Session ETD

A Novel Augmented Reality Application For A Mobile Renewable Trailer As An Emergency Response

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Abstract

The number of hurricanes and storms in the last decade have steadily increased in Texas leaving residents without water, electricity, and medical care. Electricity needed for emergency medical equipment is crucial to save victims' lives. In addition to traditional fossil fuel emergency generators, solar and wind energy based mobile renewable energy systems deployed with high quality and enhanced battery storage units improve disaster relief efforts by providing quiet, reliable, and zero-emission electricity. On the other hand, safety and emergency response operations are very important both in the industrial and disaster areas. Accidents and malfunctions in the industrial environments can cause significant economic and social impact, and an educated response to such incidents must be done immediately. However, in the case of emergency situations, not all first responders are ready to use the equipment, especially if the emergency equipment is designed for general population. The last five years have seen a tremendous increase in the augmented reality (AR) and virtual reality (VR) environment. Past research proved that, in year 2018, 12.4 million VR headsets were manufactured and shipped worldwide. An important aspect of the AR tool is to assist with learning and training skills. Moreover, an AR tool is capable of providing engaged presentation and an interactive training for industrial, manufacturing, and safety equipment. The researchers developed an augmented reality application to provide an interactive learning platform for a Mobile Renewable Energy Trailer (MRRT) that was designed and built to assist during natural disasters such as hurricanes, floods, tornadoes etc. This study explores augmented and virtual reality applications and identifies their potential within existing emergency response technologies.

This MRRT project includes design, implementation, operation and testing of a 5.5 kW mobile renewable energy system that is installed in a 20X9 feet trailer for disaster relief efforts in Texas. The MRRT contains a PV array with a rated installed power capacity of 4.4 kW, 0.3 kW wind turbine, 8x100 Ah deep-cycle battery capacity, a 2 kW additional emergency gas-generator, and an additional 3x1500 VA *Back-UPS* Pro Unit Uninterruptable Power System that will provide approximately a continuous peak power of 5 kW for 90 hours without any charging. The funding for project was provided by a local energy company to promote Environmental initiatives for cleaner energy efforts. The MRRT is towed behind a truck and ready to be delivered to disaster-struck regions to help with the immediate needs of residents by providing emergency power

including lighting, charging stations for cell phones, small tools, lifesaving medical instruments, small power equipment, Wi-Fi, and satellite services. The proposed novel AR application will both provide an interactive learning platform for MRRT for disaster relief personnel with different backgrounds and promote AR-based renewable energy applications for engineering and technology students in different institutions.

Introduction

Emergency management of natural disasters is an essential role of government. Emergency management was organized in 1979 with the creation of the Federal Emergency Management Agency (FEMA). Since that time, many states and local cities have changed the names of their organizations to include the words: emergency management. There are four phases of emergency management: mitigation, preparedness, response, and recovery. Mitigation includes activities that prevent an emergency or reduce the damaging effects of unavoidable hazards. Preparedness phase includes developing plans for what to do, where to go, or who to call for help before an event occurs. Response phase need to be done quickly to save lives, protect property and the environment, and meet basic human needs in the aftermath of natural disasters. Recovery phase focuses on the timely restoration, strengthening and revitalization of infrastructure, housing and a sustainable economy, as well as the health, social, cultural, historic and environmental fabric of communities affected by a catastrophic event. (FEMA) Emergency management has steadily increased to become the multi-billion-dollar program that exists today. The four phases need to be completed in a short time. The frequent severe weather incidents in the United States have caused damage that cost billions of dollars. Previous research [1] reported that almost one-third of existing recovery plans are in inferior quality. Therefore, several city authorities have decided to convert paper-based process to electronic-based process to take advantage of available technology in order to reduce cost and enhance response time.

Technology has become an integral part of the natural disaster communication [2] during the emergency response activities. For example, Hurricane Harvey in 2017 pronounced that more disaster victims used social media than 911 services to seek assistance [3]. The researchers have constructed a Mobile Renewable Energy Trailer (MRRT) to assist victims of natural disasters. Although the trailer does not need significant training to operate, some of the modules may not function as intended unless the required procedures are followed. Therefore, a user-friendly operation manual, called ARM (Augmented Reality Manual) is developed to avoid guestimates and provide needed assistance in a timely manner during critical times.

The ARM is a conceptual framework generated by the researchers to systematically put evidence-based practice processes into operation. The application identifies image targets to transform two dimensional still image into a more practical augmented video tutorial. Using this inquiry, pretest and posttest analyses are summarized into a meaningful statement and applied in disaster training and translation of the teaching method to STEM education.

