AI Techniques in Requirements Elicitation

Raha Alkabour*, Omer Alrwais
Information Systems Department, King Saud University, Riyadh, Saudi Arabia.

* Corresponding author. Tel.: 4695234; email: oalrwais@ksu.edu.sa (R.A.)
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Abstract: Requirement elicitation is known as the most important step in the software development process. The survey of the literature reveals that the researchers used different tools and methods for the requirement elicitation process. However, there are still many challenges in implementing the requirements elicitation activity, such as the poor communication between the user and analyst. Unfortunately, these problems may result in a futile outcome. Artificial intelligence (AI) methods may help to reduce these challenges. In general, AI is defined as the process of executing procedures on data without human intervention. The advantage of AI methodologies in requirements elicitation is that they are very interactive and intelligent. This paper will focus on exploring artificial intelligence techniques in requirement elicitation and provide a comparison between those techniques in terms of the method or technique used in the study, the benefit of the technique, the result, and the future work of the authors.

Key words: Artificial intelligence, requirements elicitation, requirements engineering, software development

1. Introduction

In the past, humans have been responsible for documenting requirements in a variety of ways. These methods include interviews with stakeholders and user requirements documents that compel the analysts to interpret stakeholder needs. However, what if you could automate this process by getting computers to listen for verbal cues from stakeholders and then translate them into a formal requirement? This is where Artificial Intelligence (AI) comes in. Recent advancements in AI systems have created new requirements engineering (RE) issues while developing AI software systems. RE for AI activities has received little research and few empirical studies [1]. In addition, many AI software solutions tend to neglect human-centered ideals in favor of technological considerations [1]. The need for perfect requirements is one of the biggest challenges facing modern software product development. Software products are forever changing and evolving, a process that often creates new requirements. As the product evolves, so must the requirements document to capture the target functionality accurately and provide a clear path to its eventual completion. Requirements elicitation can be time consuming, expensive, and even impossible if proper inputs are not available to start with [2]. The field of AI is continuously evolving and developing new techniques to help computers make decisions based on their understanding of the world around them. One example is CyberPhysical systems (CPS) must be continuously monitored in order to detect and perhaps mitigate emerging problems during normal operations [3]. Their multimodal time-series data is challenging to comprehend and assess [3]. Long-short-term memory (LSTM) networks can automate these tasks and explain various anomalies in multivariate real-time data streams [3]. RESAM, a requirements process that

combines domain experts, discussion forums, and formal product documentation, identifies and describes needs and design definitions as time-series attributes that aid in the development of successful deep learning anomaly detectors [3]. To construct successful anomaly detection models and provide explainability, researchers use a flight control system for small unmanned aircraft [3]. Requirement elicitation is the process of eliciting and documenting requirements from stakeholders [2]. These requirements are needed to design the desired system. Elicitation is often a two-way dialog between the analyst and stakeholder, where both parties must work together to gather the information needed to complete the project. The problem with this approach is that it allows for interpretation and bias, which can lead to inaccurate or incomplete data being inputted into the system. However, with advanced AI techniques like Natural Language Processing (NLP), it has become easier for computers to understand human language and derive meaning from words rather than having humans break information down into structured data. The increasing prevalence of AI technologies in our daily lives presents ethical questions [4]. The majority of studies on ethical standards and principles for AI are high-level and abstract, indicating that there has been minimal effort to operationalize ethics in AI [4]. These concepts do not meet the requirements of practical software development initiatives [4]. In the future, it will be necessary to assist in eliciting ethical criteria.

The main objective of this paper is to review related works about the different AI techniques used in requirements elicitation. To accomplish that, a literature survey was conducted. The specific research questions of this review are:

- What AI method is used for requirements elicitation?
- What was the benefit of said method?
- What is the result of the experiment?
- What is the future work of this study?

The paper is organized as follows: The

The paper is organized as follows: Section 1 is the introduction; Section 2 will list the related work used in this paper with further details; Section 3 will provide an overview of the study description and data; and Section 4 will describe the analysis performed. Section 5 presents the result of the review, which is a comparison between AI techniques, and Section 6 presents the conclusion, followed by the references.

The contribution in this paper is to provide a comparison between AI techniques used in requirement elicitation.

2. Related Work

2.1. Review Stage

This section will provide a list of relevant studies, followed by their respective objectives. Many studies have been undertaken to characterize the AI techniques used in requirement elicitation; the following literature review will be utilized to compare and contrast them:

Ref. [5] A paper that explores the use of several AI techniques in requirements elicitation.

