Limitations of Current Syntactic Analysis Models for User Stories: A Systematic Literature Review Protocol

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User stories serve as the backbone of Agile software development. User stories simply provide an understanding of the user requirements, such that it captures what the user actually needs to perform a specific task. However, stating user stories is not always according to the benchmark format, and the frequently changes in the user needs also affect the user stories, which are frequently changed. Thus, there is a problem in correctly identifying the structural elements of the user stories. In this context, traditional models as well as large language models can be utilized to analyze user stories for their constituents. Thus, this study aims to provide a comprehensive protocol to conduct a systematic literature review that identifies the limitations of current syntactic analysis models and also comes up with the fine-tuning techniques that can overcome the identified limitations. The novelty of this research protocol is that it explicitly bridges traditional syntactic analysis models and modern large language models for user story analysis. Existing protocols mainly emphasize rule-based or machine learning techniques, standalone. It will also focus on the deficiencies of conventional syntactic models and will investigate fine-tuning techniques of large language models to solve these limitations for user stories, specifically in the context of their structure.

Keywords: User Stories; Syntactic Analysis; Natural Language Processing; Large Language Models; Fine-Tuning.

Introduction:

The complexity of software systems has grown over the last few decades, which pushed developers to tackle technical and other related issues [1]. To deal with those issues, Agile software development (ASD) has emerged [2]. The core of ASD is iterative planning, refining requirements via development teams iteratively and incrementally, and motivating stakeholders to be active during the development phase. Stand-up meetings are done to manage the progress of the development team, and software product feedback can be assured via repetitive client reviews [2]. Requirement Engineering (RE) combines activities such as elicitation, specification, documentation, and validation; thus, ASD incorporates all these activities iteratively. All these are done continuously and collaboratively in each cycle of development [3].

ASD takes advantage of user stories, which represent end-user scenarios that they experienced. M. Cohn [4] points out that conversation between stakeholders and the respective development team is usually the starting point of user stories. Project documents, rules that are incorporated by business, standards, and even at the level of emails—all of these are considered requirement artifacts, which eventually help in the generation of user stories. The source of the user stories is not critical. User stories have a semi-structured template, which specifically elaborates on the end-user functionalities that are needed. That is why, for productivity and product deliverables, quality user story templates are frequently used [5]. Furthermore, the syntactic complexity and changeability of user stories [6] pose substantial issues for their automated processing. Correctly parsing user stories, especially especially complex user stories [7], and identifying key elements such as roles, activities, and goals[8] is also challenging. To this end, syntactic analysis is incorporated to cope with these problems. It can be performed via traditional models as well as via large language models (LLMs), but they have their own limitations and benefits. This study focuses on their limitations and aims to identify the optimal fine-tuning strategy for syntactic analysis using LLMs.

Research Problem:

User stories are essential in agile software development, serving as a medium for capturing functional requirements. However, syntactic analysis models struggle with inconsistencies in the structure of user stories, highlighting the limitations of syntactic analysis models. To this end, Large Language Models (LLMs) are utilized and fine-tuned as well, however, the optimal strategy for syntactic analysis remains unclear. That is why a structured study is needed to assess the limitations of syntactic analysis models and come up with an LLM optimal fine-tuning strategy.

Objective and Research Question:

This protocol is designed for the following research question and its objective.

RQ: What are the limitations of current syntactic analysis models in processing user stories, and how can fine-tuning techniques address these limitations?

Objective:

The objective of this research work is to systematically identify and categorize the deficiencies of current syntactic analysis models while processing user stories and to examine the effectiveness of fine-tuning strategies in large language models for mitigating these deficiencies, based on the literature synthesized evidence.

Scope and Significance:

This protocol will provide a detailed step-by-step mechanism to identify and investigate. the related studies and literature to address the limitations of the syntactic analysis model and exploring LLMs fine tuning mechanisms.

It will provide a detailed understanding of conducting a systematic literature review on syntactic analysis model limitations and LLM fine-tuning strategies.

Literature Review:

In today's world, software becomes essential due to the required automation of various processes in our everyday life activities, and so is the importance of software requirements in the field of software development [9]. That is why software requirement engineering and its underlying activities are also very important for the success of a software product.

Agile Software Development:

In recent years, Agile Software Development (ASD) has become a popular development approach and is widely used by the software industry for the development of software products [10]. ASD has the focus on the maximization of the business value [11] of a software product, such that it provides customers with a software product that they actually need. Most organizations adopt the Agile software development life cycle to develop software products of high quality that must be delivered on time to the customer [10].

