Designing AR / VR- Based Trainings to Build Engineering Skills for the Future

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Designing AR / VR- based trainings - to build Engineering Skills for the Future

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Abstract

An engineer's time to learn new technology is shrinking rapidly as new technologies like Machine learning, Artificial intelligence, 3D printing, IOT, Robotics etc are rapidly disrupting the industry. Can we use these very same technologies to accelerate our learning? We believe that engineering pedagogy must transition from the 2D world to the 3D world, were technologies like virtual reality (VR) and Holographic projection will lead to better understanding and retention amongst students.

Our engineers, who are involved in building new products based on advanced mobility technology platforms need extensive trainings on Autonomous, Electric and Connected vehicles. With the emergence of electric vehicles, there is an urgent need to train mobility engineers in handling EV subsystems like high voltage battery's and motors. In this paper, we will share the key learning from our recent work on designing a VR based module on electric vehicle. An engineer must be sufficiently trained and certified before he can touch a high voltage battery pack system. But how do we train an engineer – especially on battery dismantling and charging, if they cannot even touch these systems? here is where AR/VR technology came to our rescue. Salient features of this training module include virtual modes were the trainees will work on high voltage battery system dismantling, charging etc. without exposing themselves to the risks of electric shocks. We could make our engineers practice handling of battery system in virtual environment.

After our initial success with AR/VR trainings on electric vehicles, we are now exploring trainings for autonomous and connected vehicles too. Our approach could very well be extended for applications beyond automotive industry – design of aircrafts, drones, design of high voltage power transmission systems, design of nuclear reactors, practice of complex surgery procedures etc.

Keywords and abbreviations: AR/VR- Augmented and Virtual reality, EV- Electric Vehicle, BEV - Battery Electric vehicle, SDK- software development kit, IC- Internal Combustion, Learning using virtual reality. TENS - Transcutaneous Electrical Nerve Stimulation

The term EVs as used in paper refers to battery electric vehicle (BEV)

1.0 Introduction

It is important to understand how information is registered and retained by brain, the science of neuronal plasticity explains the process of learning and remembering through the receptor cells, these receptor cells are available in large quantities near the tip of our fingers, tongue and eyes. Hence when we perform task both hand, eye coordinate to activate these cells that build muscle memory and brain retains information for longer duration.[1]. To support this study there was research carried out by Work-Learning Research, Inc. in USA, which reported key factors of learning as - type of content (visual, audio, Visual audio, Text, duration of learning, Method of learning (self-learning, instructor led practical learning, practical's) and learners themselves (levels of learners) the study showed that learners who gave practical tests five times forgot an average of 2.3% content, whereas learners who got only one practice trial forgot an average of 14.3% content and learners with zero practice trials forgot 21.7% of content [2]. In present learning environment practical exposure for a mass of students is a challenge as resources can be a constraint such as availability of faculty, availability of instruments or tools, Duration of learning, adequate prerequisites etc.

In the following sections we will discuss requirements for developing VR content and how a case study was developed to systematically learn Basic structure of an Electric vehicle, charging in electric vehicle and dismantling of high voltage batteries used in Electric vehicle.

2.0 Role of VR and AR in Mechanical Engineering

The Core Mechanical Engineering Subjects such as Thermodynamics, Fluid mechanics, Strength of Materials, Automotive Engineering and Materials Science requires in-depth understanding of basic principles. For example in Thermodynamics, understanding of Enthalpy with respect to pressure and temperature need to be appreciated in practical's but imagine if these concepts are delivered in VR setup in a classroom were students can see locations of sensors in test setup and observe parameters change in graph in an immersive ambience. In Automotive engineering the application of how engine is tested in a dynamometer for its power and tuned for desired performance is an apt example. These test setups can be very costly to replicate for Educational institutes as resources required to maintain and demonstrate to students can be challenging, hence VR modules can be developed for such cases.