Ref. [6] A chatbot that could have an intelligent dialogue with stakeholders in natural language to elicit formal system needs was proposed as a solution for requirements elicitation with too many requirements, which would result in errors.

Ref. [7] This study discusses technique selection in the requirements elicitation process and proposes a machine learning model to transfer experts' knowledge.

Ref. [8] In this research, an Artificial Neural Network (ANN)-based model is developed to determine suitable elicitation techniques.

Ref. [9] A novel approach for transforming software requirement specifications (SRS) from normal

language to object-oriented models.

Ref. [10] An analysis was performed on typical user feedback contents, and the results showed that automated analysis was considerably faster than manual analysis.

Ref. [11] The purpose of this work is to demonstrate how machine learning and RE intersect.

Ref. [12] While the expert system cannot totally automate the RE process, it can help facilitate it.

Ref. [13] This study employed NLP to evaluate Wikipedia as a textual corpus in order to support RE activities such as requirement elicitation.

Ref. [14] Convolutional Neural Network (CNN) was used to classify functional and non-functional requirements.

Ref. [15] Using case-based reasoning, an algorithm was proposed with a requirement elicitation framework.

Ref. [16] Fuzzy logic was utilized in this paper to determine discordance and tacit knowledge.

3. Study Description and Data

The most crucial and difficult component of software development is requirements elicitation, because any error made during the requirement engineering (RE) process can spread throughout the development process, making it exceedingly difficult to rectify afterwards [2]. And, to avoid such errors, Artificial Intelligence (AI) techniques and methods may be useful since they help to reduce many issues, including poor communication between the user and analyst, and by incorporating AI techniques in requirements elicitation, we will get less inefficient outputs [5]. ScienceDirect, IEEE Explore, and Springer were utilized to collect the papers that were used in the literature survey to compare AI strategies in requirements elicitation, which was chosen since the resources are more easily accessible.

4. Analysis Performed

To compare AI approaches, the following descriptive analysis was conducted:

4.1. Planning

The research concept was determined during planning, as were the protocols to be employed during the review's operation.

4.2. Conducting the Review

The search was conducted in the following databases: ScienceDirect, IEEE Explore, and Springer. The search was restricted to papers published between 2015 and 2022. Using inclusion criteria, the papers most related to the research idea were found during the selection process. The following criteria have been defined:

- Studies involving the use of AI techniques for requirement elicitation.

4.3. Review Reporting

The review process begins after the study has been chosen. The results section will include a comparison of the reviews.

5. Results

In this work, a review of the literature was undertaken in order to analyze relevant research dealing with requirement elicitation utilizing AI techniques. This review investigated and interpreted the available literature relevant to this work, and the papers to be reviewed were extracted and analyzed to answer the research question.

Table 1. A comparison of recent studies on ai techniques in requirement elicitation

Ref	Method/Technique	Benefit	Results	Future Work
Siqueira *et al*. [5]	Neural Network Expert Systems Ontologies	Fixing the problems of collaborative techniques.	The study demonstrated numerous AI-developed practices and the extensive use of AI practices at every stage of requirement elicitation. In addition, a Venn diagram illustrates the appropriate problem mapping for each elicitation technique with respect to AI techniques.	The subsequent step may involve advancing outstanding issues such as imprecise and inconsistent requirements and introducing several illustrative AI solutions to tackle them.
	Sketch Based Modelling Knowledge Level Ethnography Case Based Reasoning Intelligent Agent	Fixing the problems of contextual techniques		
	Integrating Model	Fixing the problems of cognitive techniques		
Sharma *et al*. [6]	Intelligent Chatbot	Utilizing machine learning and AI, the chatbot converses with stakeholders in natural language to elicit formal system requirements and then classifies the elicited requirements as either functional or non-functional.	The Performance Evaluation for Multinomial NB was: Accuracy= 0.91, Precision= 0.91, Recall= 0.91 and the F1-Score= 0.91 The Performance Evaluation for SVM was: Accuracy= 0.88, Precision= 0.88, Recall= 0.88 and the F1-Score= 0.88	The chatbot must be optimized with extensive training data that is intelligently intended to encompass the entire scope of system requirements. To test the chatbot's capacity to elicit a complete set of system requirements, a dataset should be created. The dataset will include conversations between stakeholders and requirement analysts, as well as the resulting system requirements. From the stakeholder's response, the system could extract unambiguous requirements. The system may be expanded to conduct

