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Role of visualization in tacit knowledge: extraction and applications in software requirements

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ABSTRACT

Requirements have a proven role and considered as an important factor in designing and producing good quality software. Further available literature depicts precisely, comprehensively that poorly defined, organized requirements increase the cost of development, time for the development and more importantly leads to software product failure. It is of highest priority and importance for the developers, retailers as well as for the clients to verify that the designed and planned system satisfies their needs or not. In today's world while designing, developing system, the knowledge extraction becomes an important area for research and key focus in order to compile and share knowledge. In knowledge extraction, explicit and tacit knowledge are the two categories of knowledge. Explicit knowledge is simple to perceive and understand due to its simplicity and clarity. Tacit knowledge is not that easily understandable due to its complex nature and as it resides under the experts' mind. In this research, we have given enumerated illustrations and account of nature of tacit knowledge and different frameworks. Another vital contribution in this research is that it establishes rules and proposes a framework for tacit knowledge derivations. Further, implementing these proposed rules will help eliciting tacit knowledge without consuming more cost and effort. We have also focused on UI generation via different visualization tools or technologies developed for requirements representation that will be further validated by using case studies and using real events or scenarios data.

Keywords: knowledge; tacit knowledge; knowledge extraction; framework; UI; visualization;

1. INTRODUCTION

In requirements engineering (RE) conducting fruitful meetings and to satisfy the user needs have always been a challenge for the software industry. The requirements are considered as a major challenge and concern for any software project team. As requirements are of enormous importance for any software system under development. If one does not validate requirements at earlier phases then it becomes difficult that how to validate system latter. Therefore, it is necessary for the users or stakeholders to precisely confirm that the planned system meets their requirements and system must be described in a way that can easily be understood. Extracting knowledge enclosed by an individual is the most critical issue for most of the organizations as this is also a form of abstraction. According to Markus [1], knowledge is distinguished as the explicit and the tacit, explicit knowledge can quickly be converted into code and can be formally organized and documented. Tacit knowledge endures in people's minds and may be remains there until proper extraction method will be used. While extracting tacit knowledge, organizations face problems because dealing with explicit knowledge is simpler than tacit knowledge [2]. Extracting and handling tacit knowledge from experts is not a simple task because tacit knowledge is not explicit precisely.

In today's world, different technologies and techniques such as data mining are available which are helpful in discovering knowledge [3]. In this paper, one of consolidation effort is with tacit knowledge extraction methodologies and to recommend different rules for tacit knowledge extraction in a simple way.

This research paper is divided into 7 major section. In the Section 2 of the paper, we discussed literature review and highlighted issues faced by organizations due to misunderstanding of knowledge. In Section 3, we evaluated the different proposed rules for tacit knowledge extraction. Section 4 of the paper describes the proposed conceptual framework for extraction of tacit knowledge. In the section 5, we have designed a case study for a donation company and used visualization technologies and techniques like Pencil and MockingBird, Adobe Photoshop and Online Mockup for requirements mapping. In Section 6, the comparative analysis of the tools is carried out. Lastly, Section 7 is about conclusion which depicts that these tools are best for visualizing requirements according to users' expectations.

2. LITERATURE REVIEW

The details about the tacit knowledge extraction and visualization techniques are discussed in the literature [4, 5]. Nonaka & Takeuchi define the knowledge conversion types and suggest different methods to convert tacit knowledge

into explicit knowledge [6]. Tunç Durmuş Medeni et.al, explain a tacit knowledge visualization framework [7]. They created a virtual setting where knowledge specifications will be described by the visualized tacit knowledge with the help of their proposed framework [8]. Authors in [9], illustrated that individual can describe tacit knowledge with little struggle. Different methods are available to elicit knowledge from experts. Mainly major methods are protocol generation techniques, protocol analysis techniques, and Visualization techniques. Authors in [10, 11], demonstrates that tacit knowledge cannot be easily communicated to others. Experts cannot explain their ideas to others in such a way that they can understand it. In [12], the researchers have examined the common process used to transmit tacit knowledge in any organization that is Expert Interviews, Observations, Filling questionnaires from experts, Brainstorming, Storyboarding, Visualizations, Mind Map, Concept maps and Analogies [13].

