by applying the goal oriented method. It has been observed that during the decision making process, the decision makers use linguistic variables to specify their preferences. For example, the system should be highly secured; and the performance of system should be good. Here, the terms like *highly secure* and *good performance* are the linguistic variables. In this step, fuzzy logic has been used to model such type of linguistic variables during the SRPS process.

Step 4: Evaluation of the functional requirements and non-functional requirements by decision makers under fuzzy environment

Software requirements have been divided into two parts, i.e. FRs and NFRs. FRs describe the functionality of a system, whereas, NFRs describe the non-behavioral aspects of the system. In software engineering, NFRs are serving as criteria during SRPS process. For example, the system should be secured; and the performance of system should be high. Here, security and performance are the NFRs [16].

3. Selected existing datasets

This section presents a brief discussion on the selected set of the datasets which have been used during the SRPS process. In this section, we discuss four datasets from Sadiq and Jain [17], Zhu *et. al.* [18], Misaghian and Motameni [9] and Nazim *et. al.* [14].

3.1 Dataset-1

We have adopted this dataset from the work of Sadiq and Jain [17]. In their work, goal oriented method was employed to find the FRs and NFRs of an examination system. The list of the FRs and NFRs are given below: “*FR₁*: A printout of the student’s fee bank receipt; *FR₂*: Entry of marks (both internal and external); *FR₃*: Check out the semester’s result; *FR₄*: Make a seating plan for the exam; *FR₅*: Conduct the online exam; *FR₆*: Fill out the exam form and the system will generate the following information after it is submitted successfully: (i) Student’s roll number, (ii) Student’s name, (iii) Name of the examination, (iv) Code of the subject, (v) Name of the subject(s), (vi) Backlogs, if any, (vii) Fee(s) of examination; *FR₇*: Upload any

activity (s) related to the exam; FR_8 : Generate examination hall ticket; FR_9 : Approve examination form; and FR_{10} : On line payment of examination fee". In this dataset, five decision makers were invited to evaluate ten FRs and three NFRs. In their work, the TFN were used during the computational process. Following linguistic variables were used for the evaluation of the FR on the basis of the NFRs: "Very Weak (VW), Weak (W), Medium (M), Strong (S) and Very Strong (VS)". These linguistic variables were modeled by using the following TFN: $VW = (2,2,4)$, $W = (2,4,6)$, $M = (4,6,8)$, $S = (6,8,10)$ and $VS = (8,10,10)$ ".

3.2 Dataset - 2

This dataset was adopted from the work of Zhu et. al. [18]. In this dataset, fuzzy qualitative and quantitative interdependency graph was used for the correlation analysis of reliable software. In [18], the authors have analyzed 64 NFRs which have been divided into three layers, i.e., primary layer, secondary layer and tertiary layer. In this dataset, three decision makers were involved for the evaluation of the NFRs using trapezoidal fuzzy numbers. Following linguistic variables were used in this dataset during the evaluation process: "Extremely Weak (EW), Very Weak (VW), Weak (W), Medium Weak (MW), Fair (F), Medium Strong (MS), Strong (S), Very Strong (VS) and Extremely Strong (ES)". These linguistic variables were modeled by using the following trapezoidal fuzzy numbers: $EW = (0, 0, 0.59, 0.118)$, $VW = (0.059, 0.118, 0.176, 0.235)$, $W = (0.176, 0.235, 0.294, 0.353)$, $MW = (0.294, 0.353, 0.412, 0.471)$, $F = (0.412, 0.471, 0.529, 0.588)$, $MS = (0.529, 0.588, 0.647, 0.706)$, $S = (0.647, 0.706, 0.765, 0.824)$, $VS = (0.765, 0.824, 0.882, 0.941)$ and $ES = (0.882, 0.941, 1, 1)$ ".

