Enhancing experience and learning of first-year surveying engineering student with immersive virtual reality

Introduction

This paper, a work in progress, focuses on the application of virtual reality on first-year surveying engineering. Students enrolled in the surveying engineering major at Penn State Wilkes-Barre take SUR 111 in the fall and SUR 162 in the spring. These courses have an objective to introduce students to surveying equipment and techniques for mapping. Both courses contain outdoor laboratories with extensive use of surveying equipment. Activities are frequently affected by inclement weather (rain and snow), which leads to cancelled classes. This disrupts the educational process and limits the time students spend with instruments. In addition, student training is constrained to the area surrounding the campus due to safety and transportation issues. This reduces students' comprehension on how to apply techniques and use surveying instruments in real-world environments. The advent of cost-effective head mounted displays marked a new era in immersive virtual reality, which sparked application in science, engineering, education, etc. For instance, in environmental chemistry immersive virtual reality is utilized to conduct virtual field trips [1]. In construction engineering virtual reality is used for architecture visualization, safety training, and equipment and operation training [2]. Other recent applications examples include geohazard assessment [3], geovisualization of coral reefs [4], and virtual evacuation simulation [5]. Previous applications of immersive virtual reality in surveying engineering education are limited to desktop-based implementations [6]-[9]. However, desktop-based implementations have limitations in navigation, instrument operation, and viewing the environment, as these are controlled through a mouse and keyboard, which cannot imitate physical movements of a real laboratory. Immersive virtual reality can bring a sense of naturalism in navigation and movement of students in the virtual environment, increase their presence and immersion, and engagement with the virtual reality laboratories.

Purpose

To address these unique educational challenges, we are developing surveying engineering laboratories in immersive virtual reality. Virtual reality can place students in imaginary or realistic environments. These environments create the feeling of being there while introducing students to new and diverse locations. Students can therefore interact with the same surveying equipment they use in the real-world. In addition, these environments can create scenarios that typical students may not have an opportunity to interact with, thus exposing them to different surveying conditions.

Plan of work

One of the key aspects of immersive virtual reality is the ability to create realistic virtual environments. This gives a perception of realism and naturalism to the user. Point-clouds derived from terrestrial laser scanning (TLS) or small unmanned aerial systems (sUASs) can be used to capture 3D information and create such environments. Therefore, this research utilizes such technology to create realistic environments that will be digital recreations of real ones. The following table (Table 1) illustrates a four-year plan that was developed for this research. The project is segmented into three main components: (i) 3D data collection and modeling, (ii) software development and laboratories, and (iii) Laboratory implementation and assessment.

Table 1. Project timeline including data collection, software development, and lab implementations.

	Year 1		**Year 2**		**Year 3**		**Year 4**	
	Fall 2018	Spring 2019	Fall 2019	Spring 2020	Fall 2020	Spring 2021	Fall 2021	Spring 2022
3D Data collection and modeling	On campus data	On campus – modeling	Off Campus data	Off campus – modeling	Off campus – modeling			
Software developm ent	Develop ment of version 1	Developm ent of version 1	Version 1; development of version 2	Version 2;	Revision on version 2	Revision on version 2; inclusion of off campus exercises	Version 3	
Implemen tation			Students use version 1	Students use version 2	Students use version 2	Students use version 2	Students use version 3	Students use version 3

3D data collection and modeling

The project utilizes point-clouds acquired from TLS and sUAS, collected in 2018. The point-clouds were processed in Leica Cyclone, Agisoft Photoscan, and Autodesk 3ds Max to create realistic individual models of buildings and terrain suitable for use in the Unity game engine. Separating the data into individual models also facilitates texturing and improves performance by allowing Unity to utilize occlusion culling (only rendering objects currently in view). Figure 1a shows an example of a sUAS-derived mesh, while Figure 1b shows the modeled environment in Unity. Future data collection and modeling will include off campus locations and virtual reality environment refinements.

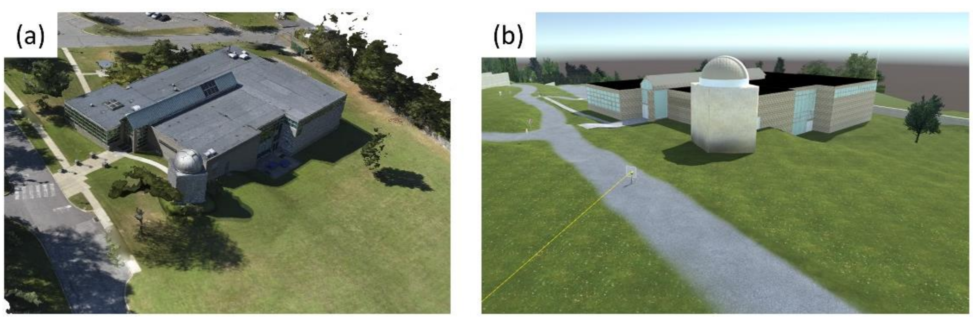

Figure 1. Campus data and virtual reality environment modeling. (a) mesh from sUAS (b) the same site in Unity.