Background and significance

Sophisticated equipment requires significant level of training to operate them correctly. At present, after disaster site inspection, the fire hazards rectification has achieved simulation exercises through fire supervision and inspection modules, which are used in two ways: First, to construct inspection scenes with 2D pictures and video material; Second, carry out practical training with realistic sites and buildings [4]. The former does not bring strong sense feeling for trainees, and it is challenging to grasp the inspection situation. The latter method is cannot meet the need due to the real scenes are limited, and it is difficult to ensure quality training. Thus, dedicated staff of first responders are assigned to the vehicles they are trained to. However, preparation for disasters may be hindered by limited access to disaster training opportunities due to their high costs and limited mobility. An alternative method to provide a cost-effective training is to develop virtual simulations to develop muscle memory [5].

Virtual Reality (VR) is a broad term incorporating a wide range of computer simulations (Blade & Padgett, 2002) that provides immersive experience to the user. Although the VR technology varies, the common purpose of the VR is to enable a human-computer interface that simulates an alternate three-dimensional environment and augmented audio-visual graphics, which is referred as Augmented Reality (AR) in this study. The use of AR provides on-demand data, thus facilitates and enriches the work of the employees [6] in real time situations. This leads towards a redesign of the training material for manufacturing and safety industry [7] and is expected to become more flexible.

Methodology

The effects of disaster training with and without ARM were explored to study the experimental design. The subjects of the study, Undergraduate Engineering Technology students from freshmen to senior year, participated in the disaster response activity with MRRT. None of the participants previously had any operation of emergency response vehicles, therefore, both the control groups and the treatment group were randomly selected to participate in the study. Two participating control groups (CG1 & CG2) were given a scenario, where they needed to operate the MRRT from a non-operational stage, to assist the disaster victims and provide power without any assistance from the trained first responders, while the treatment group (TG) received ARM to repeat the same tasks on the spot. The researchers compared the timeliness of the equipment setup between the three groups, where CG1 was asked to setup the trailer equipment, CG2 was asked to setup the trailer equipment with a step by step instructional operation manual, and the TG was asked to setup the trailer using the ARM application on a tablet or phone.

Trailer and its Application

The MRRT was developed by SHSU students and faculty comprises of PV panels with a 5.5 kW mobile power system center (MPSC) installed in a 20X9 feet trailer for disaster relief efforts in Texas. The MPSC contains a PV array with a rated installed power capacity of 4.4 kW, a 0.3 kW wind turbine, 8x100 Ah deep-cycle battery capacity, a 2 kW additional emergency gas-generator,

and an additional 3x1500 VA Back-UPS Pro Unit Uninterruptable Power System that will provide approximately a continuous peak power of 5 kW for an approximate time frame of 90 hours without any charging.

Six undergraduate students in the Electronics and Computer Engineering Technology program at Sam Houston State University worked on a summer research grant project to design and build a renewable energy based mobile powerhouse for emergency relief efforts during summer 2019. Due to the limited budget, it was initially decided to facilitate available surplus PV panels from previous projects that were connected in required combinations of series and parallel strings that would provide 4.2 kW electrical power to the battery storage. Although the open circuit and short circuit characteristics of the available PV panels were in the acceptable ranges to connect them in series and parallel combinations, the difference in power ratings, manufacturing brands, and ages would be expected to cause minor mismatch losses. However, once the array wiring was completed using 15 PV panels, the measured current, voltage, and power output values at peak sun hours were almost 45% less than expected and desired values. The mismatch losses in the array were the significant on this degraded PV performance. The problem of reduced power output was resolved by replacing all the surplus PV panels by brand new panels with exactly same power ratings and I-V characteristics that were connected in series and parallel combinations that ultimately provided the same calculated array power output.

One of the objectives of this applied research is to take the mobile power system trailer to school districts specifically in rural areas of Texas and expose students directly to operation of wind and solar PV power based mobile power system trailer as seen in Fig. 8. Students and faculty involve in the project explain basic mathematical expressions in wind and solar PV power production and how the related parameters impact the power generation in addition to main objective of providing emergency power to victims in disaster hit regions. High school students' interest to mobile energy system trailer, system operation and future job opportunities in wind and solar energy related careers were very high.

Figure 1. Mobile power system trailer taken to STEM outreach events in diverse school districts in Texas.

Augmented Reality Mobile Application for MRRT

The Augmented Reality Manual was developed to assist inexperienced first responders to obtain necessary information to accurately setup the MRRT equipment. The application was developed for Android devices to overlay a video instruction, that activates on the device's camera when it is directly pointed to the equipment of interest. For instance, the general information on the trailer as well as the power capacity, initial installation, placement of solar panels, and setup of the ground is covered when the android is pointed at the side of the trailer (Figure 2a).

