Automatic Recognition and Segmentation of Composite User Stories Based on Semantic Analysis

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ABSTRACT

User stories are often used in agile development to express user needs. Accurate and rapid understanding of user stories is critical to product development. One of the major obstacles to accurate and efficient story understanding is the ambiguity of story statement caused by the existence of compound user stories. Therefore, the understanding of user stories is crucial to product development. One aspect that hinders the efficiency of story understanding is compound user stories, especially in Chinese, so identifying compound stories in the early stages of development is a major goal of this article. This paper proposes a method for identifying and segmenting compound stories based on semantic analysis, which includes analyzing the structural and semantic features of compound stories, building a feature dictionary, and automatically recognizing compound stories based on HanLP. This paper takes the user story of a game live broadcast system as an example, and the research proves that the method proposed in this paper can well identify common compound user stories.

CCS CONCEPTS

• **Computing methodologies**; • **Artificial intelligence**; • **Natural language processing**;

KEYWORDS

Semantic analysis, Compound user stories, Segmentation recommendation, Story quality inspection

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1 INTRODUCTION

The digital transformation of enterprises represented by "digital twins" means that software developers need to develop larger, better, and stronger software systems. However, software development is a challenging activity. Agile development uses user stories to express user requirements, i.e., a concise natural language form to express user or customer needs for the system [1-3]. The requirements are not defined in advance, but become progressively clearer as the iterative process progresses through frequent interactions with stakeholders. Instead of predicting and documenting all requirements in detail in advance, the approach first guides developers to code quickly based on the resulting user stories, which are later tested by customers in actual use.

User stories are written by users or customers from the perspective of business needs which are usually described as story statements, story dialogues, and story confirmations. Because of the lack of writing experience of users or customers and their description driven by chapters and characteristics, user stories have defects in writing specifications and presentation. A user story is a semi-structured specification of requirements. A user story template usually take the following form: as [WHO], I want/want to/need/can/would like [WHAT], so that [WHY]. The expression include important elements of requirements: WHO wants it, WHAT is expected from the system, and optionally, and WHY it is important [4-5].

When chapters and features are described by larger and vague concepts, it will reduce the quality of requirements, leading to incomplete, inconsistent, and unpredictable requirements. Therefore, developers can not accurately identify requirements. If the next step of development is blindly carried out, it will lead to the problem of low user satisfaction with the system. Nevertheless, discovering and

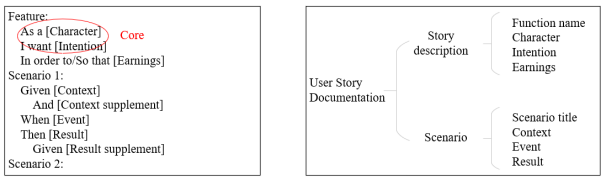

Figure 1: User Story Template Structure.

solving problems in user stories is the key to ensuring the quality of requirements and the smooth progress of agile development.

The INVEST criterion proposed by Wake [6] is currently widely used story quality analysis criterion, but this method only shows that user stories need to be independent, discussable, valuable, estimable, small-scale and testable. Some rules have been developed for the description of roles, activities, and business values in story statements, and natural language processing techniques have been used to detect them against some of the quality criteria [1]. However, the above story quality studies are based only on the template structure of user story statements, as shown in Figure 1 below, and identify structural defects, such as missing roles and redundant activities, but these user stories have a single structure and are short in length. In addition, the current applications of natural language processing techniques for user stories are divided into three categories: establishing the relationship between user stories and other requirement statement documents, extracting key information from user stories, and identifying user story defects [1]. This paper belongs to the category of the third category, and there are many studies and formed some tools for user story defect identification, but most of them give structural defects based on user story templates, which are relatively basic defect Identification.

To further enhance the quality of defect identification, this paper proposes an automatic recognition and segmentation method for composite user stories based on semantic analysis. This method first analyzes common composite user stories and extracts the composite keywords to form a composite dictionary. In the process of story analysis, the user story was previously transformed into the standard form shown in Figure 1. Then, based on the keywords contained in the composite user story, the semantic analysis method is used to identify the composite story, mark the crux of the story, and recommend the story segmentation for the structured composite story. Finally, it checks the semantic whether to meet the requirements of the story.

