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Systematic Literature Review on Software Requirement Engineering in 5.0 Industry: Current Practices and Future Challenges

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***Abstract*—The advancements in technology within the industrial era 5.0 are swiftly progressing, particularly in software research and development, exerting a profound influence on various facets of software engineering, notably known as requirements engineering. This research undertakes a systematic literature study from 2020 to 2023, focusing on software system requirements engineering publications and exploring diverse methodologies and implementations. Most are journals and proceedings within these years. This SLR identifies, evaluates and interprets the prevailing practices in Requirements Engineering within the domain of 5.0 Industry. Specifically, it sheds light on the basic method used recently, highlighting adopting agile methodologies, model-based engineering, and interdisciplinary collaboration as auspicious trends. Initially, a pool of 137 articles from Scopus discussing software requirements engineering was identified and refined to 53 final articles based on predefined keywords. This result shows that current methodologies and trends are lacking in meeting new difficulties, which was raised as the side effect of 5.0. It implies the importance of a greater emphasis on cybersecurity, agile development processes, interoperability, and the smooth integration of IoT and AI technologies. The needs are the formidable challenges stemming from the intricacies of system architectures, and the absence of standardization looms large, necessitating concerted efforts for resolution. System architecture must be made in a compact form without any bargain while, at the same time, international standards should be proposed to meet the evolution of software requirement engineering. These findings underscore the imperative for innovation, data security, and an integrative approach to navigating the dynamic landscape of Industry 5.0.**

***Keywords*—Requirement engineering; software engineering; 5.0 software industry.**

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I. INTRODUCTION

Industry 5.0 represents a new era in industrial development, characterized by the integration of advanced technologies, the Internet of Things (IoT), artificial intelligence, and cyber-physical systems. The term of Industry 5.0 was introduced in the European Commision Policy Brief in 2021 named "Industry 5.0 – towards a sustainable, human-centric and resilient European industry" (Breque et al.). This transformative paradigm shift has the potential to revolutionize software manufacturing, making it more efficient, flexible, and responsive to customer demands. However, Industry 5.0's success heavily relies also on effective requirement engineering, which forms the backbone of any engineering process. Requirements engineering is the branch of software engineering concerned with the real-world goals for, functions of, and constraints on software systems. It is also concerned with the relationship of these factors to precise specifications of software behavior, and to their evolution over time and across software families (Zave 1997). Requirement engineering in the context of Industry 5.0 brings forth a new set of challenges and opportunities that demand a reevaluation of current practices and a forward-looking perspective.

Traditionally, requirement engineering has played a pivotal role in ensuring that the end product aligns with customer needs, compliance, and quality standards (Shah and Patel). In Industry 5.0, these requirements become even more complex, as systems become interconnected, autonomous, and adaptable. In this era, where machines, humans, and data work seamlessly together, understanding and eliciting requirements takes on a whole new dimension.

The purpose of this systematic literature review is to investigate the current practices and challenges associated with requirement engineering in the context of Industry 5.0. By analyzing existing research, we aim to identify trends, gaps, and potential solutions that can guide practitioners, researchers, and organizations in their journey towards embracing the Software Engineering in Industry 5.0 paradigm. The review will shed light on the state of requirement engineering, the methodologies and tools being employed, and the key issues that must be addressed to navigate this new industrial landscape effectively.

In summary, this systematic literature review serves as a comprehensive guide to understanding the crucial role of requirement engineering in Industry 5.0. It is our hope that the insights and knowledge gathered from this review will contribute to the development and implementation of effective strategies for successful Industry 5.0 projects and systems.

II. Materials and Method

A. Research Question

The purpose of this systematic literature review is to investigate the current practices and challenges associated with requirement engineering in the industry 5.0. Therefore, in order to keep the review focused on the objectives, the research questions outlined in Table I were posed.

TABLE I
RESEARCH QUESTIONS

ID	Research Question	Motivation
RQ1	How are agile methodologies used in Industry 5.0 Requirement Engineering, and what are their pros and cons?	Explore the role of agile methods and their impact.
RQ2	To what extent does model-driven engineering shape Industry 5.0 Requirement Engineering and cyber-physical systems?	Examine the impact of model-driven engineering.
RQ3	How does interdisciplinary collaboration enhance requirement quality in Industry 5.0?	Understand the benefits of collaboration.
RQ4	What challenges do complex cyber-physical systems pose to Requirement Engineering in Industry 5.0, and how can they be addressed?	Investigate strategies for addressing complexity
RQ5	What are the implications of non-standardized practices in Industry 5.0 Requirement Engineering, and how can standardization improve efficiency?	Assess the value of standardization in enhancing efficiency.
RQ6	In a fierce competitive environment at the pre-contract stage, how do software providers deal with competitive constraints and what impact do they have on the RE process	

B. Study Selection

Study included in this SLR is only study published in English, from journal, book and conference papers. The study criteria that may be included in SLR are based on the inclusion and exclusion criteria which are presented in Table II.