User Stories in Agile Software Development:

The research work conducted by A. Hendriana et al. [12] shows that a survey of 108 agile practitioners revealed that user stories are the most widely used method for capturing requirements. The user story mainly describes user story information from three dimensions [13]: WHO, WHAT, and WHY. User stories have different templates that vary in the elements' inclusion and ordering in the user story [14]. Some of them are written as: "As a <type of user>, I want <goal>, so that <benefit>." [4], while some are in the given form "To <benefit>, as a <type of user>, I want <goal>." Thus, features of any software product are captured via agile user stories [10] while utilizing any of the above formats, but not limited to these only. That is why clients often provide user stories in a vague format, making them difficult to understand and prone to structural issues. To cope with the structural issue of the user stories, Syntactic analysis has been performed. There are traditional syntactic analysis models as well as large language models.

Syntactic Analysis in Agile Software Development:

The author Woolf [15] suggested that syntactic processing encircles those sub-tasks of natural language processing (NLP) that deal with phrases and sentence structure, as well as their internal and external relationships between them. Syntactic analysis involves the extraction of meanings from the components of a sentence or phrase and builds a semantic representation of the input phrase [16]. That is why syntactic process is the backbone of further steps, which can incorporate high-level interpretation, information retrieval, and sentiment analysis, etc.

Thus, in Agile software development, syntactic analysis has the same importance as in other disciplines. Here, mostly requirements are captured in the form of user stories [12]. That is why its structural components, like role, action, and goal, must be accurately and clearly defined, so that there is a clear understanding of the feature that is actually required by the end user of the software product.

Natural Language Processing and LLM for User Stories:

A study by I. K. Raharjana et al. [17] was conducted to review literature and capture state-of-the-art NLP applications on user stories. They depicted that to extract the aspects of what, why, and who of a user story, NLP techniques are prominently used.

Agile user stories serve as the backbone of software development, ensuring clear and structured requirement documentation. Large Language Models (LLMs) can enhance this process by automating syntactic analysis, improving clarity, and enabling intelligent prioritization for efficient agile project management. Pre-Trained Language Models (PLMs) have demonstrated impressive capabilities in solving various Natural Language Processing (NLP) tasks [18]. Researchers have observed that scaling up the model sizes significantly enhances their capacity, leading to remarkable performance improvements when the parameter scale surpasses a certain threshold [19].

Limitations of Current Syntactic Analysis Models:

The current syntactic analysis model that we have studied so far has the limitations of microtext normalization identified by [20][21][22]. Noise channel decomposition in microtext normalization is done by [20], but it still has the limitation of targeting a single-token word. Lexical Normalization was performed by [21], but there are introduced propagated errors that need to be overcome. The author of [23] stated that there is still a gap in having a deep learning normalizer. Because there is a data sparsity challenge caused by phonetic-based alterations, must be addressed. If it is not handled properly, there can be a loss in performance.

Thus, we have identified only a single topic of normalization and its related challenges while keeping in view the syntactic analysis models. For further domains and related issues, a detailed systematic literature review will be performed to identify the current syntactic analysis models' problems.

Review Methodology:

Review Type and Rational:

To conduct this research work of studying existing syntactic analysis models (e.g., rule-based parsers, statistical models, LLMs), and to identify the challenges in processing user stories. There will be a systematic literature review performed, and it is so that we have an unbiased, replicable, and comprehensive review of the current research. Due to its structured methodology, there will be clear inclusion and exclusion criteria, and it will minimize bias. The evaluation of the identified studies will be done critically. All the aforementioned benefits will lead to a reliable conclusion about the limitations of syntactic models and the effectiveness of fine-tuning techniques.

Protocol Development:

A clear and organized plan to direct the systematic review process is established during the protocol development phase. It describes the justification, goals, and established procedures that will be adhered to to reduce bias and guarantee reproducibility. The development of research questions, inclusion and exclusion criteria, search strategy, data extraction techniques, and quality assessment methodologies are all important components of this process. Peer review and methodological rigour are ensured by developing the procedure before the review is conducted. A detailed implementation to conduct the systematic literature review is depicted in Figure 1. The given PRISMA 2020 flow diagram [24] provides a planned study selection process. The actual studies will be stated in the completed review.

Research Question:

The research question addressed by this SLR is:

RQ: What are the limitations of current syntactic analysis models in processing user stories, and how can fine-tuning techniques address these limitations?

