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Integrating AI Techniques in Requirements Analysis

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Abstract: ***Requirements Analysis (RA) remains one of the most central processes in requirements engineering. It is a process of evaluating and discovering possible structures to create a contracted set of broad and reliable requirements. The major aim of requirements analysis is to produce a requirements specification document with great quality. The analysis of study exposes that experts have arranged major supports by developing various methods/tools/framework/techniques of requirement analysis process. Though, one of the major problems faced by developers is poor communication and frequently changes in requirements. These issues may lead to incompetent outcome and termination of the system development. The previous investigation exposes that Artificial Intelligence (AI) methods may support in this by restricting alterations in requirements and to propose effective communication between designers and users. The purpose of this work is to categorize the challenges in every stage of the requirements analysis and incorporation of AI techniques to solve these known challenges. Moreover, the research also determines the association between such challenges and their potential AI answer/s through Venn-Diagram. Prior studies expose that more than one AI technique available for some of the challenges, and some of the challenges are still open for further research, no AI techniques has been reported yet.***

Keeping in observation the significance of the area, foremost analysis methods and their related issues have already been recognized in one of our prior papers. This study is an addition of our prior effort and here, an attempt is made to incorporate and describe AI techniques in various requirements analysis techniques.

Keywords: Requirements Analysis, Artificial Intelligence, Challenges in Requirements Analysis, AI Techniques.

I. INTRODUCTION

The requirements engineering is the initial and vital part of software engineering process, in which user requirements are composed, understood, and identified. Requirements engineering is renowned as a vital task, since most of the software failures initiated from imperfect, improper and inconsistent requirements specifications. Multiple serious difficulties connected with software progress are associated with requirements [1].

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RE process is perceived as an assembly of activities for elicitating, analysing, documenting, validating and maintaining the set of requirements [2] [3].

Requirements analysis is one of the most fundamental process in requirements engineering since it moulds the outline of the preferred software.

It deals with requirements grouping, allocation and modelling to components, and also with identifying and resolving conflicts. Major purpose of the analysis stage is to modify and progress the requirements specified in prior stage into reliable, traceable, comprehensive and unambiguous requirements [4][5].

Parallel to the development of requirement engineering, there has been evident progress of associated disciplines such as Artificial Intelligence having an impression on software development. The integration scenario of requirement engineering and artificial intelligence is so enormous and AI techniques are appropriate to aforementioned complex requirements engineering problems. Major aim of AI techniques is to create software systems that reveal some form of human intelligence [6][7].

Major aim of this research is to revisit the approaches established in AI from the perspective of their usage in the requirements phase. Its emphases on AI methods to solve issues linked with requirements analysis phase. Rest of the research is structured as follows: Section II defines methodology, section III defines 'Issues in analysis phase' however Section IV deliver a complete discussion on 'AI Methods in Requirements analysis Phase'. Section V demonstrates 'Related Discussion and Findings', 'Conclusion and Future Work' are identified in Section VI and VII.

II. METHODOLOGY

The method 'right from the inception' in software development can curtail the requirement related issues in later phases. Requirements are increasing day-by-day in software development along with requirements issues. Therefore, there should be some procedure by which it can be known that which technique or methods are useful for decreasing these issues in requirement phase. For this, there is a need for the collaboration of requirement phase with AI. By this methodology, it can be easily known 'which techniques of AI can be associated in order to mitigate the issues of requirement phase with the help of Venn diagram'. This work will be focused on the requirements analysis phase of SDLC with the contribution of AI, but there are still major underlying issues, which need attention particularly for requirement phase.

III. CHALLENGES IN ANALYSIS

RA is one of the major procedure in RE, which contains several activities with multiple offered techniques [7] [8]. A complete research on foremost analysis methods and their related issues have previously been completed and described in one of our earlier papers [8] [9]. After a comprehensive study of this paper, it has been discovered that there are still certain challenges in analysis, which are given as follows and pictorial representation is given in Fig.1:

A. Stakeholders Interviews

This is one of the common methods used in requirements analysis. This method can aid as a means of gaining the extremely focused knowledge. Moreover, every users will have diverse concepts of their vision, which is suitable for finding the barriers during the procedure [11] [12]. Major challenges are given as follows:

- SiI1: Detailed and accurate requirements are the foundation of quality of software procedure. Foremost issue in requirements analysis is that sometimes, users may provide a vague knowledge. So, developers are required to execute the analysis to crack this vague knowledge into complete standard specification [13].
- SiI2: Users frequently change their requirements, which can increase the schedule and budget expectation [15].
- SiI3: Many actions implemented in interviews such as analysis, transcribing, interviewing, managing report can be a time consuming process [14].
- SiI4: Project stakeholders and designers fail to connect clearly with each other because of their diversity [13].