TABLE II
INCLUSION AND EXCLUSION CRITERIA

Inclusion Criteria	Exclusion Criteria
Research that discusses requirements engineering methods in software engineering	Research that does not discuss requirements engineering methods in Software Engineering
Research that discusses the implementation of software development using requirements engineering	Research that does not specifically discuss the implementation of software development using requirements engineering
The research explains the requirements engineering and implementation methods used that can be applied in industry 5.0	The research conducted does not touch on application to industry 5.0

The research papers taken are those published from 2020 to 2023, from Scopus. The defined years assumed the time at which industry 5.0 began. The research collected discussed the practices and challenges of requirements engineering carried out in industry 5.0. The specific keywords “software requirements engineering” are chosen in the research title. Next step is to use the keywords of “agile”, “model driven”, “collaborative”, “data security” and “privacy” in the research abstract. These return many results as the list of initial research which have to be identified at each stage as shown in Figure 1.

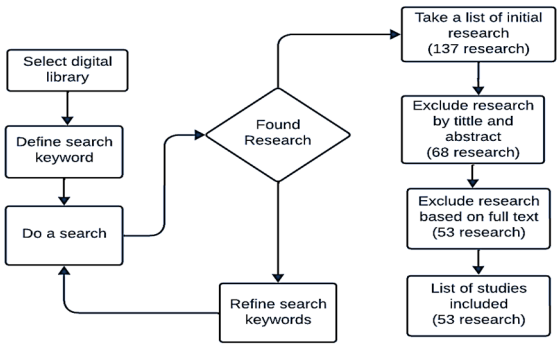

Fig. 1 Flow of research search and selection

C. Data Analysis

The analysis of the collected data followed a structured approach. The papers were categorized based on specific defined keywords and the main focus of the research. The analysis aimed to identify current methods and emerging challenges in requirement engineering in the context of Industry 5.0.

D. Quality Assessment

To ensure the quality and reliability of the selected papers, a quality assessment was conducted. Each paper was evaluated for its research rigor, methodology, relevance to the research question, and the credibility of the sources used. Papers that did not meet the predefined quality criteria were excluded from the final analysis.

III. Result And Discussion

By using the structured approach, 137 publications were found and derived into 53 by using defined specific keywords. Studies fulfil the inclusion and exclusion criteria that have been designed. The following Graph in Figure 2 shows how many publications are founded by excluding the research based on full text, ranging by year of publication from 2020 to 2023.

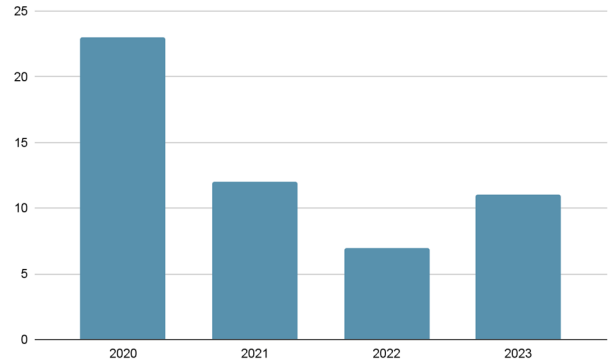

Fig. 2 Research Grouping by Year of publications

The graph shows that most publications found in the study are published in 2020 for 23 publications. For 2021, the study found 12 publications. For 2022, the study found 7 publications and in the recent year there are 11 publications founded.

After classifying the publications into years of publication, the study moved to derive how many publications were founded by using key terms specified in the beginning as recorded on the tables III below:

TABLE III
List of publications classified by method

Publication	Method
[22],[23],[61],[51],[39],[10],[52],[49],18], [16],[45],[62],[31],[40],[21],[38],[57],[27], [25],[13],[12],[43], [7],[11],[50],[8],[63], [57],[17],[6],[24]	agile
[42],[5]	model driven
[20],[58],[50]	collaborative
[42],[52],[58]	data driven
[19]	goal oriented

TABLE IV
List of publications classified by challenges

Publication	Challenge
[9], [42], [25], [44], [41]	Data Security
[42], [49], [44], [15]	Privacy

TABLE V
List of publications classified by constraint

Publication	Constraint
[28],[14],[52],[26]	Constraint

Each designated classification is described below:

A. Requirement Engineering Method and Approaches

This section presents an overview of the keywords findings related to methods used in requirement engineering in the context of Industry 5.0.

a. Agile and Iterative Approaches: Several studies highlighted the adoption of agile and iterative approaches in Industry 5.0 requirement engineering, emphasizing the need for flexibility and adaptability in rapidly changing manufacturing environments.
b. Model-Driven Engineering: Model-driven engineering was found to be a popular approach, with a focus on creating detailed models of cyber-physical systems to facilitate requirement analysis and verification.
c. Collaborative Requirement Elicitation: The collaborative elicitation of requirements involving multidisciplinary teams was noted as a best practice in achieving comprehensive and accurate requirements in Industry 5.0 projects.