Search Strategy:

Data Source and Databases:

The data sources that will be searched are IEEE Xplore, ACM Digital Library, SpringerLink, Scopus, Google Scholar, and ArXiv.

Search String Formulation:

("User Stories" OR "Agile Requirements") AND ("Syntactic Analysis" OR "Natural Language Processing") AND ("Large Language Models" OR "Fine-Tuning" OR "Transformers").

Search Process and Pilot Testing:

Keywords such as user stories, syntactic analysis, large language models, natural language processing, fine-tuning, and user story prioritization will be systematically searched. These will be searched systematically in the academic databases, which are aforementioned. Operators like AND and OR will be utilized to merge multiple keywords, and additional filters will also be incorporated for the refined output of the input query. A small sample of studies will be chosen

for the conduct of pilot testing, to validate search strings, identify relevance, and make sure that the inclusion and exclusion criteria are up to the mark to be utilized in a full-scale systematic literature review.

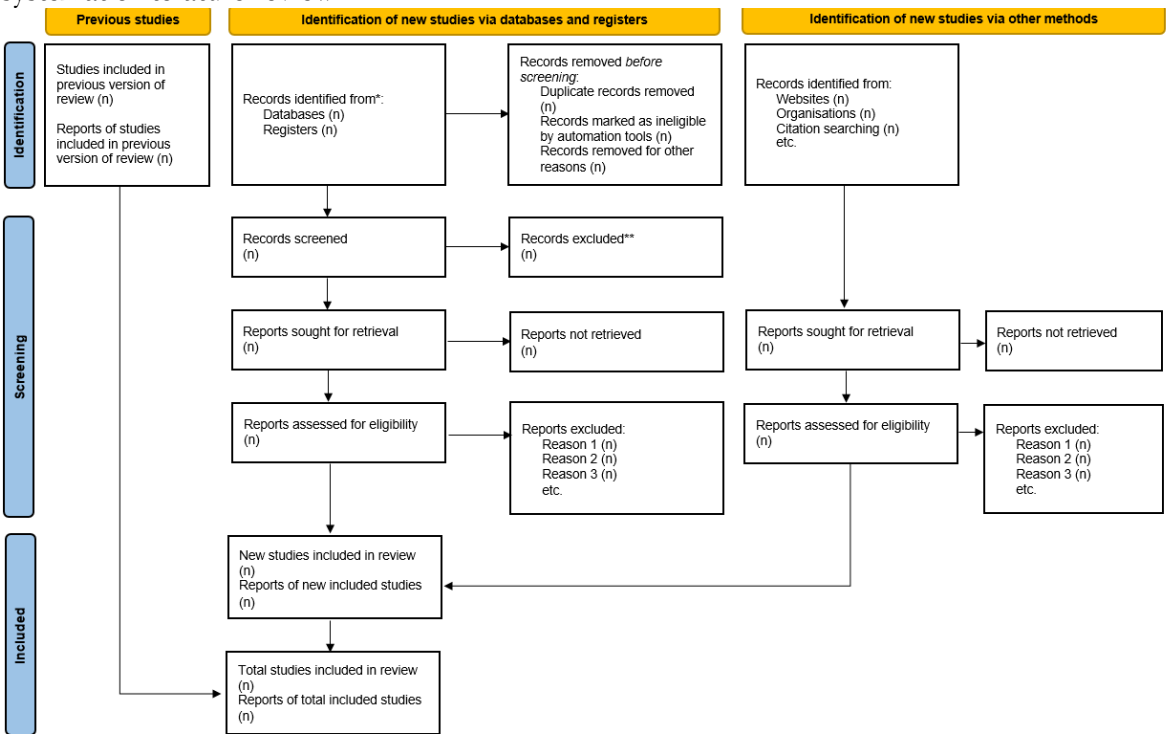

Figure 1. PRISMA 2020 Flow Diagram Illustrating the Study Selection Process.

Selection Criteria:

Inclusion Criteria:

Papers published after 2015 will be included to ensure the coverage of contemporary syntactic analysis approaches. This will also ensure the emerging deep learning and transformer-based models as well. This is because they significantly influence user story processing and research in requirement engineering. Peer-reviewed studies discussing syntactic analysis in agile user stories, research on LLM fine-tuning for software requirements processing, empirical studies, case studies, and systematic reviews relevant to the objective of this research work will be considered.

Exclusion Criteria:

Non-English publications will be excluded to ensure accurate and consistent data extraction. As it is a common approach while conducting systematic literature reviews to cope with the risk of misinterpretation. Literature which does not explicitly tackle user stories or the ones whose focus on semantic analysis without structural consideration will also be excluded. This is because they fall outside the scope of this research work.