B. Joint Application Development (JAD) Session

JAD process is used to collect business requirement while developing new systems. It is normally used in initial stages of a system development project. It is an organized environment wherein stakeholders contribute in conversation to collect and analyze their data. JAD is a technique that authorize the management and customers to work collectively [15]. Major problems with JAD are given as follows:

- JADI1: This method requires huge timings to finish important all development efforts and planning to save the structured JAD session [15][16].
- JADI2: It requires stockholder's commitment of time and efforts [16].
- JADI3: This method implicates experienced and skilled workers for active implementation of the entire project[17].

C. Contract-style Requirement Lists

It deals with high level representation for large system [18]. Additionally, conveys a explanation of requirements and contract between the developers and sponsor/s. Issues acknowledged by many researchers concerning usage of this method are given as follows:

- CRLI1: These lists generate an untrustworthy sense of agreement between the stakeholders and designers [19].
- CRLI2: It is difficult to recognize priority of requirements and suitable procedure [20].
- CRLI3: People offer different ideas of the system after reading such requirements [20].

D. Prototypes

Prototypes are generally recognized to be an essential way for discovering and enunciating designs. It delivers a solid depiction of all parts of the system and supports users to keep an idea of system design [21]. Challenges identified with the above method are given as under:

- PI1: This approach may develop the complexity as the possibility of the system may go beyond the original plans [22].
- PI2: Users get confused because the final system is slightly different from the structure of prototype [22].
- PI3: Software cost can be increased due to prototype model [23].
- PI4: Once the product prototype is demonstrated to the client, it may not be reused in a same way [23].

E. Use cases

Use cases are the broadly used tools and a significant requirement analysis technique, which plays significant role in defining the systems specifications and assisting systems development. It is a textual description, which supports stakeholders to recognize and define the details using the system [24]. Use cases and their connections can be visualized in a UML use case diagram. Key issues stated in the literature associated to use cases are given as under:

- UCI1: this method is not appropriate to record non-functional requirements such as timing, performance and security feature and their related areas [25].
- UCI2: Use-case specifications are unclear, lengthy and muddled [25][26].
- UCI3: It is a time consuming process [27].
- UCI4: There may be many use cases in the set that develop use case explosion problem in large project [27].
- UCI5: Generally use cases are written from the system's (not the actors') point of view. Use case names describe the flow of the system rather than the goals, the actor wants to accomplish [24].

F. Quality Function Deployment (QFD)

This is an organized and efficient method to describe customer desires or requirements and interpreting them into precise plans to build products to encounter those needs. This is an extremely suitable method to support development, statements and decision oriented within a product development team [28]. Major issues regarding QFD are given as follows:

- QFDI1: Customers change their requirements frequently, which involve assumptions. This is the key issue with QFD [29].
- QFDI2: QFD is a subjective technique.

Customers' responses are difficult to categorize as demands due to the vagueness in the voice of the customer [30].

- QFDI3: Another major issue is that it does not emphasize on additional features such as the cost, progressive ideas and strategy and accessible resources [28][29].
- QFDI4: QFD is not appropriate for all type of applications. For example, in the automotive trade, there are fix number of possible customers; the customer identifies their needs and the supplier acts to satisfy those [31].
- QFDI5: This requires effective and accurate data analysis because incorrect analysis can result in acquiring too much information [32].

