AKPIK 11: AI Topical Day – AI in Medicine (joint session ST/AKPIK)

Time: Thursday 14:00–15:30 Location: ZEU/0146

AKPIK 11.1 Thu 14:00 ZEU/0146

Multimodal image registration with deep learning — •Alexander Ratke[1], Christian Bäumer[2], Kevin Kröninger[1], and Bernhard Spaan[1] — [1]TU Dortmund University, Dortmund, Germany — [2]West German Proton Therapy Centre Essen, Essen, Germany

In radiation therapy, precise localisation of tumour and risk structures is important for treatment planning. Medical imaging methods, such as computed tomography (CT) and magnetic resonance imaging (MRI), allow a differentiation between these structures. Planning systems typically align CT and MRI scans rigidly to compensate inaccurate immobilisation of the patient, but distortions in MRI or movement of organs still remain.

In this project, a data set of CT and MRI scans of the head and neck areas is used to study unsupervised deformable image registration with deep learning. First, the scans are pre-processed, which includes rigid registrations and the equalisation of the image formats. Then, deep learning is employed to filter structures of an image through multiple layers and to match them to a second image. The registration model strongly depends on the choice of its parameters. Therefore, variations of these parameters are investigated on the data set. The results are presented as well as the overall workflow including the pre-processing.

AKPIK 11.2 Thu 14:15 ZEU/0146

Position reconstruction in proton therapy with proton radiography and machine learning — •Jolina Zillner, Carsten Burgard, Jana Hohmann, Kevin Kröninger, Florian Mentzel, Olaf Nackenhorst, Isabelle Schilling, Hendrik Speiser, and Jens Weingarten — TU Dortmund University, Department of Physics, Germany

In proton therapy precise patient positioning is essential for treatment quality. Current research in proton radiography (pRad) enables imaging of the patient immediately prior to irradiation. The idea is to use such pRad images to verify the patients position.

Therefore a 3D Convolutional Neural Network will be developed in order to predict pRad images depending on the CT image of an object and different translations and orientations. A minimization algorithm can then find the translation and rotation vector for which the predicted image has the smallest difference to a measured pRad image of the object, which can be used to correct the objects position. To predict pRad images, the CNN needs to be trained with pRad images and their related object translation and rotation and the CT-image.

This talk introduces the simulation used to generate these pRad training data. Simulations and reference measurements are performed with a primitive elbow phantom: a 3D-printed 3x3x3 cm^3 cube with a T-cavity for gypsum-inlays representing a stretched or bent elbow. The target is implemented in GEANT4 based on CT-data.

AKPIK 11.3 Thu 14:30 ZEU/0146

Event identification in the SiFi-CC Compton camera for imaging prompt gamma rays in proton therapy via deep neural networks — •Alexander Fenger[1], Ronja Hetzel[1], Jonas Kasper[1], George Farah[1], Achim Stahl[1], and Aleksandra Wrońska[2] — [1]III. Physikalisches Institut B, RWTH Aachen University — [2]M. Smoluchowski Institute of Physics, Jagiellonian University Kraków, Poland

One of the biggest challenges in proton therapy is ensuring that the dose is delivered to the right position. A promising approach for online monitoring of the beam range is the detection of prompt gamma rays using a Compton camera, as it provides the possibility to reconstruct the 3D distribution of the deposited dose.

The SiFi-CC (SiPM and scintillating Fiber-based Compton Camera) project is a joint collaboration of the RWTH Aachen University, the Jagiellonian University in Kraków and the University of Lübeck. The two modules of the SiFi-CC, the scatterer and the absorber, both consist of stacked LYSO fibres and are read out by SiPMs. Deep neural networks are employed to separate valid Compton events from background and reconstruct the direction and energy of prompt gamma rays. First implementations of neural networks show promising results in classification of Compton events as well as full reconstruction of the event topology and kinematics. The next step is to further optimize the current neural network implementation to gain sensitivity towards a detectable range shift in the source position. Different neural network designs as well as an evaluation of their performance are presented.