The first part of this article introduces the application research of natural language processing(NLP) in the field of requirements engineering, the classification and key words of composite user stories, and the user quality evaluation criteria required by the research of this article. The second part specifically introduces the identification and segmentation of composite user stories Steps. The third part is an experimental example, and finally gives the relevant conclusions and prospects of this article.

2 RELATED WORK

In recent years, user stories are large in number and complex in content. Improving the quality of stories is particularly important in software development. Researchers mainly conduct research in two aspects, including formulating guidelines to regulate the writing of user stories, and observing the completeness and consistency of the requirements from a global perspective.

2.1 NLP in Requirements Engineering

In the field of requirements engineering, NLP is widely used in model construction and requirement quality inspection. However, there is little research on Chinese text processing in requirements engineering. For user story quality testing, Lucassen et al. [5] defined the user story quality. Besides, a tool called The Automatic Quality User Story Artisan was built to perform the process by identifying each quality criterion. The tool generates reports related to the quality of user stories. Dalpiaz et al. [9] identified ambiguous user stories by defining ambiguous meanings and calculating the ambiguity based on the semantic distance.In order to identify duplication, the WuP similarity was utilized to determine the semantic similarity based on the aspects of what between user stories [1]. Heck et al. [11, 12] introduced traditional requirements document quality evaluation criteria for the completeness, consistency, and correctness of stories; Lucassen et al. [13] analyzed grammar, semantics, and pragmatics. Three aspects have formulated the quality criteria for user stories, but they lack operability; Wang Chunhui [7] proposed a quality inspection tool for user story statement and confirmation, but the defect recognition function of the tool is based on simple sentences and obvious structures. User stories do not involve the identification and segmentation of composite user stories.

In terms of (semi-)automated construction of demand models, some studies have used NLP to extract the concept and relationship information in the model from the demand document, and construct an instantiated model. Wautelet et al. [14] proposed the conversion of user stories to use case diagrams, and developed an editing tool that can realize user stories, use cases, and class diagrams from the three perspectives of observation requirements; Mesquita et al. [15] helped developers from The systematic perspective studies how to achieve goals and the relationship between goals, and provides a graphical editing tool to map user stories to i* models; Trkman et al. [16] provide a way to transform the ontology and business process models in user stories Methodology: Lucassen et al. [17] extracted concept models to detect the completeness of user story requirements description, and then summarized the heuristic rules for extracting concepts and relationships, and based on the rules to extract concepts to establish association relationships. And semi-automated conversion of a set of user story requirements text provided by different stakeholders into a user story model through human-computer collaboration [1].

However, none of the above studies is an analysis of the macro concepts and relationships of user stories and does not address the ambiguity of individual stories.

2.2 Composite User Stories

Composite user stories refer to users using fuzzy concepts with large features to describe the functional requirements of the system, which do not meet the standard template shown in Figure 1 and express more than one requirements. The composite stories are

often too large to obtain the standard user stories that are consistent with atomicity through a simple iteration.

The five common composite user stories and their segmentation methods are as follows:

- Segmentation according to workflow steps: First identify the requirement description statements that require workflow increments in the composite story. For example, the “and” in “I want to update and release the pricing plan to customers” indicates that the requirement can be divided into two parts of work, and the two execution actions of "release" and "update" can continue to be divided into steps; the second step is to study the steps required by the user to complete the specific workflow, and then implement the workflow through increments, which can be added here Change the amount to "Send pricing update messages to the client", "Publish the pricing plan to the customer’s household electricity display", and "Publish the price list to the customer’s smart selection interface."
- Segmentation according to business rules: Some stories seem simple, but their related business rules are very complex or extensive. In this case, the story can be decomposed to deal with the complexity of business rules. For example, "As a public institution, I want to sort customers according to different demographic methods." In this user story, demographic methods involve many standards, which can be divided into "sort by age" and "sort by family population", "Sort by income", etc.
- Segmentation according to system operation steps: Some vocabulary, such as management and control, conceal a variety of operations performed on the story, such as adding, deleting, modifying, searching, etc., and these operations can provide a natural way to segment the story. For example, "As a user, I can manage my account" can be divided into "I can log in to an account", "I can edit my account information", "I can log out of my account", and "I can add multiple accounts to my account." Devices" and so on.
- Segmentation according to the diversity of data display: Sometimes the complexity of a user story lies not in the realization of the function, but in the display of the user interface. In this case, the user story can be segmented to enrich the display interface, such as "As a user, I "I want to view my energy consumption through various charts" indicates that the story needs to be divided into "Various", changed to "Use bar graphs to compare weekly consumption", "Use line graphs to compare consumption trends over time" ".
- Segmentation according to the diversity of output objects: The user language of the system is different, and the needs can be enriched by appropriate story segmentation. For example, change "I want to send messages to customers" to "Send messages to customers in English" and "Send messages to customers in German".

