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An Innovative Methodology for Elicitation Technique Selection via Attribute Mapping

Attique Ahmed*[1] and Owais Ali[2]

[1]Department of Computer Science, Abbottabad University of Science & Technology, Havelian, KPK, Pakistan

[2]Department of Computer Science, COMSATS University Islamabad, Abbottabad Campus

ABSTRACT

The software development process relies entirely on stakeholders' requirements. The end product will likely be optimal and successful if stakeholders' requirements are integrated into the proposed system. Various Requirement Elicitation Techniques (RET) are employed to achieve a successful product. The selection of a suitable RET depends on the nature of the product under development. Therefore, a single RET cannot be universally applied to all products. This paper aims to distinguish between all RETs, facilitating analysts in selecting the most appropriate RET from the available options. Additionally, we have devised a novel mapping framework that identifies the most suitable RET for any software based on its attributes. We have also implemented this framework using an online vehicle booking system as an illustrative example.

Keywords: Requirement Elicitation Techniques (RETs), Requirement Gathering, RETs in Software Development, Mapping of characteristics

1 INTRODUCTION

As software development progresses, the number of Requirement Elicitation Techniques (RET) continues to grow. Developers constantly seek the best techniques to overcome growth and end-product usage challenges. However, this proliferation of techniques poses a significant challenge for the industry: determining which method is best and can reliably produce user-accepted products [1].

Examining existing literature reveals that over 50% of software projects ultimately fail to gain acceptance from end users or stakeholders. The failure can often be attributed to various aspects, including Requirements Elicitation, Analysis, Implementation, Documentation, and Validation. Requirements Elicitation stands out as the most critical and challenging of these phases. During this phase, crucial data and insights about the product are extracted from stakeholders. Consequently, any ambiguity or errors during this stage can lead to the rejection of the end product [9].

This paper delves into a comparative analysis of almost all Requirement Engineering (RE) techniques across different scenarios. Such a comparison aims to assist developers in selecting the most suitable method and maximizing stakeholder input. The comparison is structured into three phases.

In the first phase, the paper examines the pros and cons of each RE technique, providing an overview of the techniques in use. The second phase focuses on the characteristics of each method, aiding developers in making informed decisions about their adoption. Finally, the third and last phase presents a Requirement Elicitation framework. This framework enables developers to identify the most appropriate RE technique from the available options. An illustrative example demonstrates the selection of a suitable requirement elicitation technique according to the proposed framework.

2 ADVANTAGES AND DISADVANTAGES OF DIFFERENT REQUIREMENT ELICITATION TECHNIQUES

In Table 1 below, we initially discuss each RE technique's advantages and limitations to provide a basic understanding of each technique's key strengths and weaknesses [3, 10]. All the techniques' benefits are outlined in Table 1 to highlight their essential utilities and positive aspects [10]. The techniques are categorized into four main groups: Traditional, Cognitive, Collaborative, and Observational requirement elicitation techniques [1-2].

*Corresponding author: attiqueahmed94@gmail.com

The first group of techniques is fundamental and has been utilized since the field's inception. These techniques boast good reliability and reputation. However, over time, other techniques became necessary as the existing ones left gaps that directly challenged the end product's success [3, 4].

Cognitive Techniques also offer reliability and are primarily used for gathering information regarding system development. Collaborative and Observational techniques are also prevalent in the industry and are implemented by analysts and developers to ensure the development of demanded and reliable end products. Below, we delve into the benefits and limitations of each requirement elicitation technique, paving the way for characteristics analysis. Eventually, optimized techniques are identified to provide feasibility to developers and stakeholders [1-3].

