A Review on Collaborative Learning Environment across Virtual and Augmented Reality Technology

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A Review on Collaborative Learning Environment across Virtual and Augmented Reality Technology

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Abstract. Collaborative Learning Environment (CLE) in various application settings are presented and describe in this paper. CLE focuses on facilitating learning process through collaboration task. This paper reviews the numerous Augmented Reality (AR) and Virtual Reality (VR) technology that adopt collaborative system. It provides for an insight view of the capabilities of collaborative learning through the adoption of collaborative system in AR and VR. The adoption perspective define the cruciality to adopt collaborative in AR and VR in order to support learning process of the user of the respective task in a specific subject domain.

1. Introduction

Augmented Reality (AR) is merging real and virtual objects together into its own setting and it be known as a technology that has the ability to superimpose or overlay virtual objects onto our real world in real time. Virtual Reality (VR) on the other hand is typically referred as a fully immersive computing technology that enables user to interact with digital workspace in a unique way [1]. VR technology focus on replacing the reality with a complete virtual environment. In order to manipulate the virtual content in both AR and VR workspace, a suitable interaction metaphor is needed.

As stated in [2], AR interaction needs to deliver its own way when it means to use the real objects to manipulate virtual objects. Interaction is one of research topic in VR and AR research as claimed in [3]. Moving from only a single user interaction recently looking forward to invite more than one user to manipulate virtual objects in real-time, the researcher and developer aims to support the idea of a collaborative environment. Over the last ten years, where designing user interfaces only focus on a single user at a time, an increasing number of paper focus on potential collaborative scenario arise [4].

The growing advancement of emerging technologies increase the potential of innovative environment that can promote and facilitate learning. The ability to create an immersive educational experience can be achieve through the adaptation of VR, AR and Mixed Reality (MR) in a various type of learning environments [5]. The ability to adapt multi-user interaction in the learning environment scaffolding the concept of Collaborative Learning Environment (CLE). Implementation of multi-user interaction promotes CLE with encouragement for creative learning technique that involves user collaboration on specific task of a particular subject domain. Subsequently, in CLE users are able to collaboratively interact with multi-user in a single shared space context [6].

2. Collaborative Learning Environment (CLE)

CLE is a virtual environment that allows learning process to happen where learners engage in a common task where each individual depends on and is accountable to each other. The following subsections discuss the features and interaction in CLE.

2.1 Features of CLE

As AR and VR technology allow user to interact with virtual content either 2D or 3D data, it can simply provide a collaborative interactive environment [7]. Users able to work towards specific task in CLE through the presence of 3D interaction to execute face-to-face and remote collaboration, support of virtual object manipulation and the ability to merge the reality and virtuality smoothly.

CLE invites multiple user to share the virtual working space with other users to their own working environment in AR/VR. There are five features included in collaborative environment [7]. The features as stated in [7] that can be apply in CLE are virtuality, augmentation, multi-user, independence, and individuality. Virtuality define as object that have the potential of being viewed or examined, either do not exist or unreachable in physical spaces can be projected as a virtual content in either AR or VR domain. Augmentation in CLE allows a smooth transition between real and virtual assets in delivering the task and purpose.

In order for collaboration to happen, multi-user features are essential to support the collaborative task in CLE. Multi-user allows users to perform discussion together or other cooperative task on collaboration. Higher intuitiveness among multi-user viably collaborates with themselves utilizing typical feeling of human associations, as verbal and gestures as AR and VR support this type of interaction. User independence authorize user to have control over its own independent viewpoint and interaction without interrupting other users action. The individuality of virtual content projected are shared among all users where they can observe the same exact virtual content, in a consistent manner of visibility.

2.2 3D Interaction in CLE.

3D Interaction are human-computer interaction where task are carried out by user in a 3D spatial context. It requires a 3D or 2D input devices that later were mapped into 3D. The use of metaphors is very essential for providing user a context of way for them to interact with virtual content. Interaction in CLE virtual environment are driven by the interface design to something the user are already familiar with. Metaphors employ user knowledge and help transitioning abstract concept more concrete. User familiarity with the kind of user interfaces that users used to, can convey a better understanding on how the system should work.

3D user interfaces that is effective for collaborative environment should take account the perceptual, cognitive, and social issue. Collaborative interface is beneficial as it provides individual users the perspective of the same shared workspace [8]. This can definitely enhance the user experience in CLE and increase the learning process while user collaboratively work towards the same shared task. Typical 3D interaction are relatively common in AR or VR domain. User perform the interaction through their understanding of the user interface to select and manipulate the properties of the virtual content.

