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Virtual Reality as a Tool for Electrical Machines Assembling and Testing

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Abstract:

This study introduces, describes, and illustrates a practical application of a virtual training tool for electrical engineering education. Users can interact with and manipulate 3D models of authentic devices using this tool. Users can compare structural differences between devices, assemble and disassemble machines, and test them under extreme conditions, which is not possible when working with a real device. The three-dimensional devices are fully functional, allowing users to interact with them on all levels, including impact analysis of supply conditions.

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Introduction

Students' difficulties with science-related subjects are frequently due to the abstractness and complexity of learned concepts, as well as the fact that those concepts processes are not easily transferable to practice. Their potential growth and development, as well as exploration of more complex topics, is stifled by a lack of understanding of fundamentals (Haji et al., 2020). Since specialized equipment used for practical exercises is costly, students must exercise extreme caution when engaging in any activity involving the instruments. They are not permitted to play with the system itself, to encounter emergency states, or to observe the consequences of misconfiguration, as this may result in equipment harm and is often in violation of the facility's health and safety regulations. They are therefore unable to work independently, practice, or catch up outside of the laboratory schedule due to these working conditions. There are some solutions to this issue, and they are often linked to the use of technology such as online courses, blended learning, various computer-based platforms, and other solutions that enable students to revise their information on demand and make mistakes without repercussions. As various examples of hardware and software technologies integrated into the educational process show, the Ed-tech industry will boost education outcomes for the majority of students (Nadan et al., 2011).

Technology-based tools are finding their way to more and more educational centers all over the world (Salih et al., 2020). Paper books are being replaced by digital instructional content from open educational resources, notebooks are being pushed out by laptops, tablets or mobile phones, analogue blackboards are giving way to interactive whiteboards and, most significantly, standardized education process is being transformed into more personalized learning opportunities tailored to each individual student's academic strengths, weaknesses, preference, and goals (Courts & Tucker, 2012; Ahmed & Sallow, 2017).

The use of information and communication technologies has been proven to boost students' results or their attitude towards learning (Mustafa et al., 2020). With its continuous development and research growth, the potential of ed-tech is still uncapped. Over the last several years, virtual reality (VR) has moved from being the purview of gaming to application in professional development such as psychology, medicine as well as education. The application in the learning process is of special interest, as it gives completely new opportunities to provide information and acquire both theoretical and practical knowledge. Some of the benefits of VR application in fields of education have already been examined. Virtual reality changes completely the way the users interact with the device, it gives them freedom to experiment and come up with bold, innovative applications or prototypes without worrying about damaging expensive equipment. The relative inexpensiveness of modern virtual headsets provides even small-budget teaching institutions with the ability to carry out proper practical education, otherwise unavailable to them (Makarova et al., 2015).

The main focus of this paper is a state-of-the-art tool for both teachers and students of mechatronics. The concept utilizes a blended learning approach that combines traditional on-premises classroom methods with virtual reality as an experimentation tool. Here, specifically, it is a hybrid approach that incorporates digital media through VR into a traditional place-based learning process and is more effective in teaching mechatronics compared with traditional face-to-face methods. Virtual worlds are very easily modifiable, adaptable and can replace expensive realia without the loss of any of their advantages, at the same time providing many more opportunities of operation. The innovation of the presented tool lies in developing an original and novel electric motor training system based on VR technology. The users can observe and explore a digital, fully interactive environment created specifically for this project and dynamically change it to cater for all the needs and tasks.

Related work

Humans have always sought novel ways to fuel their creativity, such as reverie or various methods of entering altered states of consciousness. The advancement of technology has resulted in the creation of products that enable the transfer of human senses into a programmable experience space. Virtual reality is an example of such a product (VR). The simplest forms may be limited to visual and auditory stimulation alone, making them relatively simple to achieve. Thus, the most elementary VR system may consist of a monitor and a pair of speakers. However, as a result of the rapid development of head-mounted displays (HMD), these solutions have been devalued to the point where they are no longer classified as virtual reality (VR). Through the use of panoramic displays and a variety of built-in motion tracking sensors, the user may even experience fictive environments that replicate the real world in terms of appearance and physical phenomena.

