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RESEARCH IN VIRTUAL ENGINEERING

RAZISKAVE V VIRTUALNEM INŽENIRINGU

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Abstract

Virtual reality systems and 3D printing have achieved an adequate level of development to be considered in innovative applications in education and research. One of the challenges of this technology is the associated costs, which have been unaffordable for educational and research institutes. However, in recent years, computer hardware and software accompanied by the development of printing technology has made it more feasible for teaching strategies. From the research point of view, it is time for companies to innovate by incorporating new technologies, particularly those that inject products with greater intelligence and the ability to monitor, learn, and fix problems while functioning in their virtual environment.

Povzetek

Sistemi navidezna resničnosti in tehnologije 3D tiskanja so dosegle zadostno stopnjo razvoja, da jih je potrebno upoštevati in vpeljati kot inovativne aplikacije na področju izobraževanja in raziskovanja. Enega večjih izzivov te visoke tehnologije predstavljajo stroški nabave in vzdrževanja, ki so izredno visoki za izobraževalno raziskovalne ustanove. V zadnjih letih je razvoj teh tehnologij in s tem nižanje stroškov dosegel nivo, ko jih je mogoče vključiti v prihodnje strategije poučevanja in raziskovalnega dela. Iz raziskovalnega vidika, je čas, da podjetja za evalvacijo inovacij vključujejo nove tehnologije, še posebej tiste, ki omogočajo razvoj izdelkov z višjo dodano vrednostjo in omogočajo večje spremljanje, učenje in odpravljanje težav izdelkov, med obratovanjem v njihovem navideznem delovnem okolju.

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1 INTRODUCTION

In research and education, new technologies are a highly influential factor, much more than ever before. A generation of engineering students is entering higher education with significant computing knowledge, and with higher expectations that academic institutes will introduce them to appropriate technologies for their successful entry into industry. Research in virtual reality has the potential for expansion in the coming years. In the research by IEEE Transmitter, *[1]*, over 150,000 attendees of the Consumer Electronics Show produce the eight top technological trends that should be tracked. Virtual Reality (VR) and Rapid Prototyping (RP) are on the 4th and 7th places, respectively. In recent years, VR systems have received much attention from researchers and industry. Recent advances in hardware and software have brought this technology within reach of researchers at universities and in industry. As a concept, VR has been around for over forty years and is characterised by high degrees of immersion and interaction. Its main goal is to make users believe that they are actually in the computer-operated environment. A VR system has the potential to create systematic human testing, training, and treatment environments, which allow the control of complex, immersive, dynamic 3D simulated presentations. This, in turn, makes the interaction sophisticated and enables the tracking of behaviour and the recording of performance possible. VR can be identified with the following concepts: simulation, interaction, artificiality, immersion and network communication. VR implementations make use of high-speed and high-quality 3D graphics and audio with a combination of interactive devices to achieve realism and believability.

The use of this technology is spreading throughout industry, providing the ability to virtually explore a complete product before conception, to improve techniques in the process of product development using CAD software, and to validate a design before committing to making a physical prototype (Figure 1).

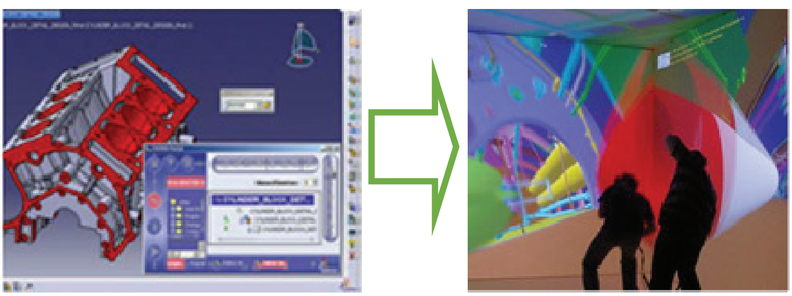

Figure 1: *Development of product design in CAD to VR*

3D printing (3DP) as part of RP is a potent tool for the design and manufacturing industries. With the rapid development of 3DP technologies in recent years, the equipment has become more affordable and accessible to the public. 3DP has been used in research and manufacturing and is used in engineering education to enhance design-related courses. Over the years, it has gradually become an essential component of the design and manufacturing curricula from first-year design and drafting courses to final-year projects. The main reason that RP has become so popular in engineering education is the simplicity of its operation, compared to traditional machining processes, and the spontaneous delivery of results, which provides a significant impact on the experience. From the literature (e.g. Sinha, *[2]*), it has been observed that RP is helpful in visualization, presenting real-world applications, and closing the gap between theories and practices. These designs involve complex geometric structures that are difficult to fabricate using traditional machining processes. With RP, the prototypes can be fabricated easily, and the projects can be completed within reasonable timeframes and budget ranges. In addition to ease of use, the freeform capability and recently available multi-material processes open new possibilities for engineering practices and some other areas.

2 PRINTING IN 3D

The Laboratory of Virtual Engineering at the Faculty of Energy Technology of the University of Maribor is equipped with two small devices and one large format state-of-the-art 3D printing device.