Table 1. Comparison of Requirement Elicitation Techniques

Category	Elicitation Techniques	Merits	Demerits
Traditional R.E. Techniques	Interviews	The proposed system is discussed in detail. Data is informative and useful.	The amount of data is huge and complex to summarize.
	Surveys	Many users can use this very cheap method to get information.	A system as a whole can't be analyzed, which is the actual demand of Elicitation.
	Questionnaire	A basic approach in which every aspect is asked remotely from stakeholders.	Only for basic and quick Knowledge. Further ideas can't be generated.
	Task Analysis	It directs the user to the system interface.	It is time-consuming because details are needed for a small product.
	Domain Analysis	It derives its strength from existing system documentation and manuals.	It becomes more than a task; it is converted into a case study.
	Introspection	It is a thoughtful and valuable technique that has almost no cost.	Comprehensive Knowledge of business areas is demanded.
Cognitive R.E. Techniques	Card Sorting	Differentiation between different requirements. Customer knowledge is analyzed.	Working in collaboration is more realistic and useful than this technique.
	Class Responsibility Collaboration (CRC)	Provides fundamentals to make UML diagrams.	It suits only designers, not a software engineer.
	Laddering	Hierarchy-based requirements arrangements.	It is not suitable for large projects because addition and deletion are complex.
	Repertory Grid	Identification of characteristics is easy.	Identification becomes hard in complex systems.
Collaborative R.E. Techniques	Focus Group	Every condition stakeholders define can be evaluated, and useful data can be collected.	In the case of multiple stakeholders, it results in a conflict.
	Brainstorming	This technique generates new ideas. Decision-making is easy.	It does not suit a Busy and Crowded environment.
	Joint Application Development (JAD)	Customer-developer collaboration is easy to use to create, change, or delete any aspect of the system.	Expert Knowledge at both ends is lacking.
	Requirement Workshop	Detailed workshops can extract large and complex data.	It has a huge cost and does not align with small tasks.
	Protocol Analysis	All the stakeholders and users must participate to create a suitable system.	Deadlock can occur due to multiple thoughts.
	Prototyping	Developing a new system becomes easy due to the involvement of stakeholders, especially in making GUI.	Time and cost are both utilized at high rates.
Observational R.E. Techniques	Ethnography	Social behaviours are brought into context to get quality attributes.	Multiple communities can create a hurdle when using this technique.
	Observation	This technique is helpful in analysts' requirement analysis and validation phases.	Observation can be partial or leftover due to travel expenses.
	Apprenticing	Facilitates cooperation between analysts and stakeholders.	The willingness of stakeholders is optional.

3 CHARACTERISTICS-BASED ANALYSIS OF DIFFERENT REQUIREMENT ELICITATION TECHNIQUES

Table 2 discusses the various characteristics of each elicitation technique, highlighting differences in aspects such as the location of the analyst and stakeholders, the role of the analyst, mode of conduction, type of data, size of data, and number of stakeholders [2].

The distinction is made regarding whether the analyst and stakeholders share the exact location. If they do, the value 'same' is entered; otherwise, if the locations differ, the value 'different' is recorded. The analyst's role is categorized based on whether they facilitate the stakeholders, lead the system, or remain passive and not directly involved.

The 'mode of conduction' column determines whether the elicitation technique is solely designed for direct Elicitation or serves other functions. Data size is a crucial consideration, where 'small' denotes a potential lack of complete data, and 'large' implies a risk of receiving vague and irrelevant data [7].

Lastly, the number of stakeholders involved is discussed to analyze the level of participation in each elicitation technique. Involving stakeholders in every instance can be time-consuming and challenging, leading to delays in finalizing the end product. Values 'One' or 'Many' are entered in Table 2 according to the appropriate case.

Table 2. Characteristics-Based Analysis of Requirement Elicitation Techniques

Category	Elicitation Techniques	Location Analyst/Clients	Role of Analyst	Mode of Conduction	Type of Data	Size of Data	Stakeholders
Traditional R.E. Techniques	Interviews	Same	To Lead	Direct	Qualitative & Quantitative	Large	One/Many
	Surveys	Different	Facilitate	Indirect	Qualitative & Quantitative	Large	Many
	Questionnaire	Same	To Lead	Indirect	Quantitative	Medium	Many
	Task Analysis	Same	Facilitate	Indirect	Quantitative	Medium	N/A
	Domain Analysis	Same	Facilitate	Indirect	Quantitative	Medium	N/A
	Introspection	N/A	Passive	Direct	Quantitative	Small	N/A
Cognitive R.E. Techniques	Card Sorting	Same	Facilitate	Indirect	Quantitative	Medium	Many
	Laddering	Same/Different	Facilitate	Indirect	Qualitative & Quantitative	Small to Medium	One
	Repository Grid	N/A	Facilitate	Indirect	Qualitative & Quantitative	Small	Many
Collaborative R.E. Techniques	Focus Group	Same	To Lead	Indirect	Qualitative	Small	Many
	Brainstorming	Same	To Lead	Direct	Qualitative	Small	Many
	Joint Application Development (JAD)	Same	To Lead	Direct	Qualitative	Medium	Many
	Requirement Workshop	Same	To Lead	Direct	Qualitative	Small	Many
	Protocol Analysis	N/A	Passive	Direct	Qualitative	Medium	Many
	Prototyping	N/A	Passive	Direct	Qualitative	Small	More than 1, not many
Observational R.E. Techniques	Ethnography	Same	Passive	Direct	Qualitative	Medium	Many
	Observation	Same	Passive	Direct	Qualitative	Medium	Many
	Apprenticing	Same	Passive	Direct	Qualitative	Small	One