Nowadays, engineering training is widely conducted by utilizing simulators and virtual reality technology. Ability to make early in-design decisions in a cost-effective manner is a feature that greatly contributed to the popularity and attractiveness of VR solutions in this field (Pantelidis, 1997). Additional benefits include a better understanding of intricacies of the design, facilitating any necessary adjustments and reducing or mitigating the time and cost factor, which haunt many modern design processes (Gandhi & Patel, 2018). In this section several state-of-the-art applications will be described briefly. A very good example is Virtual Labs (Achuthan et al., 2011) (Government of India Initiative), which provides remote access to the laboratories of various disciplines of science and engineering. Students of Indian universities can access relevant tools for learning, including web-resources, video-lectures, animated demonstrations and self-evaluation. Such tools allow to gain only theoretical knowledge on a particular subject, while the practical part is completely omitted, thus not allowing students to acquire real experience. Another good example is MARVEL project (Mueller & Ferreira, 2003). MARVEL is a virtual learning environment for mechatronics training in which students are provided online access to physical workshops and laboratory facilities from remote places and learning venues. However, both above-mentioned platforms do not use VR technology based on Head Mounted Display (HMD), utilizing only computers and the Internet.

Dinis et al. (2017) give an overview of VR and AR applications for civil engineering education utilizing gamification elements. The aim of the project was to introduce tools that would engage users in a way which is more familiar to them because of their age, motivate them by including gaming elements and at the same time transfer knowledge and practical skills necessary for their future careers. However, the main goal of the project might be summarized as explaining and defining the role of civil engineering to K-12 students and its relevance to the community. In their accompanying research, a VR platform was developed as a vehicle to educate even younger students on civil engineering. The results were highly promising and support the idea of using VR as a tool in Civil Engineering Education, as it enables users without formalized knowledge or training to properly interact with the platform. Another example of using VR in civil engineering is provided by Sampaio & Martins (2017). The authors set out to produce interactive 3D models to give users deeper insight into the structure of roofs, walls and a bridge. These scenarios were accompanied by relevant simulations of their construction and the interaction with the models enabled the users to monitor the process of development and gain valuable practical information about each element.

Electrical engineering education has also been reinforced by using a VR application (Valdez et al., 2015), the main point of which was online laboratories designed, developed and made available to students, who could access them remotely using VR. In that environment students can safely perform simple electronic laboratory experiments using relevant virtual tools, instruments, components and apparatus. Utilizing such virtual scenarios in combination with other study materials allows students to learn and participate in the education process remotely. As an added value, it eliminates risk of potentially damaging experimental strategies and minimizes costs and teachers' time burden. In (Żywicki et al., 2017) the authors address the concept of Industry 4.0 and provide a system for exploring the inner operations of an intelligent factory. The system delivers a VR-space, where employees / operators of a production system can experiment with the production cycle, which allows them to make mistakes and later learn from them without real-world consequences.

However, VR systems have much more potential and some possible development is presented in Hurtado et al. (2010) where a tool for robotics education and training is introduced. Not only does it utilize visual stimuli, but it additionally includes haptic feedback interaction and a built-in physics engine. Robotic arms can be controlled by either a virtual pendant or programmed to follow specific instructions. A study conducted on the users of this application and students who followed traditional training materials indicate the advantage of the former ones, who prove to be better equipped for working with real robots.

Method

Project Overview

Project has been created to facilitate study programs by using a state-of-the-art VR-based application developed specifically with the aim of teaching and learning mechatronics in tertiary education institutions. One of the main assumptions of this work is to deliver VR space where students can experiment with machinery and are allowed to make mistakes and learn from them without real-world consequences (i.e., damaging expensive machinery.) Moreover, the VR based tool will reduce the costs of introducing the latest equipment into the curriculum by removing the necessity of purchasing new machinery, by presenting models of selected equipment in VR. To develop the virtual environment of the prototype Unity3D - Game Engine is used. Also, the Oculus Go is used which is a standalone virtual reality headset developed by Facebook Technologies in partnership with Qualcomm and Xiaomi. It is in the first generation of Facebook Technologies' virtual reality headsets, and the company's first device in the category of standalone VR headsets, which was a new category at the time of the Go's release (Hillmann, 2019). The Go is an all-in-one headset, meaning it contains all the necessary components to provide virtual reality experiences and doesn't need to be tethered to an external device to use. It is equipped with a Qualcomm Snapdragon 821 chipset and a single 5.5-inch LCD display with a resolution of 1280 × 1440 pixels per eye and a refresh rate of 72 or 60 Hz, depending on the application. The headset uses Fresnel lenses that are improved over those used in the company's previous headset, the Oculus Rift, and provide a field of view of about 101 degrees, which gives the Go a display fidelity of 12.67 pixels per degree. Input is provided with a wireless controller that functions much like a laser pointer. The headset and controller utilize non-positional 3-degrees-of-freedom tracking, making it capable of seated or static-standing activities but unsuitable for room scale applications (Hillmann, 2019).