AKPIK 11.4 Thu 14:45 ZEU/0146

Selection of Compton events in the SiFi-CC camera using convolutional neural networks — •George Farah[1], Ronja Hetzel[1], Jonas Kasper[1], Alexander Fenger[1], Achim Stahl[1], and Aleksandra Wrońska[2] — [1]III. Physikalisches Institut B, RWTH Aachen University — [2]M. Smoluchowski Institute of Physics, Jagiellonian University Kraków, Poland

Proton therapy is a promising form of cancer treatment that uses charged protons to target and kill cancer cells. One of the main challenges in proton therapy is accurately determining the depth at which the protons will deposit their energy in the tumor.

The SiFi-CC (SiPM and scintillating Fiber-based Compton Camera) aims to enable range detection in proton therapy. It consists of multiple scintillating LYSO fibers generating signals that get read by SiPMs attached to both ends of the fibers. The camera utilizes the Compton effect and photoelectric effect to detect the prompt gamma rays produced in nuclear interactions of the protons with the nuclei in the tumor. This allows restricting the origin of the prompt gamma to a cone surface and by reconstructing many of such cones it is possible to reconstruct the source distribution of the prompt gammas.

The most recent SiFi-CC geometry has four fibers coupled to one SiPM in a shifted manner, so signals from multiple fibers get read by a single SiPM. In this talk, we present how three-dimensional neural networks can be advantageous by taking into consideration this new geometry. Hence improving the detection of Compton events, which improves the accuracy of range detection in proton therapy.

AKPIK 11.5 Thu 15:00 ZEU/0146

Fast dose predictions for conformal synchrotron microbeam irradiations — •Marco Schlimbach[1], Micah Barnes[2], Kevin Kröninger[1], Florian Mentzel[1], Olaf Nackenhorst[1], and Jens Weingarten[1] — [1]TU Dortmund, Germany — [2]University of Wollongong, Australia

An important optimization goal of radiation therapy is to apply the prescribed dose to the tumor while minimizing the dose deposition to surrounding healthy tissue. The new preclinical irradiation method, called Microbeam Radiation Therapy (MRT), enables higher control for certain tumors by spatial fractionation of photon beams compared to conventional irradiation methods. At the same time, the exposure of normal tissue remains the same.

Currently, the dose for MRT is mostly calculated with time-consuming Monte-Carlo simulations. However, for transfer to clinical application, a fast dose calculation is essential, so that therapies can be planned in a sufficiently short time. Recent studies show that MRT doses can be predicted accurately within milliseconds using neural networks. These studies, however, are limited to predicting the dose from a fixed MRT field size.

This work presents a method to extend the developed machine learning model to predict the doses from MRT irradiation fields of variable size and shape. Since there is no data from the clinic for MRT compared to conventional irradiation methods, the models are trained using a Geant4 Monte-Carlo simulation of a rodent head irradiation at the Imaging and Medical beamline at the Australian Synchrotron.

AKPIK 11.6 Thu 15:15 ZEU/0146

Thermoluminescence glow curve generation using generative adversarial networks (GANs) — •Evelin Derugin[1], Olaf Nackenhorst[1], Florian Mentzel[1], Jens Weingarten[1], Kevin Kröninger[1], and Jörg Walbersloh[2] — [1]Department of Physics, TU Dortmund University — [2]Materialprüfungsamt NRW

Personal dose monitoring is essential for a successful radiation protection program for occupationally exposed persons. The Materialprüfungsamt NRW (MPA NRW) provides thermoluminescence (TL) dosimeters based on LiF:Mg,Ti. Proof-of-concept studies to predict the day of irradiation have been successfully performed on measured TL glow curves using artificial neural networks (ANN). However, large data sets are required to train an ANN to predict the parameters of new measurements. Therefore the Department of Physics at TU Dortmund is developing multivariate methods for generating TL glow curves using generative adversarial networks (GANs). These generated glow curves will be used as training data for the irradiation day prediction model. This study trains GANs to generate glow curves using a measured data set of 4100 glow curves with 28 irradiation dates. In this talk, we present the comparison of the simulated glow curves with the measured ones and provide information about the performance and optimization of the GAN.