3DSYSTEMS CubePro Trio (Figure 2) measures 20 × 23 × 27 cm; three different materials in a single print job can be used with an accuracy of 0.3 mm. The most commonly used materials are ABS (Acrylonitrile Butadiene Styrene), a common thermoplastic known for its use in injection moulding; PLA (Polylactic Acid), a popular biodegradable thermoplastic derived from renewable resources, such as corn starch, used for many applications; and nylon, when an object requires both strength and a small amount of flexibility. The printing process is extended with another input device: iSense scanner (Figure 2) that can scan volumes of 0.2-3.0 m^3 in VGA resolution (640x480) and accuracy up to 1 mm. All equipment is from a single provider and used integrated software solutions.

Figure 2: *3DSYSTEMS CubePro Trio and CUBE iSense scanner*

TYPE A MACHINES (Figure 3) has built size of 30 × 30 × 30 cm with an accuracy of 0.2 mm and uses different materials, including PLA, ABS, INGUS, and nylon. It has its own software for optimisation of printing.

Figure 3*: Type A Machines Series 1 and corresponding software*

Figure 4: *Wind turbine CAD model, blade 3D print and turbine measurements in wind tunnel*

Figure 4 presents different stages in the wind turbine blade development, CAD model, printed blade, and picture from measurements in the wind tunnel.

EnvisionTec XEDE (Figure 5) is a state-of-the-art large-format 3D printer with a size of 46 × 46 × 46cm and accuracy of 0.05mm. The material must be 3SP photopolymers. The printer is equipped with well-known Magics software to prepare geometry and its own software to optimize printing processes on an onboard computer.

EnvisionTEC's Xede 3SP large-format 3D printer enables the production of exceptionally large 3D parts, at fast build speeds without sacrificing surface quality and part accuracy. The Xede 3SP uses EnvisionTEC's 3SP (Scan, Spin and Selectively Photocure) technology to quickly 3D print highly accurate parts from STL regardless of geometric complexity. The 3D printer is delivered and installed with all the relevant software to enable the automatic generation of supports and perfect model production. The reliability of the light source and the high-speed productivity of the Xede 3SP makes it one of the most competitive 3D printers on the market. Figure 5 shows the same very small and highly accurate printed parts and the blade of winter turbine from the same CAD model in Figure 4.

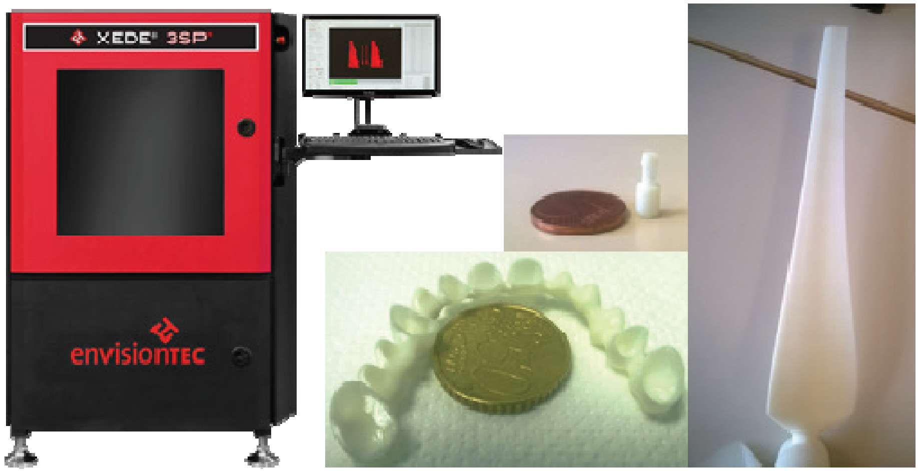

Figure 5: *EnvisionTEC XEDE and some small parts produced*

3 VISUALISATION IN 3D

The Laboratory of Virtual Engineering at the Faculty of Energy Technology has recently been equipped with technologies for VR to improve and enrich the research and, of course, educational work. Significant computing power and graphical user devices and interfaces were installed.

The Corner Cave Vario 90/180 is a flexible 3D Projection System. There are two options to use it. The first case is a double-sized Powerwall, and the second case is like a two-sided cave, as seen in Figure 6.

Two individual Powerwalls to make this possible. Each measures 3.2 × 2.0 m with WQXGA (2560 x 1600) resolution and has 5000-lumen brightness. Each Powerwall is mounted to its chassis. The chassis is mounted behind the projection surface and are on rollers to make it moveable.

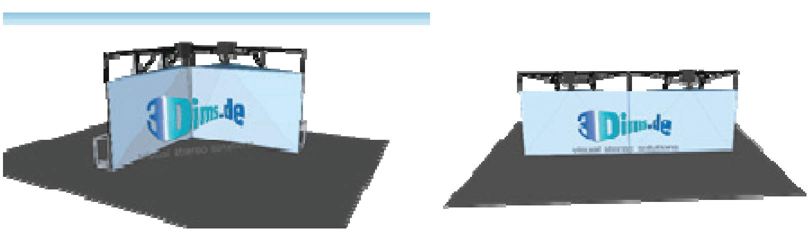

Figure 6: *Big Powerwall or Two-Sided Cave (3Dims, 2017)*

The projectors are mounted to an overhang in front of the projection surface. A BARCO F50 WQXGA Projector enables high-quality projections at small distances from the screen (Figure 7).