2.3 User Story Quality Evaluation Criteria

The quality of user stories plays a decisive role in the success of requirements engineering. Before segmentation, the requirements of unified story templates, complete key fields, and atomicity are met. The structured information is displayed in the I want to field, which reduces the difficulty of compound story recognition. After segmentation, it is necessary to further check whether the language components of the user story are complete, whether there are duplicate content in the segmented fields, and whether it meets the requirements of minimization and non-ambiguity. This is the need to ensure that the story is available after segmentation. There are many standards for user stories, and the appropriate standard is usually selected according to the application. The quality criteria that need to be met for segmentation of composite user stories in this article are shown in table 1

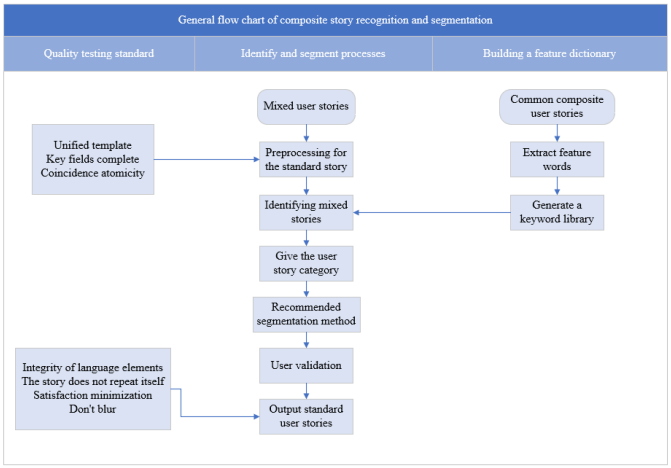

Figure 2: Flow Chart of Automatic Recognition and Segmentation Method for Composite User Stories Based on Semantic Analysis.

3 AUTOMATIC RECOGNITION AND SEGMENTATION OF COMPOSITE USER STORIES

To solve the ambiguity of user stories, this paper proposes a work processing flow as shown in Figure 2, which enables the composite user stories to be accurately identified and completed segmentation.

3.1 Mixed Story Preprocessing

Given a user story with unlimited format but accurate expression of user identity and needs. At first, generating a user story in a standard format whose keywords of the story be unified As Feature (system function name), As A (role), and I want to (action). Then user stories are classified according to roles and functions. Different roles have different demands based on system functions, and different functions have more personalized presentation to different users.

We use named entity recognition in HanLP to identify users. The "compound" of the composite user story is reflected in I Want To which is mainly used to express requirements. Besides the composite story is large and broad, which generally does not involve scene

Table 1: Quality Criteria for Composite User Stories

Detection phase	Guidelines	Description
Before split	Unified template	Use a unified format and keywords to express the story
	Key fields are complete	Roles and user activities in the story statement are not missing
	Atomicity	Include only necessary information
After split	Complete language composition	After the split, the language component of each field in the story is not missing
	Not repeating	There are no two same stories
	minimize	There are no words in the story that indicate a parallel relationship. A field only describes one situation.
	Not fuzzy	There are no fuzzy words in user stories

Table 2: Compound Story Segmentation Basis and Judgment Feature Words

Basis of partition	keywords
Workflow steps	And, or, and so on
Business rules	Different, variety, etc
System operation steps	Management, control, development, update, implementation, etc
Diversity of data display	All kinds of charts
The multiplicity of output objects	Delivery, customer, etc

description, this part will not be considered. Therefore, preprocessing focuses on adding key phrases to the I Want to field of the user story template.

