Work in Progress: Moving from Outside to Inside - Traffic Engineering Field Exercises through Virtual Reality

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Abstract

The study of traffic engineering typically uses field observations of traffic. These field observations take place along highways and at intersections. Field observations have several issues including the exposure to traffic that could be hazardous, adverse weather conditions, and the variable nature of traffic. To overcome these challenges, video of traffic and microsimulation of traffic are often used (Kyte & Urbanik, 2012; PTV Vissim 10, 2017).

Recently, VR and 360 video are being used in educational settings (Ulrich et al, 2014; Pantelidis (2010)). With the advent of Google Cardboard and YouTube support of 360 videos, along with the continuing price decline in VR systems and 360 cameras, wider use of VR for engineering education is now possible.

This paper presents work in progress to demonstrate the effectiveness of VR as an alternative to field laboratory exercises in transportation engineering. The work presented demonstrates how the experience of live field laboratory exercises have been translated to a virtual reality environment through the use of 360 video and a virtual reality viewing system.

Introduction

Traffic engineering is the study of how traffic operates and the design of systems, like traffic signals, to allow traffic to move safely and efficiently. The study of traffic engineering typically uses field observations of traffic. These field observations take place along highways and at intersections. Field observations have several issues including the exposure to traffic that could be hazardous, adverse weather conditions, and the variable nature of traffic. To overcome these challenges, video of traffic and microsimulation of traffic are often used (Kyte & Urbanik, 2012; PTV Vissim 10, 2017).

Recently, virtual reality (VR) and 360-degree videos are being used in educational settings (Ulrich et al, 2014; Pantelidis (2010)). Transportation engineering has used simulated virtual environments with driving simulators for a variety of research include work on driver behavior, driver safety, and pedestrian safety (NADS, 2017) and for driver training (Deb et al, 2017). The resources, in terms of equipment and space needed to support one person in the simulated virtual environment, are high. With the advent of Google Cardboard and YouTube support of 360-degree videos, along with the continuing price decline in VR systems and 360-degree cameras, wider use of VR for engineering education is now possible.

New generations of head-mounted displays, such as HTC Vive or Oculus Rift, have been designed to increase a sense of immersion in a virtual world (Deb, Carruth, Sween, Strawderman, & Garrison, 2017; Sobhani & Farooq, 2018). These displays have been used for educational purposes as well (Deb et al., 2017; Deb, Strawderman, & Carruth, 2018). Nonetheless, a limitation of the head-mounted technology is that the viewer cannot experience feeling of being in reality. In the meantime, 360-degree videos provide viewers with the freedom to look around and have a sense of being in the field without its risk (Sheikh, Brown,

Watson, & Evans, 2016). To the best of our knowledge, there is a lack of information regarding using VR and 360-degree video as a replacement for traffic engineering field data collection exercises. The goal of the research presented here is to determine if an outdoor field laboratory exercise that collects traffic engineering data can be translated to a VR environment using 360-degree videos.

The paper presents the work being done to translate the experience of live field laboratory exercises to a virtual reality environment through the use of 360-degree video.

The research for the overall project can be broken into three major research objectives:

1. Develop a VR 360-degree video environment
2. Develop methodology to assess how the student learning experience changes between a live field exercise and a lab-based VR 360-degree video environment
3. Conduct an experiment to assess how the student learning experience changes between a live field exercise and a lab-based VR 360-degree video environment

This work-in-progress paper focuses on the first research objective.

Methodology

The methodology used to develop the VR 360-degree video environment has five steps:

1. Select a field exercise to be translated to a VR 360-degree video environment
2. Select a study location for data collection
3. Collect the data using 360-degree video
4. Develop the VR 360-degree video environment
5. Verify that all data that would be collected in the field can be collected in the VR 360-degree video environment

Each step is described below.

Selection of a field exercise to be translated to a VR 360-degree video environment

Field experiences need to be emphasized for transportation engineering programs for students to better understand how traffic control systems work (Kyte, Abdel-Rahim, & Lines, 2003; Kyte M. and Urbanik T., 2012). The text "Traffic Signal Systems Operations and Design" is a well-regarded traffic engineering textbook. Grounded in active learning, the text is designed to help students see the traffic system, interpret what they see, connect these observations (field and simulation) to theoretical models so that students understand the traffic control system and its operations (Kyte M. and Urbanik T., 2012). For this paper, <u>Activity 11 – From Model to the Real World: Field Observations</u> has been chosen for the field exercise to be translated to a VR 360-degree video environment. This activity has been conducted as a class assignment several times by one of the authors. The other two authors have participated as a student completing this activity both in class and as part of this research effort.