				feasibility forecasting because it predicts which system requirements can and cannot be implemented. The authors also recommended developing a model that could estimate the potential cost, duration, and number of hours of labor required to execute the project.
Suran *et al.* [7]	Machine Learning Model	Presenting the optimal optimization technique selection for the case complexity characteristics of elicitation.	0. 96% accuracy and 0.97% Sensitivity.	The proposed methodology, which has the potential to automate and regulate technology selection, has the potential to become the industry standard among system analysts (requirement engineers) and practitioners.
Ramadan *et al.* [8]	Artificial Neural Network (ANN) Based Model	Selecting the proper elicitation strategies for a certain project	The network has accuracy of 81%.	To improve the model's accuracy, the authors intend to combine other machine learning techniques, such as fuzzy logic, with the proposed ANN model.
Mohanan *et al.* [9]	Natural Language Processing	Reduce ambiguity in natural language by eliciting object-oriented information from user requirements.	This research resulted in the development of an automatic method for capturing object-oriented requirement specification elements.	Software designers can enhance the acquired data and create reliable object-oriented models.
Groenet *al.* [10]		Techniques and algorithms for natural language processing are crucial for monitoring what users write about a product.	Benchmarking was undertaken to compare the efficiency of manual and automated approaches, and the results showed that automated analysis is many times faster than manual analysis and scales well for increasing numbers of user evaluations, but manual analysis does not scale well.	Provide more precise formulas for modeling the relationship between the quantity of user feedback and the total amount of effort.
Iqbal *et al.* [11]		Automated or semi-automatic semantic and pragmatic ambiguity detection within requirements.	This study's findings indicate that NLP can be applied to real-world applications.	NLP should be enhanced to eliminate residual errors. If it is to be seriously considered for use in RE, accuracy must be significantly improved.

				Future research may produce more specialized NLP tools that can aid in standardizing the domain model and serve as translators between various RE documents and structured models. A potential extension of this work could investigate NLP activities that have not yet been applied to this field and how they might be utilized in the future.
Mahmoud *et al.* [12]		Develop automated solutions for numerous extensive, error-prone, and time-intensive RE tasks at various phases of RE.	The authors claimed that their research into a knowledge-based approach to RE is still in its initial stages. They discussed their research plan for incorporating data-driven, Wikipedia-based, natural language processing, and information retrieval methods into a variety of RE tasks. Its agenda covers subjects such as word, text, and domain levels of requirements in various stages of RE. Its agenda covers subjects such as words, texts, and domain levels of requirements in various stages of RE.	Offer a fully working knowledge-based semantic framework with a set of methods and techniques that can be efficiently implemented into practice, utilizing tools and prototypes that engineers may use every day.
Haq *et al.* [13]	Expert System	RE process automation and automatic extraction, and classification of requirements from text documents.	The findings of this study demonstrate that there is empirical evidence to imply that the expert system aids RE operations at various phases utilizing various methods. The strength of this evidence, however, is somewhat constrained by the setting in which the research was done.	The authors propose to continue the review in the future to investigate how an expert system supports the entire requirements engineering process using fully automated techniques.
Bisi *et al.* [14]	CNN-BPSO	(CNN) model classify software requirements into functional requirements and non functional	The CNN-BPSO model's experimental findings outperform the CNN model in terms of prediction accuracy.	In the future, the proposed models could be used to categorize non-functional software requirements.

		requirements. CNN-BPSO model optimize the hyper parameters of CNN		
Asad *et al.* [15]	Case Based Reasoning	The requirement analyst's work will be enormously decreases for elicitation thanks to CBR.	According to the authors of this research, CBR is a useful tool in the requirement elicitation process, particularly in real-time systems for AI at the micro and macro levels.	CBR can be utilized in the future to improve the employment of AI in real-time strategic games. Drones, which are crucial in strategic warfare, can be automated using CBR.
Ahmad *et al.* [16]	Intuitionistic Fuzzy Logic	Resolve the ambiguity in the requirement statements. This approach reduces the amount of time, money, and explicit requirements for stakeholder availability at a given time in the ambiguity resolution process. Furthermore, the suggested approach analyzes conflicts between stakeholders and the elicitor and determines why they emerge as tacit knowledge or hesitation.	The experiment results show that this approach can fix detected ambiguity. In the experiments, the precision was 0.769 (76.9%), recall was 1 (100%), and F1 score was 0.869 (86.9%).	After analyzing the data in a real-world industrial setting, compare the results with manual approaches and use the median as a statistical function in addition to the mean and the range. Assess the approach's applicability to several types of ambiguity individually. Finally, merging NLP with IFS for coordination and attachment ambiguities.

