VR as a tool for EVs maintenance training

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Abstract:
The fast adoption of electric vehicles (EVs) into the automotive scene requires the development of novel maintenance training approaches. Due to its ability to create immersive and interactive learning environments, virtual reality (VR) is a powerful training tool across various domains. Trainees can visually interact with various components of an EV, practice maintenance methods, and replicate real-world scenarios in a risk-free environment by using VR's capabilities. The main benefits of using VR for EV maintenance training include hands-on practice, the capacity to replicate complicated EV systems, scalability for educating several personnel at the same time, and the possibility of interactive and adaptable learning modules. VR may provide a new sensory experience by merging haptic input and realistic visual and auditory cues, boosting trainees' spatial knowledge. The research also underlines the potential benefits of VR training, such as increased engagement, cost-effectiveness, scalability, and the ability to standardize training content. This study calls for the use of VR technology as a teaching tool for EV repair, emphasizing its potential to alter the way personnel are trained and skilled in this changing automotive scene. The findings highlight the importance of preparing a skilled workforce capable of meeting the demands of sustainable mobility.

Keywords:
VR, training, EV, sustainable, electric vehicle

1. Introduction

The early 2000s marked the rise in popularity of electric vehicles. In 2004, Tesla Motors began production of the Tesla Roadster, which was delivered to customers in 2008. The Roadster was the first fully electric vehicle powered by a Li-ion battery that was deemed road-ready, with a driving range of 320 km on a single charge. In December 2010, the Nissan Leaf appeared on the Japanese and American markets. It was the first modern electric vehicle without any emissions that fell under Nissan's "Zero Emission" brand. When the Li-Ion battery arrives at the repair center, it typically goes through the following phases: Diagnostics and testing, where the battery gets checked for damage and tested for faults. The diagnostics team will determine the next steps that need to be taken. Next, a team of specialists trained to work with high-voltage components repairs or replaces the parts highlighted by the diagnostics team, and finally, the battery assembly is reattached to the vehicle. Li-ion batteries contain toxic metals such as cobalt, nickel, and manganese, and so the process of training EV battery repair technicians can involve risks. A technician without the proper training for dealing with EVs can experience life-threatening risks. The following are some of the things that may go wrong during the repair process: Wrong Diagnosis: Without the proper knowledge of dealing with EVs, a technician can easily make a wrong diagnosis, which leads to a loss of money and time. Safety Concerns: EVs have high-voltage systems, and if the technician isn't prepared on how to safely deal with the situations, he might be in danger. High voltage may lead to electric shock, fire, and a number of other life-threatening situations. Due to all these stated reasons, training in VR is an ideal solution for all companies that manufacture EVs as well as all repair shops.

2. Health risks

The increase in the number of electric vehicles (EVs) being sold is causing a greater need for a special training program to work on EVs in the future. This section will explain why the training sector is facing new challenges. The main difference between electric cars and regular cars is that electric cars have a high-voltage battery. High voltage means a certain range of electric current that is considered dangerous. According to European rules (ECE R100) [2] and American rules (SAE J1766-2014) [3], for alternating current (AC), a high voltage is between 30 volts and 1000 volts. For direct current (DC), a high voltage is between 60 volts and 1500 volts. The battery in electric vehicles (EVs) usually has a voltage of 355 volts (DC) [4]. However, some EVs, such as the Nissan Leaf [5], have a higher voltage of 360 volts [6]. Based on [7], car companies are designing batteries for electric vehicles (EVs) that can have voltages of up to 850 V DC in the future. Therefore, using high voltages in cars can be dangerous because you could get an electric shock or burn yourself. Electric vehicles (EVs) have built-in safety features to prevent people from experiencing an electric shock. One of these safety measures is the service disconnect. This measure will turn off the high-voltage loop. However, employees in the vehicle repair industry are required by law to attend specialized training programs (e.g., [1], [8]). For instance, they must understand where the safety features are located in the car and how they operate. There are some dangers to your health when working on electric vehicles because they have a lot of electrical parts and a high-voltage system. So, you need to take extra precautions. The health dangers for people working with EVs are not small. For instance, if a car mechanic accidentally touches a cable with too much electricity or a battery with a problem, they could get a shock. When you get an electrical shock, you might have a dangerous heart problem called ventricular fibrillation or get burned. This means it is very important for the people who work on electric vehicles (EVs) to have a lot of knowledge and skills. This includes, among other things, knowing where the parts are located, understanding the dangers of high voltages and high currents for our health, knowing how to use protective equipment correctly, knowing how to provide first aid, following safety rules (for example, wearing protective gear) and turning off the powerful electrical system.