3.3 Dataset - 3

Misaghian and Motameni [9] proposed a method for the prioritization of the software requirements using tensor decomposition. In this dataset the requirements of the Automated Teller Machine (ATM) were used during the software requirements prioritization process. The following steps were included in this method: (i) "identifying stakeholders", (ii) "determining the FRs and NFRs", (iii) "eliciting importance values", (iv) "constructing the tensor", (v) "decomposing the tensor" and (vi) "recommending ordered lists of FRs and NFRs". Following is a list of FRs and NFRs of an ATM system: "FR₁: Withdraw cash; FR₂: Check balance; FR₃: Transfer funds; FR₄: Change PIN number; FR₅: Print transaction money; FR₆: Change withdraw limit; NFR1: Availability; NFR2: Security;

NFR₃: Usability; NFR₄: Performance; and NFR₅: Reliability". In this dataset, crisp values were used during the decision making process; and the FRs and NFRs were assessed using the following scale: No importance = 0.001, Very low importance = 0.25, Low importance = 0.5, High importance = 0.75 and Very high importance = 1.00.

3.4 Dataset- 4

In our previous work [14], we have generated a dataset for medium set of the software requirements by considering the following steps: (a) "identification of stakeholders and its goals", (b) "decomposition and refinement of goals using goal-oriented technique" and (c) "evaluation of the FRs and NFRs by decision makers' by using fuzzy numbers". In our work, we have considered the software requirements of an IES. In our study, the FRs and NFRs were evaluated by five decision makers. The decision makers used the following linguistic variables to evaluate the FRs: "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)".

List of FRs: FR₁: Login module- can be used by students, teachers and administrators; FR₂: To fill the application form for the examination. The information given in this form will display on the student's admit card / hall ticket. Following are the sub-requirements of FR₂: FR_{2.1}: Name of the student, FR_{2.2}: Name of student's father, FR_{2.3}: Name and year of the examination, FR_{2.3.1}: If the student is in first year, the IES will generate the student's Roll Number, FR_{2.3.2}: If the student is in the second, third or fourth year, the students will enter the roll number and enrollment Number, FR_{2.4}: Subject codes and names of theory and practical Courses (papers of current semester and backlog, if any). If a student fails in some subjects and does not provide information regarding backlog papers when filling out the examination form, the IES will notify the student about any backlog papers, FR_{2.5}: The student's photograph, FR_{2.6}: Student's signature, FR_{2.7}: HOD/COE approval, FR_{2.8}: has the student paid the fee or not?, FR_{2.9}: Is there a possibility that the student has diabetes? If the answer is yes, then the student will be allowed to bring medicine and eatables inside the examination room. This requirement will be linked to the Institute's medical center in order to provide information to the doctors, FR_{2.10}: Need of writers for students who are physically disabled or blind, FR_{2.11}: Some necessary information from the Institution or University for the students, like the students must arrive at the examination center at least 30 minutes before the examination begins; the students must have the valid college

Identity card etc., FR_{2,12}: The admit card or hall ticket be downloaded only after paying the examination fee and late fee, if any; FR₃: Check the student's internal assessment marks of theory and practical courses; FR₄: Examine the semester's final results; FR₅: Generation of the student's fee receipt, if he/she has deposited the fee of the semester and backlog papers. A code will be provided by this requirement that will be used as an input for FR_{2,8}; FR₆: Generation of seating arrangement 15 minutes prior the start of the examination. Sub-requirements to this requirement are as follows: FR_{6,1}: Number of the room, FR_{6,2}: Details regarding the floor; FR₇: To display the theory/practical exam's details, including examination codes and dates, as well as the COE's signature; FR₈: To enter the marks of internal assessment (Theory/Practical); FR₉: Marksheet generation for the semester results. Sub-requirements to this requirement are as follows: FR_{9,1}: The Institution's or University's Logo, FR_{9,2}: The Institution's or University's name, FR_{9,3}: Student's name, FR_{9,4}: Student's roll number, FR_{9,5}: Student's enrollment number, FR_{9,6}: Name and the code of the subject, FR_{9,7}: Maximum/minimum marks, FR_{9,8}: Marks scored by students; FR₁₀: Migration certificate. Sub-requirements to this requirement are as follows: FR_{10,1}: Fee must be paid and enter the fee receipt number into the system to obtain the migration certificate, FR_{10,2}: Student's roll number and FR_{10,3}: Student's enrollment number; FR_{10,4}: Final year's marksheet should be upload. The NFRs are as follows: Security (NFR₁), Cost (NFR₂) and Usability (NFR₃).

