Teaching Multidisciplinary Teams Requirements for Undergraduate Students: an Approach to Augmented Reality Software in Design Thinking Context

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***Abstract*—Augmented Reality (AR) has the advantage of allowing the use of tangible actions and multimodal operations. It is believed that the development of AR scenarios is a difficult task, requiring knowledge and understanding in several areas. With this, the disciplines of Software Engineering play a fundamental role in the development of these scenarios. The teaching of requirements and concepts of elicitation is primordial in the first years of the courses of Computing. A systematic review to map the use of Requirements Engineering in the development of AR scenarios pointed to a gap regarding the requirements elicitation process for AR, which led us to think of a teaching strategy to help undergraduate students to specify AR scenario requirements. Therefore, in 2016, we conducted experimental tests at the University Technological Federal of Paraná with the undergraduate students of Systems Analysis and Development and Software Engineering, to present a strategy that would contribute to the elicitation of requirements for RA scenarios. These experimental tests verified the strategy, and the results indicate if it is possible to help the students in the elicitation of requirements for AR scenarios from this approach..**

Keywords—Augmented Reality; Requirements; Process..

I. INTRODUCTION

In recent years there has been an exponential growth of new technologies that appear to enhance the understanding of information [1]. Among these we can highlight the augmented reality technology (RA).

Augmented reality is characterized by the inclusion of virtual objects (such as images, texts, animations) in the real world, by means of technological devices, allowing the user to explorer these scenarios and attractive fortified Royal [2]. The RA combines multimedia and virtual reality to present mixed elements of good quality and provide real-time interaction [3]. Currently AR systems have achieved various areas such as education, health (psychology rehabilitation), marketing, industry among others [4].

From the technological point of view, the applications of AR have three fundamental features: combining the real world with the virtual; be interactive in real time; and adjust the virtual objects real environment [4].

AR applications offer a strong appeal to constructivist approaches in education, whereby students are active and can target your own learning [2].

Considering the use of AR, there is still little research on the development of requirements specification templates for AR systems. For the construction of AR systems, software engineers are a problem, because, in the literature there are only narrow tips, projects, guides that are untapped problems specific to each researcher [1]. In contrast to these systems of AR, there are several ways to model the requirements of transactional systems, among them one can highlight the use case diagrams, sequence, flow charts and many others.

In this context, this work presents how undergraduate students can be able to capture requirements of AR. The students learn and use a custom approach from requirement engineering that includes features of Augmented Reality Scenarios. After the experimental tests carried out in the year 2016 at Paraná Federal Technological University with undergraduate students of the courses of Bachelor of Software Engineering and System Analysis, the students learn an advanced way for approach multimodal systems requirements.

In the following sections will be presented the theoretical foundation, the process, methods and procedures, analysis of results and conclusions.

II. THEORETICAL FOUNDATION

The undergraduate program in Software Engineering aims to train human resources fully capable of conducting activities of planning, construction, management (design and quality) and maintenance of products featured software, in order to meet the current needs of the labor market. The needs that can be met mainly cover the development, deployment and management of projects and knowledge to use in organizational processes, infrastructure and maintenance of software. The course develops the scientific spirit within the Software Engineering, to solve critical and efficient, problems involving a combination of computational and human resources related to collection, storage, retrieval, distribution and use of data, using creativity in the application of

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information technology for the design, deployment, administration and maintenance of systems.

The graduate Software engineering course must:

• Extract data, analyze, model, document, validate and manage software requirements;

• Design software (architecture and detailed design) and perform modeling, analysis and quality evaluation considering methods, architectural models and design patterns in these activities of the process;

• Program with quality and as a team. Includes methods, techniques, technologies and tools;

• Keep the software evolves qualitatively;

• plan and execute the verification, validation, reviews, inspections and tests;

• Manage software projects;

• Customize software processes and contribute to process improvement projects;

• Convey ideas clearly in verbal or written form;

• Exercise the knowledge through the use of technologies, tools and methods;

• Select appropriate technologies for a specific software development context

Given this background of undergraduate program in Software Engineering, Figure 1 is a compiled of course disciplines found in Brazilian universities.

