Vortex : virtual reality system to check radiation exposure levels

Developed at the Technology Department of the Culham Centre for Fusion Energy, the VORTEX software combines virtual reality with radiation transport calculations in order to accurately determine the total dose to operatives and equipment during maintenance tasks in radiation environments. Used in a fission or fusion plant environment, VORTEX will enable the detailed planning of such tasks with a view to minimizing the exposure of the workforce. The software has the potential to be used in a variety of demanding environments, including those outside of the nuclear sector, such as space, high energy physics or healthcare.

Description of the technology

Many engineering and scientific institutions are exploring the use of VR with large science datasets. VR has a great potential for fusion research in the analysis of its complex physics-based datasets. VORTEX (Virtual Operator RadiaTion EXposure) is one application that has been developed for the visualisation and analysis of predicted radiation dose to workers carrying out tasks around reactors during shutdown. A VR model of these radiation environments, combined with 3-D dose data maps, enables the planning of operational procedures to reduce the dose received by workers, and minimise exposure times. It also provides safe virtual operation training and rehearsal, visualisation of radiation dose rates, and estimation of doses received by workers.

Highly detailed CAD models exist for the machine to help with engineering analysis and the installation of new hardware. These models are very complex and cannot be used directly for radiation transport calculations and VR purposes. For virtual reality the JET machine 360° three-dimensional model was simplified using the commercial software Space claim and 3D studio max. These were used to reduce the number of polygons and small objects to increase the performance and frame rate of the VORTEX software.

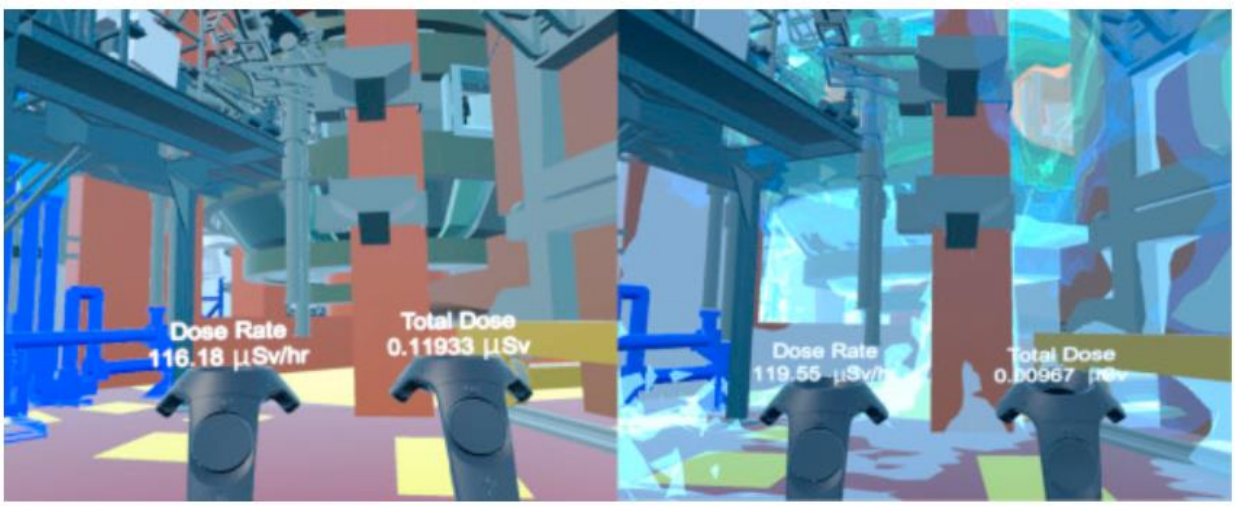

Figure 1: Screen shots taken from VORTEX inside the virtual JET model. The right image shows the radiation contours overlaid over the geometry with the colours indicating the intensity of the dose rate (UKAEA/CCFE, Culham Science Centre).

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Innovation and advantages of the offer

The use of immersive virtual reality, with highly accurate radiation transport maps of entire machines and buildings, allows operators of fusion devices to plan and optimise procedures by practising them in a real-time virtual environment. As well as allowing operations to be optimised and improved, it will also provide accurate determination of doses to people and equipment during complex procedures in radiation environments. For example, simulation shows a 40% reduction in overall dose for a procedure when using a virtual reality model of JET when compared with traditional mesh interrogation techniques. This is due to better spatial and temporal tracking of the procedure in VORTEX.

Non-fusion Applications

The software has the potential to be used in a variety of nuclear environments, including those outside of the fusion ecosystem. In addition to this the technology could be adapted for utilization within any other industries where remote handling and monitoring could be beneficial such as radiology practice in healthcare, space or high energy physics.

EUROfusion heritage

VR has a great potential for fusion research in the analysis of its complex physics-based datasets. The work delivered through this technological development at UKAEA combines shutdown dose calculations with a virtual reality model of the Joint European Tokamak (JET). The shutdown dose calculations were performed for various time steps during the JET DTE2 campaign using the UKAEA code MCR2S which links MCNP and FISPACT-II using the rigorous two step method. The 3-Dimensional dose and activation data created by MCR2S have been integrated into the game engine Unity using C# routines to create VORTEX. This model enables more precise planning of operational procedures by having the operator/planner walk around the virtual environment using a virtual reality headset such as the Oculus rift or the HTC vive.

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