4. Case study

The objective of this section is to apply the proposed method for the generation of the large set of the software requirements of an IES. In our previous work [14], we have generated 32 FRs and 3 NFRs for an IES. In this study, we have adopted the steps proposed by Sadiq [19] for the identification of the software requirements based on the stakeholder's roles and responsibilities. In our work, we have identified twenty stakeholders for the identification of the software requirements of an IES. The list of the stakeholders is given below: S₁: "stakeholder for the elicitation of FRs", S₂: "stakeholder for the elicitation of NFRs", S₃: "developer" and S₄₋₂₀: "end users". In the present work, we employed the same linguistic variables and TFNs that we have used in [14]. After applying the goal oriented requirements elicitation techniques, the following FRs and NFRs of an IES have been identified. The goal graph for software requirements of an IES is given in Figure 1.

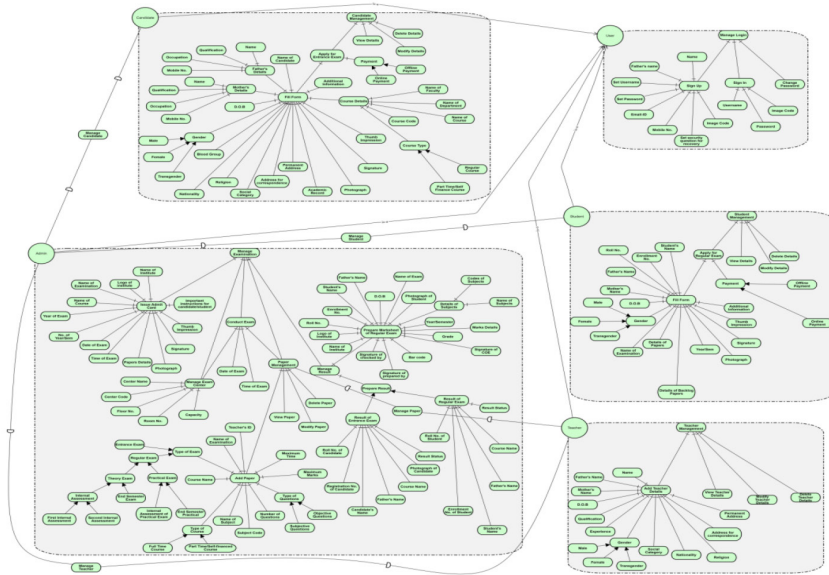


Figure 1

Goal graph for the software requirements of IES

List of FRs: SR_1 : Login module for users (FR_1), i.e., student, a teacher, an administrator. This requirement has the following sub-requirements: SR_2 : Sign up for a new users ($FR_{1.1}$), SR_3 : Name of the user ($FR_{1.1.1}$), SR_4 : Father's name of user ($FR_{1.1.2}$), SR_5 : Set username for login ($FR_{1.1.3}$), SR_6 : Set password for login ($FR_{1.1.4}$), SR_7 : E-mail ID of user ($FR_{1.1.5}$), SR_8 : Mobile number of user ($FR_{1.1.6}$), SR_9 : Set security questions for password/username recovery purpose ($FR_{1.1.7}$), SR_{10} : To check whether the user is human being or a machine ($FR_{1.1.8}$), SR_{11} : Sign-up ($FR_{1.2}$), SR_{12} : Sign in ($FR_{1.2.1}$), SR_{13} : Using password for sign in ($FR_{1.2.2}$), SR_{14} : Generating test images to confirm that the user is a human not a robot ($FR_{1.2.3}$), SR_{15} : A user can change his/her password if he/she forget it ($FR_{1.3}$); SR_{16} : This module is for the management of examination by the administration (FR_2). This requirement has the following sub-requirements: SR_{17} : Issue admit card of student/candidate ($FR_{2.1}$), SR_{18} : To print the name of the institution ($FR_{2.1.1}$), SR_{19} : To print the logo of the institution ($FR_{2.1.2}$), SR_{20} : To print the name of the examination ($FR_{2.1.3}$), SR_{21} : To print the name of course ($FR_{2.1.4}$), SR_{22} : To print the year of examination ($FR_{2.1.5}$), SR_{23} : To print the current semester, ($FR_{2.1.6}$), SR_{24} : To print date of examination ($FR_{2.1.7}$), SR_{25} : To print the time of examination ($FR_{2.1.8}$), SR_{26} : To print the details of paper(s) ($FR_{2.1.9}$), SR_{27} : To print the