3.1 Selection Criteria

The literature was filtered based on predefined inclusion and exclusion criteria to ensure the selection of studies of high relevance and quality. The inclusion criteria mandated that studies be published in peer-reviewed journals or conference proceedings, written in English, focused on specific neural network architectures (FNNs, RNNs, and CNNs), and applicable to software cost estimation [19, 22]. Conversely, exclusion criteria eliminated non-peer-reviewed articles, papers not in English, studies not directly addressing neural network applications in cost estimation, and outdated research not reflective of current advancements in neural network technologies [19]. This meticulous selection process also involved assessing the methodological rigor of studies and their direct relevance to the comparative analysis goal of this review [19, 23].

3.2 Approach to Data Synthesis

The information of the selected papers was synthesized through a multistep process. Initially, key data points such as the neural network architecture utilized, application context in software cost estimation, methodology, results, and conclusions were extracted and organized in a tabular format for preliminary comparative analysis [23, 24]. Following this, a thematic analysis was undertaken, categorizing findings from the studies based on similarities and differences in approaches, results, and implications. It facilitated the identification of predominant themes, trends, and research gaps [19, 23, 24]. The synthesis aimed to integrate insights across studies, comparing the efficacy and applicability of different neural network architectures in software cost estimation, providing a nuanced understanding of the field [25].

4 NEURAL NETWORK ARCHITECTURES FOR COST ESTIMATION

The application of various neural network architectures in software cost estimation represents a significant advancement in predicting project costs more accurately and dynamically. This section examines the roles and effectiveness of Feedforward neural networks (FNNs), Recurrent Neural Networks (RNNs), and Convolutional Neural Networks (CNNs) in software cost estimation.

4.1 Feedforward Neural Networks (FNNs)

Feedforward Neural Networks (FNNs) are foundational to artificial neural network designs, characterized by a unidirectional data flow from the input to the output lay-ers, without feedback loops [26]. FNNs' structure comprises an input layer representing cost-driving factors, one or more hidden layers for data processing, and an output layer for cost prediction. Their capacity to model complex, non-linear relationships between input variables and outputs renders FNNs particularly suitable for software cost.

5 FRAMEWORK FOR SELECTING SUITABLE TECHNIQUE

A comprehensive system analysis proposes a complete framework (Figure 1). This framework aids in determining the best requirement elicitation technique based on the proposed system's attributes, characteristics of all techniques above, and on-ground analysis conducted by the analyst.

The proposed system attributes are defined by stakeholders, outlining the system and their requirements for the final product. The number of stakeholders is also specified in this step to assist the analyst or developer.

All elicitation techniques are outlined within the framework, which is essential for mapping them with the system to be created. The characteristics were thoroughly discussed earlier in this study and are well-suited for implementation in any upcoming system.

An on-ground analysis conducted by the analyst is also incorporated as input into the framework. Observation is imperative before requirement engineering, as it helps identify the social environment in which the proposed system will operate and evolve. Criteria may change as situations develop, prompting adjustments to the elicitation technique based on realities.

These three inputs are fed into a mapping function, which integrates inputs from all three sources to yield outcomes with the most suitable techniques. These techniques align with the system attributes defined by stakeholders, characteristics provided by this analysis, and situations outlined by the analyst. In the framework's results section, the analyst evaluates the outcome of the entire process and identifies the best technique for requirement elicitation. This technique is more likely to result in a successful product by the end of the software development life cycle process.