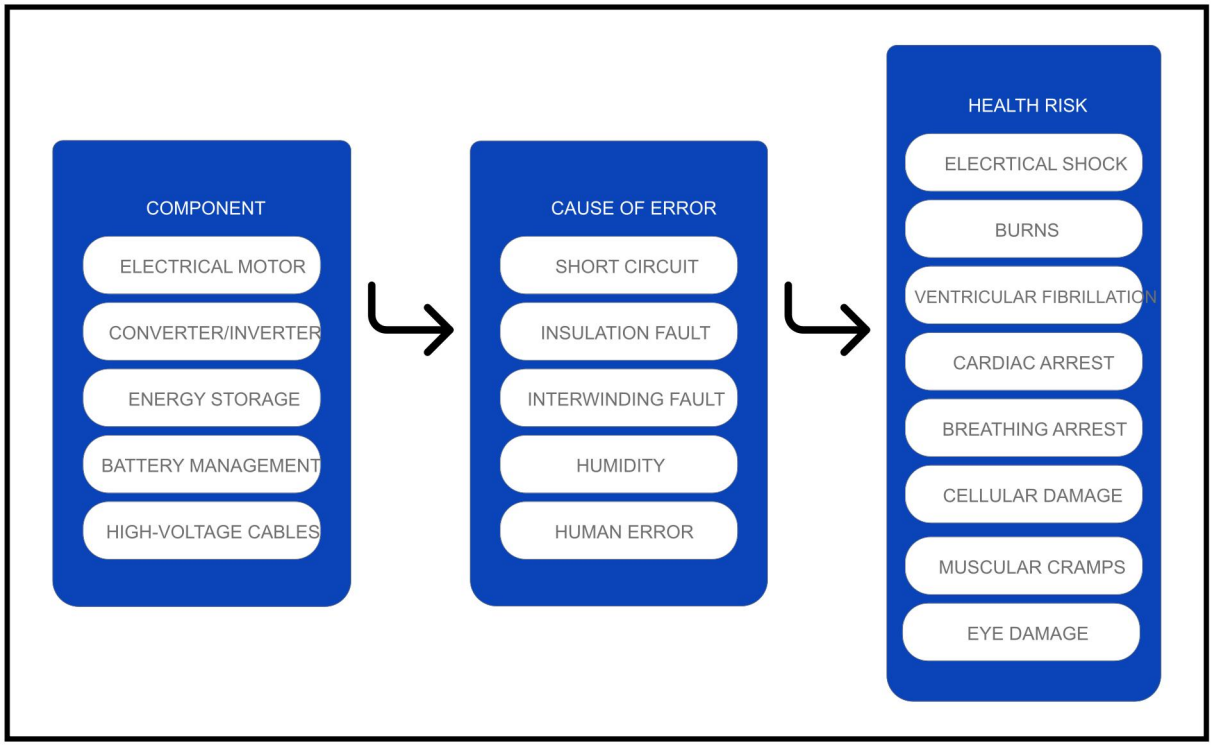

Figure 1. Health risk of some selected components

3. Advantages of VR in Electrical Vehicle training and maintenance

The main advantage of VR in EV maintenance is the opportunity to provide specialized training for technicians. VR can help technicians upgrade their skills and be prepared for real-world challenges. Replicated scenarios of the product lines enable the identification and diagnosis of issues without the need to stop production. This decreases the wait time and improves the quality of the production capacity. The benefits of VR training are the following:

- Increased safety and ability for the technicians to get familiar with the various tools and machines without the risk of injury,
- Increased efficiency that comes from VR being able to simulate various scenarios and states that mandates usage of different types of tools in the correct way,
- Saves on costs that are needed to get all of the tools required for a trainee to successfully deal with all possible situations,
- The ability to better understand and repeat the process, which leads to greater self-confidence,
- The ability to create and replicate situations that are more complex or that are impossible to replicate in the real world helps the technicians better deal with the rare scenarios that can happen.
- Technicians can train in different locations without needing to be in the same place at the same time, which is a benefit for a company that has multiple training locations.

4. Training procedures in VR

The training can be grouped into general lectures for safety and equipment usage as well as repair procedures that can be standardized and/or custom tailored to a company's needs based on their training program. VR allows for the transmission of clear and precise instructions (Figure 2) to the trainee to make sure that they follow the training procedure while maintaining safety practices.