photograph of the candidate/student (FR_{2.1.10}), SR₂₈: To print the signature of candidate/student (FR_{2.1.11}), SR₂₉: To print the thumb impression of candidate/student (FR_{2.1.12}), SR₃₀: To print the important instruction for candidate/student regarding the examination, if any (FR_{2.1.13}), SR₃₁: Manage examination centre (FR_{2.2}), SR₃₂: Name of the examination centre (FR_{2.2.1}), SR₃₃: Code of the examination centre (FR_{2.2.2}), SR₃₄: Floor number (FR_{2.2.3}), SR₃₅: Room number (FR_{2.2.4}), SR₃₆: Capacity of the room (FR_{2.2.5}), SR₃₇: Conduct the examination (FR_{2.3}) {the examination centre related information can be accessed from FR_{2.2} and exam papers related information can be accessed from FR_{2.4}}, SR₃₈: Manage date of the examination (FR_{2.3.1}), SR₃₉: Manage time of examination (FR_{2.3.2}), SR₄₀: Manage examination paper(s) (FR_{2.4}), SR₄₁: Add new paper(s) (FR_{2.4.1}), SR₄₂: The ID of the teachers who want to add paper(s) (FR_{2.4.1.1}), SR₄₃: Name of the examination (FR_{2.4.1.2}), SR₄₄: Type of the examination (FR_{2.4.1.3}), SR₄₅: Entrance examination (FR_{2.4.1.3.1}), SR₄₆: Regular examination (FR_{2.4.1.3.2}), SR₄₇: Theory exam (FR_{2.4.1.3.2.1}), SR₄₈: Internal assessment (FR_{2.4.1.3.2.1.1}), SR₄₉: First internal assessment (FR_{2.4.1.3.2.1.1.1}), SR₅₀: Second internal assessment (FR_{2.4.1.3.2.1.1.2}), SR₅₁: End semester exam (FR_{2.4.1.3.2.1.2}), SR₅₂: Practical exam (FR_{2.4.1.3.2.2}), SR₅₃: Internal assessment of practical exam (FR_{2.4.1.3.2.2.1}), SR₅₄: End semester practical exam (FR_{2.4.1.3.2.2.2}), SR₅₅: Name of the course (FR_{2.4.1.4}), SR₅₆: Type of the course (FR_{2.4.1.5}), SR₅₇: Full time/regular course (FR_{2.4.1.5.1}), SR₅₈: Part-time/Self-financed course (FR_{2.4.1.5.2}), SR₅₉: Name of subject (FR_{2.4.1.6}), SR₆₀: Code of subject (FR_{2.4.1.7}), SR₆₁: Total number of questions (FR_{2.4.1.8}), SR₆₂: Type of questions (FR_{2.4.1.9}), SR₆₃: Subjective questions (FR_{2.4.1.9.1}), SR₆₄: Objective questions (FR_{2.4.1.9.2}), SR₆₅: Maximum marks (FR_{2.4.1.10}), SR₆₆: Maximum time to be allotted (FR_{2.4.1.11}), SR₆₇: View paper(s) (FR_{2.4.2}), SR₆₈: Modify paper(s) (FR_{2.4.3}), SR₆₉: Delete paper(s) (FR_{2.4.4}), SR₇₀: Manage result (FR_{2.5}), SR₇₁: To prepare the result of both entrance as well as regular examinations (FR_{2.5.1}), SR₇₂: To prepare the result of entrance examination (FR_{2.5.1.1}), SR₇₃: To print the roll number of the candidate in the result (FR_{2.5.1.1.1}), SR₇₄: To print registration number of the candidate in the result (FR_{2.5.1.1.2}), SR₇₅: To print candidate's name in the result (FR_{2.5.1.1.3}), SR₇₆: To print father's name of the candidate in the result (FR_{2.5.1.1.4}), SR₇₇: To print name of the course in the result (FR_{2.5.1.1.5}), SR₇₈: To print photograph of the candidate in the result (FR_{2.5.1.1.6}), SR₇₉: To print the result status (FR_{2.5.1.1.7}), SR₈₀: To prepare the result of the regular examination (FR_{2.5.1.2}), SR₈₁: To print student's roll number in the result (FR_{2.5.1.2.1}), SR₈₂: To print student's enrolment number in the result (FR_{2.5.1.2.2}), SR₈₃: To print student's name in the result (FR_{2.5.1.2.3}), SR₈₄: To print father's name of the student in the result (FR_{2.5.1.2.4}), SR₈₅: To print course name in the result (FR_{2.5.1.2.5}), SR₈₆: To print