Study Selection Process:

Initial filtering will be based on title and abstract, then full-text screening will be done using inclusion/exclusion criteria and quality assessment scoring.

Data Extraction and Management:

Data Extraction Strategy:

Data will be extracted from selected studies using a predefined data extraction form. Data will be collected systematically to document relevant information, including Title, Year, Source, Research Method, Dataset Used, Model Utilized, Evaluation Metrics, Limitations, and Key Findings of each publication. The data will be collected in such a way that ensures bias reduction and accuracy as well. Conflicting findings will be addressed using structured narrative synthesis. Studies with conflicts will be analyzed based on the context of research work, quality scores of

methodology, sources of data, and model characteristics. Stronger weighted evidence will be prioritized from the methodologically robust studies, while discrepancies will not be aggregated; these will be reported explicitly and discussed as well.

Data Item and Extraction Form:

The data items that will be required to be grabbed from each selected study are mentioned in Table 1. Based on these data items, we will have our extracted data.

Table1. Data Extraction Field

Data Field	Description
Title	Title of the study
Year	Year of publication
Source	Journal/Conference name
Research Method	Empirical, Experimental, Theoretical
Dataset Used	Dataset for training/testing
Model	NLP/LLM model used
Evaluation Metrics	Accuracy, F1-score, Precision, Recall
Findings	Key insights

Managing and Storing Extracted Data:

The extracted data will be managed and stored such that the relevant study details (Author, Publication year, methodology, and findings) will be organized into Excel sheets or Word documents which can be managed using Mendeley or EndNote referencing tools. This ensures easy accessibility, consistency, and traceability during data analysis. Google Drive or GitHub can be used to keep the data live and accessible at all times. This ensures data integrity and facilitates collaboration among researchers.

Quality Assessment:

Assessment Criteria:

The quality of the selected studies will be measured so that it identifies whether the aim of the study is clearly mentioned. Findings are credible and important; a diverse context is explored, knowledge is extended, techniques for prediction are described thoroughly, the link between interpretation and conclusion is clear, and data complexity is conveyed. These quality checks are adapted from the work of Kitchenham [25].

Quality Rating Method:

The response to each quality assessment question will be recorded in a Yes/No/Partially keyword. "Yes" will correspond to "1", "No" will identify "0", and "Partially" will correspond to "0.5". This scale is adopted from Damir Azhar's work [26]. The three-point scale is implemented to isolate varied degrees of compliance with the quality criteria qualitatively, to ensure a clear and well-adjusted assessment of research works that partially comply with technical and reporting requirements.

Data Synthesis and Analysis:

Synthesis Approach:

The Qualitative and Quantitative data synthesis approach will be incorporated for the conduct of the systematic literature review. It could be in mixed mode as well.

As per the quantitative approach, data synthesis will be accompanied by statistical techniques (e.g., meta-analysis). Numerical data will be combined from various studies to identify patterns, trends, and effect sizes across a given dataset.

As per the qualitative data synthesis approach, data will be synthesized via thematic or narrative techniques. It will analyze the data to interpret it and summarize the findings where the data is non-numerical. These techniques are useful when there is variation in study design or metrics.

In mixed mode, both the quantitative and qualitative methods of data synthesis will be incorporated as per requirement, so as to catch a detailed idea about the topic which is under observation.

Tools and Techniques for Analysis:

This study will utilize Microsoft Excel, Word, Google Sheets, and Docs for data organization and analysis. to organize and analyze data.

For qualitative coding and thematic analysis NVivo or Atlas. ti could be utilized, while for quantitative analysis, Comprehensive Meta-Analysis (CMA) or RevMan could be used to come up with statistical results of the extracted data.

Instruments like Zotero, Mendeley, and EndNote help monitor sources and ensure accurate citations. These tools enable a structured, efficient, and reproducible synthesis of review findings.

Expected Outcomes:

When this systematic literature review protocol is executed, it will yield a detailed and structured synthesis of current research work in the domain of syntactic analysis for user stories. Some expected outcomes are as follows:

Syntactic analysis models taxonomy applied to process user stories, including traditional machine learning, rule-based, and large language model-based techniques.

Limitations linked with current syntactic analysis approaches categorization while dealing with the structure of user stories, variability, and enhancement.

A mapping between fine-tuning approaches and the identified syntactic limitations. This will apply to fine-tuning techniques in large language models that mitigate these limitations.