User Interface

The user interface (UI), in human–computer interaction, is the environment where the interaction between human and machine occurs. The aim of UI is to allow ergonomic, effective and efficient control of the machine. The design of the user interface is an integral part for the intended user experience. In this project's UI two mode are use exploration mode and other mode and each of them has normal and transparent mode as presented in Fig.1.

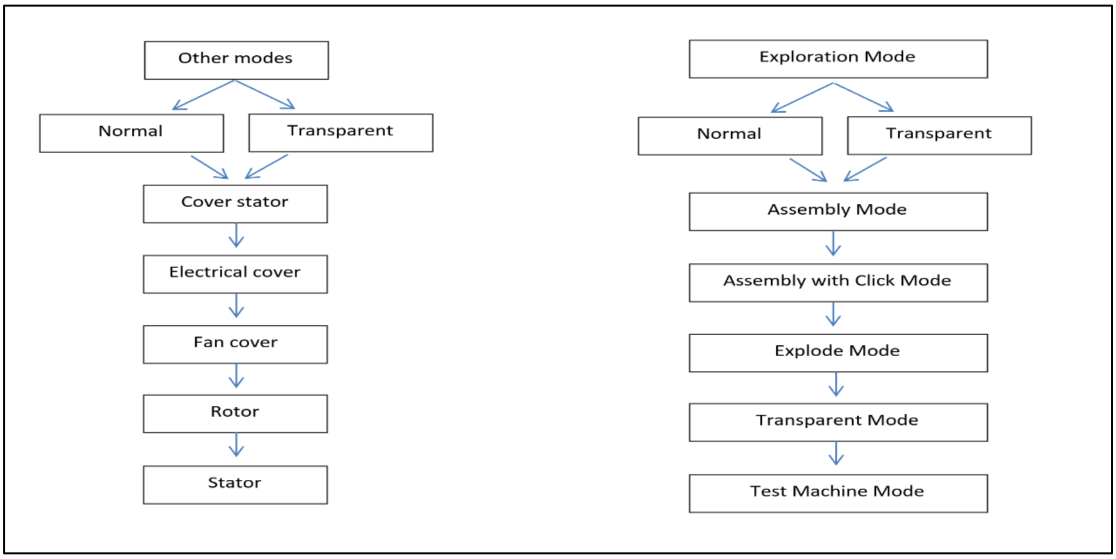

Figure 1 Flow chart of exploration mode and other mode

Application scenario

The exploration mode provides various environment for users like assembly, assembly with click, explode, transparent and test machine mode. Each of this mode has its own UI environment as shown in Fig.2.

Assembly mode - makes the machine assemble which means you can see all parts of machine separately.

Assembly with click mode – makes the machine assemble with the ability for clicking on any part of it, so can be easily accessible.

Explode mode – this mode makes each parts of the machine independent.

Transparent mode – this mode makes every parts of the machine transparent so they can see the inside of the machines as shown in Fig.3.

Test machine mode – in this mode you can test the machine.

