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THE DEVELOPMENT OF CLOUD-BASED AUGMENTED REALITY SYSTEM FOR SMART LEARNING APPLICATIONS

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Abstract

The emergence of augmented reality (AR) technology has gained a large amount of attention in the Industry 4.0. AR App design is a new methodology in training and learning. We proposed the cloud-based AR App and machine learning in smartphone. The objective of this research is to develop cloud-based AR system for interactive AR training and machine vision applications. We adapt cloud service APIs, ARkit design method and machine vision in this research. First, we implement the cloud-based AR App using ARkit and cloud APIs. We build AR solar cell panel inspection App using machine vision algorithms. The research results demonstrate the effectiveness of proposal cloud-based AR system. In conclusion, the proposal AR system and machine learning could provide innovative framework in Industry 4.0 applications. Research results also could be useful for AR researches in user interactions and simulations.

Keywords: Technology, Augmented Reality (AR), Cloud Services, Multimedia Design, Smart Learning Applications, Machine Learning

Introduction

In recent years, a rapid development of AR technology creates core values for industry innovative in Taiwan. The major high tech companies have already invested in VR/AR business, such as Google, Apple, Amazon and Microsoft. As "5+2" industrial innovation in Taiwan, AR technology and cloud services could enhance industrial competitiveness. From perspective of AR development, multimedia design can be enhanced on AR design and user interaction. From point of view of industry innovation, AR industry could assist economic development and increase venture capital.

AR App design is a new driver in learning applications. Smart learning is structured around two main components of interactive AR and cloud services using smartphone. The objective of this research is to develop the cloud-based augmented reality design system for smart training and learning. We adapt three key technologies such as semantic web service, interactive AR method and machine vision algorithms in this research.

The AR smart glasses with cloud services would be useful in smart learning applications. We adapt AR/VR for student game courses and projects exhibition. From 2015 to 2018, we successfully create three courses, such as 3D game design, Innovation management, Simulation science and honorably received awards and research projects from Ministry of Education. From our student assessments, they could achieve better learning outcomes from AR projects and Apps development. The courses improve student's ability to understand AR method for industry projects.

This paper is organized as follows: we present the cloud-based AR system architecture and implementation in Section 2, and we implement AR Apps for smart learning and machine learning applications in Section 3. We discuss the AR Apps and experiments results in Section 4 and conclude the AR methodology in multimedia design and future research in the final section.

Research Background and Motives

In the age of Industry 4.0, computer vision is applied to product manuals and instructions, in particular exploiting AR immersive technology. Michael Porter (2017) published one important article about a manager guide about AR technology in Harvard Business Review, and he defined why every organization needs an AR strategy. There is a fundamental disconnect between the wealth of digital data available to us and the physical world in which we apply it. The research results received a great response and attention from industry and academy.

Suen (2015) proposed the interactive content sharing method for classroom platform. Using above research results, Suen (2016) created three courses focus on learning courseware Apps using AR methodology. This approach is significantly superior to those classes using traditional methodology.

Scurati (2018) proposed a controlled and exhaustive vocabulary of graphical symbols, to be used in AR to represent maintenance instructions. The research result shown that the most frequent maintenance actions used in user manuals and converted them into graphical symbols successfully. Chen (2018) demonstrated an interactive teaching system that uses mobile augmented reality to improve the learning efficiency of a mechanical drawing course. Frydenberg (2017) proposed a project-based and collaborative learning approach in undergraduate level course, students communicate, research, develop together with the main goal to improve their digital literacy skills. Students create the AR-based 3D content and better understand the impact of this new technology and its business applications. Valentini (2018) integrated force feedback into an AR environment to perform real-time morphing of geometrical surfaces with design tasks. The project objective was to give the designer a computer-aided design tool that allows for the modification of a component shape directly touching its virtual representation. In AR App and design process, the force feedback could be useful in 3D modeling and game objects collision condition.

Blanco (2018) reviewed AR applications for shipbuilding and smart manufacturing. In their research, they described AR design system, which is based on a fog-computing architecture. Further the use of three AR devices (a smartphone, a tablet, and a pair of smart glasses), two AR software development kits was described. The results shown a remarkable performance differences among the different AR tools and the impact of factors like lighting, pointing out the best combinations of markers, and hardware and software to be used depending on the shipyard scenario.

Cloud-based AR system and methodology

We adapt cloud-based AR system to learning courseware and AR industry Apps. AR is the combination of digital content and human 3D input in real-time space. In our design App, we use smartphone to display 3D models in real scene. The Pokémon Go game (2016) successfully got attentions in game industry. This innovative idea also got great feedback from students in Taiwan. As AR tech growing, the 3D graphic has accelerated the industry path in AR ecosystem. Apple recently entering the AR business with release of ARKit for iOS and Google's release of ARCore SDK for Android in 2017. Porter (2017) described the effects of AR already be seen across the value chain and organization strategy globally. By combining the strength of human and machine, AR will dramatically increase value creation.

