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A virtual platform for remote surveillance, intervention planning and real-time feedback in research facilities

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Inspections and interventions in radioactive environments are often reliant on human personnel because of the complexity of the infrastructures that have not been designed for robotic or remote access. This is the case also for particle and nuclear physics experimental facilities which can become highly activated over time. To alleviate problems with the decommissioning of the ATLAS inner detector at the Large Hadron Collider at CERN, a Virtual Reality (VR) Platform has been created. The platform provides a tool for training purposes in-situ and on mock-ups of the real detectors. Information on immediate and accumulated radiation doses can be fed back live or analysed in depth later.

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Figure 1: A comparison between the technician at work as captured by a camera with the LEDs used by the motion capture system and the avatars in the VR suite.

1. Introduction

These proceedings present a virtual platform developed to facilitate the planning of tasks and training of personnel in radioactive environments. This development has focused so far on a very specific scenario: The decommissioning of the Inner Detector (ID) of the ATLAS experiment, located at the Large Hadron Collider (LHC). The High-Luminosity LHC phase will require upgrades of the ATLAS detectorto cope with the harsh environment at the HL-LHC, including a complete refurbishment of the ID. Due to activation through exposure to intense high-energy beams during the data-taking, Radiation Protection (RP) procedures are relevant during the ID decommissioning.

2. Radiation Protection Planning with Virtual Reality

As Low As Reasonably Achievable (ALARA) is the guiding principle for interventions. Projected radiation levels based on FLUKA simulation determine what ALARA Level applies and the amount of effort needed to plan and supervise the works [1]. For accurate radiation estimates, several parameters need to be known (e.g. cool-down times) which are often subject to change (extension of machine running or shutdowns, optimisation of work procedure) and require frequent re-evaluations. Position and duration of work are usually estimated by project engineer and the information is logged in spreadsheets.

A new and more flexible approach with better ways to estimate positions and to log the has been developed and have been implemented in a virtual reality (VR) platform. This approach combines FLUKA radiation map [2] with detailed CATIA[1] drawings in a `Unity`-based tool. Dose rate calculations obtained from FLUKA simulations have a granularity of 5-10 cm with a 20% uncertainty compared to reference measurements. CATIA/CAD drawings are cleaned up and reduced in complexity, then imported into a Virtual Reality (VR) Suite. Following up on initial studies [3], `Unity` has been chosen as being cross-platform with readily available documentation.

In first instance, the approach utilizes a mock-up replica of the ID. The technician carries out parts of the works as with the real detector and is recorded by a commercial motion capture system, `PhaseSpace`, with is based on LEDs and 3D cameras. The total dose at torso position is calculated based on the captured data overlaid with the `Fluka` radiation maps. Both, instantaneous and accumulative dose can be tracked as shown in Figure 2.

[1]CATIA V5 is CERN's main platform for mechanical computer-aided design, https://plm-service.web.cern.ch/tools

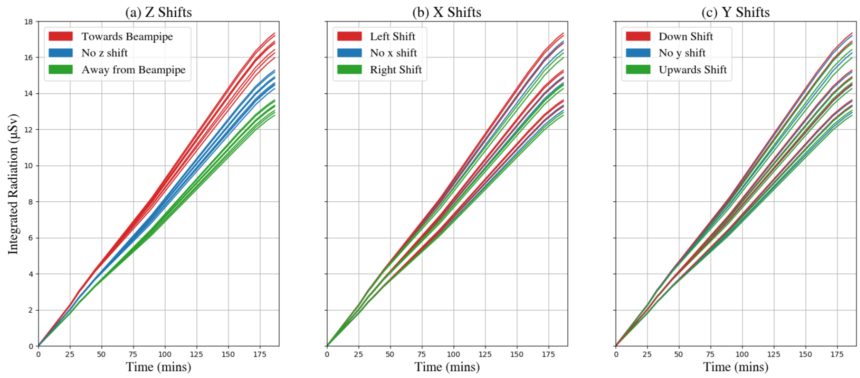

Figure 2: Uncertainties on from the shifts, comparing from the shifts in the different directions by showing them separately for z, x, and y-shifts.

The motion capture data can be read in real time - which allows for live feedback during actual works or training on mock-up detectors with immediate feedback on estimated dose based on the position data. The motion capture data can be saved for later analysis, e.g. to study uncertainties (see Figure 2). Uncertainties are determined by varying the starting position of the motion by 10 cm in any direction (27 variations in total). The strongest correlation is with the z -axis, meaning, moving closer to the beam pipe results in a higher dose. Overall, this gives an uncertainty of a bit less than 20% which is within the 20% uncertainty of the dosimeter measurement. Converting the dosimeter uncertainty of 20% into a position uncertainty gives a margin of 25 cm on the positions over the course of decommissioning. In any case, a safety factor is applied to ensure that the actual collected dose is not higher than the planned one.

3. Outlook and conclusion

A new approach to radiation protection planning has been introduced and uncertainties on the resulting estimated studied. Further work includes the implementation of 3D model realism and improved import of geometry models with studies to improve the VR to eventually test augmented and fully virtual reality training. Improvements to the motion capture could be achieved by using wireless motion tracking e.g. using neural network technology. Finally, applications to other decommissioning or intervention scenarios are envisaged and collaborations would be welcomed.

References

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