6. Conclusion

Requirements elicitation is defined as the process of gaining a clear understanding of the needs and constraints of a project, as well as understanding each stakeholder's perspective on those needs and constraints. It is the basic and most important activity of requirements engineering; however, it is not free from errors and flaws. Due to this, a number of studies have been conducted on requirements elicitation in order to prevent the elicitation errors that may appear during the process of requirements gathering. Requirements are sometimes difficult to interpret by developers because they lack a clear definition and description that facilitate better understanding. Sometimes, vague and ambiguous phrases can be found in the business rules that make it hard for software engineers to decide what the specific requirement means. In these cases, AI techniques can be broadly used to support the understanding of requirements. The paper

presented many practices developed in AI and the massive use of AI practices in requirement elicitation. In addition, a comparison of AI techniques in relation to requirement elicitation is also accomplished. In future work, the next step may be to introduce more exemplary AI techniques to overcome issues associated with requirements elicitation.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Raha Alkabour: Data curation, methodology, analysis, interpretation of results and writing; Omer Alrwais: Conceptualization, methodology, initial submission and supervision; all authors had approved the final version.

References

[1] Khlood, A., Abdelrazek, M., Arora, C., Grundy, J., & Bano, M. (2023). Requirements elicitation and modelling of artificial intelligence systems: An empirical study.

[2] Rajagopal, P., Lee, R., Ahlswede, T., Chiang, C. C., & Karolak, D. (2005). A new approach for software requirements elicitation. *Proceedings of the Sixth International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel*.

[3] Islam, M. N. A., Ma, Y., Alarcon, P., Chawla, N., & Huang, J. C. (2022). RESAM: Requirements elicitation and specification for deep-learning anomaly models with applications to UAV flight controllers. *Proceedings of the 2022 IEEE 30th International Requirements Engineering Conference*.

[4] Siqueira, D. C. J., & Canedo, E. D. (2022). Exploring ethical requirements elicitation for applications in the context of AI. 150–163.

[5] Sharma, S., & Pandey, S. K. (2019). Integrating AI techniques in requirements elicitation. *Proceedings of the International Conference on Advancements in Computing and Management* (ICACM) 2019.

[6] Surana, C. S. R. K., Shriya, D. B. G., & Shankar, S. P. (2019). Intelligent chatbot for requirements elicitation and classification. *Proceedings of the 2019 4th International Conference on Recent Trends on Electronics, Information, Communication and Technology*.

[7] Ibrahim, H. M. E., Ahmad, N., Rehman, M. B., Ahmad, I., & Khan, R. (2019). Implementing and automating elicitation technique selection using machine learning. *Proceedings of the 2019 International Conference on Computational Intelligence and Knowledge Economy*.

[8] Ramadan, N., Abdelaziz, A., & Abdelghany, A. (2016). A hybrid machine learning model for selecting suitable requirements elicitation techniques. *International Journal of Computer Science and Information Security*, *14*, 380–391.

[9] Mohanan, M., & Samuel, P. (2016). Software requirement Elicitation using natural language processing.

[10] Groen, E., *et al*. (2018). Is there really a need for using NLP to elicit requirements? *A Benchmarking Study to Assess Scalability of Manual Analysis*.

[11] Iqbal, T., *et al*. (2018). A bird's eye view on requirements engineering and machine learning.

[12] Mahmoud, A., & Carver, D. (2015). Exploiting online human knowledge in requirements engineering. *Proceedings of the 2015 IEEE 23rd International Requirements Engineering Conference*.

[13] Haq, B., *et al*. (2019). Use of expert system in requirements engineering process a systematic literature review. *China Emerging Technologies*.

[14] Bisi, M., & Keskar, K. (2020). CNN-BPSO approach to select optimal values of CNN parameters for software requirements classification. *Proceedings of the 2020 IEEE 17th India Council International*

Conferenc.
[15] Asad, M., *et al*. (2017). Requirement elicitation of real time systems by case base reasoning.
[16] Ahmad, Y. W. M., Nasir, W. K., Husain, S., & Ibrahim, N. (2021). An intuitionistic fuzzy based approach to resolve detected ambiguities in the user requirements document. *IEEE Access*, *9*, 114547–114563.

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