Integrating AI Techniques in Requirements Phase: A Literature Review

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ABSTRACT
Requirements phase acts as a foundation stone for ensuring the success of any software development process. Over the year, researchers have proposed various techniques/tools for the different activities of the requirements phase of SDLC, but at the same time, there are certainly new research questions and issues too. One of the prominent issues is the maximum human intervention in the requirements phase due to being a conceptual phase of SDLC. Research studies reveal that Artificial Intelligence (AI) techniques have been found to be a good solution to minimize the human intervention by offering some tools/ techniques to automate certain processes up to some extent. In this paper, our aim is to highlight the significant contributions in the related area/s and to identify future research directions, based on the published work. The research is considered with respect to AI techniques developed to address specific requirement tasks, such as elicitation, analysis and modeling etc.

KEYWORDS
Requirements Engineering (RE), Requirements Phase, Artificial Intelligence Techniques, AI techniques in Requirements Phase, SDLC.

1. INTRODUCTION
Requirements phase is the foremost phase in the SDLC, which refers to the process of producing, estimating, specifying, associating and changing the objectives, functionalities, qualities and constraints to be achieved by a software system. Quality of requirements is responsible for the failure and success of the any software [1]. Many of the projects failed due to the lack of clear understanding of the requirements [2]. It has been reported that 71% of the software fails due to poor requirements [3]. CHAOS report from the Standish Group, which reported the reasons for IT project failure in the USA, indicated that project success rates were only 34%, with the rest of projects being either "challenged" in some way or failing out rightly due to poor requirements [4]. A recent survey shows that IT pays for poor requirements gathering in a large way [5].For managing failures and drawbacks of software systems due to poor requirements in software development, there has been a visible growth of related disciplines; integrating AI techniques in requirements phase is having a great impact on the same. Artificial Intelligence is the intelligence of machine, which provides creativity, solving problems, pattern recognition, classification, learning, induction, deduction, building analogies, ontologies and knowledge. It is concerned with the study and creation of computer systems that display some form of intelligence and efforts to apply such knowledge and techniques to the design of methods and computer based programs that can understand a natural language or human intelligence.

In software development, requirements phase is considered as a phase having ample scope to incorporate AI techniques because of requirements' environments. However, requirements tend to be imprecise, incomplete and ambiguous and have a big impact in all the development stages. Therefore, the usage of AI techniques in order to improve requirements phase favorably affects the quality of overall software life cycle [6].

This paper aims to study the techniques developed in AI from the standpoint of their applications in requirements phase. In particular, it focuses on techniques developed or that are being developed (under conceptual stage/s) of AI that can be arranged in solving problems associated with requirements phase of SDLC. The rest of the paper is organized as follows: In the Section II, a survey of the significant contributions is briefly reported. Afterwards, Future Research Directions are proposed in Section III. Finally, Conclusion is reported in the SectionIV of the paper.

2. A SURVEY OF THE RELATED RESEARCH
Various researchers are proceeding to incorporate AI techniques in various activities of requirements phase. Therefore, a dynamic progress has been visualized, recently. Some important contributions gain focus and appear valuable among all. For analysis on these developments, a selection from the trend setting research contributions is briefly described as follows:

KatjaSiegemund, Edward J.Thomas,Yuting Zhao, Je Pan and UweAssmannpresented a Meta Model for ontology-driven goal-oriented Requirements Engineering. This model combines ontology consistency checking and rule driven completeness tests to measure the validity and coverage of the evolving requirements model. They assured that this approach is capable of dealing with a reasonably complex set of requirements from a real-world problem, and can quickly identify 'where these requirements are inconsistent or incomplete'. This model can be integrated into the requirements engineering work flow [7].

Haruhiko Kaiya and Motoshi Saeki presented software requirements analysis method based on domain ontology technique, where they established a mapping between a requirements specification and the domain ontology, which represented semantic components. The proposed technique is known as Lightweight Semantic Processing. This method involves a thesaurus and inference rule, which is suitable for semantic processing. This ontology based method enables us to

detect incompleteness and inconsistency about a requirements document, to measure the quality of the document, and to predict requirements changes in the future versions of the document [8].

FaridMeziane and Sunil Vadera proposed a study on AI for improving all the phases of the software development life cycle. They provided a survey on the usage of AI for Software Engineering that covers the main software development phases and AI methods such as Natural Language Processing (NLP) techniques, neural networks, genetic algorithms, fuzzy logic, ant colony optimization and planning methods. They focused on the issues of requirements phase and also described the AI techniques for solving these issues. Further, they gave suggestions for future research [9].

