Impact of Incorporating Virtual Reality into Information Security Forensic Teaching Activities on Learning Motivation

Wei-ming Ma
Department of Information Management, Cheng Shiu University, Taiwan, R.O.C.
Email: k3666@gcloud.csu.edu.tw

Abstract

From the 2016 Pokémon game to the world's madness, we are excited about the development of augmented reality and virtual reality, but the virtual reality takes longer to become mainstream, because it requires specialized viewing equipment. And we are more interested in the mobile augmented reality, because the equipment required is ubiquitous, and the user experience and return on investment are high. This research is based on the virtual reality to build the information security forensic practice teaching mode, the use of virtual reality technology to develop information security forensics laboratory on the computer, simulation of computer forensics practice virtual situation, such as: assembly of computers, computer forensics process, identification other computer devices and connectors allowing students to learn, research, explore, and experience a stable information security forensic teaching structure in an immersive environment. After the first semester of practical teaching in 2018, it was proved that virtual reality technology was interactive, immersive and perceptive. Compared with other teaching activities, it could make learners have a deep sense of presence and improve learners' learning motivation and enhance learning performance. The business model of augmenting reality and virtual reality is not yet mature. We expect their demand and effective use in the education market to establish a new successful business model.

Keywords: Virtual reality, augmented reality, information security, forensics, virtual lab
I. Introduction

Information Security Forensics is one of an important subject of information security courses. The study developed teaching materials for a new Information Security Forensics course founded by Information Security Talents Cultivation Plan and new style information security practice demonstration course, Ministry of Education. The purpose of the course is to reach the goal of establishing industrial-professional security and cross-functional important information security skills and the key points for implementation, combined with the teaching energy of the colleges and universities, training the practical security and talents to enhance the energy of practical teaching.

The practice-orientated information security forensics teaching materials include 18 module. It plans 80 minutes lecture and 70 minutes practice for 3 credits and 3 hours course. The practice laboratories are also design for the students to have hand-on experience in the teaching activities to achieve students’ information security forensics knowledge and skill.

In general, information security forensics laboratory is required to be certified by the Taiwan Accreditation Foundation to perform digital forensics tasks. In the promotion of information security forensics courses, It was found that all partner schools lacked computer forensic laboratories. Only theoretical explanations can be made in teaching. Learners are less able to appreciate the information security forensic laboratory equipment and its importance. The purpose of this research is to develop an information security forensics virtual laboratory applied to practice laboratories in class activities to increase the learning motivation, and then the result is compared to other activities.

II. Literature Review

In this section, the previous study related to virtual reality and augmented reality apply to education, and virtual reality and augmented reality software to make an Information Security forensics virtual lab (ISFVL) are briefly described.

1. Virtual reality and augmented reality apply to education

Tsai (2008) study aims to establish a man-machine interaction teaching platform of geographic information through the integration of virtual reality (VR) and geographic information systems based on the cultural and natural environment of Tamsui town in Taipei County. Then we proceed to a series of tests and interviews with 76 social studies teachers in elementary and junior high schools, and the result shows that the system could bring a distinct improvement in traditional geography teaching.

Weissblueth and Nissim (2018) found that VR learning environments helped student teachers increase their social and emotional involvement in learning and enabled them to become more innovative and creative as they harnessed the powers of VR. VR challenges learners with active teaching and learning and transforms student teachers into active participants who create and innovate.

Piromchai (2014) studied VR has been introduced to the medical field and used in medical education as an alternative high-fidelity simulator. The major contributions are the ability to provide repetitive practice under controlled environment, self-directed learning and proved construct validity. Shieh et al. (2017) built full-mouth VR models based on real clinical cases to create a learning environment with opportunities for repeated practice by the students before they proceed to clinical dentistry. The VR-incorporated teaching plan for clinical dentistry can enhance student learning interests and outcomes by offering vivid 3D environment and real-time interaction in dental education. Thus, the proposed teaching plan is proven to be a favorable approach for students learning how to diagnose oral diseases, perform examinations, and design treatment regimens.

Yanovich and Ronen (2015) studied the use of VR technology as a means of demonstrating and learning motor abilities in many types of populations and situations. VR can be an effective means of teaching and training basic motor skills, sometimes even superior to “real-life” because of the highly
modifiable environment and difficulty in the comfort of one’s clinic or home.