Research gaps that are identified and open issues that can enhance future research works on domain specific adaption of LLMs in the field of requirement engineering.

Collectively, the above-mentioned outcomes are predictable to give technical guidance for researchers and applied perceptions for software engineering experts trying to enhance the automated examination of user story structure while benefiting from modern language models.

Practical Implications:

This systematic literature review is expected to provide concrete value to both tool developers and practitioners. Synthesized outputs can support user story quality assessment for agile teams by highlighting common syntactic deficiencies and structural discrepancies that affect clarity and implementation. This will help to refine user stories before sprint planning, which is a main task of product owners and scrum masters. Further, the outcome will help tool developers by guiding the limitations of current syntactic analysis techniques and highlighting strategies of fine-tuning LLMs that can be employed in the requirement engineering tools. Such intuitions can advise the expansion of automated user story analysis, prioritization, and validation tools that are aligned in a better way with the agile practices, as well as changing project requirements.

Limitations of the Review Protocol:

Potential Biases:

While conducting this study, there could be the possibility of publication bias, selection of study bias, search bias, language bias, and data extraction bias as well.

In publication bias, favoring published articles or peer-reviewed ones has the chance to overlook some grey literature outcomes and may miss some insights that are valuable. To this end, they may be incorporated as per requirement of this study.

Studies that are inconsistent and incomplete have the chance to be incorporated; this can induce selection bias. This is due to the subjective judgment or poorly written selection criteria of the studies. To overcome this bias, clear and purpose-based inclusion and exclusion criteria of the study selection are already defined.

Using limited databases or suboptimal search queries may exclude relevant studies, resulting in a shallow understanding of the domain and limited insights.enerate some fruitful outputs as well. To this end, a comprehensive search strategy, keywords, and Boolean operators are defined that will be incorporated into this study.

This study focuses only on English literature, which may introduce language bias. Due to this literature in other languages is already skipped, which may result in poor output at the end. To overcome this bias, if necessary, this study will include other language studies.

As the results will be compiled by the researcher and as a human, there is the chance that he/she may misinterpret the results of a study, which can bring inconsistencies in the overall results of this study. Thus, there is the possibility of data extraction bias as well. To overcome this bias, there will be the utilization of pilot testing, standard extraction forms, and cross-validation from multiple reviewers.

Threats to Validity:

This study could have some threats to validity as well. Amongst them, there are internal validity, external validity, construct validity, and conclusion validity.

During data extraction, data classification issues and interpretation of the result can incorporate internal validity. This will be overcome while taking care of the extraction data forms and cross-checking the results from multiple reviewers.

The limited generalization of the result can induce an external validity threat. This is due to focusing on too specific a domain, dataset, or tool. To overcome this threat, studies from various domains that come under the same broader topic of this research work will be selected, and result will be compiled.

There could be a chance of ambiguous key concepts that can bring a construct validity threat to this study. To overcome this threat, the study will clearly define its inclusion criteria and key concepts as well. This will make sure consistency in studies that are to be shortlisted for this research work.

There can be a chance of conclusion validity. It can result in erroneous and exaggerated conclusions. This is due to the low number of studies, deficient data synthesis, or subjective analysis. To overcome this threat, this study will assess every shortlisted study quality as per the aforementioned quality criteria and will also incorporate the standard data synthesis tools and techniques.

Conclusion:

Expected Contribution:

This research work is expected to come up with a structured amalgamation of existing research in the field of syntactic analysis of user stories, while consolidating evidence systematically on the limitations and strengths of the existing analytical techniques. Comparative analysis will be performed such that the review will provide understanding about frequent structural issues in user story processing and the degree to which current models tackle them. To map these limitations to the LLMs' fine-tuning techniques, this research work aims to identify emerging research trends as well as highlight gaps where existing resolutions remain unsatisfactory.

The projected results of this research work are to inform researchers and practitioners about an evidence-based foundation for coming up with more robust, domain-specific syntactic analysis models. Furthermore, expected outcomes are intended to support technical decision-making in the future while dealing with natural language processing-based requirement engineering research works, specifically within the domain of Agile software development.

Future Work:

In the future, the outcomes of this research work will provide a foundation for the improvement, development, and empirical advancement of a domain-specific syntactic

analysis model, leveraging LLMs fine-tuned and agile datasets from the real world. Furthermore, future work may extend this groundwork towards automating related tasks, such as prioritization of user stories, thus backing a more intelligent and adaptive agile requirement management system.

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