The activity's objective is to "represent and interpret queue accumulation polygons for a range of traffic flow and control conditions". It has four data collection tasks – 1) observing and recording the physical elements of the intersection; 2) observing and recording the operation of the traffic signal at the intersection that includes recording the order of traffic movements, the type of movements, and the duration of the green, yellow and red clearance intervals for each movement; 3) observing and recording the length of the queue as a function of time and signal display status; and 4) observing and recording the vehicle headways as vehicles pass through the

intersection while the signal is green. From this data, students are asked to 1) develop a sketch of the intersection, 2) describe the sequence of traffic movements observed, 3) describe the queue patterns observed, develop a queue accumulation polygon that results from the data, and use the queue accumulation polygon to compute total delay experienced by drivers, and 4) use the observed headway data to estimate green utilization time and the number of cycle failures.

Select a study location for data collection

The intersection selected for this study is 67th Street and Pacific Street located by the Scott campus of the University of Nebraska in Omaha, NE (see figure 1). This intersection is adjacent to the Peter Kiewit Institute Building where a portion of the University of Nebraska-Lincoln's Civil Engineering department is located. This intersection is readily accessible to students and has been used to support field data collection for the traffic engineering course at UNL for many years.

Figure 1. Study intersection.

Collect the data using 360-degree video

The equipment used to collect the 360-degree video consisted of four Garmin Virb 360-degree cameras, each mounted on a Manfrotto Nanopole Lightweight Two-in-One Portable Stand. To better view the signal heads, a Sony Handycam camera with a 10X optical zoom was used. It was mounted on a standard tripod.

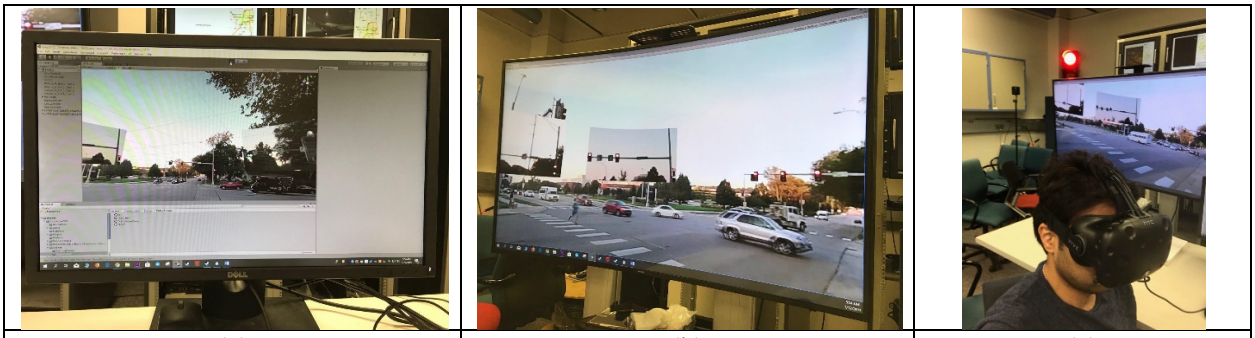
One 360-degree video camera was used on each approach and placed in line with the stop bar on the opposite side of the sidewalk from the street. This placement is generally where you would stand to collect the data for the textbook activity and just out of the way of pedestrians on the sidewalk. Video data were collected at various times of the day for 10- to 15-minute periods. The limited time for each video collection was constrained by the life of the 360-degree video camera battery. Sunny days with little or no cloud cover produced the best video quality. All video was recorded in September 2018.

Develop the VR 360-degree video environment

To develop the VR 360-degree video environment, an HTC Vive was used. This technology contains a collection of software and hardware so as to simulate an immersive three-dimensional (3D) situations. Unity 2018.1.1f1, a game development engine, was utilized to develop the 3D world and HTC Vive and its controllers (figure 2) were used in this world so as to see and interact with the videos, respectively. HTC Vive is a head-mounted display that was released in 2016, proving to be a light-weight and cost-effective virtual reality headset, free of many of the limitations found in the previously commercialized products (Deb et al., 2017).

Figure 2. HTC Vive headset and its controllers

The process of creating the VR 360-degree video environment has two main steps. First, the HTC Vive and its controllers were defined in Unity to create an immersive and interactive virtual environment. Second, the edited 360-degree videos were transferred into Unity to create the 360-degree video environment of the intersection. Figure 3 shows the completed VR module in Unity while the viewer and the instructor used it to observe the videos.



(a) (b) (c)

Figure 3. The virtual learning environment (VR module) includes: (a) computer desktop screen (b) instructor view, and (c) student view (with HTC Vive head-mounted display).