G. Requirement Specification

Requirement specification is a comprehensive depiction of the preferred behavior of the system. It offers the functionality and user features of the system and classifies the particulars associated to entirely functional and quality requirements of the system [33][34]. Key issues perceived with requirement specification are given as below:

- RSI1: Budget, human resource restrictions and system limitations are the major road blocks to implement some requirements [33][34].
- RSI2: Another issue is few of the part of requirements document may be inconsistent with the problem that the specification explains [35].
- RSI3: Sometimes, the essential information associated with the issue being described by the software may be improper/ incomplete from requirements document [35].
- RSI4: Some part of facts may not be appropriate/ superfluous to the issues being solved [35].
- RSI5: Sometimes described requirements in document may have multiple clarification/ vague statement. [34].

H. Modelling

Requirements' modelling uses a mixture of text and diagrammatic forms to depict requirements in a way that is comparatively easy to understand to validate software requirements. It provides an intelligent understanding to the expertise in dealing with the information, function and behaviour of a system. The method improves the fundamental idea for analysis in the stage of completeness, consistency, and accuracy of the requirements. [35]. Major issues related to modelling are given as follows:

- MI1: The system must reproduce the requirements of several areas such as support staff and senior management. Each area has diverse priorities and goals, which becomes a reason for conflict [36].
- MI2: The significant issue of modelling is missing or incomplete understanding of 'software development'. [36].
- MI3: Sometime project stakeholder may not be clear about their requirements in beginning [36].
- MI4: Changing the requirements by project stakeholders during the progress of the system is one of the foremost issues [36].
- MI5: This method may not be used by cheaper projects because of automated code generation [36].

I. Viewpoint- Oriented Analysis

It is vital to assemble and achieve data from varied viewpoints. This method captures the limited data around system's requirements. The foremost intention of this method is to gather and organize diverse type of material such as system environment and application domain, which are required for a system's development [37]. Major issues in viewpoint method are given as follows:

- VAI1: One of the major issues is incompatible nature of viewpoint with other SE approaches [37].
- VAI2: Inflexible viewpoint model is also a major challenge. The model should not be too restricted in its explanation of a viewpoint [37].
- VAI3: Some of viewpoint method has a fixed notation for declaring requirements. It takes time to define requirements in any suitable notations [37].
- VAI4: This method is to sustenance the supervision of large amounts of data [37].

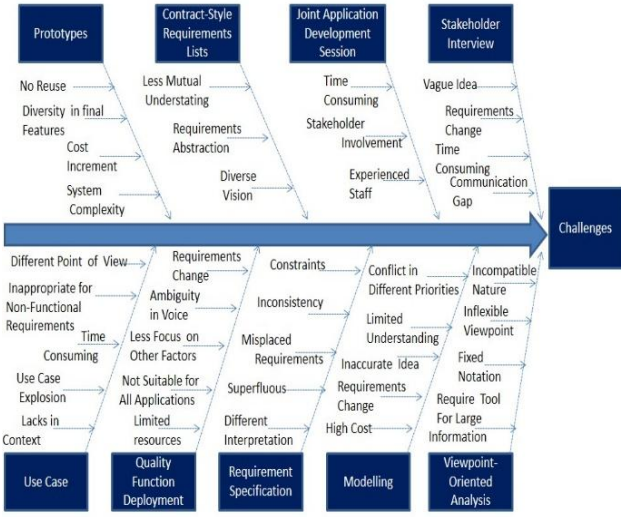

Fig.1. Requirement Analysis Techniques and Challenges

IV. AI TECHNIQUES IN REQUIREMENTS ANALYSIS

Foremost AI techniques with respect to aforementioned challenges related to analysis have been presented in the subsequent section.

A. AI Techniques to overcome the Issues of Stakeholder Interviews

Major AI techniques related to stakeholder interview techniques are given as follows:

• AI (Si1) - Neural Network: Discovery, prediction and analyzing are the major focus during requirements analysis. Therefore, for making this process easier, there is a ideal tool of AI named neural networks,

which is used for issues that involve grouping, provide analytical input structures [14][18][19]. It supports to identify software risks related to modules and risk analysis in software maintenance.

• AI (Si2) - Knowledge Based System: A significant issue in requirements analysis is to solve and trace the dependencies between system's requirements and feature of associated structures. Knowledge engineering is a sub part of AI that offer a process of computer system known as expert systems to check the quality of software [38].