Software development and laboratories

The software will focus on two main surveying tasks: (i) leveling with an automatic level and (ii) traversing with a total station. Both exercises are part of SUR 111 and SUR 162, and principles of these tasks are used in several labs of the two courses. Version 1 of the software will include leveling, which is the process of determining accurate elevation differences and establishing vertical benchmarks [10]. Figure 2 shows real and modeled versions of the leveling instrument. Version 2 will include refinements on user interface and object interaction. The user interface will be modified on the student experience in version 1. In addition, version 2 will include the second surveying task, which uses a total station instrument. This is a more complicated instrument than leveling, therefore research will focus on replicating this in virtual reality. Finally, version 3 will include the off-campus locations; therefore, the student will have a variety of terrains to choose from, which will test their skills, if they follow the principles and techniques taught in class, and their adaptation in new terrain environments.

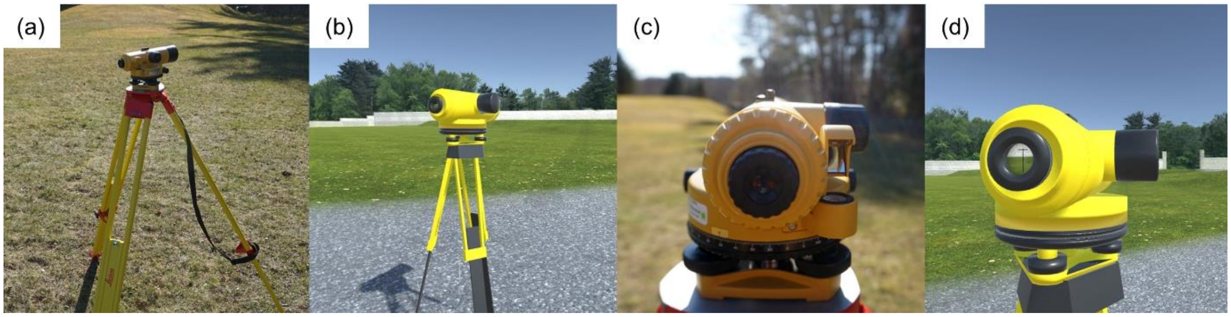

Figure 2. Real automatic level instrument and modeled virtual reality instrument. (a) automatic level on a tripod (b) model in virtual reality (c) close up image of automatic level (d) close up view of automatic level in virtual reality

Laboratory Implementation and assessment

The developed software and exercises can be used to (i) prepare students before the actual laboratory, (ii) replace physical laboratories when weather does not allow conducting the physical one, and (iii) advance and enhance student skills by using additional terrains (this will be version 3). Student assessment will include pretests and posttests to assess student performance on low-level cognitive outcomes, i.e., ability to remember theory and techniques. Furthermore, we will augment our evaluation approach with video recordings of virtual laboratories. We will assess critical thinking based on their selected approach to survey an area, comprehension based on whether they follow discussed procedures, and student competence with using virtual instruments. In addition, the project will use surveys with questions that aim to understand student background (in terms of prior virtual reality and surveying experience), how virtual reality aids to enhance their surveying knowledge and skills, as well as feedback for further improvement. Therefore, data analysis will consider student experience with virtual reality, gaming, and surveying techniques.

Future work and impact

Supplementing and enhancing real laboratories with virtual ones can aid students increase their learning engagement and enhancing their surveying and engineering skills. A long-term goal of this study is to identify the role of virtual reality in surveying education and how it should be implemented to increase instructional efficiency. 3D data acquisition and modeling are an integral part of surveying education, therefore, exposure of students to virtual reality environments, created using modern surveying technologies (such as TLS and sUAS) can broaden first year student awareness of the possible career paths in surveying engineering. Future work will focus on implementing version one of the immersive laboratories, as well as including more terrains (from off campus locations), surveying exercises (e.g., total station and topographic mapping), and making refinements in the handling of the instrument and virtual reality environment.

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