Medical Imaging Data Analysis Using 3D Deep Learning Models Towards Improving the Individual Treatment Plans

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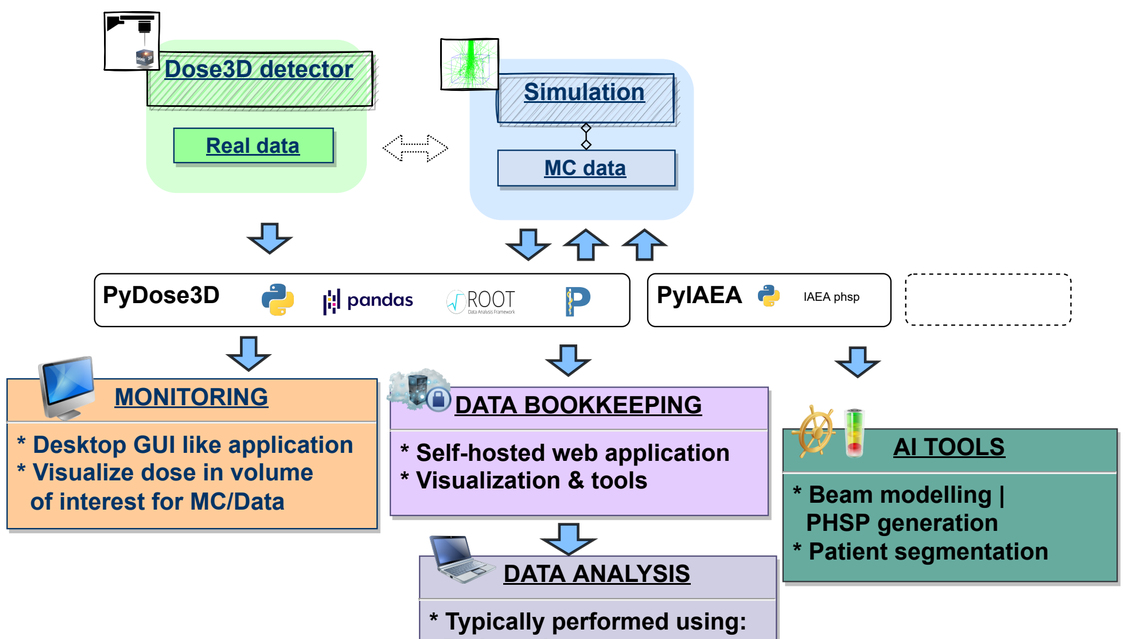
Dose3D and ML

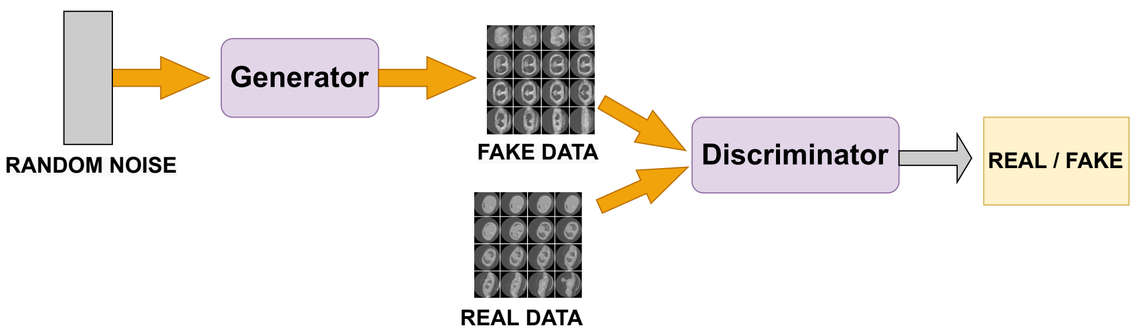
- TEAM NET Dose3D Project is being supported by Machine Learning (ML) techniques in the process of building the tool for geometry delivery for 3D detector ⇒ see contribution **A Reconfigurable Detector for Measuring the Spatial Distribution of Radiation Dose for Applications in the Preparation of Individual Patient Treatment Plans**
- Geometry is in the form of a 3D Computed Tomography (CT) scan of the human body with highly precise delineation of affected area
- The process of extracting the desired object from a medical image (segmentation) is performed by automatic tool based on deep learning model



