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A novel Virtual Reality interface for 3D CAD design

Figure 2: Comparison between traditional CAD workflow and VR-enhanced workflow

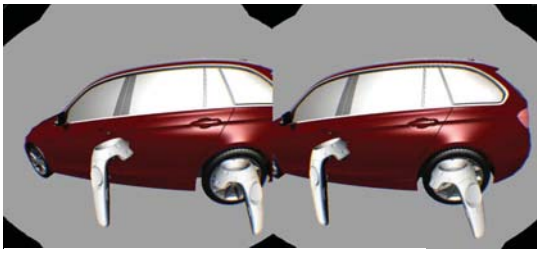

Figure 3: Navigation of a mechanical 3D model

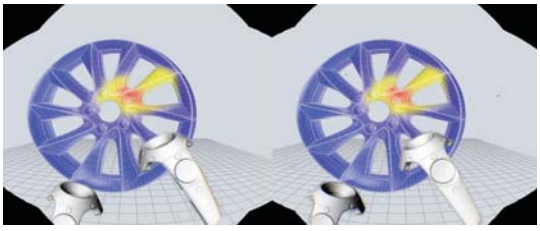

Figure 4: FEM analysis in VR

ABSTRACT

The growing request of interactivity in real-time simulation for mechanical and civil engineering requires new models and methods for analysis, going deeper and deeper into components details and virtual reality constitutes an answer capable to drastically change the future of CAD/CAE software. The proposed platform constitutes the first 3D virtual reality CAD software, offering design editing and review with an increasing level of interactivity. The interaction is provided using an existing and cost-effective tracking devices, the HTC Vive. The use of an off-the-shelf tracking device offers versatility and reliability to give commands in an easy and user-friendly way. More specifically, the aim of this work is to demonstrate how virtual reality, with the right level of interactivity, can reduce the development time while at the same time offering increasing level of detail. This is demonstrated through a comparison between the number of operations required in a classical design editing software against our novel solution. Besides, it is demonstrated how load analysis on mechanical components can be performed in virtual reality offering a new perspective to computer aided engineering.

1 - INTRO

Recent investments of worldwide companies in the area of virtual reality as an aid for the design editing and review have been leading computer scientists towards a new technological challenge: bring interactivity from 2D screens to a fully immersive 3D environment. Past research in this field demonstrated that CAD/CAE software in virtual reality can help in different fields such as architecture [1] or automotive [2] and even in healthcare [3] for rehabilitation purposes. However, the big limitation of the use of virtual reality is the effective interaction between users and computers, indeed existing systems are not user-friendly and their use is still limited to research purposes or game consoles. In contrast to previous research tools, Mindesk aims to overcome the big limitation of interactivity offering an effective tool for CAD design editing, review, and analysis. The system consists of a hardware-software platform that uses body's natural movements as commands in the virtual environment, the tracking system beside the novel immersive 3D graphical user interface produce an effective CAD/CAE software. Moreover, the virtual 3D environment allows designers to visualize finite elements analysis offering an high-level sensation of details in 1:1 scale visualization.

2 - SYSTEM OVERVIEW

Instead of re-inventing the CAD/CAE software, the proposed platform has been thought as a plug-in to be added on existing software tools able to bring functionalities to a new level of interactivity. Our solution includes software and hardware components, the former is a virtual reality plug-in with side by side interfaces towards CAD/CAE software and hardware. Whereas the latter consists of a tracking system including a custom interface between the HTC Vive and the CAD/CAE software.
An architecture overview is summarized in Figure 5, where the Mindesk plug-in constitute an interface between software and hardware. Although this can already be an important contribution, our solution includes also a friendly user interface to give the user the capability to switch among several tools directly in the virtual environment using the tracking device. This is not limited to the HTC Vive but it also include an electronic pen able to provide further functionalities (see Fig 7). Each single component is described in the following sections.

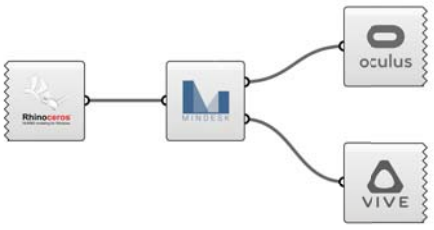

Figure 5: Architecture overview

Figure 6: Immersive UX and UI

Figure 7: Potential utilizations of Mindesk interface

3 - SOFTWARE INTERFACES AND 3D USER INTERFACE

Focusing on the software, the first plug-in can work in the Rhinoceros environment, it captures the scene status, process it, generating a VR-compatible output in real time that is visualized on a head mounted display, or HMD (see Figg. 2 and 3). The processing runtime runs on the GPU and it is meant to be highly scalable on multiple hardware devices. In fact, Mindesk runtime supports both Oculus Rift and HTC Vive and will be expanded to new VR and AR devices like Meta and Microsoft Hololens. The plug-in is meant to work with other CAD platforms as well. Both interaction features and GUI have been developed on independent software layers (Mindesk SDK) interacting with the local software API taking control of its functionalities.
The plug-in is able to visualize the custom designed virtual toolbar which provides to the user a seamless way to access an high number of CAD features while immersed in VR. Currently it supports 20 functionalities including model navigation, move, scale, rotations, and geometrical constraints.
VR-CAD interface can optimize FEM simulations in large number of different ways: VR 6 DOF input can be used to displace loads and force vectors on the model, set constraints, and set section planes. In Fig. 4 a result of a FEM simulation (Von Mises stress) is displayed in VR.

4 - TRACKING INTERACTION

The tracking is performed by calculating the position and the orientation of the tracking device in the real world and reprojecting it into the virtual environment. As the application is meant to be of general purpose, it supports several, and interchangeable, tracking systems. The HTC Vive (see Fig. 7, left side) constitutes a robust and off-the-shelf solution offering high reliability, on the other side, our custom 3D immersive pen (see Fig. 7, right side) introduces new functionalities and provides to users the most natural tool to interact with CAD software.

5 - DISCUSSION

In order to demonstrate the strengths of using our new software, we ran a comparative experiment. We asked an experienced CAD drafter to design a 60 floors highrise using McNeel Rhinoceros 5 with its traditional interface. Then - after a short training session - we asked the same person to build the same model, through the same identical process, in VR. It resulted in a 50% time reduction performing 3D modeling with Mindesk interface with respect to classical CAD modeling (15'02" with a 2D interface, 7'04" with our VR interface). [4]

6 - REFERENCES

[1] H. Graf, "A "Change 'n Play" Software Architecture Integrating CAD, CAE and Immersive Real-Time Environments," Computer-Aided Design and Computer Graphics (CAD/Graphics), 2011 12th International Conference on, Jinan, 2011, pp. 3-10. doi: 10.1109/CAD/Graphics.2011.82
[2] G. Monacelli, and S. C. P. Elasis. "VR Applications for reducing time and cost of Vehicle Development Process." (2003).
[3] Sugarman, H., Weisel-Eichler, A., Burstin, A., & Brown, R. (2011, June). Use of novel virtual reality system for the assessment and treatment of unilateral spatial neglect: A feasibility study. In 2011 International Conference on Virtual Rehabilitation (pp. 1-2). IEEE.
[4] https://vimeo.com/183913726/e621e9b302