Li Shunxin discussed the ontology related concepts and theories, put forward the general framework of using an ontology needs analysis, and then used example to illustrate 'how to use ontology needs analysis, validation and improvement'. The researcher described that ontology, which is a formal description of the concept of sharing, stressing the link between real entities, is the abstract of a specific exist, having sharing, reasoning function [10].

Farah NaazRaza focused on techniques, which are developed in AI and their applications in Software Engineering. The researcher proposed a comparative study between the software development and expert system development and also focused that how expert programmers analyze, synthesize, modify, explain, verify and document programs, and to apply that theory towards automating the programming process. The researchers further focused on the absence of risk management strategies or risk management phase in AI based systems [11].

Hany H Ammar, WalidAbdelmoez, and Mohamed Salah Hamdi provided surveys on the application of AI approaches to the Software Engineering processes. The researchers reported that these approaches are helpful improving in reducing the time to market and improving the quality of software systems. They used the terminology and the processes defined by the IEEE 12207 standard of Software Engineering and carried out a mapping of current AI techniques. These AI techniques attempt to automate or semi-automate tasks and produce optimal or semi-optimal solutions in much less time. They discussed about the open problems of requirements phase and also described AI techniques to solve some issues of requirements phase [12].

Mark Harman described the role of AI in Software Engineering and focused on relationship between approaches to AI for SE. They discussed that first step for the successful application of any AI technique to any Software Engineering problem domain, is to find a suitable formulation of the Software Engineering problem so that AI techniques become applicable. Further they highlighted the challenges in related area/s [13].

William Scott and Stephen C. Cook proposed the architecture of an intelligent requirements elicitation and assessment assistant. They introduced the attributes needed to define a requirement and the qualities of good requirements and requirements sets. This research program is a rigorous attempt to identify and demonstrate a reasoning strategy, which provides significant cognitive support for requirements elicitation and evaluation. Further, they focused on the inclusion of AI to perform requirements analysis and this is followed by a review of intelligent requirement analysis tools identifying the need for enhancements [14].

Jonathan OnowakpoGoddeyEbbah reviewed techniques developed in AI, which is deployed in solving problems associated with Software Engineering. They focused on automated tools and Meta programing, which is developed in NLP, program browser, which is useful in different portions of a code that are still being developed or analyzed, possibly to make changes and another technique is automated data structuring, which is used for high-level specification of data structures to a particular implementation structure [15].

Nguyen, TuongHuan Vo, BaoQuocLumpe, Marku Grundy and John presented a critical part of Requirements Engineering (RE). In this paper, they presented a novel knowledge-based RE framework (KBRE) in which, domain knowledge and semantics of requirements are central to elaboration, structuring, and management of captured requirements. Moreover, they also showed 'how they facilitate the identification of requirements inconsistencies and other related problems' [16].

S. Arun Kumar and T.Arun Kumar focused on the impact of requirements management characteristics in global Software development projects based on Ontology approach. Major contribution of this study was to analyze the requirements management issues and challenges and provide solution for global software development projects [17].

MasoudMohammadian focused AI techniques in Software Engineering. Organizations demand to build software applications adequately and quickly. One approach to achieve the same was to use automated software development tools from the very initial stage of software requirement up to the software testing and installation. This study explored the use of AI techniques and suggested a method that can determine requirements for classification of organizations [18].

Klaus Pohl, PetiaAssenova and Ralf Doemges also applied AI techniques in Requirements Engineering. They used the NATURE (Novel Approaches to Theories Underlying Requirements Engineering) project and produced five theories, which are based on AI techniques for supporting and improving the requirements engineering process. In addition, they described the dimension of requirements phase and practical software problem [19].

Jose delSagrado, Isabel M. del Aguila and Francisco J. Orellana proposed an architecture for the use of synergies between Knowledge Engineering and Requirements. This study presented the architecture for the seamless integration of a CARE (Computer-Aided Engineering Requirement) tools to manage requirements with some AI techniques such as Bayesian networks and metaheuristics. Specially, a Bayesian is used in the requirement validation task in order to validate the Software Requirements Specification of a software development project. Metaheuristic techniques are used in the problem of selecting the subset of requirements among a whole set of candidate requirements proposed by a group of stakeholders. The main aim of this study was to define a three layer architecture, which is used to allow a seamless collaboration between RE tasks and AI techniques in order to perform software development process. [6].