2.1 Tacit knowledge extraction issues

In this section, we have discussed and featured the tacit knowledge problems in context of different stakeholders, which are as follows [4, 14]:

A. *User/Expert Based Problems*

- Most of the users cannot express their thoughts precisely. In this scenario, interviews method must be applied and visualization method can be used to explain requirements.
- Sometimes the user is not from computer world (non-technical) and he/she cannot understand what is possible or impossible, thus, they may ask something impossible. In this case, "mediator" is required who will act as a bridge between user and expert. Simulations (or graphical notations) are also used to model the system for clarifying these aspects in knowledge system besides mentioned issues and problems [12].
- In large projects, different meetings might be needed. In this case, electronic mail (Email) will provide a good solution. It is easy to clarify the fuzzy parts or to get ready for the meeting through pre-scheduled email [12].
- It is not mandatory that all people will be attending meeting. In this scenario, e-mail, e-Discussion Boards, audio and Video Conferencing will be good alternatives.

B. *Expert Based Problems*

Common users and developers are using different vocabulary and dialects. In this case, visualization can be the best solution. Moreover, observation techniques can also be used. In observation engineer observes the user actions and records its actions [15].

2.2 Nature of tacit knowledge

Eliciting explicit knowledge is simpler and easier than tacit knowledge extraction [16], nature of tacit knowledge makes it difficult to capture. Tacit knowledge lies in human memory. It is difficult to evolve methods that can extract knowledge from human minds. It is also noticed that different organizations like medicine companies, chemicals and IT industry which depends on small expert teams and individuals faces difficulties when these experts decide to leave organization. Thus, developing such techniques and tools which help in eliciting knowledge from these experts is difficult [17, 18]. Nature of tacit knowledge is discussed in the Figure 1 below, in some situations, extracting explanation from experts about their procedures, methods and techniques in doing a distinct task is difficult because of observations, qualifications, associations, judgements, hunches, inherent talents, skill expertise, experience, know-how, which are embedded within experts' mind [7, 15, 19].

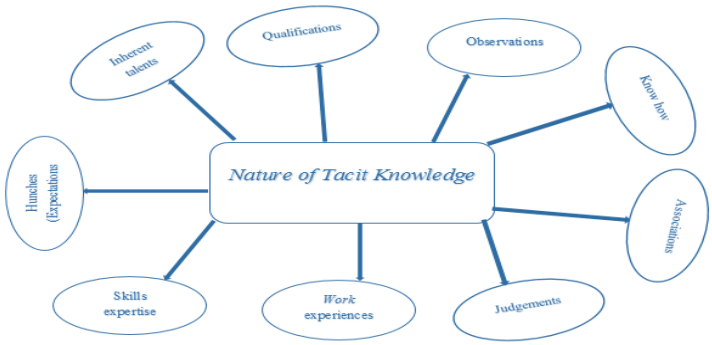

Figure. 1 Nature of tacit knowledge

3. PROPOSED RULES FOR TACIT KNOWLEDGE EXTRACTION

In this section, we have proposed the rules for tacit knowledge extraction that are listed below:

1. Identify the domain knowledge and area experts by concluding what the problems within the area are.
2. Explain the problem with its solution.
3. Explore all the databases, classes, functions, their attributes and relationships.
4. Identify the pre-conditions and post-conditions.
5. Identify an effective and efficient knowledge extraction process for capturing reliable tacit knowledge. Avoid unimportant knowledge which is not related to specific area [20].
6. To simplify and analyze the fuzzy details, use different techniques like interviews, observation, questionnaires, audio and video conferences, visualization, storyboarding and mind mapping.
7. Finally convert the extracted knowledge into coded program.
8. At the end evaluation of extracted knowledge will be done by experts. Each expert's functionality will be tested against the other [21].

