ST 1: Computational Methods and Simulation

Time: Tuesday 13:45–15:15 Location: ZHG003

ST 1.1 Tue 13:45 ZHG003

Geant4 Tool for Characterizing and Optimizing Albedo Dosimeters: Impact of Filter Configuration and Material Composition — •Suliman Harbaji[1], Kevin Kröninger[1], Andria Michael[1], Jörg Walbersloh[2], and Jens Weingarten[1] — [1]Technical University Dortmund, Dortmund, Germany — [2]Materials Testing Office, Dortmund, Germany

Thermoluminescence albedo dosimeters are employed to measure neutron and photon whole-body doses resulting from occupational radiation exposure. These dosimeters operate based on the albedo effect, in which neutron radiation is backscattered by the body and subsequently detected by the dosimeter components.

The albedo dosimeters consist of an arrangement of four detectors embedded in neutron absorbers, commonly referred to as filters. A critical factor in dosimeters functionality is the configuration of these filters. Additionally, the composition and thickness of the filters have a significant influence on the detection efficiency.

For a detailed characterization of albedo dosimeters and their functionality, a simulation tool was developed using Geant4. The study focuses on neutron interactions with the dosimeter under various filter configurations, material compositions, filter thicknesses, and detector material thicknesses. The results of the simutation provide valuable insights into optimising the detection properties and therefore improving the measurement accuracy of albedo dosimeters.

In this talk, the developed Geant4 tool and the results of the simulations will be presented and discussed.

ST 1.2 Tue 14:00 ZHG003

Experimental tuning of Geant for Cherenkov radiation of electrons — Yazeed Balasmeh, •Daniel Berker, Ivor Fleck, and Lars Maczey — Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Geant4 is a powerful tool and indispensable for the investigation of particle interactions as well as detector developments. But since there exists a variety of parameters, it is possible to make too idealistic simulations. Verifying a simulation by an experimental setup is a proper way to achieve simulations as realistic as possible. The aim of this talk is to experimentally verify the production of Cherenkov radiation as simulated in Geant4.

The main setup consists of a Strontium-90 source, placed in a vacuum chamber, whose emitted electrons with energies up to 2.2 MeV are bent in a homogeneous magnetic field with an adjustable field strength between 20 mT and 80 mT. After passing through the magnetic field, the electrons will hit a PMMA layer producing Cherenkov photons, that are detected by a SiPM array. A collimator in front of the PMMA reduces the energy spread to values below 5%. The setup is calibrated with Bismuth-207 to confirm the energy of the electrons after passing through the magnetic field.

This talk presents the current status of the experiment and underlines the importance of the interplay between simulation and experimental verification. In conclusion, I want to discuss my results regarding the development of a Cherenkov Compton camera.

ST 1.3 Tue 14:15 ZHG003

Fast dose predicition for treatment planning in matRad — •Ruben Trimpop[1], Carsten Burgard[1], Tobias Cremer[2], Cornelius Grunwald[1], Kevin Kröninger[1], Florian Mentzel[2], Marco Schlimbach[1], and Jens Weingarten[1] — [1]TU Dortmund — [2]Formerly TU Dortmund

Microbeam radiation therapy (MRT) is a preclinical method for tumor treatment, demonstrating potential for improved post-treatment outcomes. The method employs a multi-slit collimator to produce dose peaks with high dose rates, separated by valleys of lower dose rates. This method of spatially segmenting the beam, combined with applying high dose rates over a short amount of time, called FLASH-Therapy, enhances the survivability rate of healthy tissue.

A major impediment to the utilisation of this method is the large amount of time it takes for dose prediction using conventional methods. Previous research has successfully used Machine Learning (ML) networks to significantly reduce the required time for dose prediction.

In this work a ML network is integrated into matRad, an open source software for radiation treatment planning, developed for research purposes, substituting matRads internal dose prediction with a ML based dose prediction. This is one of the first steps to fully enable treatment planning for MRT.

This presentation will showcase the first results of ML integration into matRad, highlighting the advantages of ML-based dose prediction for MRT.

ST 1.4 Tue 14:30 ZHG003

Improving Brain Tumor Characterization Using Generative Neural Networks and Raw MRI Data — •Marco Schlimbach, Jens Kleesiek, Kevin Kröninger, Moritz Rempe, and Jens Weingarten — TU Dortmund University

Characterizing brain tumors from MRI scans remains a significant challenge in clinical practice. Determining the specific tumor type often requires invasive biopsies, which hold risks for patients. Research efforts aim to improve non-invasive tumor characterization by using machine learning techniques. However, despite significant advancements, the accuracy of these methods has not yet reached the level needed to reliably replace biopsies. Current state-of-the-art algorithms commonly rely on reconstructed MRI images optimized for human interpretation. These images are the result of complex reconstruction pipelines that discard the raw phase information.

This study investigates the diagnostic potential of raw MRI data, which retains phase information and provides a more comprehensive representation of scanned tissue. A novel workflow is introduced to generate synthetic raw MRI data, including both healthy scans and scans with lesions. By leveraging generative machine learning techniques alongside raw MRI data, this approach aims to reveal new features and insights that could enhance non-invasive tumor characterization.

ST 1.5 Tue 14:45 ZHG003

Autoencoder-based Anomaly Detection in MRI Raw Data — •Jessica Mnischek, Jens Weingarten, Kevin Kröninger, and Marco Schlimbach — TU Dortmund

Tumor distinction in medical imaging remains a challenging task due to the subtle differences between various tumor types and abnormal tissues. Magnetic Resonance Imaging (MRI) is a powerful diagnostic tool widely used in the detection and monitoring of tumors, providing detailed visualization of soft tissues.

To enhance diagnostic accuracy, machine learning methods have been increasingly applied to MRI data. Among these methods, autoencoders have demonstrated potential in detecting subtle differences between healthy and diseased scans. By training on healthy datasets, they learn compact, efficient representations of typical tissue patterns. When applied to diseased datasets, the reconstruction error can highlight anomalies, thereby facilitating the detection of irregularities that may indicate the presence of disease.

This study investigates the application of autoencoders to raw MRI data, which preserves the complete acquired information, including both magnitude and phase components. In contrast, standard MRI analyses mostly rely only on magnitude information. By working directly with raw MRI data, this approach explores the potential of utilizing phase information to more effectively differentiate between healthy and tumor-affected tissues.

ST 1.6 Tue 15:00 ZHG003

Cycle GAN-Based Style Transfer for Image Registration between Clinical and HiP-CT — Lukas Johanns[1], Michael Windau[1], Lucas Cremer[1], •Claire Walsh[2], Joe Jacob[2], Joseph Brunet[3], Paul Sweeney[4], and Stijn Verleden[5] — [1]TU Dortmund — [2]UCL London — [3]ESRF Grenoble — [4]Cancer Research UK — [5]UZA Antwerp

Registration is an image processing algorithm that enables the alignment of scans across domains. It finds applications in disease tracking and research, in the operating room, and as a preprocessing step for other machine learning algorithms.

However, registration across modalities requires careful tuning and preprocessing of the dataset, as different domains are often difficult to compare.

To improve the performance of registration algorithms, a Cycle-GAN model for style transfer is used as a preprocessing step. This model transfers the style of the target domain to the input image to enhance registration performance. This project investigates the performance and feasibility of such a deep learning model applied to Clinical-CT scans and high-resolution/high-contrast HiP-CT scans (Hierarchical Phase Contrast Tomography). In this talk, the concepts of registration and Cycle-GANs are briefly introduced. Afterwards, the results of our style-transfer network are presented, followed by a discussion of a future feasibility study for registration.