Prince Jain highlighted the interaction between Software Engineering and Artificial Intelligence. This study explored the framework of interaction on, which both fields are communicating with each other. This framework had four major classes of interaction such as software support environment, AI tools and techniques in conventional software, use of conventional software technology and methodological considerations [20].

Seok Won Lee and Robin A. Gandhi presented an Ontology-based Active Requirements Engineering novel framework that adopted a mixed-initiative approach to elicit, represent and analyze the diversity of factors associated with software-intensive systems. This framework integrates various RE and knowledge engineering techniques to address the complexities of software intensive systems. They also highlighted the case study on theDepartment of Defense Information Technology Security Certification and Accreditation Process (DITSCAP) automation from the practice of their framework with appropriate tool support that combines theoretical andpractical aspects [21].

Christian R. Huyck presented a study on NLP along with Requirements Engineering. The Researcher focused on the issues of requirements and provided NLP systems for solving requirements issue. NLP tools can easily be used by Requirement Engineers to simplify their work and to act as simple checks. He also presented a prototype system used for detecting ambiguity. This mechanism helps to develop a domain model of the documents, which can be used in NLP, but can also be used as a primary component of the document specifications [22].

JörgRech and Klaus-Dieter Althoff focused on both fields AI and SE along with their status and future trends. They proposed short overview on commonalities between AI and SE. Further, they focused on Agent-Oriented software engineering, knowledge-based software engineering, Computational Intelligence and Ambient Intelligence along with their future work [23].

CharuKhatwani proposed a study on the techniques developed in AI from the perspective of their application in SE. The main aim of this study was to improve the approaches in SE with the intelligence possessed by Artificial Systems and to bring the two ends together to make a robust, reliable and well define framework of conventional software. This framework could help to provide greater power to the overall system. The principle of this methodology is captured in the notion of RUDE (Run, Understand, Debug, Edit) cycles and its modifications. Through these software systems must strive to construct programs which are understandable [24].

sharing, trust, team work and requirements flow down [16][17].

- Automated programming has great impact on requirements phase. Related studies reveal that automatingprogram development must be language independent [18]. To achieve this objective may be one of the future work.
- Interaction between AI and requirements phase is well recognized in the industry andAcademia. But there is still a need to reduce issues, which comes while communicating the AI and RE [19] [20].

3. FUTURE RESEARCH DIRECTIONS

Integrating AI techniques in requirements phase is a wide as well as fertile area of research. Researchers are doing a fantastic work in the related area/s but there is still a good scope of further research for making them more imperative. Accordingly, various future research directions in the aforementioned area/s have been identified and given as follows:

- Ontologies are useful for representing and interrelating knowledge in requirements phase. Although, there exists various ontology requirement models but there is not any description on the concept of 'how a model can be integrated with other ontology models, which can cover all the aspects of software development' [7]. This may be one of the future research area.
- In the last few years, there has been a lot of interest in the use of domain ontologies for requirements phase. But there is a lack of specific supporting tools in ontology to support the requirements phase of SDLC. In additions, another major issue, which seems to be unclear is 'how to handle domain ontology'. Therefore, there is a need to develop ontology supporting tools along with test cases, which will help to encapsulate knowledge and rules governing a specific domain in one single resource. So, this may be one of the future work [8] [9] [10].
- AI is a very dynamic research area for requirements phase, with a wide variety of methods and technologies. At current, there is no agreement on a collaboration of techniques included methods and drivers to use AI techniques in Requirements Engineering. There is a need for the development of a framework that would contribute in combining various AI techniques along with their drivers for requirements phase. This framework could also provide guidance on when to use a particular technique and methods for particular requirements issue [11] [12] [13].
- Many of AI techniques has been integrated in requirements phase for increasing the quality of software but studies reveal that most difficult problem is the problem of transforming requirements into architectures. Further research is needed in this area to address the ever increasing complexity of the requirements phase [14].
- Intelligence computing plays an important role in solving the traditional problems found in requirements phase. But, there is a need to increase methods, which can make this approach easier for requirement engineers [15].
- Another future work may be to implement an ontology based knowledge management system or ontology based metrics for various application domain like e-health and e-learning system, and to measure various factors such as knowledge
- To adopt the systematic usage of the Ontology-based Active Requirements Engineering framework in other applications and domains, there is a need to develop formal definitions and empirical evaluations. That can be considering as one of the future work [21].
- In the requirements phase, there is a lot of emphasis on identifying errors occurring in the early stages of software development before moving to design. The use of NLP techniques to understand user requirements and attempt to

derive high level software models automatically is still and will remain a hot research topic although there are some issues that are relating to these approaches such as the use of ad-hoc case studies and difficulties in comparing the developed systems [22].

