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VIRTUAL REALITY AND CONTROL SYSTEMS: HOW A 3D SYSTEM LOOKS LIKE

L. Pranovi, M. Montis, INFN-LNL, Legnaro, Italy

Abstract

Virtual Reality (VR) technology and its derivatives are mature enough to be used in environments like a nuclear research laboratory, to provide useful tools and procedures to optimize the tasks of developers and operators. Preliminary tests were performed [1] to verify the feasibility of this technology applied to a nuclear physics laboratory with promising results. Since this technology is rapidly diffusing in several different professional heterogeneous environments, such as medicine, architecture, the military and industry, we tried to evaluate the impact coming from a new kind of Human-Machine Interface based on VR.

PRELIMINARY WORKS

In a complex environment like a nuclear facility, many tasks can be difficult to execute because of the limitations (in terms of time and availability) due to the normal operations. In this scenario, the usage of Virtual Reality Technology can be an extraordinary way to overcome these limitations.

Among the several possibilities offered by the daily work, we focused on three main aspects: data collection (used to verify the incoherencies among the data provided by the groups involved in specific tasks and projects and to correct them on design and documentation), training (used to train operators to work in parts of the particle accelerator, giving them the opportunity to familiarize with the system despite its real availability) and machine maintenance.

The studies executed and the proof of concept designed and implemented verified the maturity and the versatility of this technology: the application developed gave us preliminary good feedbacks for the areas of interest previously mentioned and the results were very promising and pushed us to extend studies and application functionalities of the prototype, embracing different hardware solutions and integrating heterogeneous data and information.

At the same time, the work done has been consolidated and extended: the training based on VR technology has obtained several good feedbacks (Figure 1) and, accordingly, a new VR experience for radioprotection staff is under discussion.

VIRTUAL REALITY AND AUGMENTED REALITY TECHNOLOGIES

In the last decade, the mayor IT companies invested a lot of effort in VR technology and, as results, several products arrived on the market.

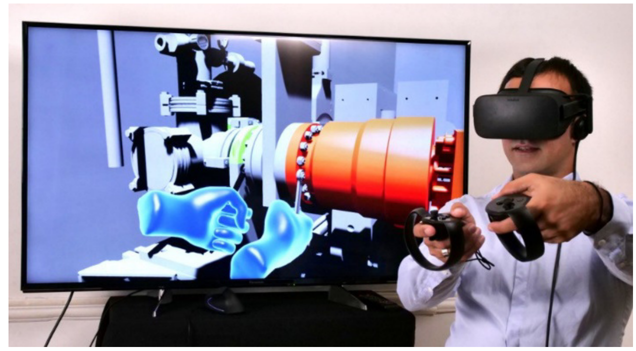

Figure 1: Beta tester for VR training.

At the same time the cost related to this kind of products become more attractive for the end user. In these last years, while VR devices are becoming quite common, first AR (Augmented Reality) type controllers are going to be available on the market (with high costs) [2].

These two kinds of technologies have different characteristics and, as consequence, offer different experiences to the user. Comparing them, it is possible to analyse VR in an interactive computer-generated experience taking place within a simulated environment, that incorporates mainly auditory and visual, but also other types of sensory feedback. It is rapidly diffusing among several different professional environments, such as medical, architecture, military and industry, with different level of interactions, based on the experience required. On the other hand, AR technology is defined as "an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory and haptic, somatosensory and olfactory. AR can be defined as a system that incorporates three basic features:

- a combination of real and virtual worlds
- real-time interaction
- accurate 3D registration of virtual and real objects.

The overlaid sensory information can be constructive (i.e., additive to the natural environment), or destructive (i.e., masking of the natural environment). This experience is seamlessly interwoven with the physical world such that it is perceived as an immersive aspect of the real environment" [3]. It is possible to say that augmented reality alters one's ongoing perception of a real-world environment, whereas virtual reality completely replaces the user's real-world environment with a simulated one.

However, AR technology has a distinct disadvantage compared with virtual reality: visual immersion. While VR completely covers and replaces your field of vision, AR

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can only project images in a limited area in front of your eyes. This aspect must be kept into account when AR applications are going to be developed for supervision and control.