• AI (Si3) - Case Based Reasoning: CBR technique is used to evaluate the improvement procedure by mentioning to formerly stored cases (past practices). Each unit is assembled as an autonomous operational unit and combined after the conclusion of a release. The use of CBR during the requirements elicitation phase is a vibrant step to handle vague and complex requirements that are frequently given by the stakeholders [38].

B. AI Techniques to overcome the Issues of JAD Session

In this section, the prospect of integrating AI techniques to solve the challenge linked to JAD methods has been discovered. These techniques are given as follows:

• AI (JAD1) - Expert System: The expert system is a program covering a prepared form of information, which follows expert problem solving abilities in a limited domain of expertise. The system is capable to achieve skilled levels of problem solving performance. By integration of AI techniques, the knowledge acquisition procedure can be streamlined. It reduces the prospective for human errors between the problem domain experts and knowledge engineers. The vast amounts of historical data for an organization can be rotated into information that the knowledge-based expert system can draw upon to solve problems [39].

C. AI Techniques to overcome the Issues of Contract-style Requirement Lists

Major AI technique, which may be used to solve the issues connecting to contract-style requirement lists techniques, are given as follows:

• AI (CRL1) - Case- Based Ranking: Requirements prioritization plays a central role in software development and permits for scheduling software releases, merging strategies for budget management as well as market strategies. It includes requirements arranging approximations with projects stakeholders preferences processed through machine learning techniques [40].

D. D. AI Techniques to overcome the Issues of Prototypes

Major AI techniques, which may be used to overcome the issues relating to prototype techniques, are given as follows:

• AI (P1) - Knowledge-Based Prototyping Approach: This approach encompasses a graphic speculative model for labeling system performances; a frame based Software Requirements Specification Language (FSRSL) to indicate the inside practices of the theoretical model and to additional comprehensive actions and constraints; a catalog for loading description files and a database for keeping rules of specification transformation and analysis. The prototype containing automated tools can be generated in smaller time with low cost [41].

E. AI Techniques to overcome the Issues of Use Case

Major AI techniques, which may be apply to solve the issues connecting to use case techniques, are given as follows:

• AI (UC1) - Ontology: One of the issues encountered in SE is developing software with quality at reduced effort, time and cost. This involves a strong understanding of the features that develop software and the relations among them. In this trend, ontology can assist in execution, interpretation on knowledge gathered from requirements using UML diagrams. Web Ontology Language (OWL) offers to develop domains for information, specification, and delivers the tools about their knowledge. It aids communication among different people associated with building a software and later can be used as a common tool for requirements analysis [42].

• AI (UC2) - Natural Language Processing: NLP is a field of both AI and computational linguistics, which is used to ease the connections between computers and human (natural) languages. NLP has significantly contributed to the area of human-computer interaction. Mostly, NLP engaged to repeatedly extract the data kept in natural language and convert it to a machine comprehensible format [39].

• AI (UC3) - Machine Learning: It is a subset of AI, which is operated by data with the capability to study, evaluate and improve by using algorithms that offer novel visions without being evidently programmed to do so. It is well-suited for dealing with big data [38].

F. AI Techniques to overcome the Issues of Quality Function Deployment

Major AI techniques, which may be apply to defeat the issues connecting to quality function deployment, are given as follows:

• AI (QFD1) - Computational Quality Function Deployment: The manual quality deployment tools are restricted in their procedure and reuse. Computational tools can ease these limits. Additionally, AI tools can be used to improve the productivity of manual QFD tools and improve their functionality. It also offers provision for the information gaining, utilization, and communication stages related to QFD tools [27][28][30].

• AI (QFD2) - Speech Reorganization: Speech recognition is the procedure of taking out text records or some method of meaning from speech input. Speech analytics can be measured as the subpart of voice processing, which transforms human speech into numerical forms appropriate for storage. Speech analysis processes can also be called digital speech coding [43].

• AI (QFD3) - Agile Methodology: Agile framework is centered on standards like active conversation between the team and users, constant delivery and flexible methodology to development. The environment of software denotes that alteration can be done anytime even before the last phase of software. It provides great flexibility to correct and precise the results to their needs.

The agile models deals with the processes that are accomplished to accommodate rapidly changing requirements [8].