4. FRAMEWORK FOR TACIT KNOWLEDGE EXTRACTION

The proposed framework shows that different levels of tacitness are used to transfer knowledge effectively from expert to inexpert. Based on experience, expert will determine the level of tacitness. Then he/ she will select the most appropriate method to transfer tacit knowledge. For example, with the low level of tacitness, if the expert wants to transmit tacit knowledge, the most suitable method is software requirement specifications (SRS) [13]. Qualitative as well as quantitative approach is used for developing framework. The proposed framework is shown in Figure 2.

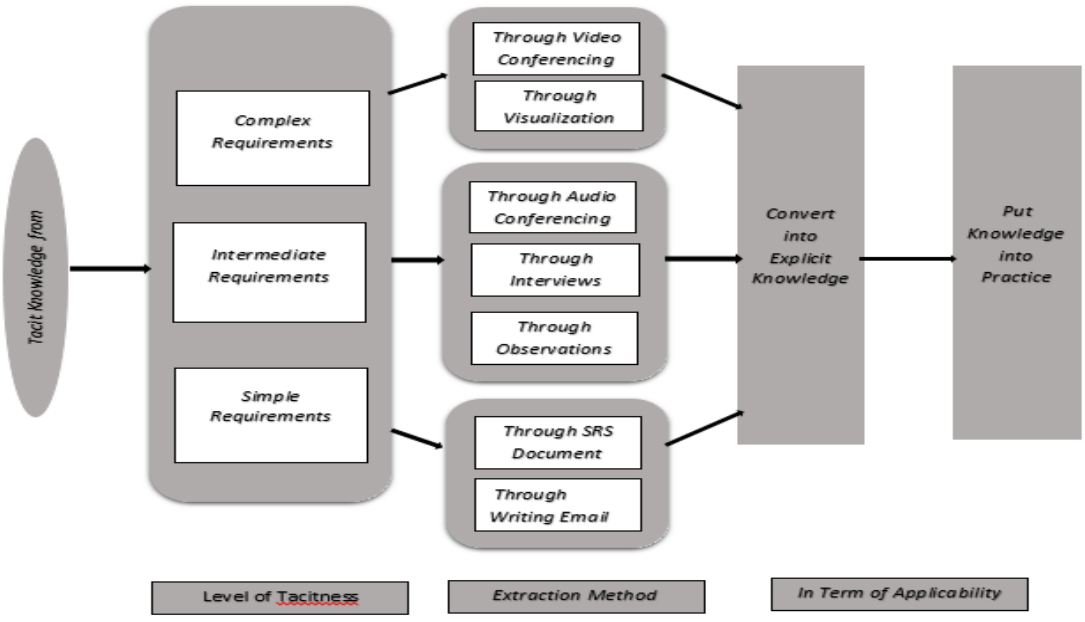

Figure. 2 Proposed framework for tacit knowledge extraction

5. CASE STUDY

The use of visualization tools could reduce the communication gap between the customer and developer resulting in a more effective requirements validation process [1, 22] This research work reviews two existing functional requirements UI visualization techniques by using case study of a donation company. In this research, we develop a case study for an online portal of all donors to access the page and pay donations using easypay channels. All registered Companies with PAYPAL will sign-in to mobile account to collect payments online. The donor will choose any registered company and will be routed to the payment page where he will insert special details and amount then choose the preferred payment method and Pay the amount and will be routed back to the thank you page. The company will keep updating the donors about the progress of the project. This will be done by progress bar. A drop-down search

should also be available to search for typical type of project. The type of the project will be set up by partner admin at the time of project creation. The search types that should be allocated to projects should be zakat (alms-giving), education help, sadqa (alms-giving), help in medical bills and miscellaneous. The features for reports generation will download the report, using search by date/time and other fields or different filters (app or WEB). For visualization of this case study, we use four visualization or UI generation technologies, which are Pencil, Mockingbird, Online Mockup and Adobe photoshop.

Pencil is a visualization tool that provides different built-in shapes collection for creating desktop user interface as well as mobile platforms. It provides support for exporting documents into popular formats such as text documents and Adobe PDF. Pencil has a clipart browser tool, integrated with 'Open Clipart' that helps users easily find clipart by keywords and with simple drag-and-drop operations added to support the drawing. Pencil provides inter-page linking i.e. elements in a drawing can be linked to a specific page in the same document [23]. Visualization of case study through Pencil project is shown in Figure 3.