status of the result (FR_{2.5.1.2.6}), SR₈₇: To prepare the mark-sheet of regular examination (FR_{2.5.2}), SR₈₈: To print institution's name on the mark-sheet (FR_{2.5.2.1}), SR₈₉: To print institution's logo on the mark-sheet (FR_{2.5.2.2}), SR₉₀: To print student's roll number on the mark-sheet (FR_{2.5.2.3}), SR₉₁: To print student's enrolment number on the mark-sheet (FR_{2.5.2.4}), SR₉₂: To print student's name on the mark-sheet (FR_{2.5.2.5}), SR₉₃: To print the student's father's name on the mark-sheet (FR_{2.5.2.6}), SR₉₄: To print student's date of birth on the mark-sheet (FR_{2.5.2.7}), SR₉₅: To print examination's name on the mark-sheet (FR_{2.5.2.8}), SR₉₆: To print year/semester of examination on the mark-sheet (FR_{2.5.2.9}), SR₉₇: To print student's photograph on the mark-sheet (FR_{2.5.2.10}), SR₉₈: To print details of subjects on the mark-sheet (FR_{2.5.2.11}), SR₉₉: To print details of marks on the mark-sheet (FR_{2.5.2.12}), SR₁₀₀: To print student's grade on the mark-sheet (FR_{2.5.2.13}), SR₁₀₁: To print the signature of person who prepared the mark-sheet (FR_{2.5.2.14}), SR₁₀₂: To print the signature of the person who checked the mark-sheet (FR_{2.5.2.15}), SR₁₀₃: To print the signature of C.O.E (FR_{2.5.2.16}), SR₁₀₄: To print the bar-code (FR_{2.5.2.17}); SR₁₀₅: This requirement is for the management of the candidates appearing for the entrance examination (FR₃). This requirement has the following sub-requirements: SR₁₀₆: Candidate can apply for entrance examination (FR_{3.1}), SR₁₀₇: Fill the entrance examination form by the candidate (FR_{3.1.1}), SR₁₀₈: Candidate's name (FR_{3.1.1.1}), SR₁₀₉: Details of candidate's father (FR_{3.1.1.2}), SR₁₁₀: Name of father (FR_{3.1.1.2.1}), SR₁₁₁: Qualification of father (FR_{3.1.1.2.2}), SR₁₁₂: Occupation of father (FR_{3.1.1.2.3}), SR₁₁₃: Father's mobile number (FR_{3.1.1.2.4}), SR₁₁₄: Details of candidate's mother (FR_{3.1.1.3}), SR₁₁₅: Name of mother (FR_{3.1.1.3.1}), SR₁₁₆: Qualification of mother (FR_{3.1.1.3.2}), SR₁₁₇: Occupation of mother (FR_{3.1.1.3.3}), SR₁₁₈: Mother's mobile number (FR_{3.1.1.3.4}), SR₁₁₉: Candidate's date of birth (FR_{3.1.1.4}), SR₁₂₀: Candidate's gender (FR_{3.1.1.5}), SR₁₂₁: Candidate may be a male (FR_{3.1.1.5.1}), SR₁₂₂: Candidate may be a female (FR_{3.1.1.5.2}), SR₁₂₃: Candidate may be a transgender (FR_{3.1.1.5.3}), SR₁₂₄: Candidate's blood group (FR_{3.1.1.6}), SR₁₂₅: Candidate's nationality (FR_{3.1.1.7}), SR₁₂₆: Candidate's religion (FR_{3.1.1.8}), SR₁₂₇: Candidate's social category (FR_{3.1.1.9}), SR₁₂₈: Candidate's address for correspondence (FR_{3.1.1.10}), SR₁₂₉: Candidate's permanent address (FR_{3.1.1.11}), SR₁₃₀: Candidate's academic records (FR_{3.1.1.12}), SR₁₃₁: Details of the course to be applied by the candidate (FR_{3.1.1.13}), SR₁₃₂: Name of the faculty in which candidate have to apply (FR_{3.1.1.13.1}), SR₁₃₃: Name of the department (FR_{3.1.1.13.2}), SR₁₃₄: Name of the course (FR_{3.1.1.13.3}), SR₁₃₅: Code of the course (FR_{3.1.1.13.4}), SR₁₃₆: Type of the course (FR_{3.1.1.13.5}), SR₁₃₇: Course may be a regular course (FR_{3.1.1.13.5.1}), SR₁₃₈: Course may be a part-time/self-financed course (FR_{3.1.1.13.5.2}), SR₁₃₉: Candidate's photograph (FR_{3.1.1.14}), SR₁₄₀: Candidate's signature (FR_{3.1.1.15}),