A similar useful platform is Augmented reality which is a tool for mass education, here 2D images can be coded to display 3D content once its decoded. A simple device like a basic android supported mobile can be used to visualize 3D content overlaying it on text content of books. A suitable example can be, when a student visits a lab to enhance his understanding on working of an Engine but cannot recollect the lecture taught in class, can overlay tab on components that can decode information.

An educational institute is a best place to introduce AR and VR for its courses but will face challenge in creation of content. For instance, a subject matter expert cannot develop a content of his own as its not his core competency but there should be an arrangement were computer science departments can work with SME to create content. The department of Information technology and computer science Engineering should introduce this technology in their curriculum and nurture the innovative ideas in their incubation project cells.

3.0 Hardware and software requirement for developing Virtual reality Module

To establish virtual reality lab, we may need below infrastructure.

Software requirement:

Flow for creating VR content	Software Infrastructure required
Story board creation (1)	*XD adobe* (software) for information flow and User interface and User design (1)
Content creation (2)	To build assets and virtual atmosphere, one will need software's like *Maya*- to create high poly 3D models (Autodesk) ,*Z-brush* to make high poly to low poly and texturing (2)
	To perform a desired task with the 3D model game engines are needed such as *Unity*, *Unreal* which work on programming languages such as C++ and C sharp. There are many opensource SDKs available online to test the functionality
	For any personalized animation like gesture control which requires content to interact with user - a Green room is required to capture motion with stereo cameras
Optimization (3)	Optimization: Level of detailing should be optimized as the processing capability of the graphics card and the processor is limited, for example if user must focus on a scenario unwanted graphics should be rendered (3)
Build (4)	Now we can build the content as a executable file that can be viewed on *STEAM VR* software. (4)

Hardware Requirement:

To view VR content - a graphic card, a PC and a head mounted display with navigation sensors are required. Attached is the sample web site https://www.nvidia.in/object/vr-system-requirements-in.html for detailed specifications

Below are few important parameters to look for in these hardware's:

a) Head Mounts Fig 1: There are two major competitors – HTC and OCULUS which house Sensors that range from position tracing of the head to eyeball movement. They are wired with the CPU as of now but will soon be having a wireless communication.

b) Graphix card Fig 2 : Basic Graphix card should have Refresh rates 60Hz to 150 Hz, Clock speed 0.8GHz to 1.5Ghz and Memory size 4GB to 6GB DDR5 or 6, number of HDMI ports minimum 2 for communication with PC and with head mount..

c) PC - CPU: Intel Core i5- 4590 equivalent or greater Memory/RAM: 8GB+, Video Output: 1x HDMI 1.3, Ports: 3x USB 3.0, OS: Windows 7 SP1 (64bit) or higher

Fig 1: Head mount

Fig 2: Graphix card

4.0 Application of a VR modules in Electric vehicle Training

There is a sudden surge amongst the OEMs to adapt to Electric and Hybrid vehicles as Government in India has mandated to have EVs contribute up to 30% of all vehicle sales by 2030 [3]. Today Electric vehicles operate on high voltages ranging from 60V-400V at high current discharge levels that uses supply voltage up to 1000V AC form the grid to the chargers.

Before user handles electric vehicles he should be aware of IEC and ISO standards and Electric vehicle architecture. EV's are mostly powered by lithium ion battery's as it has high energy density to power output with it comes many validation requirements, Research is InProgress for scenarios such as overheating tests, high battery drain rates, repeated charging and discharging, thermal shocks, vehicle squeezing, drop tests, mishandling of wiring (short circuiting) etc. For every possible test case researcher must understand what happens to the cell chemistry and reactions. Once system is robust user must practice using safe procedures while handling the system.

There was a case on an incident that was published by BMW SAUBER F1 TEAM during an electric vehicle race competition, where one of the team member experience shock on touching car body but driver remained unharmed as he was insulated. Considering this background an attempt was made on how we can use VR to mitigate these scenarios and practice safe handling procedures. In Table 1, procedure to approach a learning module is briefed.