G. AI Techniques to overcome the issues of Requirement Specification

Major AI techniques, which may be apply to defeat the issues connecting to requirement specification, are given as follows:

• AI (RS1) - Knowledge Based Systems (KBS): Reuse of expert design information can play an important part in refining the quality of the software. KBS is used to collect, input and outputs of the system's operations and design families. The system examines the KB and suggests a design outline, which is developed by the user to completely fulfill the requirements [38].

• AI (RS2) - Ontology: Ontology is established by many organizations to integrate, reuse and combine data and knowledge and to accomplish interoperability and communication between their software systems. There are two types of ontology: 'Commonsense ontology' with the aim of describing an assembly of top-level concepts and related relations which are independent of a specific application domain and 'Domain ontology', which provides a conceptualization of a specific domain [36].

• AI (RS3) - Fuzzy systems: Fuzzy systems (FS) use fuzzy sets to fix the vague and unfinished data. Fuzzy set association includes any value between 0 and 1. These fuzzy models can define ambiguous speeches as in natural language. They are mostly simple to understand and apply [37].

• AI (RS4): Lightweight Semantic Processing Approach: This approach establishes a planning between ontological elements and requirements specification. This method permits to have the probability of programming, semantic analysis and requirements reports in a requirements document. This method supports to generate high quality requirements specifications [44].

H. AI Techniques to overcome the Issues of Modelling

Major AI techniques, which may be apply to defeat the issues linking to modelling, are given as follows:

• AI (M1) - Knowledge-based expert system: These are interactive computer programs, which includes experience, judgment, intuition, and other experts to deliver knowledgeable advice about a variety of tasks [36].

• AI (M2) - Ontology: Major issue under RE is to manage incompleteness or inconsistencies in requirements specifications. Ontology provides proper illustration of information and the relationships between theories. It offer the clarity to appropriately capture requirements [40].

• AI (M3) - Genetic Algorithm: A foremost problem in RE is that it frequently faces conflicts and immaturity. Various stakeholders may have different views and expectation about the system; so, they allocate their particular priorities to certain phases. The development team also struggles to capture clear requirements. Genetic algorithm is regarded as a significant and prevalent evolutionary computing practice from the computational intelligence domain. It predicts the preliminary selection from the set of population [40].

I. AI Techniques to overcome the Issues of Viewpoint-Oriented Analysis

Major AI techniques, which may be apply to solve the issues relating to viewpoint- oriented analysis, are given as follows:

• AI (VOA1) - Neural Networks: Neural Networks have been regarded as a significant tool for classification. These are substitute to many predictable classification methods. These are nonlinear models, which creates them flexible in modelling real world complex relationships [37].

• AI (VOA2) - Agent Methodology: This has gained focus in the previous years. An agent system is a society of AI software agents that cooperate by swapping knowledge and by exchanging with each other to complete some global goal. It describes the ideas to use to model software. The aim of agent-oriented procedures is to care for all the stages of the life cycle of an agent-based application [8].

V. RELATED DISCUSSION AND FINDINGS

Based on the above facts, Venn-Diagrams have been plotted to represent relationship between analysis issues and availability of appropriate AI technique. The connection, e.g. one to one and one to many have been recognized between the issues and potential AI technique/s. The same is given as follows:

• It is exposed from the mapping given in Fig. 2 that for every issue excluding SiI4, minimum one AI technique is presented in the previous work. However, for SiI4, no AI technique/s has been recounted yet.

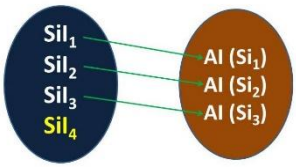

Fig. 2 .Mapping of Stakeholders Identification Issues

• Fig.3 reveals the relation between AI techniques and issues associated with the JAD method. At least one AI technique exists for each method, while $JADI_2$ does not have any AI technique.

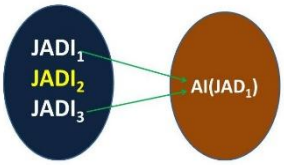

Fig. 3. Mapping of JAD Techniques Issues

For contract requirements techniques, Fig.4 indicates that for two issues, at least one AI techniques is available in the literature. However, for first issue $CRLI_1$, no AI technique/s has been presented in the literature.