Huang et al. (2012) attempted to build a collaborative VR learning system (CVRLS) for medical education with a multi-user, cross-platform collaborative virtual learning environment. The learners and instructors were able to perform collaborative learning and engage in group discussions regardless of their locations and types of computer systems.

Tao and Chuang (2017) combined motion sensing and VR technology to build a virtual learning environment to support game-based learning activities at elementary school. Their results reveal that the positive impact of motion sensing technology on engagement in learning activities, and enhance the learning performance. Chen et al. (2013) developed the gear instructional module using augmented reality (AR) for learning indigenous culture. The trial teaching and observational records from the instructional activity were used to show that the developed module can promote the student's learning interest and the learning motivation. Hsieh, et al. (2012), applied AR technology to APP which can bring some education and entertainment features for kids under five to eight ages. Through this project, kids can learn the culture, food, flag and other information about different countries.

2. VR and AR software
   (1) Unity 3D: is a comprehensive creative game engine that is positioned in 3D video games, architectural visualization, social and communication, e-commerce, 3D animation and other types of interactive digital content (Sinicki, 2017; Merel, 2017).
   (2) Unreal Engine: The Unreal Engine provides a world of fantasy, as well as building teams, building resources, building workflows, and tools. Under the new project of Unreal Engine, we can choose the VR template of the blueprint to quickly build a VR project, and create authentic and immersive content, AR, VR and mixed reality content to render complex scenes with extremely high number of frames. The Unreal Engine is designed for high-end applications such as 3A-level games, movie production, and realistic visualization applications (McCaffrey, 2017).
   (3) iClone: is an instant 3D animation software. iClone 7 integrates real-time effects technology, including scene design, character creation, animation, and movie narrative, giving the most user-friendly environment and simplifying the 3D production process. iClone 7 animation process can seamlessly integrate with all 3D software and game engines of the industry standard, such as Unity and Blender, and can be applied in virtual implementation, movie, interactive media creation (Liu and Wu, 2017).
   (4) 3ds Max: Easy to create 3D objects for Unity development scenarios.
   (5) CoSpaces: Students can create any 3D object, add animation code, and explore immersive digital content. From informational pictures to virtual displays, social science is built through project-based learning and creativity (CoSpaces, 2018).
   (6) Leverage the power of ARCore, Google's new AR platform, to create state-of-the-art AR applications, using ARCore learning environment understanding, immersive computing and motion tracking core concepts, and through ARCore and OpenGL, machine learning, etc. combine to extend AR applications. Digital assets, use 3D/VR/AR creativity, creativity and understanding, teamwork. Course management, collaboration, space galleries and examples (Glover, 2018).
   (7) Mystycraft (2018) also known as 101 Creative World: It is an application software developed by the mainland China international network dragon. It has the style of Chinese culture. It has beautiful picture quality during playback. It is easy to operate in a modular block mode. The 3D model is complete and it is very easy to get started. Application software. However, the server is set in the mainland China or Hong Kong, and the connection speed is delayed.

III. Information security forensics virtual lab development

The Information Security Forensic Virtual Laboratory (ISFVL) is a designated location for computer surveys of collected evidence. The laboratory houses the instruments, software and hardware required for the investigation, suspicious media and forensic workstations. The universal modelling language (UML)
methodology were used to analysis and design the ISFVL as the follows.

(1) Requirement analysis

Refer to the EC-Council (2017) and myself teaching experience the ISFVL requirements are:

a. Environmental requirements: Proper room size; good ventilation and air conditioning; ceilings, walls, floors, etc. help to identify the laboratory atmosphere. Considering the atmosphere of the computer forensic laboratory, ergonomics, lighting, room temperature and communication are an important factor.
b. Communication requirements: exclusive Internet and communication lines, multiple backup lines for communication lines in case of emergency, dedicated network.
c. Power requirements: good power supply, emergency power supply and lighting system.
d. Security requirements:
   (a) Forensic laboratory should have only one entrance, and all windows should be closed.
   (b) Register should be maintained containing details such as the visitor’s name, date and time, purpose and address.
   (c) A visitor identification certificate should be provided to make it easy to distinguish between laboratory staff and assign personnel to guide.
   (d) All visitors’ electronic login logs should be maintained.
   (e) Multi-layered intrusion alarm system should be installed in the laboratory.
   (f) Guards should be deployed in the forensic laboratory.
   (g) The camera should be placed in and around the laboratory to monitor personnel actions.
   (h) Water fire protection system and gas fire protection system are ready.

