

Review of Augmented Reality Agent in Education

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Abstract—Augmented reality becomes mature enough to create various applications for end users especially in education field. This is also supported by the presence of more affordable smart phones. The features offered by augmented reality applications could make students more easily understand the lessons and the learning process more fun. Most of current augmented reality applications still present information that is always the same from time to time, there is no personalization in order to obtain an appropriate learning experience for each student. Most of the studies concentrate on the aspect of personalization assures that agents approach is needed to make the learning experience more personal and exciting. This paper aims to review the literature concerning augmented reality agents, its earlier and possible usages in educational setting.

Keywords—agents, augmented reality, learning, review

I. INTRODUCTION

Technology has become an important part of our society today and has also changed the way people think and apply knowledge. Augmented reality technology is able to provide a layer of virtual information that may include images, text, video, and audio over interactive real world objects in real time and registered in 3D. Augmented reality can support smooth interaction between real and virtual environments. Augmented reality technology has also gained attention in education because of its ability to bridge the gap and bring more tangible approach to learning experience. Activity of student-centered learning can be improved with augmented reality applications that are able to combine the virtual and real experiences. The learning experience that uses augmented reality will look more realistic, authentic, interesting, fun and can increase learners motivation [1] [2].

Along with the growing of technology, augmented reality agents appear to offer new ways of human computer interaction. In such systems, computers are no longer considered as a complex tool but rather as intelligent companions that help task management and routine operations. The advanced multimodal communication capabilities of augmented reality, which exist in the same physical environment as user, are able to create a rich user interaction [3]. Therefore, the behavior planning of augmented reality agents is an important aspect because it is closely related to the perception of users. This is a complex task because it requires careful consideration and involves many fields of research.

The purpose of this study was to obtain relevant research articles about augmented reality agents in education. In the next section will discuss the background of augmented reality technology and agent in learning, how they are used in a previous study and its potential in the field of education. Our

research method is presented in the following section that discusses the review that has been performed followed by the results section. The discussion section closes the paper with a brief discussion of the research issues on augmented reality agents.

II. METHODOLOGY

To accomplish the objective of this review, numerous electronic databases from the IEEE, the Science Direct and the Google Scholar were used to search for the following combination of keywords: augmented reality, agent in learning, and education. The review covered articles published between 2005 and 2015. From the collected articles above, we only selected publications relating to augmented reality agents in learning and education issues. Finally, comprehensive reading, reviewing, discussions, summarizing and make our conclusions.

III. AUGMENTED REALITY

In the Reality-Virtuality (RV) Continuum by Milgram, augmented reality lies between the real and virtual environment [4]. In the Reality-Virtuality Continuum line, as shown in Figure 1, the augmented reality is close the end of the real environment where perception is dominated by the real environment augmented with the information generated by the computer. Augmented Reality refers to systems that mostly synthetic with some additional images of the real environment to the virtual objects. Augmented Reality and Augmented Virtuality is part of Mixed Reality. Azuma described the three features of augmented reality environment: combined real and virtual objects, interactive in real-time, and registered in 3-dimension [5]. Augmented reality applications can potentially be applied in various practical cases such as marketing, tourism, gaming, entertainment, as well as in education.

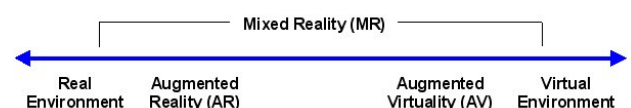


Fig. 1. the Reality-Virtuality (RV) Continuum by Milgram

Augmented reality technology has been found more than 50 years ago, but the use of augmented reality applications for learning is still as far as research in the laboratory. Although it has been quite a lot that has been developed, only a few prototypes were pretty decent and feasibility are also necessary in order to be accepted by users [6]. Research on augmented reality so far mostly concentrated on the development of the

augmented reality technology, for example, various types of display and output devices [7] and algorithms to recognize and to track the real world objects to be combined with the augmented reality technology [8]. Research on the augmented reality has been conducted primarily to evaluate the technical demonstrations augmented reality application, focusing on the study of perception and cognition, the performance of user tasks or aspect relating to other uses [9] or to provide usability guidelines oriented to design [10]. Although many stating the advantages that can be obtained with the implementation of augmented reality, the further implementation requires an understanding of the users perception of this technology. There are some problems with the human factor in the augmented reality applications which are expected to be completely usable and user-friendly [11].