Linear Algebra	Algorithms	English Instrumental	Software Engineering	Discrete Mathematics	
2 algorithms	Computer architecture	People management	Logic for computer science	Software Production process	
1 database	Data structure	Computer network	Object-oriented programming	Operating Systems	
Object-oriented analysis	2 database	Software requirements	Integration Workshop	Web programming	
Web programming 2	D Software configuration management	Research methodology	Probability and statistics	Human-Computer Interaction	
Programming for mobile devices	Foundations of intelligent systems	Software Project management	2 Integration Workshop	Entrepreneurship and innovation	Verification and validation
Software quality	Ethics, standards and professional attitude	Concurrent and Distributed programming	Software architecture	Intelligent Systems Applied	Final project 1
Software maintenance	Software Producer market	Humanities, social and citizenship	Security and audit Systems	Final project 2	

Figure 1: Grade of the Courses of the Software Engineering course in Brazilian Universities

Note in Figure 1 that there is no discipline in Software engineering that refers to virtual environments.

A systematic review of the literature conducted prior to this work. Second Kitchenham [16], the systematic review of the literature is a methodology used to gather evidence about a specific research question. One of the activities associated with the revision is the selection of primary studies. Other activity associated with the review is the presentation of the results of the primary studies that meet the purposes of the review. The results are usually summarized in tables and an alternative to reduce the time consumed to understand the data is the use of graphical representations.

The systematic review carried out pointed to a gap on the RE processes for system development of AR. The studies identified in the review, show that the air intake systems feature interactive handling, navigation and selection asocial to user actions in the environment in which it is immersed. In this context, the requirements of AR are imposed directly by the human senses.

Because of this, sensing a real distance growing found in literature refers to propose a teaching strategy to assist students to specify software requirements for scenarios of AR in Software engineering disciplines, and to achieve that goal were experimental tests in undergraduate classes of the course of Software Engineering in which was found the grip of such strategy.

According to Kirner [6], the RA has several ways to be set. An environment of RA consists of a predominantly real scenario with some embedded objects [7]. To interact with the environment the user can use since until their own hands markers for manipulating virtual elements in the real world. The interaction occurs always in real time, not depending on the medium used to interact [7]. In a nutshell RA is the integration of real world and virtual elements, creating a mixed scenario in real time.

According to Jacobs [8] augmented reality provides the user the handling of objects with his bare hands, enabling an attractive and motivating interaction with the environment. However, in order for the virtual elements are part of the real environment and are handled, you must use a software computer vision capable of real environment and positioning of the elements, in addition to trigger technological devices suitable for RA.

Second Kirner [7], the RA has several configurations, one of them works through recognition of a card with symbol. The software renders the image captured by the camera device and identifies the position of the symbol, then the software provides virtually on screen object based on this positioning, as shown in Figure 2.

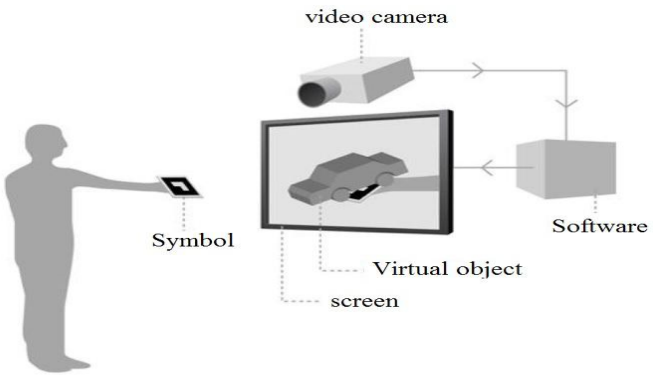


Figure 2: Functioning of Augmented Reality (Adapted [9])

The cards have two-dimensional codes and are responsible for designing the virtual objects in a real-world scenario, with the aim of improving the information displayed, expanding the boundaries of interactivity and even enabling new technologies to be used [9].

AIR environments have a very big potential of development. The successful development of software is measured primarily by the way which is driven [7], to be successful it is important to realize a process of identification and documentation of the needs and purposes of the software, the stage of requirements engineering (RE).

The discipline of requirements engineering aims to identify requirements. The RE is the process to extract, describe, document and validate a software product requirement, through the identification of interested parties [10]. The curriculum of this discipline follows a process proposed by Somerville [14], can be accomplished in 4 stages: (i) feasibility study; (ii) requirements gathering and analysis; (iii) Statement of requirements; (iv) Requirements validation, as shown in Figure 3.