(2) Use case diagram for ISFVL

Visual Paradigm Enterprise version 15.2 has been used to draw ISFVL’s UML Use Case Diagram. Use cases are Manage ISFVL, Enter ISFVL, Assembly PC, Acquire Data from Hacked PC, Identify Connectors, as shown in Figure 1:

![UML Use Case Diagram](image_url)

**Figure 1. Use case diagram for the ISFVL**

Complete a practical course teaching environment design manual, including: CDX Kali Linux digital forensics environment, Windows operating system digital forensics environment, Mac operating system digital forensics environment, Android mobile device digital forensics environment and other four different operating system environments.
(3) Sequence diagram for ISFVL

User is outside environment, the HTC Vive Headset, ISFLV security Door, computer devices, assembly PC, Hacked PC, Forensics PC, RJ45 connector, Other connectors are classes’ activity. The user wears the headset then start the game. Five tasks should be finished in order. The 5 tasks are briefly described as the follows:

(1) Task 1: User teleports to location 1, grabs access card going to ISFVL, finish task 1.
(2) Task 2: User teleports to location 2, grabs any computer devices to the correct location in the computer case until all the devices on the right location and finish task 2.
(3) Task 3: User teleports to location 3, unplug the network connector, grabs the mobile disk drive, perform bit by bit stream backup the data from hacked PC, finish task 3.
(4) Task 4: Teleports to location 4, arrange the colored-wire order, and finish task 4.
(5) Task 5: User teleports to location 5, point at the different connectors to read the information, finish task 5, and leave the ISFVL, is shown in Figure 2:

![Activity diagram for ISFVL](image)

**Figure 2. Activity diagram for ISFVL**

(4) Practice ISFVL

The play the simulation game the HTC Vive VR Headset device, Execution Environment PC with GeForce GTX, Cloud can be deployed on a PC connecting to the Unity Assets and Steam VR cloud service. Finishing simulated three scenarios, the students can familiarize him/her-self with the computer digital forensics laboratory devices which can be used in digital forensics, computer introduction, network introduction and other courses, as shown in Figure 3:

![Student applying HTC Vive ISFVL](image)

**Figure 3. Student is applying the HTC Vive ISFVL**
IV. Learning motivation

1. Practical teaching activities for information security forensics courses

The information security forensics was given to 39 seniors in undergraduate of MIS. The network and information security special topic was given to 6 freshmen in a master's program of MIS. The 6 practical activities coordinate with the course modules for undergraduates, and the forensics investigation process, the evidence extraction and analysis on the Cyber Defense Exercise (CDX) platform at National Center for High-Performance Computing designed in a closed network forensic implementation environment, as shown in Table 1:

Table 1. Practical activities of the forensics course in the first semester in 2018

<table>
<thead>
<tr>
<th>Date</th>
<th>Teaching activity</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep, 18, 2018</td>
<td>Forensics Investigation Process</td>
<td>Learn correct forensics investigation processes</td>
</tr>
<tr>
<td>Sep. 25, 2018</td>
<td>Evidence extraction and analysis on CDX platform</td>
<td>Apply autopsy to evidence extraction and analysis</td>
</tr>
<tr>
<td>Oct. 16, 2018</td>
<td>Raspberry Network forensics</td>
<td>Hand on experience, collaborate teaching by professional manager</td>
</tr>
<tr>
<td>Oct. 17, 2018</td>
<td>Field Trip to Tainan division of National Center for High-Performance Computing</td>
<td>Visit the national information security center and know advanced technology</td>
</tr>
<tr>
<td>Dec. 11, 2018</td>
<td>Database forensics</td>
<td>The electronical page was used to practice the database transaction log.</td>
</tr>
<tr>
<td>Dec. 18, 2018</td>
<td>Catch The Flag (CTF)</td>
<td>Apply information security skill to solve real problems</td>
</tr>
</tbody>
</table>