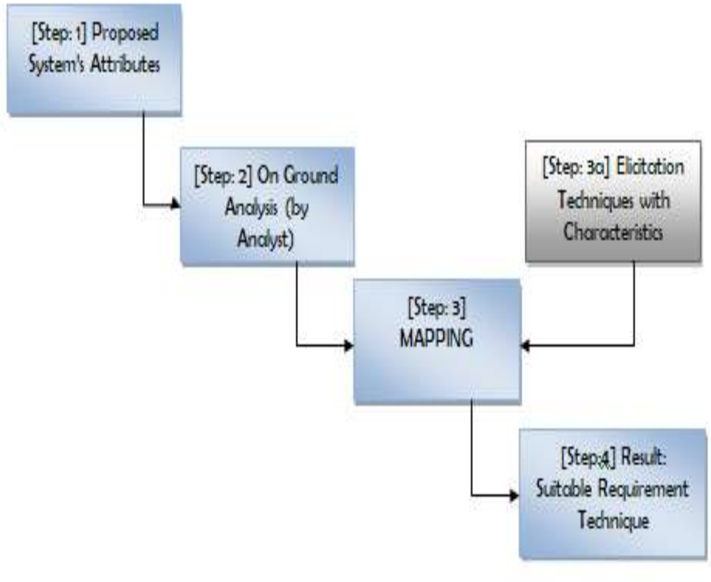

Figure 1: Characteristics-Based Analysis of Requirement Elicitation Techniques

6 IMPLEMENTATION OF FRAMEWORK

A comprehensive study of different elicitation techniques is conducted, considering various parameters. Subsequently, a framework is proposed wherein all these parameters are integrated, and a suitable solution in the form of an elicitation technique is provided.
A real-world project is defined here to articulate the framework above more effectively. This project serves as the basis for implementing the proposed framework. Ultimately, an elicitation technique that aligns with the given project's requirements is determined after the implementation.

7 RUNNING EXAMPLE

The online vehicle booking system is a web-based project designed to enable customers to interact with the organization and reserve vehicles by executing specific functions on the web portal. Upon validation by stakeholders, the organization dispatches the vehicle to the customers' specified location provided during online form submission. Payment methods are integrated into the web portal or app for customer convenience.
This system operates through distinct modules, such as the customer and administrator modules. Customers can browse available vehicles and submit requests through the store. Administrators manage vehicle bookings and other platform-related tasks. Additionally, the company employs individuals responsible for end-to-end task delivery, resulting in three modules: client, agent, and employees. The project encounters certain real-world situations, which are detailed below.

Step 1: Within the aforementioned online web project, several stakeholders exist, including administrators, employees, and end users/customers. While administrators and employees are consistently available for requirement elicitation, customers are absent during the startup phase of the web portal. Thus, the analyst must undertake specific functions to gather customer needs from the portal, which is essential.

Step 2: Regarding the project's scope, the platform has diverse users. Therefore, we must focus on characteristics that ensure seamless access for multiple users to the system.

Step 3: Given the substantial number of customers accessing the system, each with varying levels of internet and web app proficiency, it's crucial to implement situational measures to ensure reliable usage for all customers.

Step 4: This project shares demanded characteristics with previously developed projects. It is not entirely novel; hence, implementing use cases can aid in evaluating the elicitation technique.

Elicitation techniques can vary based on the situation, as what works in one scenario may not be suitable for another. However, the effectiveness of a technique depends on its relevance to a specific domain. In the context of an online vehicle booking system, convening all employees and stakeholders for interviews is a viable approach. Brainstorming is also valuable, especially for involving customers who may not always be accessible during development. Document analysis can provide insights into previous work on similar projects.

While each technique has its merits, selecting a single one ensures reliability in the development process. Interviews with organizational stakeholders and document analysis to understand customer/end-user demands are the most suitable techniques.

8 CONCLUSION AND FUTURE WORK

This paper extensively delves into various requirement elicitation techniques, conducting a three-dimensional analysis. The first dimension involves an in-depth examination of different requirement elicitation methods. The second aspect employs an efficient characteristic-based analysis across all techniques. Finally, the research culminates presenting a mapping framework practically applied to a running example.

While we've furnished a comprehensive, implementable framework for selecting suitable requirement elicitation techniques, future considerations may include prioritizing time complexity based on thorough research. Additionally, various industries possess pre-implemented techniques, which may prove successful or unsuccessful depending on the context. Therefore, implementing characteristic-based techniques on samples from specific regions or industry types could be advantageous.

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