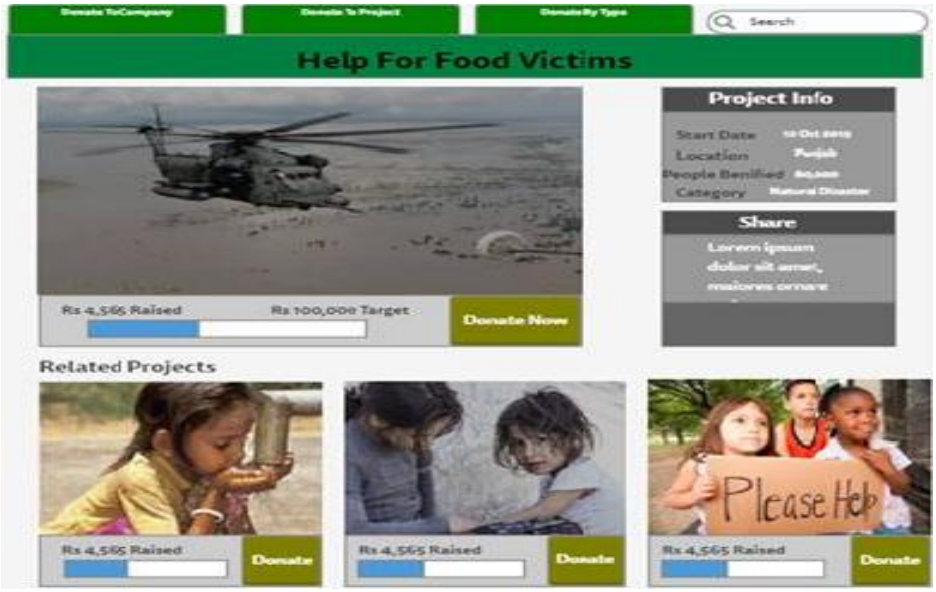

Figure. 3 Visualization of case study through Pencil

Mockingbird is a web-based software used to create and preview visualizations of the application. It is a GUI interface, with drag and drop options, collective page linking, resizing of text and the ability to share mockups with direct link. Visualization of case study through Mockingbird is shown in Figure 4.

Figure. 4 Visualization of case study through MockingBird

Online Mockup is a web app that allows us to create wireframes, diagrams and prototypes. It is an online design platform that helps us to develop fast, simple and beautiful designs to validate and visualize requirements. Visualization of case study through online mockup is shown in Figure 5.

Figure. 5 Visualization of case study through MockingBird

Adobe Photoshop is Visualization and graphic design software. It helps us to create images and designs in order to visualize requirements by using layer based editing system. It is highly usable software for graphic designs creation. Visualization of case study through online mockup is shown in Figure 6.

Using these different tools and technologies that are Pencil and MockingBird, Online Mocking etc., we have illustrated here via graphical representations of the highlighted case study instead of its textual representation. In a software team the mentioned visualization have more applications and much needed feedback than a common textual representation. As it makes more sense for the stakeholders, like requirement engineers, designers, developers or even customers, to proceed with the functional, non-functional or domain requirements for the product under review.