2. Student learning feedback

Learning Motivation Questionnaire designed by Guay et al., (2000) was used to get students’ feedback. Items are scored on a 7-point Likert scale, 1: not at all in agreement to 7: completely in agreement. There are 4 items per subscale and thus a total of 16 items. Each item represents a possible reason for going to school. The questionnaires were dispatched to the undergraduate 38 students and 6 graduates after 6 activities. The analysis result, as shown in Figure 4:
From Figure 4, the comparison of the ISFVL teaching activities with the other five activities can indeed enhance the learner motivation. It may be that at the beginning of the semester, the information security forensics program is a basic course, relatively simple, and the learner's learning motivation is very high. ISFVL can experience a pleasant immersive learning experience. In other teaching activities, especially at the end of the period, the CTF is problem-oriented learning. It is necessary to integrate the knowledge of information security and digital forensics learned in this semester. The difficulty is high, and the students are faced with difficult problems and uncertainty. Therefore, the motivation for learning has generally declined. In the teaching suggestions, when the CTF activities are carried out, if the teacher can give more tips, help to reduce the uncertainty, and have confidence in the ability to handle information security, I believe that the motivation for learning must be improved.
V. Conclusions and Recommendations

1. Conclusions

To reach the goal of establishing industrial-professional security and interdisciplinary important information security skills are the key points for implementation, combined with the teaching energy of the colleges and universities, training the practical security and talents to enhance the energy of practical teaching. This research applied the virtual reality technology to develop information security forensics laboratory on the computer, to simulating computer forensics practice virtual situation, such as: assembly of computers, computer forensics process, identification other computer devices and connectors allowing students to learn, research, explore, and experience a stable information security forensic in an immersive environment. After the first semester of practical teaching in 2018, it was proved that virtual reality is interactive, immersive and perceptive. Compared with other teaching activities, it can make learners have a deep sense of presence and improve learners’ learning motivation and enhance learning performance.

2. Recommendations

The ISFVL is recommend to teach the Information Security Forensics basic modules such as forensics investigation process, hard disks and file systems, and data acquisition and duplication in high school, undergraduates, and graduates, as shown in Table 1:

<table>
<thead>
<tr>
<th>Student Sources</th>
<th>Course</th>
<th>Recommend Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third grade, Senior High School</td>
<td>Information security special topics</td>
<td>• Forensics Investigation Process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Hard Disks and File Systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Data Acquisition and Duplication</td>
</tr>
<tr>
<td>Senior Year, MIS or CS</td>
<td>Introduction to computer,</td>
<td>• Forensics Investigation Process</td>
</tr>
<tr>
<td></td>
<td>Introduction to Network,</td>
<td>• Hard Disks and File Systems</td>
</tr>
<tr>
<td></td>
<td>Information security forensics</td>
<td>• Data Acquisition and Duplication Malware Forensics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Network Forensics</td>
</tr>
<tr>
<td>Freshman in a master's program,</td>
<td>Network and Information security special</td>
<td>• Forensics Investigation Process</td>
</tr>
<tr>
<td>MIS or CS</td>
<td>topic</td>
<td>• Hard Disks and File Systems</td>
</tr>
<tr>
<td></td>
<td>Information security forensics special topic</td>
<td>• Data Acquisition and Duplication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Malware Forensics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Network Forensics</td>
</tr>
</tbody>
</table>

Table 1. The information security forensics virtual lab utilization
References


摘要

從 2016 年寶可夢遊戲造成全世界瘋動，我們對於擴增實境與虛擬實境的發展感到興奮，但虛擬實境需要更長的時間才能成為主流，因為它需要專門的觀賞設備。而我們對於行動擴增實境更感興趣，因為所需設備無處不在，使用者的體驗和投資回報率很高。本研究是以虛擬實境為基礎建立的資訊安全鑑識實務教學模式，運用虛擬實境技術在電腦上開發資訊安全鑑識實驗室，模擬電腦鑑識實務虛擬情境，如：組裝電腦、電腦鑑識流程、識別電腦其他裝置與接頭等，使學生在一種身臨其境的環境下進行學習、研究、探索、體驗穩定的資訊安全鑑識教學結構形式。在 2018 年實施實務教學第一學期後，證明虛擬實境技術具有互動性、沉浸性、感知性特性，與其他教學活動比較，可以使學習者更具備深刻的臨場感，確實提高學習者的學習興趣，並增進學習成效。擴增實境與虛擬實境的商業經營模式目前尚未成熟，我們期望它們在教育市場的需求與有效運用，可以建立起新的成功商業經營模式。

關鍵詞：虛擬實境、擴增實境、資訊安全、鑑識、虛擬實驗室