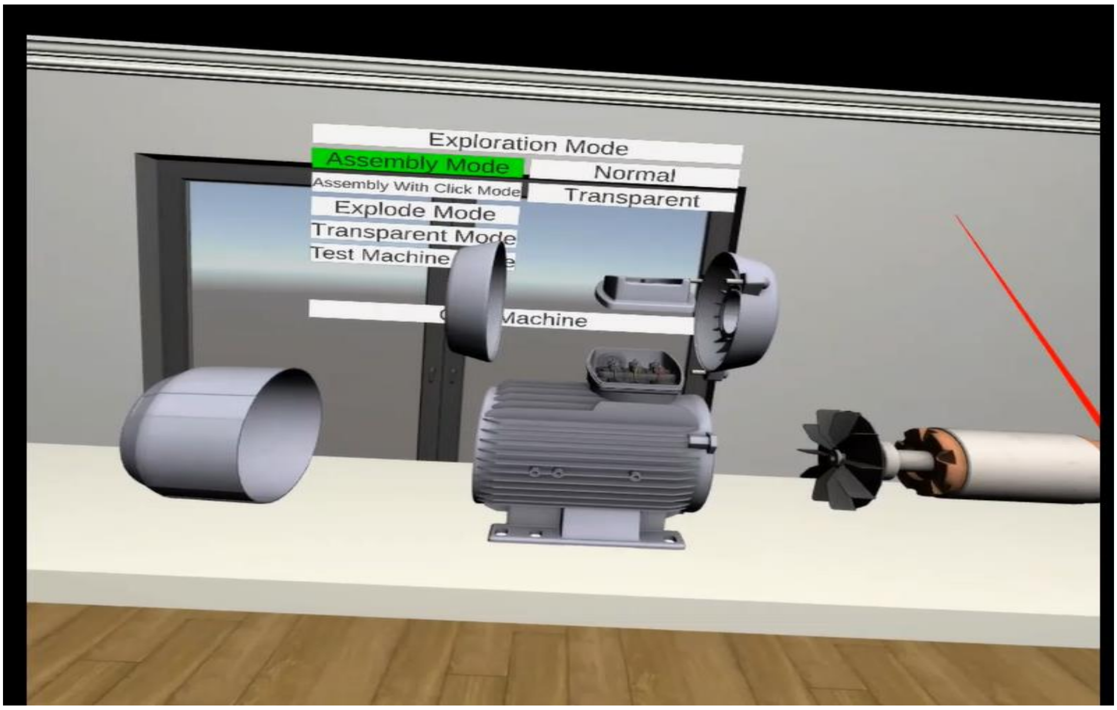

Figure 2: Explortion mode

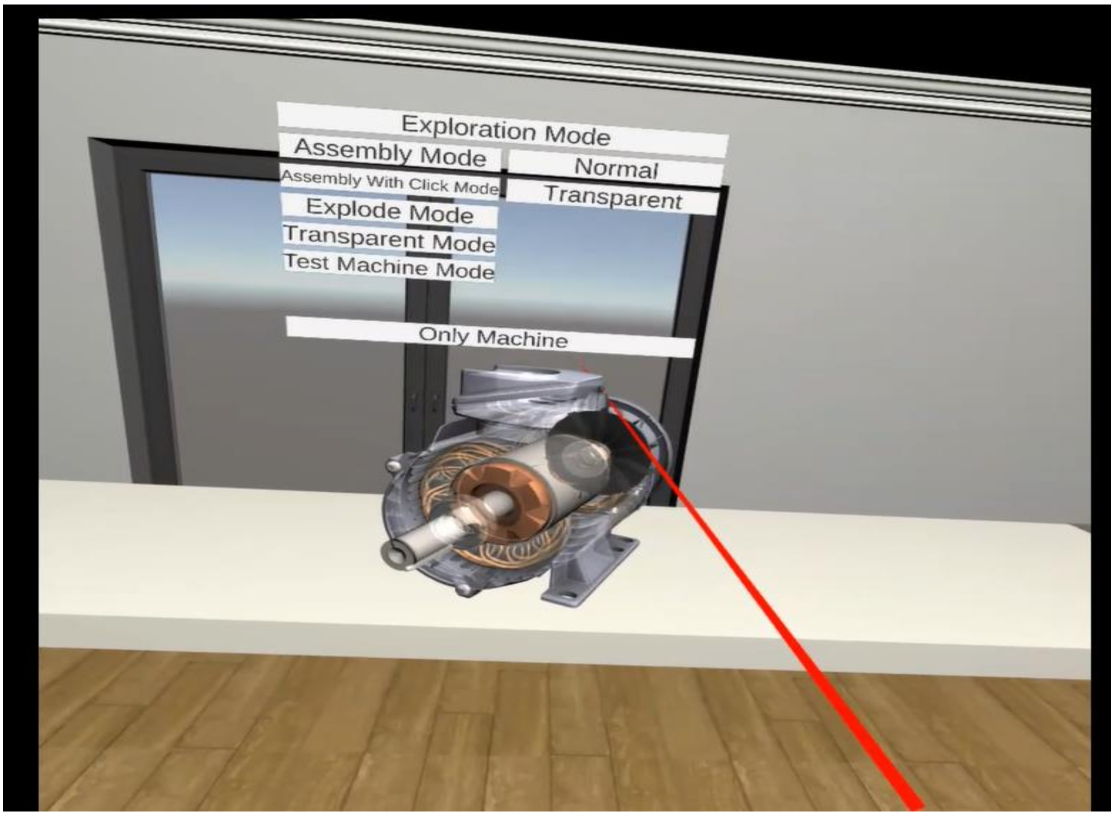

Figure 3 Tranparent mode

The others mode provides virous parts of machine for users like cover status, electrical cover, fan cover, rotor and stator. Each of this mode has its own UI environment as shown in Fig.4.