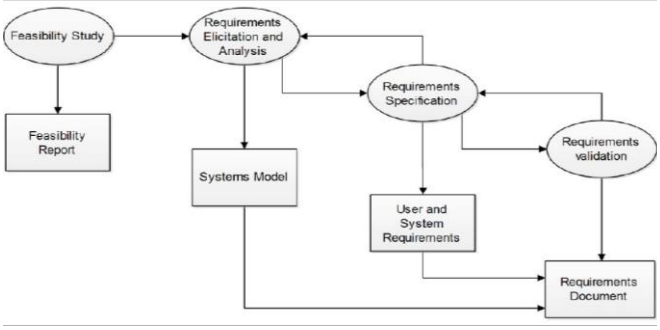


Figure 3: Requirements Engineering Process

In possession of some data, it is possible to identify a gap about RE processes for developing AR scenarios [11]. It is possible to notice that the literature does not support the features of air technology. Since AR is complex and possess specific characteristics of handling, interaction, navigation and selection.

III. The Process

The process was developed to achieve the objective of the work, so the proposed model should be able to perform the intersection of traditional software requirements with specific requirements of AR applications, in addition to the conventional requirements of the environments required in software development.

The development process of specification and analysis of requirements for AR applications is based on two specific actions: the virtual environment and its interface must be adapted to the real environment; and the performance of the scenario, so that the benefits of the use of AR are achieved at the execution speed must be appropriate to the environment.

Seen this distancing between the processes of RE for developing scenarios of AR, it was possible to generate a process of specification and requirements analysis for construction of scenarios of AR. This process (Figure 4) follows an iterative development approach. The main objectives of a process for AR are the participation of users with the virtual environment, so that they can examine and experience the environment and make possible changes and/or improvements; and an easy scenario adaptation and handling. It is important to stress the need to identify the attitudes, behaviors and user needs in order to generate quick prototypes that can be analyzed and evaluated by the user.

The stakeholders in AR project combine IT professionals (coding, image processing) and in many times non-IT professionals (like marketing, design and sound expert for example). For this fact, the interactive incremental development can promote the interaction between them and the mistakes can be solved in early phases of development.

The step from Elicitation of requirements has on purpose to identify and describe the information needs of the virtual environment, involve actions that aim to capture and record the correct understanding of the expectations and needs of the user. The activities contained in this step are: definition of functional requirements, describe explicitly the features and services of the system. Non-functional requirements definition, the function of setting properties and constraints of the system, these requirements are linked to the design phase of the project. Non-functional requirements tend to be more critical than functional requirements. Non-functional requirements are related to aspects of software, hardware and external aspects, must take into consideration the quality factors required by AR scenarios, being some of them: data, environment, usability, lighting, focal length [7]. User requirements should describe functional and non-functional requirements so that they can be understood easily by the user. And finally the definition of specific requirements of air, which has as a characteristic to provide the functions that should be used in scenarios of air.

The step project identifies the input and output technologies and generates a prototype AR scenario. Input technologies are key to AR, such as scenarios, gloves, helmets, goggles, video cameras, markers (colored, among others), in addition to other objects. Output technologies present the information from users, such as Visual devices, earphone, microphone, Visual devices, among others. The definition of hardware and software define the equipment that will be used and can enable integration with any multimedia, considering that at the end of this step a prototype must be delivered to the user, the image to 3D conversion is necessary, this conversion is performed with the help of a specialized editor for the file to be compatible with AR scenarios and hardware and software. The definition of behaviors and interactions should be set out the objects with geometry characteristics, scale, color, texture; the behaviors that these objects can perform; and the interactions necessary for the virtual environment [7].

The Requirements assessment aims to analyze and assess extracted requirements to ensure the quality of the software.

Because it is an iterative process, the generation of prototypes is being successively refined, until reaching an implementation that meets the requirements initially identified.