These papers show the example of the possible use of augmented reality in elementary education setting [12] [13] [14], higher education [15] [16], education game [17] [18], cultural heritage [19] [20] and art [21] [22].

IV. AGENTS IN LEARNING

A software agent is a computer program that functions as an agent on behalf of a user or another program, working autonomously and continuously in a particular environment based on a goal [23]. It is inhibited by other processes and agents, but is also able to learn from its experience in functioning in an environment over a long period of time. The ability to communicate and to cooperate are two features of software agents which facilitate a dynamic configuration of the augmented reality application [24]. Some research displays that agents may help make more meaningful learning experiences and outcomes [25], and can be used as learning pal, pedagogical teacher, avatar, etc. [26].

The design augmented reality agents based on the approach that the user only needs to give the well-known objectives, and leaving the resolutions to the software agents. A software agent shows a number of features that make it distinctive from other traditional components, such as adaptation, autonomy, character, collaboration, communication, flexibility, goal-orientation, mobility, self-starting, and temporal continuity.

V. AUGMENTED REALITY AGENTS: PAST RESEARCH RESULT

Research on augmented reality has been running for decades, but the potential and usability in the learning process is still at an early stage. Research on augmented reality mostly about the technological aspects and not the value of pedagogic [27]. However, many of current studies deal with augmented reality agents. In this section, we present a review of literature on augmented reality agents in education. Table I displays a list of selected papers that give attention to the research on augmented reality agent.

According to Barakonyi and Schmalstieg [28], augmented reality agent can attract the user's perception of the state of both the virtual and real world, e.g. virtual agent can plan path to avoid real world obstacles. To prove the use of embodied autonomous agents as key visual interface elements and innovative authoring methods and tools using augmented reality environments, Barakonyi et al. introduced numerous

TABLE I. LIST OF AUGMENTED REALITY AGENTS RESEARCHES

Authors	System	Nature
[3] [28]	Virtual animated person	Virtual character that trying to balance over marker
[3] [28] [29] [30]	AR Lego	AR Lego can avoid collision and can give suggestion to assembly
[3] [28]	MonkeyBridge	Virtual character autonomously plans their path and behavior
[3]	Augmented piano tutor	The AR application serves as a piano teacher
[31]	ARUDesigner	The ARUDesigner help designer to assess design solution in a real workspace
[32]	Virtual animated person	The cooking navigation system
[24]	Information visualization	Communication between the user-agents and the provider agents

augmented reality applications [3] [28] [29] [30], especially the MonkeyBridge show us how the agent can decide how to plan their path. They gained experience how to design visually attractive augmented reality application technically and financially feasible. Agents with autonomous actions reduce the required precise user input to ensure accurate agent operation.

Urban design is conventionally viewed as a highly collaborative activity and its costly nature dictates that error and mistakes could easily induce budget overflow and time waste. The ARUDesigner (augmented reality-based urban designer) system could allow the designers with help of software agent to evaluate design solutions in a real and familiar workspace [31]. Although some technical difficulties introduced negative performance factors on the outcome, but the system have significant potentials in future.

Miyawaki and Sano studying the support systems for human life in the ubiquitous environment, especially on cooking navigation systems. It can recognize the progress of cooking with help of image recognition from cameras and offer appropriate instructions by movie or text. The cooking agent can make the cooking process more enjoyable [32].