The generated user stories are checked for template consistency and key field integrity. For any user story $u_i \in U$, let the roles and activities in the story be respectively represented as r_i、a_i, and the integrity detection rule of key fields is:

$$conComplete \leftrightarrow r_i \neq \ \wedge a_i \neq$$

Satisfying the above formula means that the user stories generated based on the unified template also satisfy the integrity of key fields. Atomicity is reflected in the fact that the generated stories do not contain other irrelevant fields related to the recognition of composite stories except the fields of roles and actions.

3.2 Recognition and Segmentation of Composite Stories Based on Feature Lexicon

The recognition and segmentation based on feature lexicon include three key steps: constructing feature lexicon, identifying compound stories and segmenting user stories.

3.2.1 Build a Word Base. Feature words refer to words that can directly classify a user story as a compound story. These words have certain rules, such as "and" and "or" in the feature words list shown in Table 2. However, in addition to the common feature words, the mining of other feature words has a certain subjectivity. What are the words that need to be divided according to the operation steps of the system? Which words imply that the system needs to consider the diversity of data presentation and output objects? At present, there is a lack of a large number of user story data to mine the rules, so in the early stage of system construction, the thesaurus needs to be built manually, and then the domain thesaurus can be automatically extracted after the amount of data gradually increases. Table 2 is a summary of the five types of composite stories in 2.1. Key words:

The feature lexicon should not only contain words with parallel meanings and implied meanings, but also contain some special symbols. When the sentence contains punctuation marks such as "(), {}, [],„", the marked sentence should be divided at the expression point. These symbols are the easiest and standard-flow way to identify a composite story.

3.2.2 Identify User Stories. After the preprocessing of user stories, the key fields of the stories are stored in the story structured document. Each key field is treated as a sentence, and sentence components are identified by syntactic analysis. Specifically, HanLP is firstly used in the field of I Want To to perform word segmentation (to represents word segmentation results), dependency parsing (Dep Tree represents visual syntactic analysis results), and semantic role labeling (SRL PA1 and SRL PA2 represent semantic role labeling results from different perspectives) for any sentence S. For example: "As a game blogger, I want to check the age and gender profile of my fans" in which "game blogger" is a noun phrase made up of two nouns to indicate a story character, and "fan age and gender profile" is a juxtaposition, forming a verb and object relation with "check". The specific execution results are shown in Figure 3. The identified noun "game blogger" is the content of the As a field, and the verb-object phrase is the content of the I Want To field, which contains parallelism and belongs to the compound story, and should be divided according to "and".

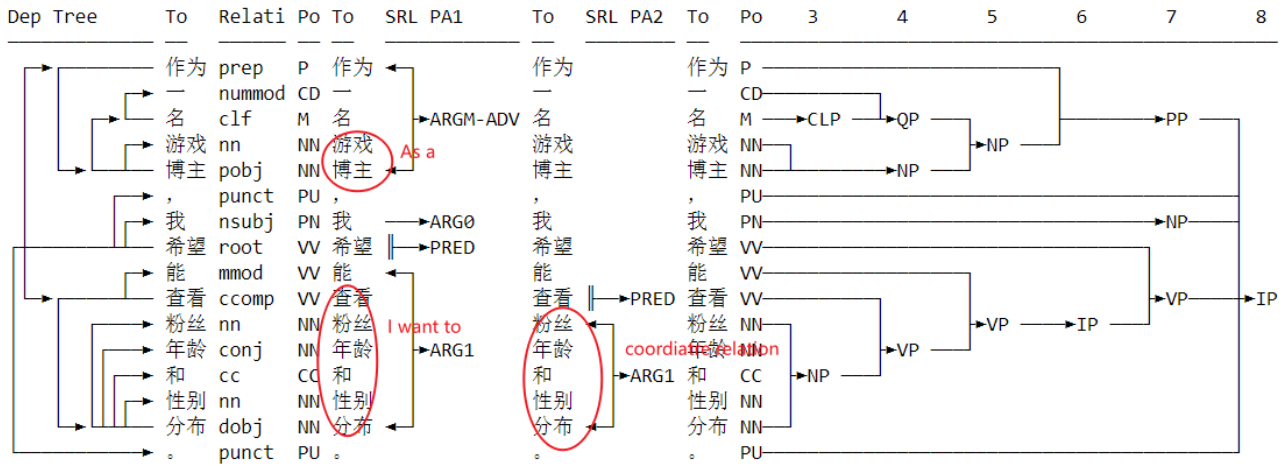

Figure 3: Example of Parsing.