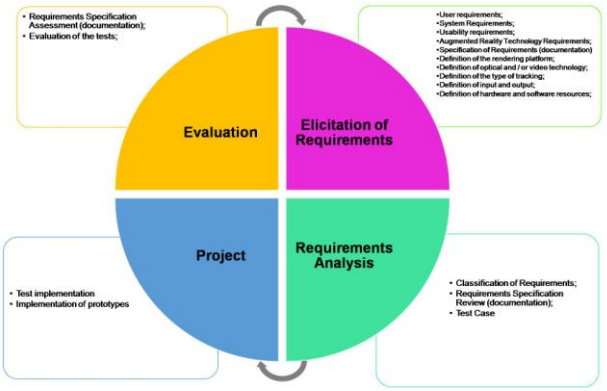


Figure 4: Elicitation, Design and Evaluation process for the development of RA Scenarios

IV. Methods and Procedures

Second Mafra and Tariq [5] proper understanding of a given problem is a fundamental prerequisite for the processing of the same screening, in addition to the experimental application in Software Engineering provides appropriate resources for understanding and recognition between the different variables of a scenario established.

To verify that the process can be used in requirements analysis and specification, an experimental test supported by [5], from a segmented execution plan in the following steps: definition of environment, definition of the Subject, sample Definition and implementation of the experimental test.

The environment used for this work is the academic, with undergraduate students of the course of analysis and systems development of Federal Technological University of Paraná (Cornélio Procópio), with a computer available to each participant.

Each participant must have access to a form of characterization of the entities, in which the objective is to identify the participant as the minimum requirement to participate in the experimental test is studying the discipline of Software engineering.

The choice of sample definition in the Protocol of the experimental test is important because the sampling plan is to assess the importance of the reliability of the results and the tolerance in respect of possible errors involved and aso methods by which errors can be controlled [5]. Given this concept, sample definition characterizes the amount of subjects (in our case, undergraduates who have studied the discipline of Software Engineering). In other words, our non-probability sampling is, because the participants were selected according to the characteristics mentioned previously. 30 participants were selected.

Emphasizing the goal of experimental test to verify that the proposed process can be used in the specification and requirement analysis in air, the RA scenario chosen to perform the test, it is Hypermedia with augmented reality about the animals, a tool of Raryel c. Souza, Claudio Kirner and Tereza g. Kirner, and can be found online at link: http://ckirner.com/flaras2/repositorio/hipermidia-animais/. This application was developed using the authoring tool for authoring applications of augmented reality Raryel Costa Souza, by Claudio Kirner, Hippolytus Douglas France Moreira, the purpose of the application is to provide an interactive and cost-effective way to aid the study of the basic characteristics of some vertebrates and invertebrates [12]. With this concept and execution of the scenario, it was possible to elicitar the requirements of that application of inverse way, which means that the requirements have been specified with the final application, and so be able to describe to the participants what the purpose of the application and how it should be.

The experimental test run aimed to characterize the steps that the researcher will follow to achieve the same. The steps are defined:

1. Having a lab available at the University;

2. Gather the students selected for the experimental test;

3. Ask each student to fill out the Caracteziação form of the participants, containing: name, email, Studied the discipline of Software Engineering, Has experience with AR scenarios. A form template can be accessed on the link https://goo.gl/HpBNce.

4. Deliver the consent form printed for signature, available at https://goo.gl/usWevJ.

5. Present to the students an introduction of RA and the proposal of the specification process and requirements analysis in scenarios of RA;

6. Describe the scene of which should be designed;

7. Ask each student to develop (in a Microsoft Word document) the two phases of the process: Requirements and design specification, except two activities: conversion of images, Creation of 3D elements and implementation of the environment;

8. Ask each student to save your specification and design and send .doc or .PDF to email the person responsible for the experimental test;

9. After sending, each student must Access a quiz with 8 questions and answer them. A template of the questionnaire is available at the address https://goo.gl/iEuU33. Table 1 presents the model questionnaire.

10. Present to the participants the RA application ready; the end product of which was described in the presentation of the scenario (step 5).

11. Compile the results of the project participants have developed in step 6.

12. Evaluate the results from step 6 and step 8.

13. Carry out the assessment of requirements Elicitation phase.

1: Questionnaire

1. Identifying the requirements was an easy task.
2. I was able to identify the Non-functional Requirements

3. I was able to identify the Data Requirements.
4. I was able to identify the Environmental Requirements
5. I was able to identify User Requirements
6. I was able to identify the Usability Requirements

It's worth pointing out that 30 questionnaires were analysed and a total of 240 answers since each student answered a questionnaire with 8 questions. In addition to the experimental test examined only two phases of the project, requirements specification and design.