Flow chart

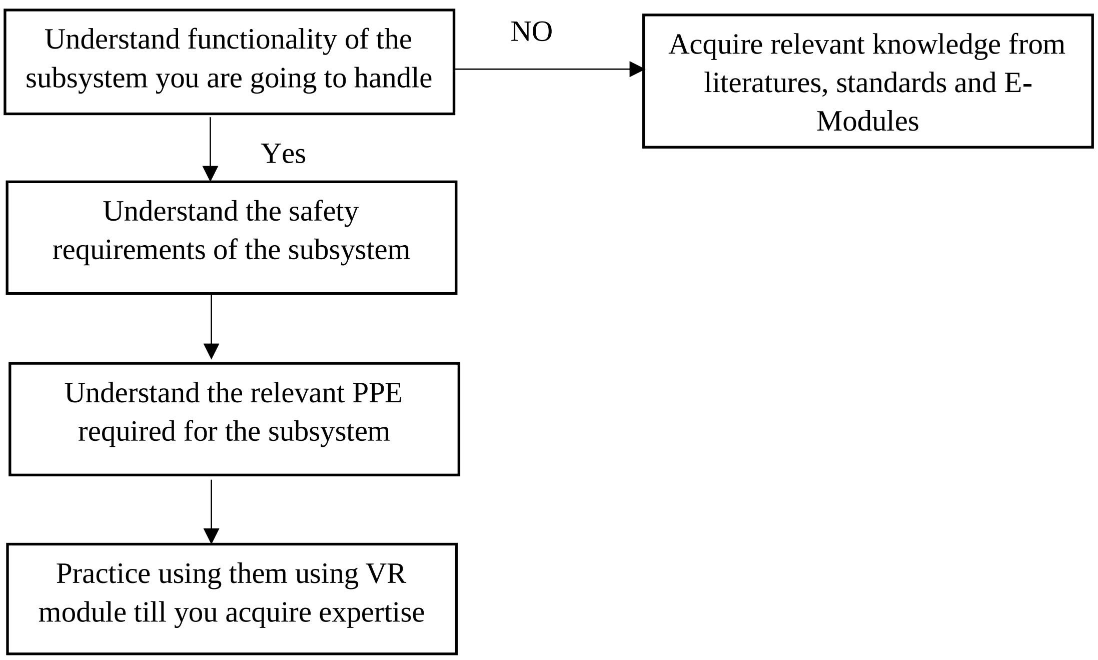

Table 1

5.0 VR module Visualization

In Level 1 User will start building his awareness on BEV and an IC engine-based vehicle, where he will be able to visualize scene as in fig 3 and hear about the working of an IC engine. Student will be briefed about the modes of operation in EV such as a test scenario where driver tries to accelerate while batteries are still plugged in and are getting charged, this not a right mode of operation were vehicle will not start.

User visualizing basics of EV module

Fig3: IC Engine components and its location in vehicle

Fig 4 and Fig 5 shows BEV configration and component locations with differnet available confrigrations that will be visualised. Students will be briefed about individual componets such as Motor, chargers, batterys and its construction.