Table 3: Syntactic Structure Summary Table of Key Fields

keywords	Parts of the sentence
Feature	Subject + (adverbial) + predicate + (attributive) + object
As a	Noun Phrases (noun + noun)
I want to	(adverbial) + verb + object
In order to	(adverbial) + verb + object

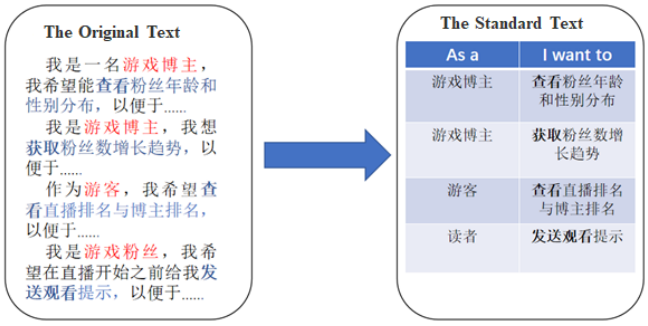

Figure 4: The Text Is Converted to A Template Example.

As shown in Table 3, preprocessed user stories all have a fixed syntactic structure, and user stories can be identified and processed according to the judgment of the syntactic structure.

Firstly, the number of verb-object structures in the" I want to" field is detected, namely the number of verbs and the number of objects. More than two verbs or objects indicate that the story needs to be divided by the verb or object as the boundary. Secondly, the verb in each verb-object structure is identified to determine whether it is a divisible system operation step of "management, control, development, update, implementation", etc. Finally, check the modifiers such as adverbials in the sentence. If there are words such as "various, according to and respectively", mark them out and wait for the subsequent segmentation steps.

4 CASE STUDY

This paper conducts an experimental study on user stories of a game live broadcast system. The data set contains a total of 4 users, 9 functions, 34 user stories and 72 scenes. The results of classifying user stories by user and function are shown in the table below. The functions shown in Table 4 are the basic requirements of the platform users for the system, and there are more problems of fuzziness due to the wide range of requirements. Tourists do not log in, register or exit in the system, but focus on the design of their personal homepage, game content display and recommendation mechanism after entering the platform. Fans need good recommendation mechanisms more than bloggers; Bloggers have more information than other users to analyze comments, followers, etc. The administrator is only concerned here with the system administration function.

4.1 User Story Recognition and Segmentation

After the classification of 34 mixed user stories, the information of As A and I Want To fields is extracted by template. In the extraction process, punctuation marks and stop words are not removed, but only words representing purpose and meaning are deleted. Search the feature words in the field of I want to in the standard form of user stories. First, analyzing text to find the punctuation marks representing the relations of juxtaposition and inclusion.

Users in this system contains game fans, game bloggers, and database administrators which have different requirements for the system. The interface presented to game fans and game bloggers is also different when it comes to logging in. Therefore, the division based on the two dimensions of role and function can provide a good basis for the subsequent composite story segmentation.

After processing the data source, the results satisfied the user story standard in Figure 1 are shown in Figure 4. In this task, named entities with key phrases were extracted from the 34 user stories, and these elements were distributed according to a template.