V. Analysis of the Results

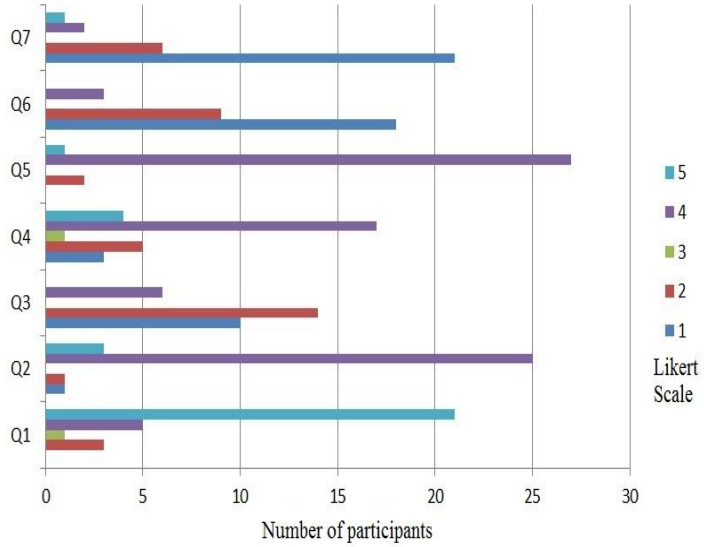
After running the experimental protocol, the authors collected the responses in the questionnaire, 240 and they have tabbed on a worksheet so that the results could be analyzed.

The options of answers to the questions of 1 to 7 that makes up the questionnaire (see table 1) are characterized by Likert scale [15] (1-strongly disagree 2 disagree; 3;-I don't agree or disagree; 4-Agree; 5-I fully agree). The question 8 is characterized for being binary, i.e. two possible answer Yes or no.

By analyzing the chart you can see the subtitles 1 Q1 to Q7, the x-axis represents the issues elaborated by the authors; the y-axis represents the amount of experimental test participants, and the colored columns 1 to 5 scale for each question.

Based on the chart 1, can be say that approximately 86% of the participants considered the requirements specification using the proposed process an easy task. On the other hand the question 3 (Q3) presented the participants ' difficulty in identifying the data requirements, it is believed that this difficulty is given by quality factors required by an application of AR.

Watching the chart 1, on Question 2 (Q2) more than 90% have had ease in identifying the functional and nonfunctional requirements. The question 4 (Q4) 70% agree with ease in identifying environmental requirements, Issue 5 (Q5) introduced a facility to identify user requirements. In dissent to Q5, the 6 Question (Q6) presented a high concordance for not identifying the usability requirements.

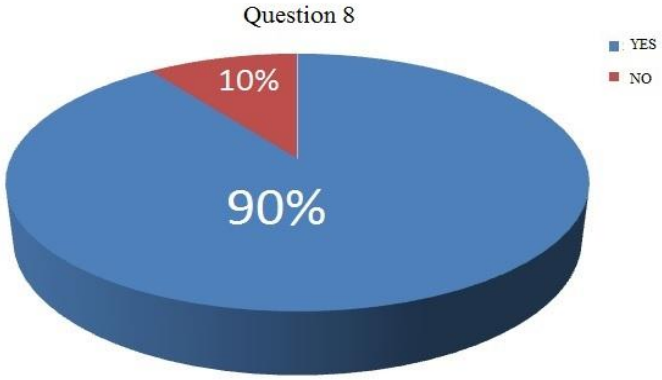


Graphic 1:Average Questionnaire Responses

Finally, and not least the chart 2 displays the question 8 (Q8), where it can be observed that 28 participants (90%) would use again this process for the construction of other scenarios of augmented reality.

Taking into consideration the Likert scale [15], it can be affirmed that the relationship of the Q1 with the Q2 are similar, since most participants agree that they had a facility to identify the functional and nonfunctional requirements.

The Q3 presented a divergence in your result, it is believed that the identification of data requirements was not easy due to not understanding, as these requirements are related to aspects of software, hardware and external factors that determine the conditions or restrictions of AR scenarios.



Graphic 2: Question 8 (Q8) states that 90% of participants use the process again.