Figure 2a. Right side view of MRRT

Figure 2b. Visual description of the trailer and its operation from the side of MRRT

The equipment panel inside the trailer will need additional instruction to activate the flow of usable energy to the disaster victims. The SHSU undergraduate student demonstrates various switches and their purpose in order to operate the panel safely. The user needs to point the device's camera onto the panel to receive the video tutorial and safety procedures via the application (Figure 2a).

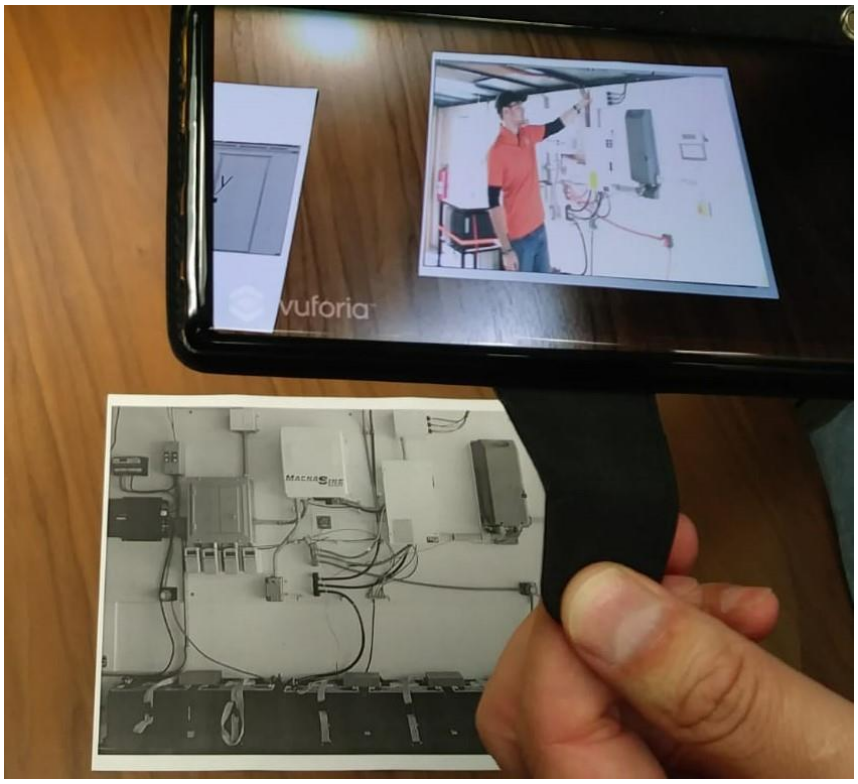

Figure 3. Visual demonstration of electronic panel inside the trailer for safety and accuracy

Experimental Setup

The purpose of this study is to investigate how an augmented reality technology can improve the operation of a mobile first response rig. The original plan was to test the hypothesis, three groups of participants with no prior knowledge of operating any first response vehicle were targeted during the winter break of 2019. Due to the severe weather and lack of participation during the break, the researchers will be collecting the data during the spring 2020 semester and the outcomes will be disseminated in upcoming conferences and/or journal articles.

Three groups of participants with n=30 in each group will be asked to setup MRRT, without any training, to the fully operational stage, where a disaster victim can utilize the renewable energy from the trailer. The first group will receive no instruction and assistance during the process. The second group will receive a booklet manual that describes the operation of various units and provides step-by-step tutorial to setup the rig. The third group will receive a tablet with ARM installed and asked to setup the trailer to the fully functional state. All three groups will be observed for the accuracy, safety, completeness of the rig, and timeliness to finish the setup.

Collected data will be analyzed in SPSS' analysis of variance for significant differences and Tukey test to compare the groups. Researchers' previous studies with AR have proved that the technology can significantly improve the training. Therefore, larger number of participants are necessary to derive to a more accurate result.

Conclusion

Emergency management is integral to the security of our daily lives, and as such it should be integrated into our daily decisions rather than being called upon major disasters. In addition, Emergency management programs cost multi-billion dollars placing a large burden on local, state, and federal governments. To achieve that, Effective training program in response to natural disasters which enhance communication and quick respond to natural disasters are essential in response to catastrophic events. The ARM is expected lead to reduce the time and cost of training to use the Mobile Renewable Energy Trailer (MRRT). Although the collection of data during the winter break did not occur, the researchers have started collecting information from the participants. This will result in reduce communication error and enhance safety and productivity in case of disaster events.

Future Work

Due to the low observed data, the outcomes of the preliminary results will be communicated during the conference in March. However, a full report of the collected data and its analyses will be disseminated in upcoming conferences. Figure 4 shows the demonstration of the trailer setup for the current collection of data.

Figure 4. Data collection process to demonstrate full setup of the trailer from ARM

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