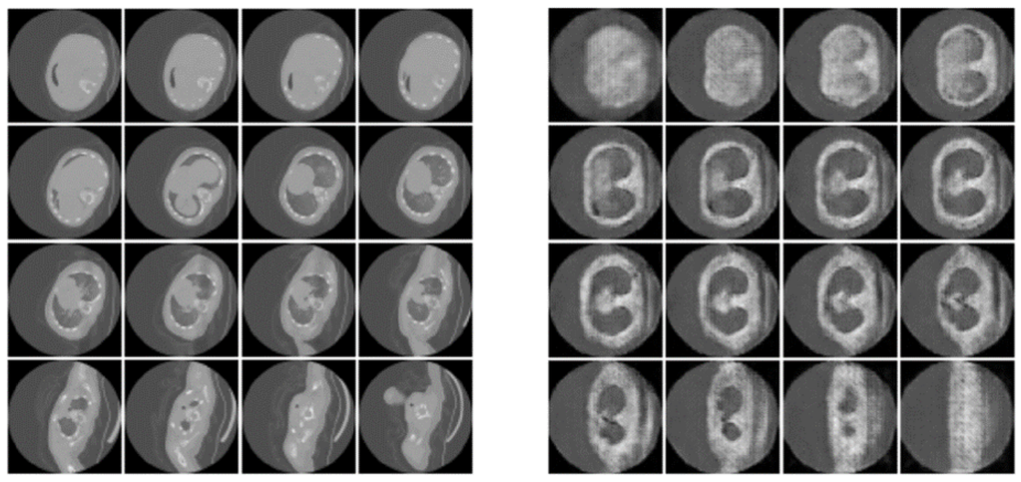
PyDose3D is the software package for data handling and analysis tools that aim is to guarantee a smooth data flow and its proper interpretation between different project areas.

Data augmentation

- Data augmentation is the process of artificially increase the size of data by generating new data samples on the basis of real data
- Due to data limitations and privacy issues well performed data augmentation may play a big role intelligent medical data analysis
- One of techniques for data augmentation is generating new data instances with using of generative deep learning model, such as Generative Adversarial Networks (GANs), that consists of two neural networks pitting one against the other



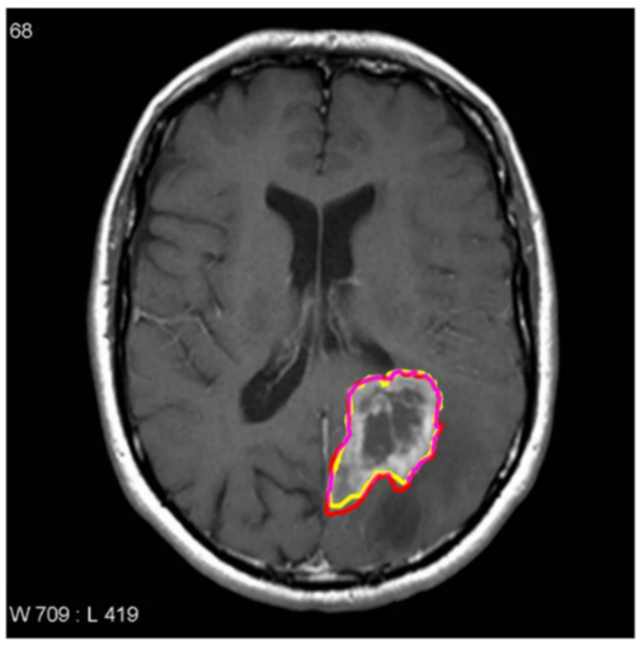
- The very first deep learning model based on GANs has been built and tested for medical data augmentation purposes



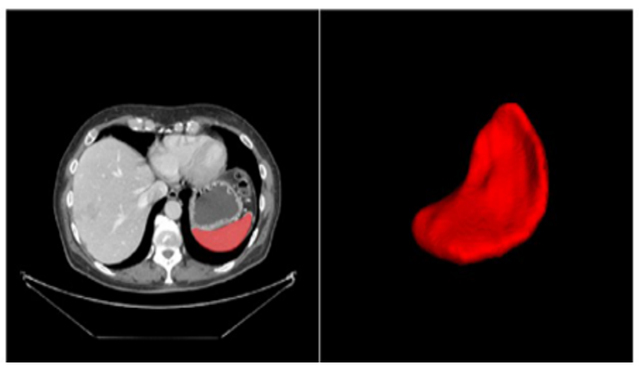
The figure presents original data sample from public database [1] (left) and data generated by generative GANs model built and trained using MONAI.

Segmentation

- Segmentation is the process of detection of boundaries within an image in order to distinguish between the affected area and surrounding healthy organs
- High precision is required
- As standard, segmentation is being done manually by medical specialists
- The current stage of Machine Learning techniques development proves that the automatic segmentation results can, in some cases, surpass human capabilities



Motivation to build the automatic segmentation tool comes from the fact that delineations performed by a few different specialists can vary from each other. The figure presents an example of manual anatomical segmentation done by first (red) and second author (yellow) with intersection (purple) [2].



Technically, automatic medical image segmentation is the process of assigning a label to every voxel in 3D image such that voxels with the same label define the volume of a specific part of the human body. The figure presents a spleen segmentation from CT scan [3].

Clara and MONAI

Working in three dimensions requires high computational power and GPU's support in the process of ML models training. This is the reason for using dedicated platforms such as NVIDIA Clara with the Python framework MONAI on the backend. Those technologies provides most advanced techniques and implementations such as:

- domain-specific GPU optimization
- state of the art pre-trained deep learning models
- AutoML - automatic parameter tuning
- Federated Learning - training an algorithm across multiple devices holding data samples without exchanging them
- set of tools for medical data transformations

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