Following the same divergence of Q3, Q4 showed a similar result, because the identification of environmental requirements was not considered easy. In virtual scenarios to requirements specification of environment deserves special attention, it must be set to a greater or lesser degree of realism, as the virtual elements will adapt to the real environment [7]. With that, a prior knowledge in RA scenarios would be relevant to elicitar such requirements.

User requirements Q5 were easily identified by most participants, since these requirements must meet the external user needs they tend to be objective about the characteristics of the proposed scenario.

Usability requirements in a scenario of AR (Q6) is an important item in an interface, as a result the success or failure of a software depends on factors such as ease of learning, seen that the identification of these requirements becomes a difficult task in the process of specification [10].

The Q7 has generated new questions, because the majority of the participants disagreed about the difficulty to identify the input and output technologies, so much so that most stated difficulty identifying data requirements. Which leads to the conclusion that there are many problems inherent in the scenarios of RA compared to traditional scenarios [7]. The Q8 identified an acceptance of the proposed process, however the same will undergo improvements and refinement because of the results collected and analyzed.

VI. Conclusions

Augmented reality is an area that offers numerous oportunidadades of scientific research and innovation, as it is an area considered new and offer meet the needs of users [10].

AR is an area of knowledge that offers several opportunities for scientific research and innovation, since it is still considered a technology that is constantly growing, and also to offer users better interactions with the virtual world through intuitive interfaces.

The absence and limitations of guides in the literature guided the need for the development of this research, the work reported the gap found in the process of specification and analysis of requirements in development of AR applications, aggravated by limitations of guides in the literature to assist in this process. It is believed that such a gap directly interferes with the development of an application, whether it is conventional or virtual environments, it is assumed that the benefits obtained during the specification and analysis of requirements should reward in a significant way the satisfactory result of the application, since the activity of specification and requirements analysis to be a critical success or failure factor of project development.

With the study and applications of experimental tests it was possible to develop an approach based on concepts of RE and AR for the process of specification and analysis of requirements for the development of AR applications. It can be adapted by its users and follow from a classic cycle to an iterative cycle, from which prototypes are created, which are evaluated, refined, following specification documentation, in order to obtain the desired final product.

The proposed approach establishes a structured set of activities and techniques that contribute and guide requirements engineers, requirements analysts, developers and others, to obtain a complete and objective specification, analysis and evaluation of the requirements, and iteratively refines them if necessary. required.

The characteristics generated in the activities proposed in the approach can contribute to the construction of both virtual systems and traditional systems, since the approach can be adapted for each specific scenario.

Based on the objectives of the study, the statements contained in this study refer to the literature available, the research methods used, and as a result the publications made during the study development. This work provides a refined theoretical reference on the context of RE in AR applications, which tends to make feasible the construction of knowledge. From the above, the research is expected to contribute to a broader view and understanding of the RE process in AR applications.

And to meet such requirements, it is necessary for user to review prototypes of the software along the steps shown in Figure 4. It is important to highlight the need to assess each specific feature of AR [10].

In this scope, there was a meaningful acceptance of this process among the students who attended the experimental test.

This work presented a process that assists in the specification and analysis of virtual scenario requirements, based on software engineering concepts and the specific characteristics of AR.

The process follows an iterative approach, in which the requirements are specified, evaluated and refined, in order to user satisfaction. It is necessary to identify that this process will not eliminate the requirements analyst contact with the client.

To check the viability of this process, the authors conducted a trial test with the purpose of analyzing whether it would be possible to specify requirements for AR scenarios by following a specific process. The experimental test showed results described in section V.

Among the future works means that there is a need to apply this test in other environments to validate the positive results obtained so far. There are several aspects that may be extended, in order to add new features and improve the performance of applications.

In General, lack and limitation of literature guides guided the need for research in the areas of AR and RE and the adaptation of the process to help undergraduates in the specification and requirement analysis of scenarios of AR.

However, it can be concluded that the proposed process assists in the development of AR scenarios. Therefore, it is necessary that the disciplines of the course of Software Engineering, more precisely the discipline of Requirements Engineering, include the teaching of the development of virtual environments.

There is great potential for growth in this line of research. Evidence of RE in RA applications is still scarce in the literature so far. Thus, it was possible to detect an approach using the ER concepts and evidencing the characteristics of the RA technology satisfactory in the requirements analysis specification for RA.

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