SR₁₄₁: Candidate's thumb impression (FR_{3.1.1.16}), SR₁₄₂: Some additional information to be filled by the candidate, if any (FR_{3.1.1.17}), SR₁₄₃: Payment for entrance examination (FR_{3.1.2}), SR₁₄₄: Offline mode for payment (FR_{3.1.2.1}), SR₁₄₅: Online mode for payment (FR_{3.1.2.2}), SR₁₄₆: Candidate can view his/her own details (FR_{3.2}), SR₁₄₇: Candidate can modify his/her own details (FR_{3.3}), SR₁₄₈: Candidate can delete his/her own details with some restrictions applied by administration (FR_{3.4}); SR₁₄₉: This requirement is for the management of students appearing for the regular examination (FR₄). The sub-requirements for this requirement are as follows: SR₁₅₀: Student can apply for regular examination (FR_{4.1}), SR₁₅₁: examination form to be filled by the student (FR_{4.1.1}), SR₁₅₂: Name of the student (FR_{4.1.1.1}), SR₁₅₃: Enrolment number of the student (FR_{4.1.1.2}), SR₁₅₄: Roll number of the student (FR_{4.1.1.3}), SR₁₅₅: Father's name of the student (FR_{4.1.1.4}), SR₁₅₆: Mother's name of the student (FR_{4.1.1.5}), SR₁₅₇: Date of birth of the student (FR_{4.1.1.6}), SR₁₅₈: Gender of the student (FR_{4.1.1.7}), SR₁₅₉: Name of the examination (FR_{4.1.1.8}), SR₁₆₀: Details of exam paper(s) (FR_{4.1.1.9}), SR₁₆₁: Details of backlog paper(s), if any (FR_{4.1.1.10}), SR₁₆₂: Year/Semester of examination (FR_{4.1.1.11}), SR₁₆₃: Photograph of the student (FR_{4.1.1.12}), SR₁₆₄: Signature of the student (FR_{4.1.1.13}), SR₁₆₅: Thumb impression of the student (FR_{4.1.1.14}), SR₁₆₆: Some additional information for the student regarding examination (FR_{4.1.1.15}), SR₁₆₇: Examination fee payment (FR_{4.2}), SR₁₆₈: Online payment mode (FR_{4.2.1}), SR₁₆₉: Offline payment mode (FR_{4.2.2}), SR₁₇₀: Student can view his/her own details (FR_{4.2}), SR₁₇₁: Student can modify his/her own details (FR_{4.3}), SR₁₇₂: Student can delete his/her own details with some restrictions applied by administration (FR_{4.4}); SR₁₇₃: This requirement is for the management of teachers (FR₅). This requirement has the following sub-requirements: SR₁₇₄: A teacher can update his/her profile (FR_{5.1}), SR₁₇₅: Name of the teacher (FR_{5.1.1}), SR₁₇₆: Father's name of the teacher (FR_{5.1.2}), SR₁₇₇: Mother's name of the teacher (FR_{5.1.3}), SR₁₇₈: Teacher's date of birth (FR_{5.1.4}), SR₁₇₉: Teacher's qualifications (FR_{5.1.5}), SR₁₈₀: Experience (FR_{5.1.6}), SR₁₈₁: Teaching experience (FR_{5.1.6.1}), SR₁₈₂: Research experience (FR_{5.1.6.2}), SR₁₈₃: Industry experience (FR_{5.1.6.2}), SR₁₈₄: Gender of teacher (FR_{5.1.7}), SR₁₈₅: Social category of teacher (FR_{5.1.8}), SR₁₈₆: Nationality of teacher (FR_{5.1.9}), SR₁₈₇: Religion of teacher (FR_{5.1.10}), SR₁₈₈: Teacher's address for correspondence (FR_{5.1.11}), SR₁₈₉: Permanent address of teacher (FR_{5.1.12}), SR₁₉₀: Teacher can view his/her own details (FR_{5.2}), SR₁₉₁: Teacher can modify his/her own details (FR_{5.3}), SR₁₉₂: Teacher can delete his/her own details with some restrictions applied by administration (FR_{5.4}).