In our cloud-based AR design method, first we focus on marker-less AR design method. In learning process, we successfully use e-Learning services (for example, Moodle Web and e-Profile Web), in combination with AR Apps. Students use 3D models to build AR contents using 3D Max / Maya software. Students export the 3D models into FBX file format with 3D mesh and texture images. Our study found the combination of the personalized learning and AR APP produce better learning processes. We are very glad that our students could benefit from AR courses and could startup their AR/VR business. From 2016 to 2018, we realized AR/VR is an emerging technology that complements the student perception of the world around them.

AR game design metrics are particularly useful to AR learning research. These game data provide opportunity to address key questions, whether any AR scene are underused, if players utilize game features as intended, or whether there are any barriers hindering player progression. This kind of AR game metrics can be recorded during all phases of AR apps development in Chen (2017), Matsas (2017), Drachen (2011) and Lameman (2010) related researches.

The objective of this research is to develop cloud-based AR system for content creation and machine vision applications. Figure 1 shows the flowchart of proposed AR system method.

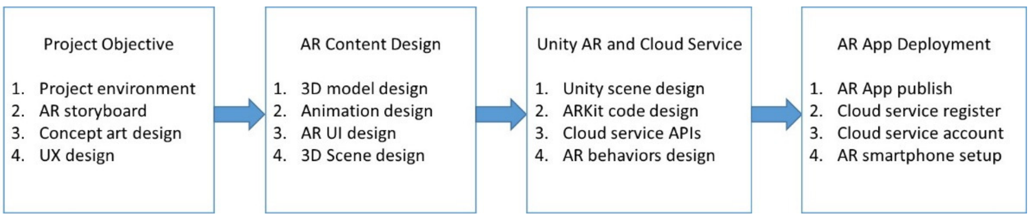

Figure 1. The cloud-based AR system design method

We implement AR learning App that supports the interaction process through smartphone and cloud services. With Moodle web and smartphone, we could create AR Apps for the following objectives:

Objective 1: AR game content courseware

Objective 2: 3D model design and art design
Objective 3: Cloud services for AR Contents
Objective 4: AR live steam demo

In our AR App implementation, we first create a new project in Unity3D environment, and we could import AR unity package, such as Vuforia or ARToolkit, into project. In our AR courseware, we could build a game scene with the camera, image recognition, and virtual object. Using our AR App, students could apply the Unity AR-ready scene for their projects.

Step 1: First, we design main camera with SDK-specific AR components attached.
Step 2: AR objects representing an image target, with the specific component identifying the AR image to use and where to find image marking.
Step 3: AR objects to render when mark target is recognized at Unity3D, parented by the target, and registered to the target's position in the AR scene.
Step 4: AR scene hierarchy, arranged according to the requirements of student projects and art design.

We use AR App for student term project demo. In AR course materials, we provide graphic cards with AR markers, student could explore AR scene with cards. We also show students a marker-less version that support spatial mapping method. Students should be able to design AR app for their projects. Recently, we could use holographic AR device, such as Microsoft HoloLens (2018), to scan environment and map its 3D space.

AR system implementation and discussion

The AR-based courses were taught to 210 students from 2016 to 2018 at I-Shou university, and our AR Apps are successfully added in cloud server. In particular, students can use cloud server for upload/download 3D contents. The course questionnaires are used for collecting quantitative data, and the answers to the hand-on projects defined in AR Apps. The goal of AR apps is to create good AR user experiences.

We implement cloud-based AR Apps using Unity3D game engine and cloud service APIs. With proposal AR method, we could create 3D contents and projects as shown in Figure 2. Students also could demo their term AR project using AR Apps.

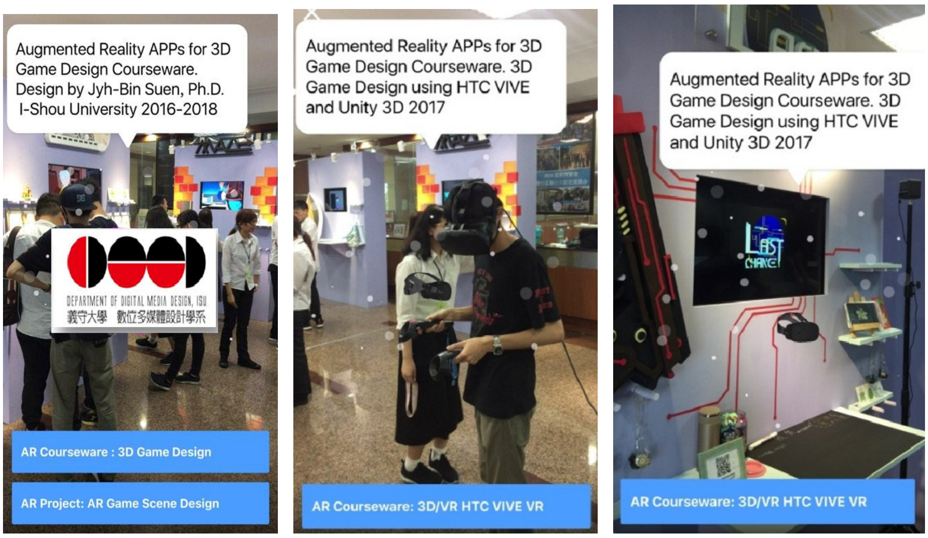

Figure 2. The cloud-based AR App for courseware applications

Within proposal AR App method, we also design a solarcell panel inspection application using machine vision algorithm, as shown in Figure 3.