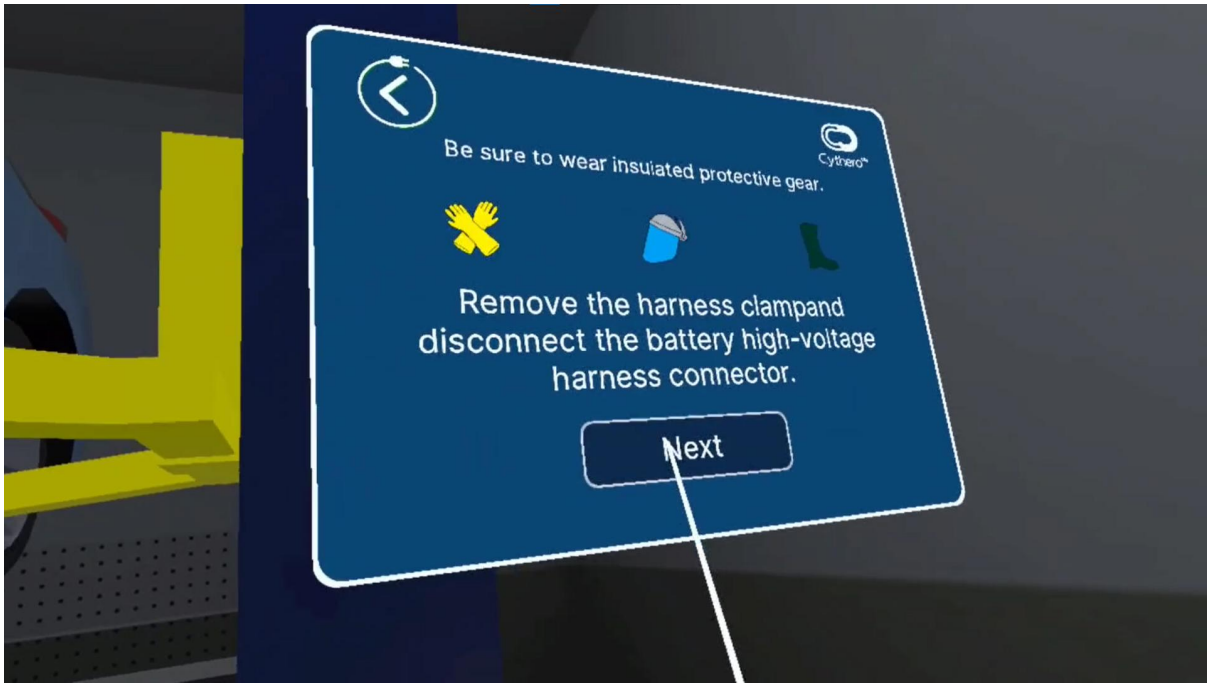

Figure 2. Instructions in VR

The training in VR is accomplished by using visual and auditory cues such as highlights (Figure 3), arrows, pings to guide the trainee to interact with the environment in order to complete a task.

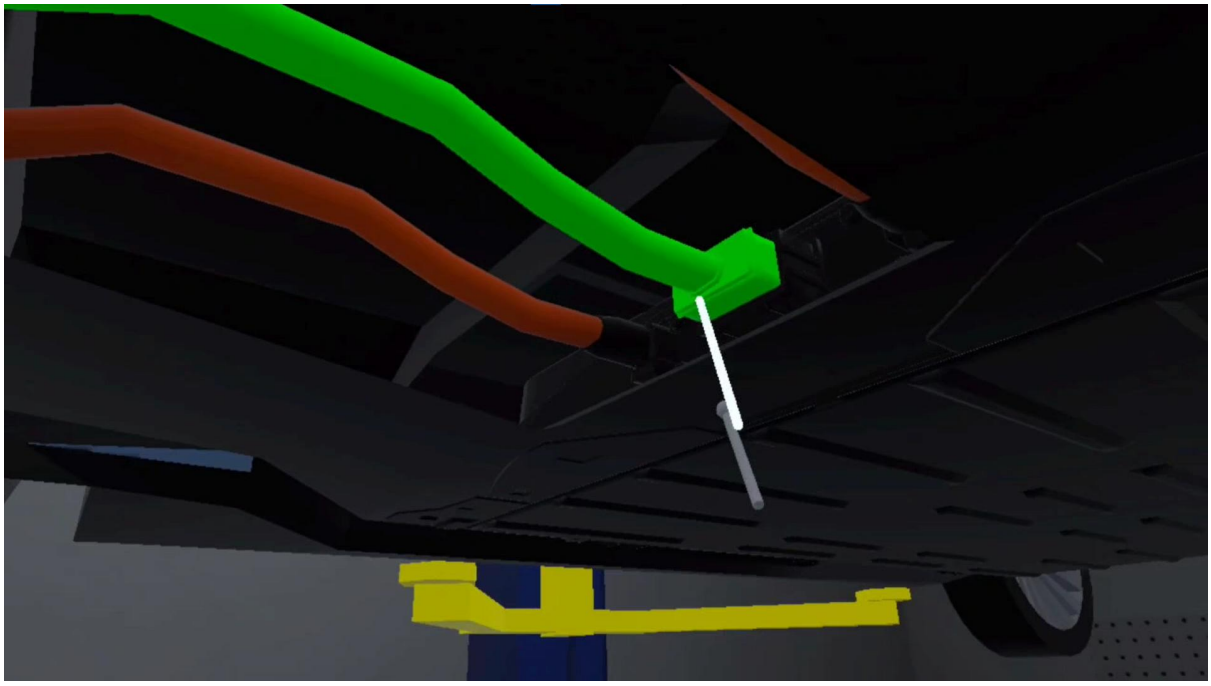

Figure 3. Visual Cues

General lectures can have the trainee learn about their equipment through quizzes, prompts, and interactions with their environment such as picking the right equipment for a job, identifying faulty equipment and learning about general hazards and how to avoid them.