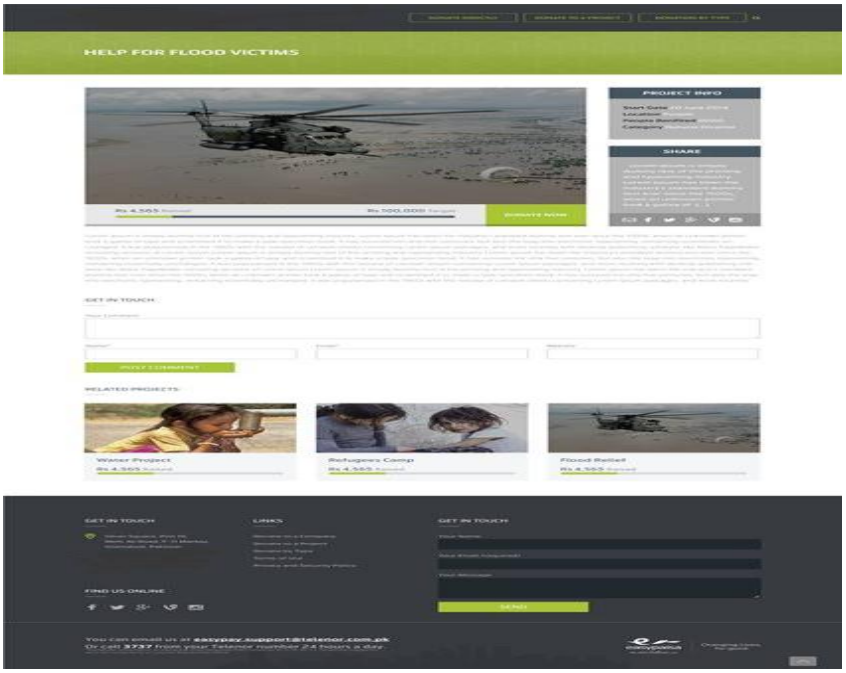

Figure. 6 Visualization of case study through Adobe Photoshop

6. EVALUATIONS

Using these four tools like Pencil, online mockup, Adobe Photoshop and Mockingbird, we have illustrated here graphical representations of these knowledge attributes in mentioned case study instead of its textual representation. Here we construct a table with different attributes and compared different visualization tools on the basis of our implementations and observations. After making in depth analytical assessments we have found that Adobe Photoshop is best tool for visualizations and graphic designing as it is more user friendly, free of cost, effective, customizable, fast and learnable as shown in Figure 7.

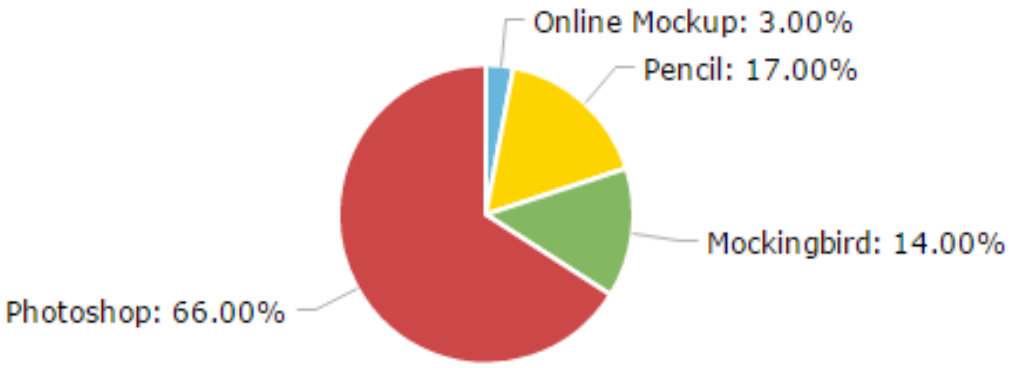

Figure. 7 Photoshop is highly usable for visualization

For detailed analytical assessments of the mentioned tools on basis of some attributes is shown in Table I.

Table. I GUI tools comparison for visualization

Attributes	*Online Mockup*	*Pencil*	*Mockingbird*	*Adobe Photoshop*
Fast	✓	✗	✓	✓
Easy to Learn	✓	✗	✓	✓
Effective	✗	✗	✗	✓
Time Saving	✓	✓	✓	✓
Rich in Controls	✗	✗	✗	✓
Free	✗	✓	✓	✓
Customize	✗	✓	✗	✓
User Friendly	✗	✗	✗	✓

7. RESULTS AND FINDINGS

For assessments of the parameters, we used three-point scale in a graph i.e. 3, 2, 1 as Best, Average, and Worst respectively. Different values for different parameters with selected visualization tools are verified. The calculated values of parameters are used for conclusion and investigation of this study. The overall comparison based graph for these four visualization tools is shown in Figure 8. After analysis, we found that, among different techniques for tacit knowledge extraction, visualization is best as through visualization, expert shows his/her ideas diagrammatically and other stakeholders can easily understand it when pictorial form is presented in front of them.