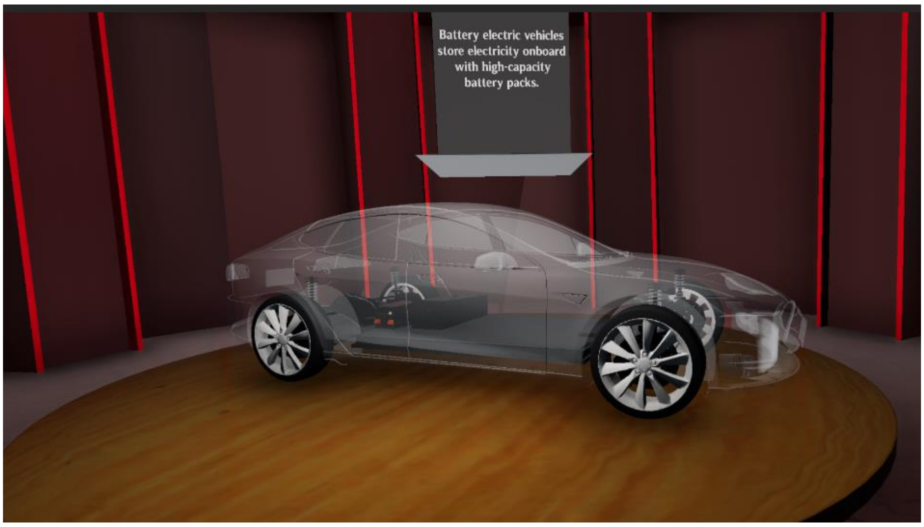

Fig 4: Layout of BEV

After gaining basic knowledge on the BEV user will know how the charge is flowing to different components once you key in and acclerate the throttle as in fig 5. Different modes of motor operation can be visualised such as regeneration on braking and depletion of batterys in acceleration mode.

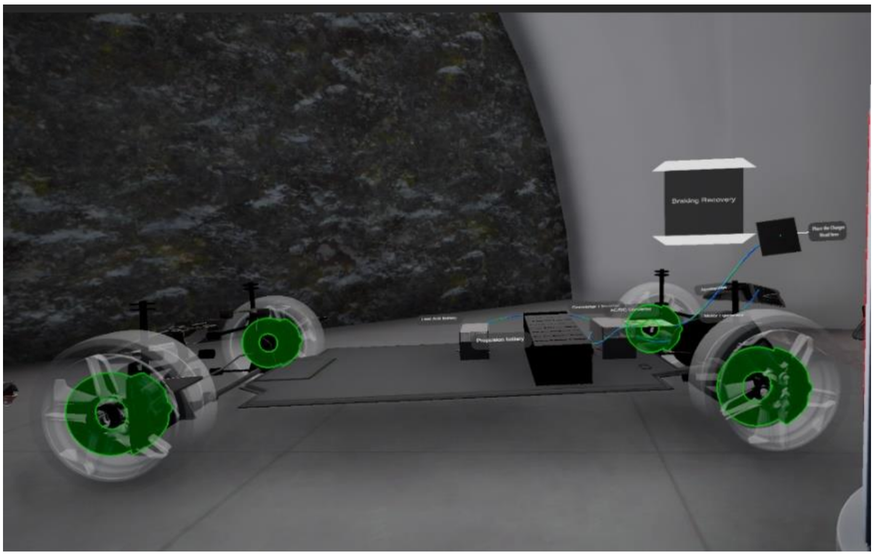

Fig 5 : Working of an EV

User will understand differnet types of chargers and their rate of charging as shown below