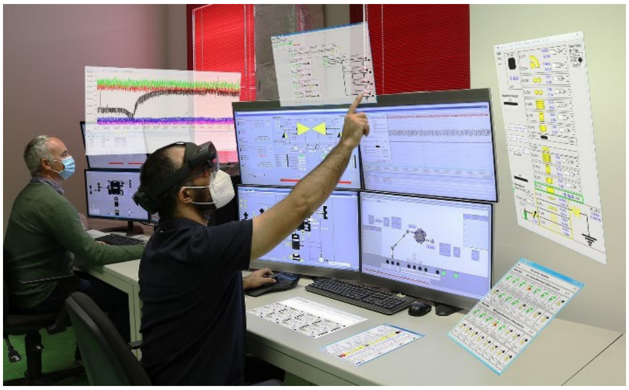

Figure 2: Panels in AR added as additional virtual desktop in the main control room.

AR IN NUCLEAR FACILITIES

The technology is designed for free movement, while projecting images over whatever you look at, with the possibility of introducing additional information.

For our preliminary study, HoloLens 2 display by Microsoft® [4] were used as AR device: it is a combination of waveguides and light projectors which are inside the enclosure above the brow. HoloLens 2 uses laser light to illuminate the display [5].

HoloLens 2 has been designed as a tool useful in an heterogenous set of environments and operations, such as manufacturing shop floors, field services, construction sites, remote work, sales, teaching and so on. In a facility like a nuclear plant, the introduction of this kind of device can increase performances and help operators in numerous tasks:

- provide an easy way to recall information during apparatus maintenance
- communicate with colleagues and teams through dedicated communication apps
- introduce a new concept of Human-Machine Interface (HMI) where the classical control panels are extended with virtual ones

The principal user case has been the definition of a virtual console used by operators working with the cyclotron apparatus at LNL. A renewal process is ongoing, in parallel with normal operations, in order to upgrade the apparatus high-level control interface. In this scenario, additional screens are reproduced in AR next to the normal control monitors (Figure 2). This configuration lets users have the main screens devoted to monitor and supervise the machine provided in AR while the normal computer-based HMI can be used to interact with the control (sending command and execute procedures).

The AR screens are a reproduction of the console panels, optimized for HoloLens device. This approach simplifies the machine conduction because all the graphical user interfaces are harmonized among them.

Under technical aspect, Unreal Engine [6] software has been used. The choice of this tool has been based on two factors:

- the experience acquired with the work done with VR experiences
- the availability of dedicated Software Development Kit (SDK) optimized for AR technology.

It is important to underline that all the screens defined in AR are devoted only for monitoring: no commands or machine's procedure can be executed via AR technology. This condition has been adopted to guarantee safety and reliability for users and apparatus.

Further studies and tests are ongoing to provide control information during maintenance: the goal we want to achieve is to provide at least the same control panels available to operators working close to the machine during local supervision. Preliminary tests have been done (Figure 3) with promising results (i.e., touchless controls maximize the cleaning of environment and tools), but more effort must be invested in this task.

Figure 3: Preliminary tests with AR technology for maintenance operations.

FURTHER DEVELOPMENTS

The work done and exposed is a preliminary test for a more stable solution of virtual monitoring and it requires further development regarding reliability and usability. The main gaol we want to achieve is to extend the usage of virtual desktops not only for supervision but also for control: this step can have an important impact in term of space optimization and portability.

Concerning this goal, additional studies and investigations are required to evaluate the effort required to realize multi-user and multi-platform solutions.

As the number of AR tools is on the rise, it is also critical to evaluate and select additional tools and software needed to develop more AR experiences.

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CONCLUSION

Augmented Reality technology is rapidly becoming an important asset in many professional fields. In an environment like nuclear facilities, it has the potential to redesign the concept of Human-Machine Interface and it can extend the usage of control parameters outside the classical control room. The preliminary tests done realizing new control panels in AR confirmed the huge potential of the tool, but further effort is required to fully integrate this technology in an heterogenous system (in terms of software and applications) like the one nuclear facility represents.

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