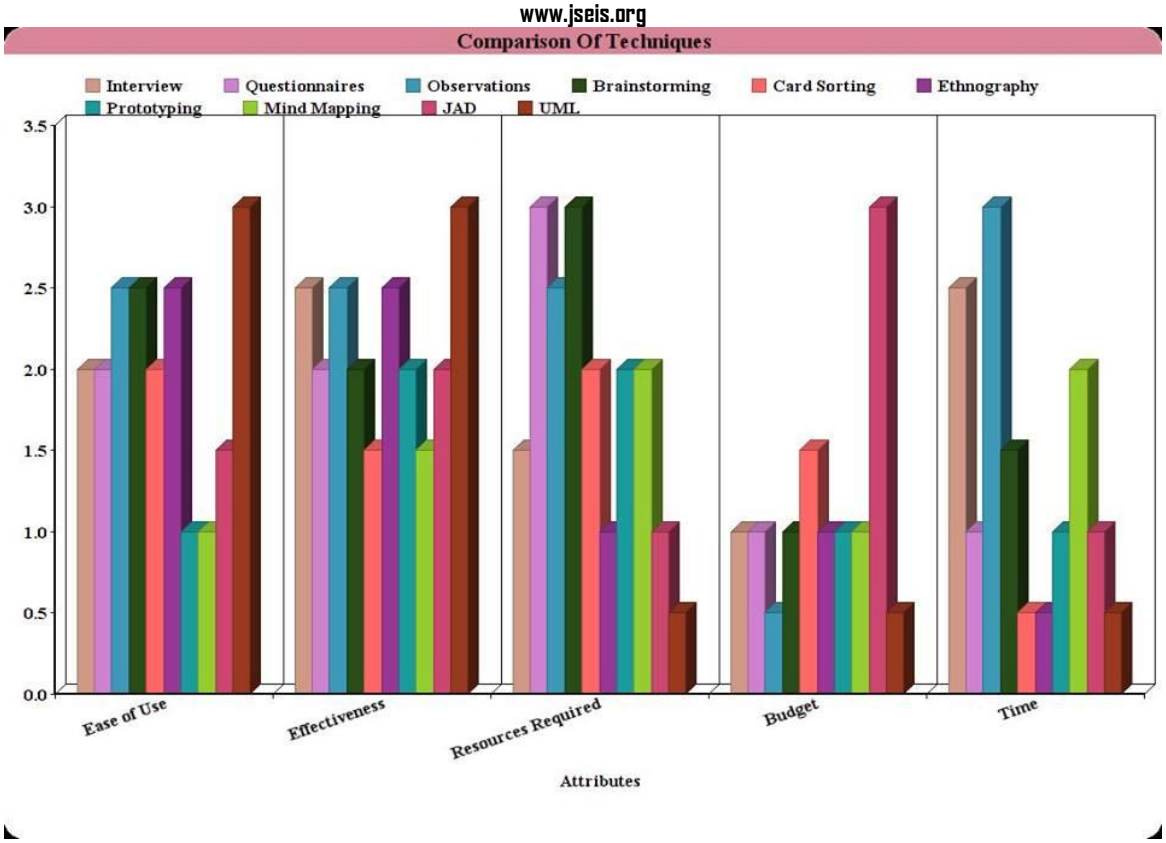

Figure 8. Visaulization comparison techniques

8. CONCLUSION

In real life now a day in order to extract, compile and share knowledge is itself a comprehensive research scenario. Further, the knowledge extraction becomes an important area for research especially due to multiple applications of data mining, data warehousing. This work presents a comprehensive methodology via proposed framework (rules) that results tacit knowledge extraction in an easy way. We have also discussed and elaborated issues faced by organizations due to misunderstanding of knowledge, rules for tacit knowledge extraction, conceptual framework for extraction of tacit knowledge. We have validated a study for a donation company and we have used different visualization tools that are Pencil and MockingBird for requirements mapping, also can be seen clearly that these tools are best for visualizing requirements. The proposed methodology and its visualization representations are very good depiction and need of visualization in software requirements. These visualizations have more meanings and manifestation for different stakeholders from the customer or development sides, simply because they are much more understandable than the predecessors.

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