Level 1 : House hold charger as in Fig 6

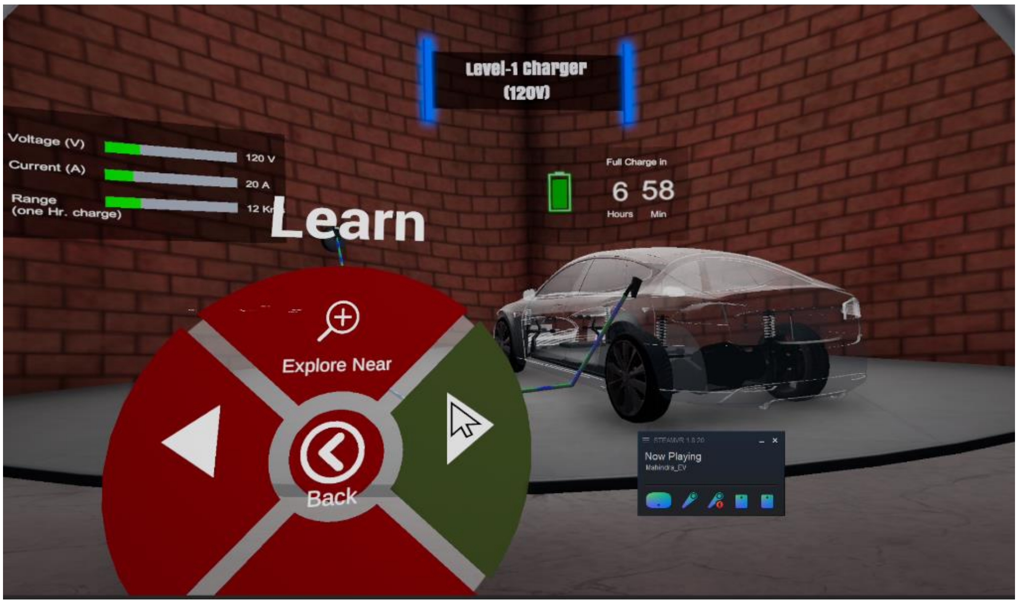

Fig 6: Level 1 Charger

Level 2 Industrial charger: 415 V

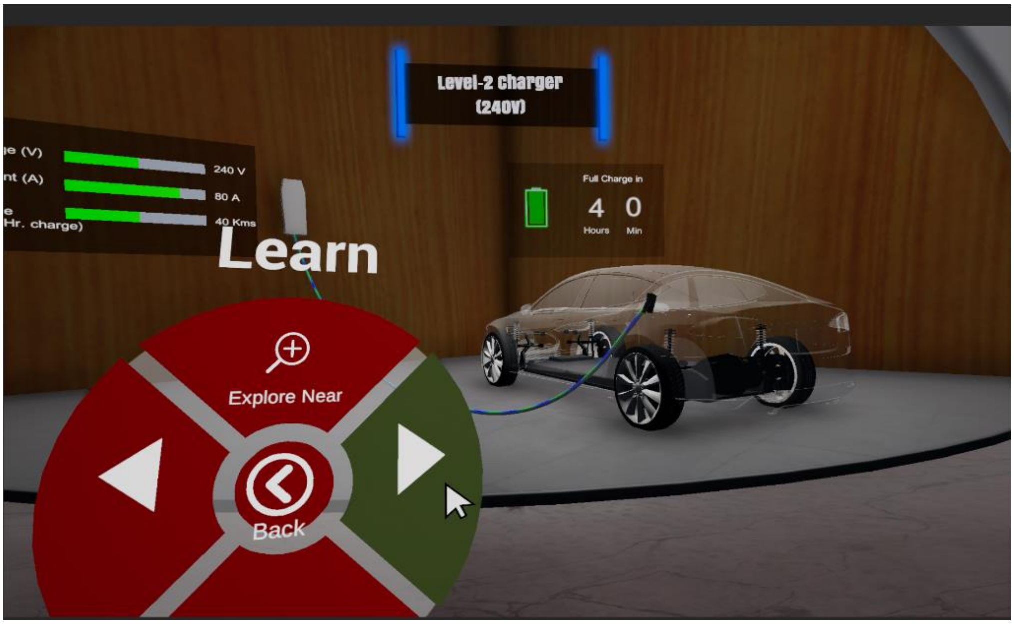

Fig 7 : Level 2 Charger

Level 3 Industrial charger DC – DC fast charger

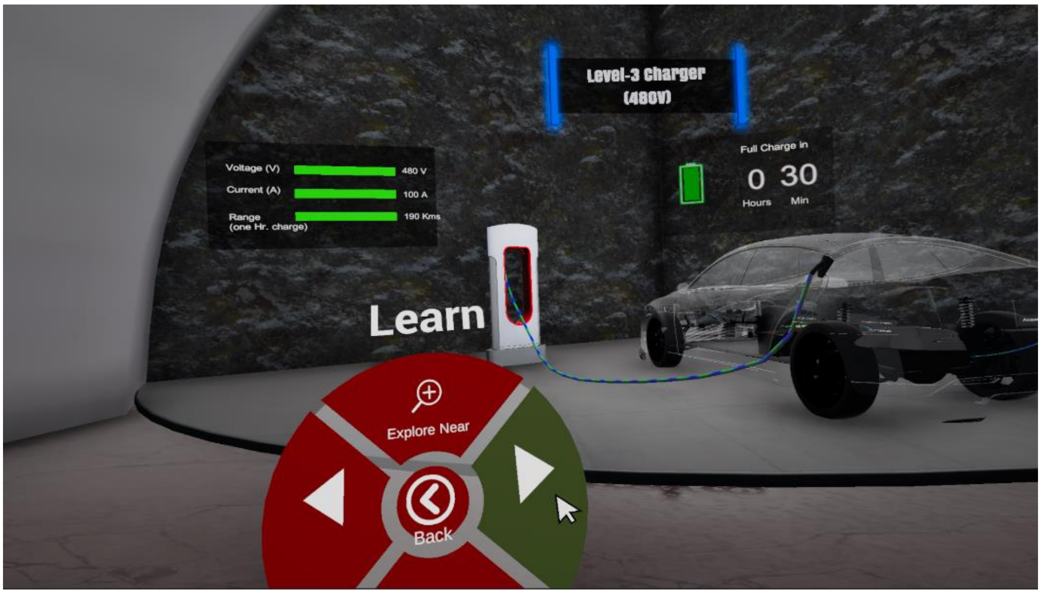

Fig 8: Level 3 Charger

After understanding the charging modes, user will understand how to hold the charger and plug in the charger. He will be able to visualize the charging of battery and how current will be flowing when you accelerate and brake in a vehicle:

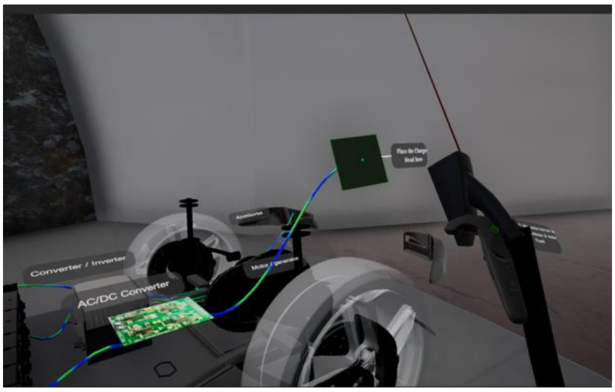

Fig 9: Plugging in the charger

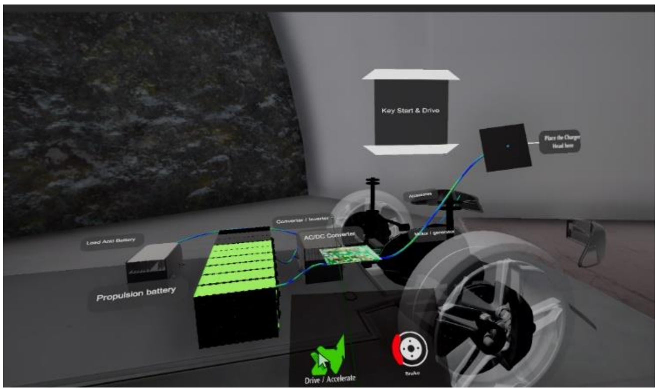

Fig 10: Regeneration mode

In the last module student will be selecting the right PPE to dismantel different components in sequence by diagonising the fault systematically.

User will practice see if following things are in place such as electrostatic mat,Toxic and white light protecting mask etc. where warning will be given on wrong selection of PPE, or a wiring.User will undergo assesement on on multiple choice questions after completing the module,post which he can be allowed to go for realtime vehicle assessment.

6.0 Future scope of work

In coming years VR modules can be made more immersive by use of Haptic suite that uses Transcutaneous Electrical Nerve Stimulation to send electrical pulses to the brain. This electro-stimulation improves the learning experience by nurturing 360-degree awareness and engage using muscle memory. The paramters such as Force, Frequency,Pressure and Temprature can be felt in such simulations and once this technology is commercial, we will implement it on EV project to give user a scaled magnitude of impact on electrical shocks if he mishandeling an electrical connection in an EV.

Teslasuit is one such company working on the project of integrating biometric system by gathering real-time data from users to train itself and relay on emotional state, stress level, and key health indicators like blood pressure, heart beat etc of the user.

Image courtesy : Teslasuit

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