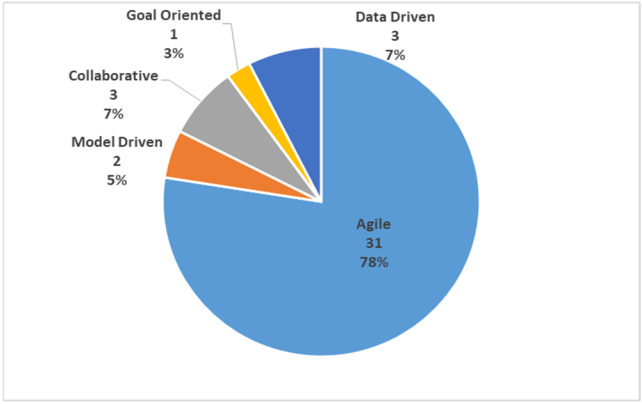

Fig. 3 Pie Graph: Software Requirement Engineering by Methods being used

Figure 3 shows that most publications found were mostly using Agile methodology to do the software requirement engineering. It is 77% or as much as 31 publications. Next, there are 3 publications or 8% using Collaborative methods, another 8% of data driven methods being used and the rest 5%, or two publications, are those at which model driven methods were used. This is obvious why Agile methodology is commonly adopted nowadays as the organization and stakeholder needs also raise vividly. Rapid growth in software engineering was also triggered by COVID-19 pandemic in which people's dependency for the existence of many applications need to be updated faster (Qahtani, 2022).

B. Requirements Engineering Challenges

This section outlines the challenges of Requirement Engineering identified in the literature related to requirement engineering in Industry 5.0.

a. Data security:
Data Security has been an issue in the whole software research and development stages. In terms of Requirement Engineering, publications concerned about Data Security took place as much as 5 publications or 56%.
b. Privacy:
Several papers, 4 Publications or 44%, raised concerns about privacy in the context of interconnected systems,

indicating the need for robust approaches to minimize the unstandardized matter.

Finding through the study shows The Challenges of Software Requirement Engineering in Figure 3 as follow:

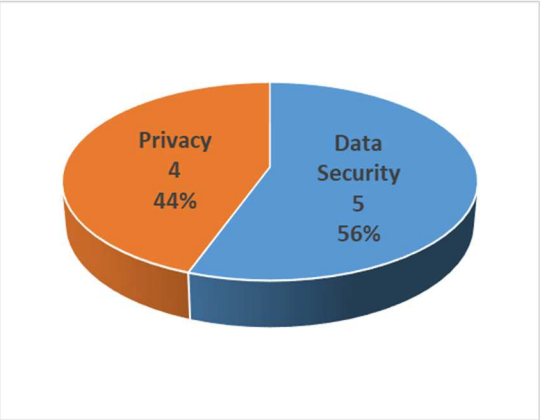

Fig. 4 Pie Graph: The Challenges of Software Requirement Engineering

In the competitive realm of pre-contract Requirements Engineering (RE) in software development, key constraints necessitate a fast-paced, resource-efficient, and competitive approach. Time pressures demand swift proposal formulation, while resource limitations and cost considerations emphasize resource efficiency. The competitive landscape intensifies the need for standout proposals, and uncertainty looms due to these constraints. These factors collectively define the distinctive nature of pre-contract RE, where software providers must navigate challenges with speed, efficiency, and competitiveness (Vera, 2021)

In the paper of [28] there are several problems that can disrupt the requirements engineering process, including: Data limitations: This journal may only use a limited sample of data or only test the system in certain cases. This can affect the generalization and applicability of the system to a wider range of situations; Validity and reliability: Although this journal presents results showing that this ontology-based system is effective in selecting the most qualified personnel, it is important to consider the validity and reliability of the methods used in this research

In the paper [14], the problem discussed is the complexity of searching for and selecting software components that can be reused to meet business needs. This complexity can be caused by a variety of factors, including the lack of comprehensive evaluation models for software components, difficulty in describing software components with appropriate detail, and difficulty in matching requirements with existing solutions.

The journal of [26] states that the requirements elicitation process aims to obtain a preliminary version of the requirements before their specification, but it is difficult to know if the elicited requirements have the desired attributes (i.e., these requirements are complete, correct, consistent, etc.)

IV. Conclusion

In this comprehensive systematic literature review, the examination of software requirement engineering in the context of Industry 5.0 highlights the urgency of adapting current practices to address emerging challenges. Industry 5.0 demands a heightened focus on interoperability, cybersecurity, agile methodologies, and the seamless integration of IoT and AI technologies. Successful software projects in this evolving industrial landscape will require continuous adaptation and innovation. Embracing these insights, stakeholders can better prepare for the future, ensuring that software requirements meet the dynamic and interconnected needs of Industry 5.0.

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