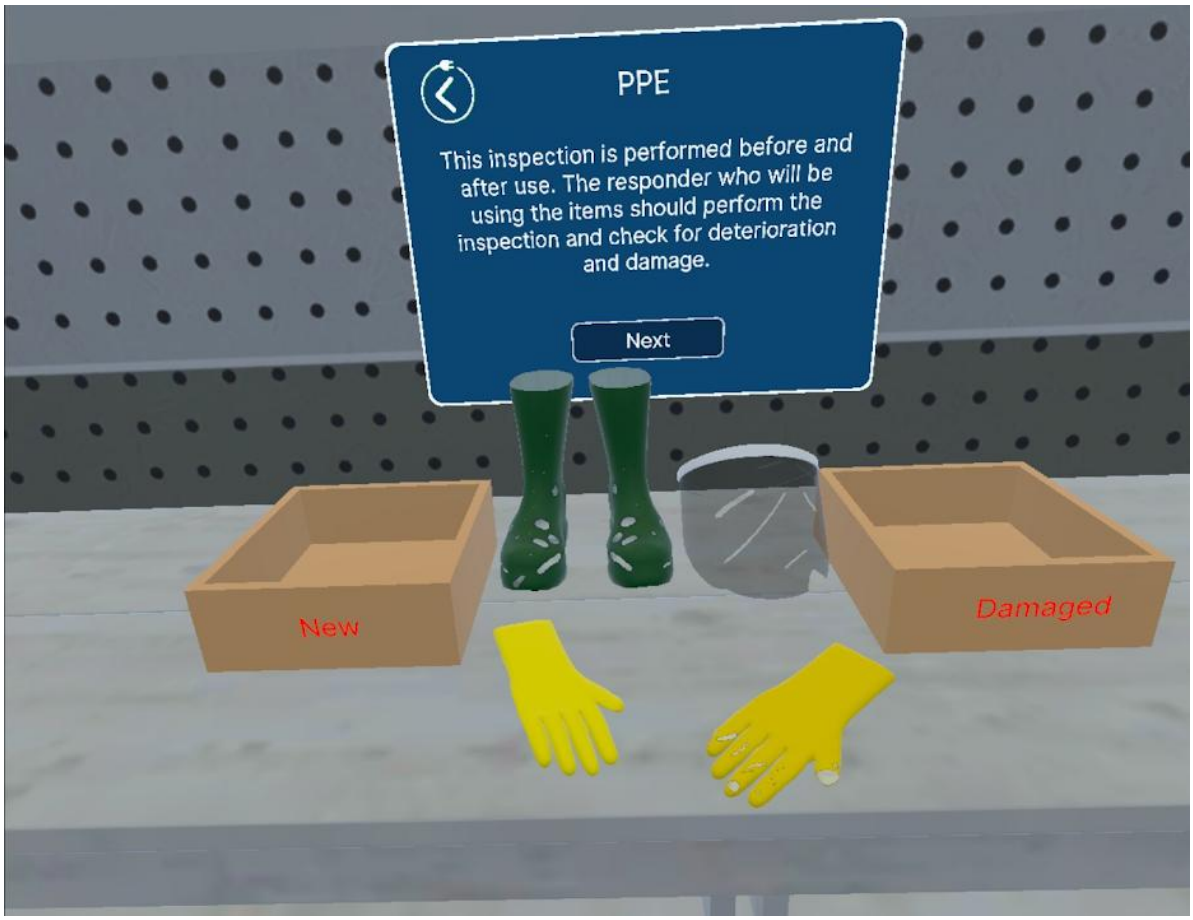

Figure 4.Equipment identification

5. Conclusions

As both the EV and VR industries grow and become the main stream, most companies should look into implementing VR into their training programs, as it can wildly improve the training time needed for technicians to be field-ready, cut down on the cost of training, and avoid the risks of personnel harm. VR can be a great tool for companies to do decentralized training of new and existing technicians, as it doesn't require the trainer to be at the same place as the trainee. Training applications can be equipped with a system to record and save training sessions for further review and performance tracking, which can help pick out outstanding trainees as well as help out trainees struggling with certain topics.

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