- Detailed research on AI techniques is needed such as to develop covering knowledge-based systems for learning software organizations, the development of computational intelligence and knowledge discovery techniques for software artifacts, agent-oriented SE, or professional development of ambient intelligence systems [23][24].

Based on these aforementioned research directions, various sub areas have been identified; a pictorial representation of the same is given as follows (in Fig 1):

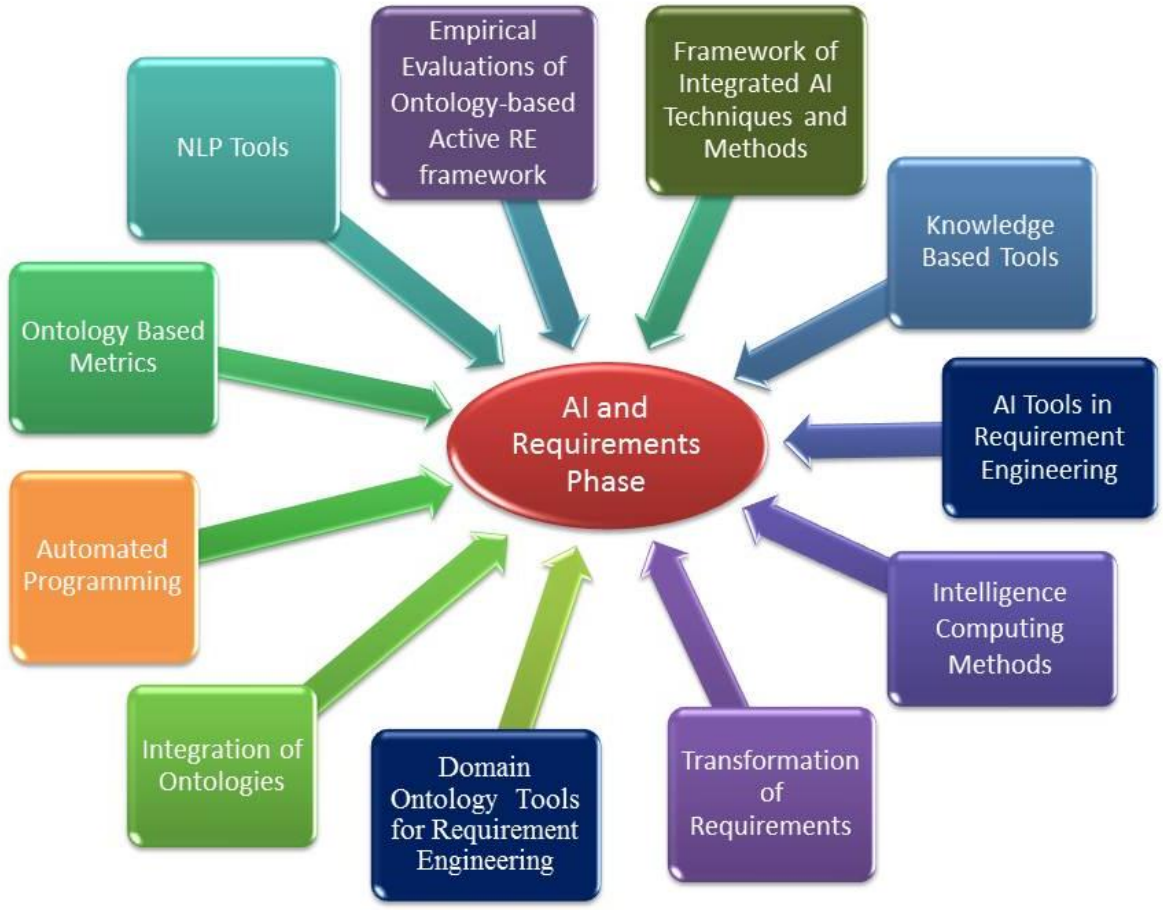

Fig.1 Future Research Directions

4. CONCLUSION

Research studies reveal that AI has a great impact on requirements phase of SDLC. In the current scenario, the demand to formulate a framework, based on integration of AI techniques and methods, ontologies, knowledge based matrices and others techniques/tools has increased dramatically, which is raising many new research questions. Accordingly, the paper presented a systematic review of related research contributions along with future research directions. The paper will provide a significant support to the entry level researchers in the related area/s to get the direction/s for future work. To formulate a framework for integrating AI techniques in the requirements phase may be one of the prominent area of further research.

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