3. Collaborative in AR and VR

AR and VR are well known technology that adopt collaborative as a medium of interaction that allow multiple user to collaboratively work on specific task. Learning process able to happen through collaboration of multiple user that work together in search for understanding, meaning, solution or product of the learning. Table 1 presents the papers ranging from year 2016 to 2018 that adopt collaborative concept on the respective domain and type of collaboration. The collaborative concept applies on various application setting that includes medical, engineering, education and more.

Table 1. Collaborative in AR/VR and Collaboration form.

Year	Research works	Domain		Collaboration Form	
		AR	VR	Co-located	Remote
2018	Collaborative Virtual Reality for Low-latency Interaction [11]		✓	✓	✓
2018	BoatAR: Multi-user Augmented Reality Platform for Boat [9]	✓		✓	
2018	Couples Designing their Living Room Together: A Study with Collaborative Handheld Augmented Reality [10]	✓		✓	
2018	SimCEC: A Collaborative VR-Based Simulator for Surgical Teamwork Education [12]		✓	✓	✓
2018	Emotion Sharing and Augmentation in Cooperative Virtual Reality Games [13]		✓	✓	✓
2017	CoVAR: A Collaborative Virtual and Augmented Reality System for Remote Collaboration [16]	✓	✓		✓
2017	Collaborative VR Painting in Web Browsers [14]		✓	✓	
2017	Remote Collaboration in AR and VR using Virtual Replicas [17]	✓	✓		✓
2016	Interactive Augmented Reality: A New Approach for Collaborative Learning [6]	✓			✓
2016	MedicalVR: Towards Medical Remote Collaboration using Virtual Reality [15]		✓		✓

Collaboration system is no longer a foreign matter in AR and VR domain. Table 1 shows 3 papers that implement collaborative system in AR domain [9, 10, 6], 5 papers in VR domain [11, 12, 13, 14, 15] and 2 papers that adopt both AR and VR domain [16, 17]. The table also present a number of 3 papers with co-located type of collaboration [9, 10, 14], 4 papers with remote collaboration [16, 17, 6, 15], and 3 papers that support both co-located and remote collaboration [11, 12, 13]. Among the various papers reviewed, there are several papers that apply the collaborative system in medical field settings. The VR simulator that aim to assist human motor rehabilitation in [11] focus on the CLE between therapist and patient respectively. Basic surgical routines of VR simulator in [12] considers task performed individually and collaboratively among a team of undergraduate students. MedicalVR as in [15] collaboratively shared the recorded digital breast imaging data to the possible remote collaborator in VR through network. The collaboration among users in the applied application settings allows information exchange hence establish a learning process.

In addition, three of the reviewed papers, [9, 10, 14] presents their applied application settings under the design and configuration theme. An AR boat configuration system [9] that allows multi-user to interact with the boat component in same shared space. The interior design AR application [10] allows two user to collaboratively design their living room through the virtual workspace. Multi-A-Painter [14] a multi-user VR collaborative system that works on a browser that supports WebGL and WebVR. Users in the same session work collaboratively design an empty space into a new virtual world give a sense of shared space. Knowledge and information transfer between users when exchanging roles promotes the establishment of CLE. On the other hand, two reviewed papers [13, 16], both focus to incorporate other input modalities such as facial expression and eye gaze tracking to increase social engagement and support collaboration awareness among users in collaborative environment. Higher level of social engagement are believe to benefit numbers of application such as education where collaborative learning can be establish [13]. The AR and VR collaborative system in [17] allows remote collaborator to work together with the local user in AR using virtual replicas

representation. Remote user able to control the virtual replicas to refer parts of an aircraft engine combustion chamber. This approach are appropriate for training purposes. 3D Jigsaw AR puzzle application [6] allow users to collaboratively work together to complete the puzzle. The work aim to use the AR technology in order to establish collaborative learning. The users work in a different physical space but in the same network.

4. Conclusion

AR and VR as a mature technology able to adopt collaborative system in various application setting that can allow multiple user to work together working on a single shared space and task. The collaborative manner in the system allow learning process to happen when each user capitalize on one another's resources and skills. Knowledge created through collaborative learning are within populated members who are actively sharing experience and play asymmetric roles. Collaborative learning allows the others learn new things, understand clearly of certain task or able to make something faster through help of expertise [6]. Based on various paper of collaborative in AR and VR, it clearly shows that collaborative system applied in the technology can facilitate learning through various occasion and environment setting either in learning [6], art [14], medical [11, 12, 15], engineering [17], interior design [10] and conventional industry [9]. CLE should able to provide users with the product of the knowledge they gain through the collaborative task performed in either AR or VR environment.

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