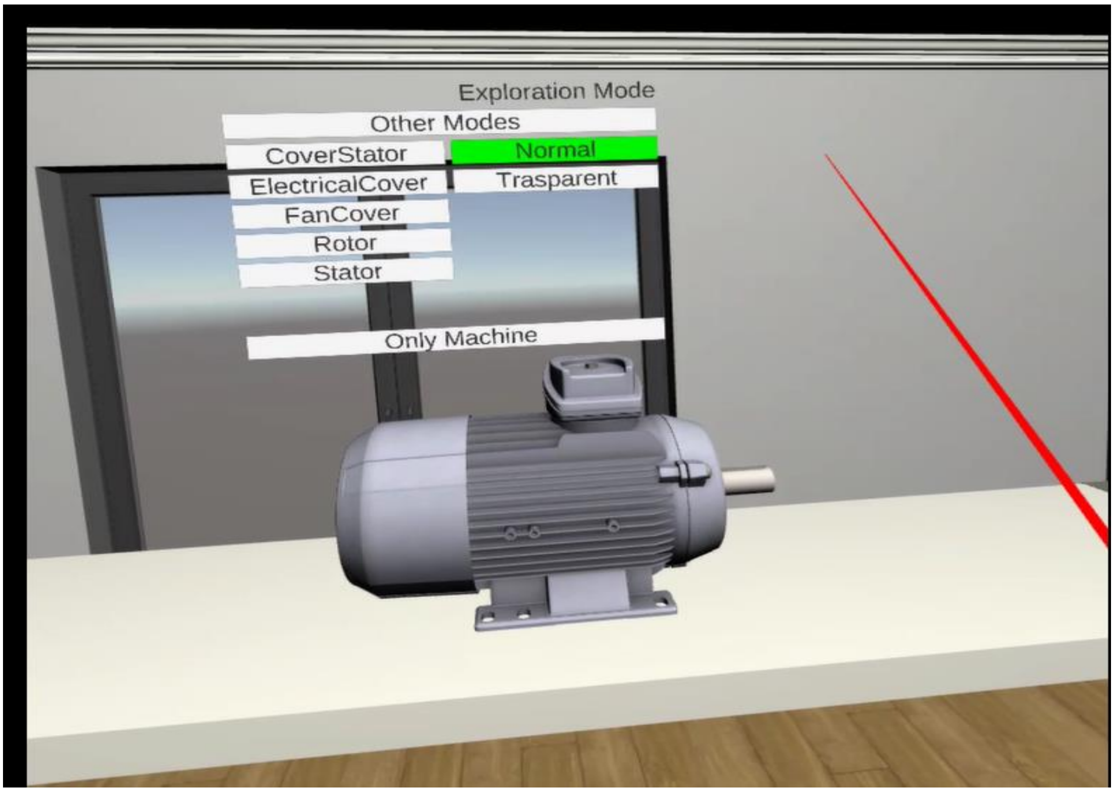

Figure 4: Others mode

Conclusion

The purpose of this study was to create an interactive virtual reality environment to demonstrate how VR can benefit the mechanical and electrical laboratory. Users can interact with and manipulate 3D models of authentic devices using this tool. Users can compare structural differences between devices, assemble and disassemble machines, and test them under extreme conditions, which is not possible when working with a real device. The three-dimensional devices are fully functional, allowing users to interact with them on all levels, including impact analysis of supply conditions.

From a technical standpoint, further development of this project would require incorporating additional devices and functions to transform the prototype into a fully functional mechanical and electrical laboratory tool. To maximize the application's utility in a real-world setting, it would be necessary to make it available on multiple virtual reality platforms. This enables the application to be used on smaller, less expensive devices, making it more portable (remote learning) and economically attractive.

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