List of NFRs: *NFR*₁: Security; *NFR*₂: Cost; and *NFR*₃: Usability.

After the elicitation of the FRs and NFRs of an IES, the next step is the evaluation of the FRs on the basis of NFRs by all decision makers. In this study, we invited five decision-makers from different software companies located in Delhi/NCR region and universities/institutions. Taking FR_1 and NFR_1 , the five decision makers evaluated the FRs. According to DM_1 , the FR_1 should be highly secured (NFR_1), so the entries of DM_1 (row) and NFR_1 (column) for FR_1 contains VH. In the same way, the FR_1 was evaluated by the remaining decision makers. The same procedure was applied for the remaining FRs; and finally, the preferences of all the decision makers for the remaining FRs and NFRs were evaluated. Table 1 shows the evaluation of the two FRs based on three NFRs by five decision makers. The results after the evaluation of the remaining FRs based on three NFRs are given on the following web addresses:

<http://iiisc.in/dataset.html>

https://github.com/nazimjmi/SoftwareRequirementsDataset/blob/main/SR_Dataset.pdf

Table 1
Evaluation of FRs by five DMs based on three NFRs

DMs	FRs	Non-Functional Requirements(NFRs)			FRs	Non-Functional Requirements(NFRs)		
		NFR_1	NFR_2	NFR_3		NFR_1	NFR_2	NFR_3
DM_1	SR_1	VH	VH	H	SR_2	VH	H	M
DM_2		H	H	M		H	M	M
DM_3		VH	M	H		H	H	VH
DM_4		VH	H	VH		VH	VH	VH
DM_5		VH	H	VH		H	L	H

5. Conclusions and future work

This paper presents a method for the generation of a large dataset for SRPS research. The proposed method includes the following steps: (a) identification of stakeholders, (b) elicitation of software requirements using the goal-oriented concept, (c) formation of decision maker committee and (d) evaluation of the functional and non-functional requirements by the decision makers in a fuzzy environment. The stakeholders for the elicitation of the software requirements are identified based on their roles and responsibilities. In the proposed method, a goal oriented requirements elicitation method has been used for the elicitation of the different types

of software requirements. As a result, we have identified 192 software requirements which include both the dependent and independent requirements. The results of this paper can be used as an input during the decision making process of the SRPS. In future, we shall try to generate the datasets for other research problems like software cost estimation and software requirements analysis.

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