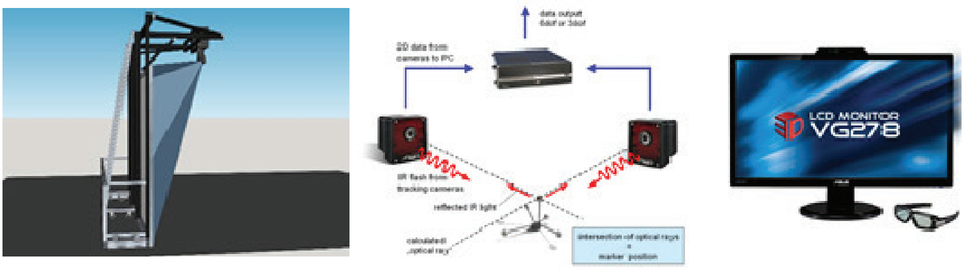

***Figure 7**: Projection distance, motion tracking system and 3DVision (VRLogic; nvidia.com)*

The laboratory is equipped with three 4K resolution monitors enabling to work stereo 3D on a computer monitor with NVIDIA 3DVision equipment on 200Hz (Figure 7).
Such powerful computer graphics are supported by two workstations, each with following main specifications:

- Intel Dual Socket Motherboard
- 2× Intel® Xeon E5_2699v3, 18 cores 2,3GHz (Haswell) main onboard CPUs
- 128 GB DDR4 RAM
- 400GB SSD, 2TB HDD
- Nvidia Quadro M6000, Nvidia Tesla K40 12GB 2880 CUDA Cores,
- Intel X450 Dual 10GBase.

Other equipment is needed for work interactively in a virtual environment. We use an ART Trackpac4 System with four cameras as the tracking system (Figure 7) of movement in the working area with an ART controller, targeting shutter glasses and wand (Figure 8).

***Figure 8**: Interaction devices: Wand, Master Shutter glasses and 3D SpaceMouse*

P3D Virtual Sight (VRLogic, 2017) is a virtual reality software solution designed for the visualization of digital aspect mock-ups at a 1:1 scale on multi-screen immersive systems. Visualization on a 1:1 scale makes it possible to assess objects with regard to their actual size and complements the photorealistic rendering quality of the Lumiscaphe (2017) rendering engine with an extra dimension of realism. P3D Virtual Sight conforms to a wide range of configurations. It is suitable for various visualisation profiles and modes, such as multi-screen devices, image walls based on juxtaposed projections, immersive systems of the CAVE type or Head Mounted Displays.

P3D Virtual Sight (Figure 9) also supports multiple stereoscopic display modes and can be interfaced with various tracking systems to enhance sensorial experimentation during project review.

Figure 9: *VR pilot software on monitor and in corner cave*

For modelling and geometry creation, the laboratory is equipped with CATIA, SolidWorks, and Ansys software for advanced numerical analysis as could be seen in Figure 10.

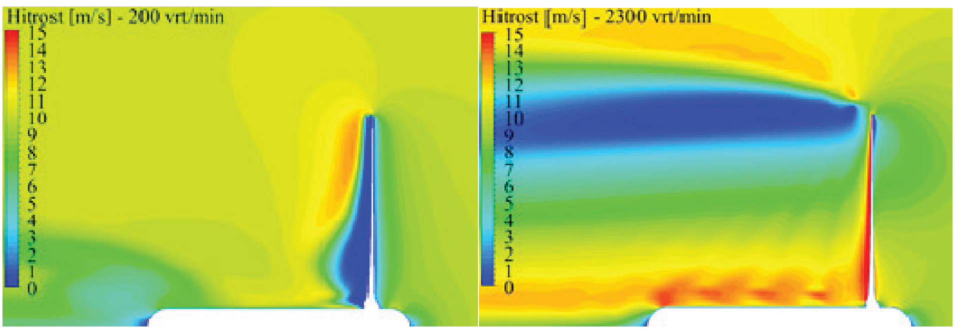

Figure 10: *Results of numerical analysis of wind turbine from Figure 4*

4 CONCLUSION

Interactive and immersive 3D visualisation virtual reality technology and rapid prototyping are ubiquitous in research institutes and in industry and will have a profound impact on research and manufacturing processes in future. These technologies represent a tool that can create a pipeline for cooperation and research with industry and prepare the next generation of graduate engineering with the required skills. While cost is recognised as a key challenge, leading institutes have already implemented the technology for research and education purposes. However, the more the technology advances, the more affordable it becomes. Thus, it is expected that institutes will implement the necessary hardware and software level for virtual reality and rapid prototyping to be strategically adopted in the future of engineering.

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