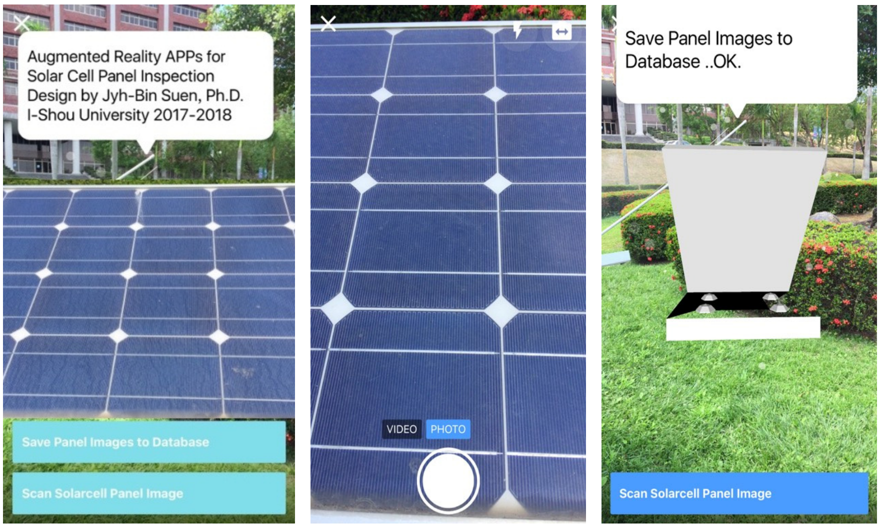

Figure 3. The cloud-based AR App for solarcell panel inspection applications

Recently, global research in the field of machine intelligence is seeing a rapid growing. Several conceptual breakthroughs in neural networks and access to powerful smart devices have led to AI applications that can process information in a human thinking. AlphaZero (2017), the AI software created by

Google DeepMind, has beaten the world's best chess-playing computer program, having taught itself how to play chess. In our machine learning implementation, we use TensorFlow library to design AR application. TensorFlow is an open source software library for high performance computation toolkit. TensorFlow design architecture allows us to deploy our AR Apps and machine learning projects. In our research project, we successfully create machine learning AR APPs, students could train neural networks in AR applications and run trained models in inference mode, as shown in Figure 4.

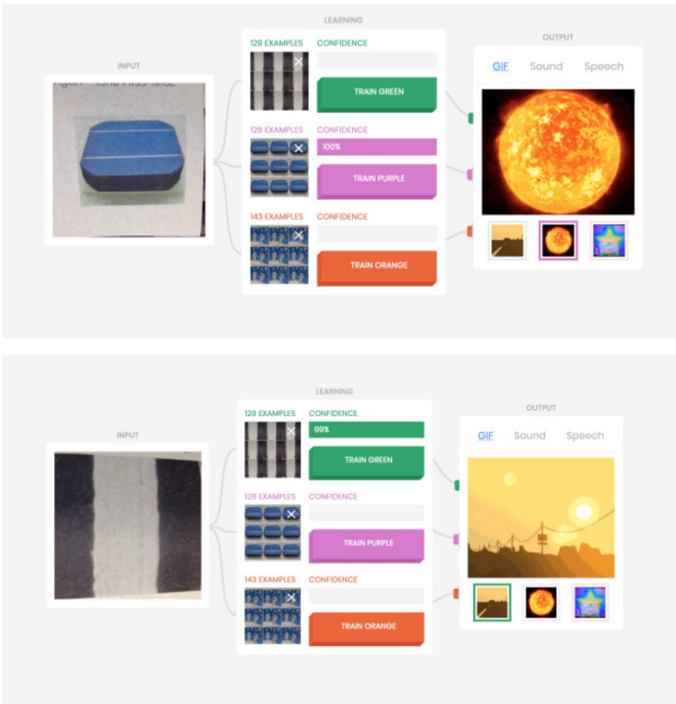

Figure 4. The cloud-based AR App using TensorFlow toolkit

The research results would be summarized as below: (1) We first developed the cloud-based AR system method using ARkit and cloud service. (2) The proposed AR App could use to create 3D contents and scenes for industry applications. (3) We shown three AR projects using our proposal AR method.

Conclusion

The objective of this research is to develop cloud-based AR system for interactive AR training and machine vision applications. We adapt cloud service APIs, cloud-based AR method and machine vision in this research. Our research results could be applied generally to a wide variety of augmented reality industry applications. The AR developers willing to add new features to their AR App should consider the results that users tended to focus mainly on the AR core features. Also, we provide the real-world AR projects could be useful in developing the cloud-based AR system.

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