Verify that all data that would be collected in the field can be collected in the VR 360-degree video environment

If the VR 360-degree video environment is to work as a substitute for field data collection, we need to verify that all the data can be collected using just the collected videos. After recording and editing videos, traffic filed data was collected manually per instructions in the text (Kyte M. and Urbanik T., 2012) to as closely represent field data collection as possible. The instructor view shown in figure 3 (b) was used to do this data collection. The Apple iOS app Timestamp by Emerald and Sequoia was used to collect all timed data. The data were then downloaded to a spreadsheet format.

Next the same data were collected using the VR 360-degree video environment developed in Unity for the HTC Vive. The HTC Vive controllers were used as data collection devices in the VR 360-degree video environment. The data collected with the controllers were then downloaded into a spreadsheet format.

With the data collected these two different ways, a comparison of the two data sets was made. This comparison is discussed in the Results section that follows.

Results

While all data collected in the two methods were compared, only two comparisons are presented here. All other comparisons are in the process of being analyzed.

Comparison of Cycle Times

Cycle times were collected for three consecutive cycles. The same cycles were observed in both environments. Figure 4 presents the data.

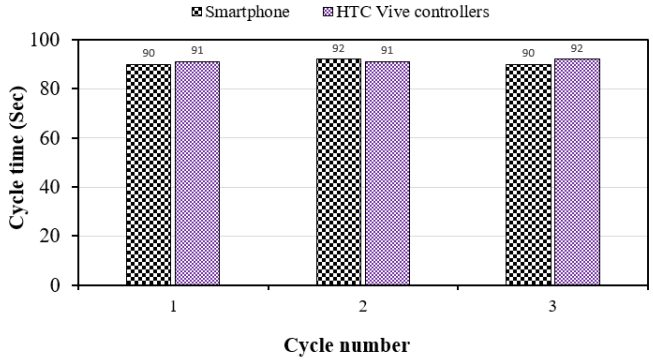


Figure 4. Comparison of cycle time duration using two data collection techniques.

The difference between the two methods is less than 2 seconds for cycle lengths of generally 90 seconds or about 2.2% difference. This difference may be attributed to the data collection environment, the method of data collection, and general random error from human operation of the app and the HTC Vive controllers.

Comparison of Green Time Utilization

Data to compute the green time utilization were collected for five consecutive cycles. The same cycles were observed in both environments. Figure 5 presents the data.

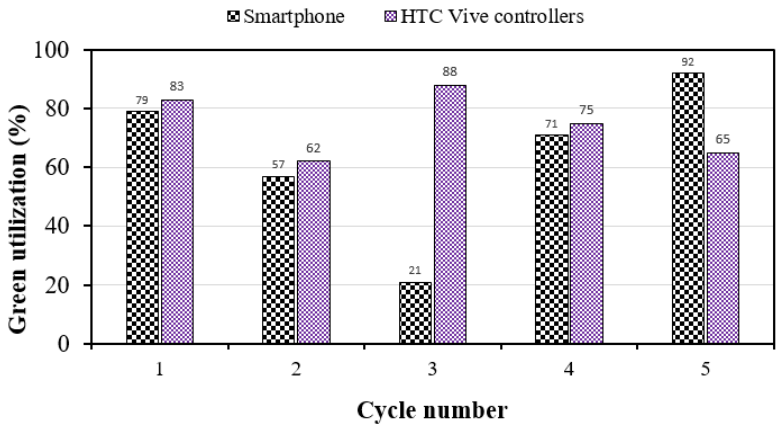


Figure 5. Comparison of green utilization time.

In this case, three of the five cycles (1, 2 and 4) had similar results but two cycles (3 and 5) had notable differences. For cycle 3, the data collected with a smartphone gives a much lower result than that collected with the HTC Vive controllers. The opposite occurs for cycle 5. We believe that the large differences seen in cycles 3 and 5 are due to the difficulty that one person has when collecting the data needed for green time utilization as data is being collected for the when the light turns green and then to yellow and also for when vehicles cross the stop bar. To do this, the person collecting the data has to look at two different locations – the stop bar in front of them and the signal displays to their right on the opposite side of the intersection. When collecting the data needed for green time utilization in previous years in the field, one of the authors has observed that this is one of the more challenging field data collection efforts. Having a team of two or three students work together to collect this data is generally what is needed for field work. For all data collected to compare the field data to that collected with the HTC Vive, one observer collected the data by himself. As currently developed, the VR 360-degree video environment can only be used by one student at a time. Work is being done to redo this data collection using two observers in both the manually collected data and the VR 360-degree video environment data. We expect that two observers are needed instead of the one used to date.

Conclusion

The results of the work to date are promising. It does appear that a VR 360-degree video environment can be used to replicate a field data collection experience. More work is needed to allow either two observers to interact in the VR 360-degree video environment or to present the views of the system differently to improve the accuracy of the data collection.

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