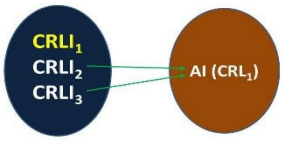

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Fig. 4. Mapping of CR Techniques Issues

Fig. 5 exposes the connection between AI techniques and issues related to the prototype method. It is evident that only one AI techniques is available for three issues; however, the issue, PI_4 does not have any AI technique.

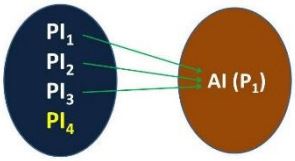

Fig. 5.Mapping of Prototypes Techniques Issues

In the similar outlines, mapping is also presented related to Use case techniques issues and AI techniques in Fig. 6. It seems that there are three AI techniques presented in the literature for four issues but UCI_5 does not have any AI technique.

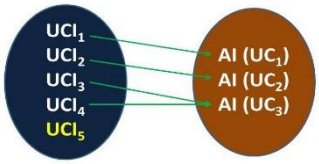

Fig. 6. Mapping of Use Case Issues

• It is visible with the support of mapping between QFD issues and AI techniques given in Fig.7. that every issue has at least one AI techniques except the fourth issue $QFDI_4$ for which no AI technique/s has been found.

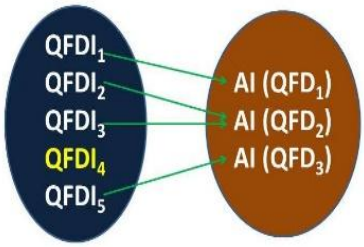

Fig. 7. Mapping of QFD Issues

• Fig. 8. reveals the relations between AI techniques and issues associated with the requirement specification method. For each issue, at least one AI technique exists but the issue RSI_2 does not have any AI technique.

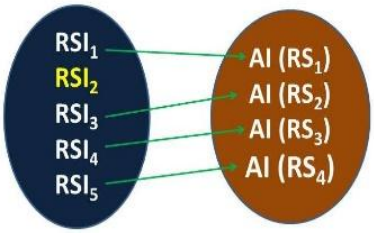

Fig. 8. Mapping of Requirement Specification Issues

• Fig. 9. Demonstrate the mapping between modelling issues and AI techniques and it is noticeable from the figure that for every issues except MI_1 have AI technique/s.

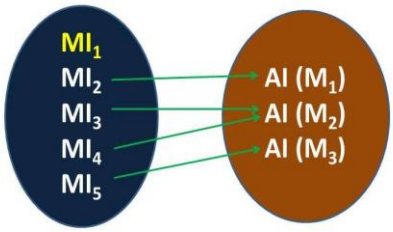

Fig. 9. Mapping of Modelling Issues

• Keeping the statement of the associated facts, mapping is drawn related to Viewpoint-Oriented Analysis issues and AI techniques, in Fig. 10. It is noticeable from the mapping that for last two issues i.e. $VOAI_3$ and $VOAI_4$, no AI technique/s has been presented in previous work.

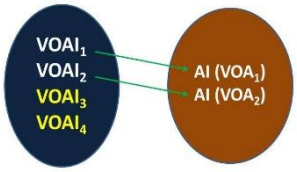

Fig. 10. Mapping of Viewpoint Analysis Issues

VI. CONCLUSION

Requirements analysis is one of the acute process in requirements engineering since it moulds the summary of the anticipated software end product. Though, requirements engineers claim that requirement analysis a very hard and curious activity to evaluate requirements due to several issues. Major issues such as poor communication, ineffective techniques and frequent changes in requirements are a foremost reason for system failure. However, explaining these issues at some level is important for the dynamic development of the software development. Similarly, the research study presented various practices established in AI and vast use of AI methods in every process of requirement analysis phase. Moreover, appropriate mapping of the issues suitable to every analysis technique with respect to AI methods has also been demonstrated with the support of Venn-Diagram. These figures described an idea of the current situation of the study in the part combine with the opportunity for upcoming research.

FUTURE SCOPE

Upcoming work may propose new approaches to overcome these challenges along with robust validation results. Advance research may be directed for integration of AI techniques in various events of requirements analysis phase. This work may offer a substantial supervision to the RE experts in evolving a quality software with less time and cost.

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