VI. POTENTIAL AND CHALLENGES

A. The Educational Benefit

This section presents the advantages the use of augmented reality agent for the learning process. The unique capabilities of augmented reality to display information, almost in any form of media, above virtual real-world environments, the augmented reality offers the potential for a learning process that cannot be achieved by other technologies. The augmented reality application can also support to increase the student skills such as critical thinking, communications, and problem solving, because the augmented reality application is suitable to make an immersive hybrid-learning environment [33]. Students who have difficulty visualizing complex learning concepts can be aided by the ability of augmented reality application that allow students to view the learning content in 3D perspectives. New ideas and experiences that cannot be seen directly in the real world by the students can be better understood by using augmented reality [13] [34] [35]. The

gap between students and knowledge has actually reduced by learning through the uses of augmented reality game in education.

The augmented reality support students to study and to picture new concepts with the simulation of computer-generated objects in real time [35], achieve significantly higher learning understanding [34], and satisfaction [36] than those who learn in the old-fashioned learning system. The augmented reality integration opportunities are increasing with the widespread usage of mobile devices such as smartphone and tablets.

The augmented reality learning environment can increase students level of engagement with course content, especially when they go outdoor for physical exploration [33] [35]. The augmented reality learning environment can also catch students attention and increase students motivation [37]. Students usually motivated on educational games until they find the answer what make them curious.

Registered in 3D is other feature of augmented reality which can support better collaboration in learning process, students were permitted to control the 3D virtual objects with other students or teachers. The augmented reality technology shows an important role in the collaborative learning affectivity that has supported students to reach higher stages of learning efficiency, engagement, and enjoyment.

B. The Challenges

Although the augmented reality based learning system significantly affects the learning process, there are still some negative problems and tasks remain to be answered. The cognitive overload as experienced by students is the most frequently reported issue of the augmented reality implementation during the learning process [33]. Researchers concluded that cognitive overload usually caused when the students get a lot of information, a complex task, and also unfamiliar with the technology. Therefore, it is necessary to improve learning ability and reduce loading problems by designing appropriate scaffolding mechanism and instruction.

Another challenge as reported is the issue of hardware and software. Dunleavy et al. reported that GPS (Global Positioning System) failure experienced within augmented reality application, talks with teachers and students indicated that the most significant weakness when using the augmented reality application is GPS reading error, which caused great dissatisfaction [33]. They believe that with the information technology continues to grow, the issue of GPS reading errors and device stability can be solved soon. Another problem found during the review process was at the time of implementation, some teachers feel confusion to ensure the process of implementation of augmented reality applications will not be experiencing technical difficulties. The user also find it hard to display and to explore the virtual registered 3D contents of augmented reality on smartphones [38] because of the limitation of the screen.

Currently, implementation of augmented reality in education field still limited to certain user group, most of the applications of augmented reality in education field have not been able to adapt the information presented according to the users who digest it. Users do not have same intelligence background, therefore it is necessary to design applications

which is able to adapt the information correspond to the users need, or known as personalization. Personalization of augmented reality in education can be achieved by implementing agents. Barakonyi et al. show us the potential implementation augmented reality agents in game domain [29], the virtual character able to plan their path and behavior. This condition proves that implementation of augmented reality agents in education also an interesting field for research.

VII. CONCLUSION

There are advantages and challenges in the implementation of augmented reality agent in the learning process. We believe that the potential of augmented reality agent will continue to grow and be known, especially among researchers in the field of education. By using appropriate educational strategies, augmented reality agent capable of providing a range of benefits and effective learning experience for students. This review is expected to help understand the role of augmented reality agent in the learning process. Augmented reality agent in the learning process shows positive effects, the result has been demonstrated in the form of motivation, learning performance, engagement, and collaboration. A new opportunities in order to create a learning experience that is more attractive and interactive been supported by augmented reality technology agent. Further research and investigation is needed to overcome the shortcomings and improve augmented reality agent in an educational setting.

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