Table 4: User-Feature Story Number Distribution

Function/users	login	registered	exit	game	Recomm-ended	Comm-ents	Personal home page	Focus on	System management
tourists				1	1		1		
fans	1	1	1	2	2	1	1	1	
blogger	1	2	1	3	1	2	3	4	
managers									4

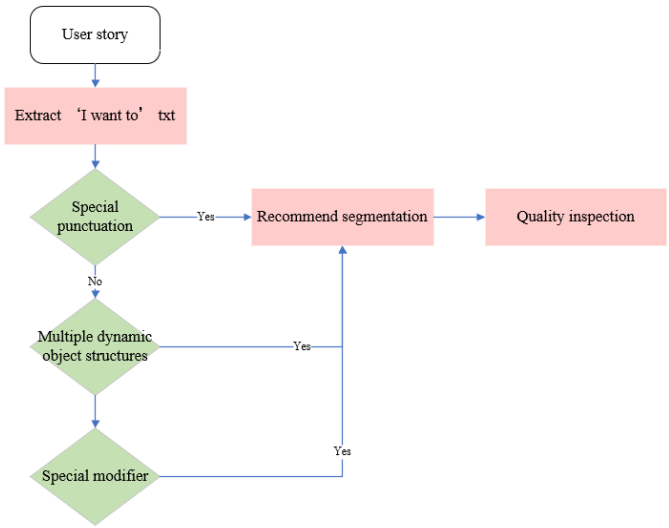

Figure 5: Example Experiment Steps.

In this stage, a total of two unqualified user stories are found. They are "I want to view and follow the popular users of the website" and "I want to view the user information (field and expertise) I follow". These two stories contain punctuation to indicate juxtaposition and are composite user stories that should be recommended separately in the next step. The experimental steps for the example are shown in Figure 5

- Looking for the number of verb-object structures in the sentence: the number of verbs and objects. This section finds two composite user stories: "I want to review and rate a game" and "I want to check my followers and followers". The former contains two verbs "to publish" and "to score", while the latter contains two objects "to follow" and "to follow".
- Looking for special verbs. There is only one such error, which is "I want to manage the information of the data table. "The "management" behavior in this story can be broken down into "New," "Delete," "Modify," and "Find."
- Looking for specific adverbials and modifiers. There are seven of these errors. For example, "according to" in "I want to rank my game a certain way" indicates a need to split the criteria. The word "visual" in "I want to get visual information about the number of followers" suggests that multiple graphs should be used to reach the user's goal.

4.2 Results and Analysis

The example in this paper takes 34 user stories involving different functions and different users as the research object, and then carries out the identification of composite stories according to the identification steps given in this paper after the standardization of stories. The error rate of the story in this paper is 29.4%. Compared with the experiment's results of experts, a set of composite story identification methods proposed in this paper is proven to be effective. The identification of composite stories is different from other text analysis methods, which tend to remove punctuation marks, adverbials, conjunctions, prepositions, etc. to simplify the algorithm and better analyze the meaning of the sentence. And the recognition method proposed in this paper pays less attention to semantics, because the recognition of complex stories is based on the modification components.

5 CONCLUSION AND DISCUSSION

The paper studies the process of recognition and segmentation of composite user stories. This method firstly analyzes the structural and semantic features of them, and extracts the composite keywords to form a composite dictionary. Then user stories are transformed to the standard shown in Figure 1. Based on the feature words contained in the composite user story, the composite

story is identified, the crux of the story is marked, the segmentation recommendation is given, and finally, whether the semantics meet the requirements of the story is checked. The segmentation of composite user stories helps to eliminate grammatical errors in the description of the user story itself, as well as conflicts, repetitions, and ambiguities between stories.

In view of the difficulties arising from this paper and the problems inherent in the current field, future work can be carried out in the following areas:

- There is little research on Chinese text processing in requirements engineering. Thus, many popular methods on user story should be verified in Chinese. Besides, Chinese user story face more language problems.
- Foreign studies on user stories are also based on data sets with a small amount of data, so recall rates and accuracy cannot be calculated. Therefore, the requirements engineering field lacks a baseline standard to verify the effectiveness of the method.
- The dictionary in this experiment is constructed by expert. But if large amount of data can be automatically captured keywords, it can automatically generate feature dictionary.

Through story segmentation, the functional requirements of story statements can be enriched, and for potential user needs, it is believed that explicit description of obvious functions can significantly improve the work efficiency in the software development process. In addition, user stories can also be segmented according to the main workload, story piercing, etc., but this method needs to be based on consideration of the actual work progress of the system. The accuracy of automatic segmentation is not high, so this article does not consider the above situation. Follow-up work is expected to be carried out on the basis of large-scale Chinese data sets, and eventually form a comprehensive quality detection platform for user stories.

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