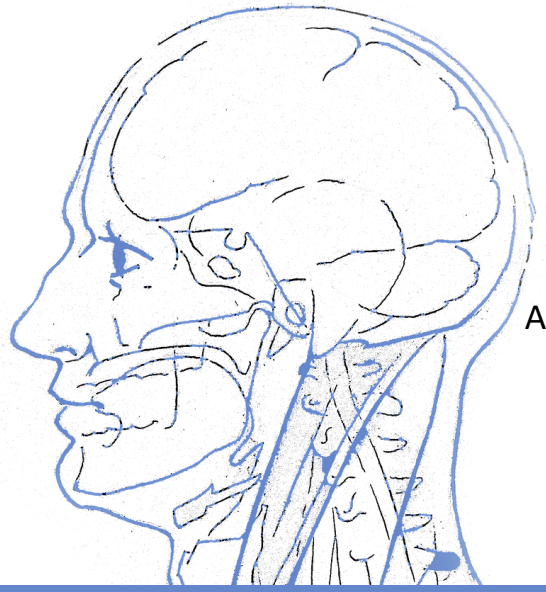
Polygon for working with data of brain computed tomography and Magnetic Resonance Imaging



Anikina A.I.[1]

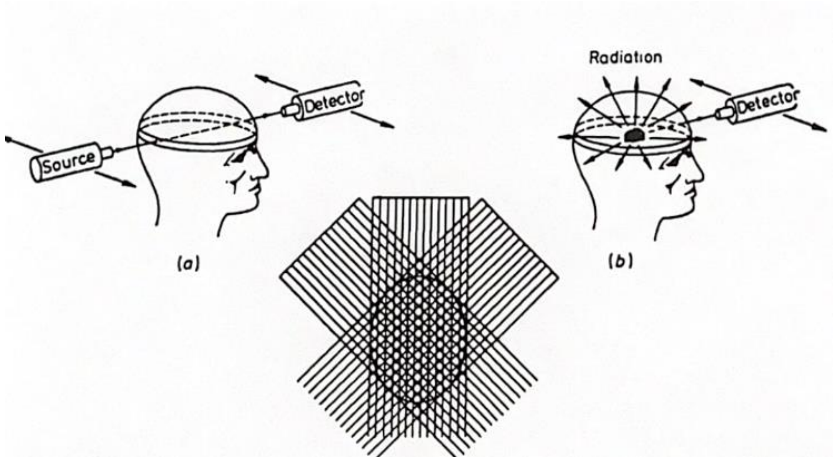
Anikin I.V.[2], Streltsova O.I.[1], Belyakov D.V.[1], Zuev M.I.[1], Kokorev A. A.[1], Andreev G.I.[3], Grigorov G.G.[3]

[1] *Meshcheryakov Laboratory of Information Technologies (MLIT, JINR)*
[2] *Bogoliubov Laboratory of Theoretical Physics (BLTP, JINR)*
[3] *Federal Medico-Biological Agency (FMBA)*

The task of image reconstruction

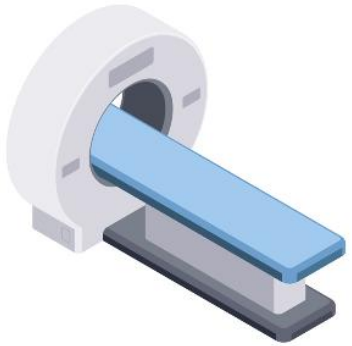
The task is to study the internal structure of subjects without breakings and cutting. The medical CT methods which exist nowadays suffer from many different difficulties (blurred zones on images). The practical application involves the analysis and visualization of CT data including **transmission (a)** and **emission (b)** processes.

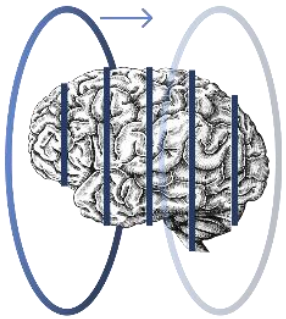
The purpose of project is the development of CT data visualization and possible improvements of CT images which should eliminate the blurred zones.

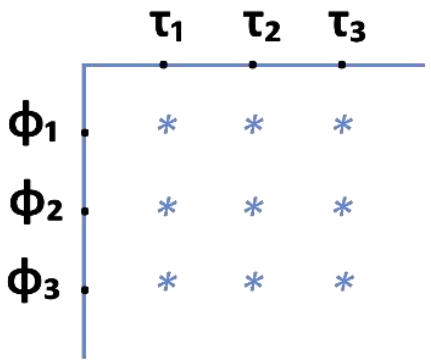


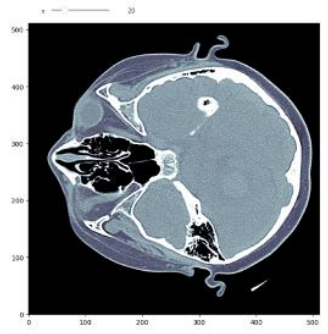
Scheme of reconstruction

CT machine → CT scan → Matrix of intensity ratio → Reconstruction of images









standard method leading the blurred zones

proposed method that should eliminate the blurred zones

In practice, the original slice function differs from the reconstructed forms. Our principal goal is to minimize the mentioned difference using a new mathematical method. To this aim, as a preliminary stage the corresponding polygon of CT-data analysis is planned to be created.

CT data workflow

Input data

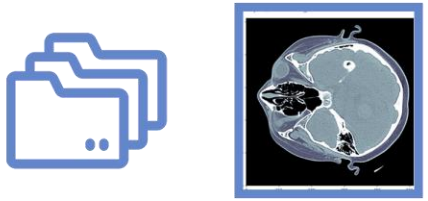
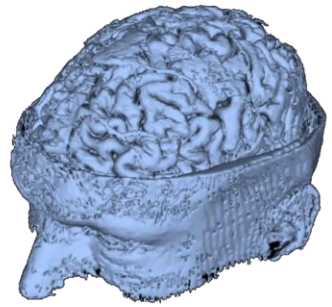


Image preprocessing

- Noise reduction
- Contrast enhancement
- Segmentation

Visualization



The ML/DL/HPC ecosystem

Component for educational purposes (without GPUs)

For teaching students
https://studhub1.jinr.ru

For conducting workshops within the framework of JINR scientific events
https://studhub2.jinr.ru
https://studhub3.jinr.ru

Component for carrying out resource-intensive computations (with GPUs)

https://jhub1.jinr.ru
https://jhub2.jinr.ru

HPC component for scientific projects (with installed specialized libraries)

BioProject services
https://cell.jinr.ru
https://mostlit.jinr.ru
https://bio-dashboards.jinr.ru/morris

CVAT services
https://159.93.36.88:8080
https://159.93.36.67:8080

Jupyter Books infrastructure
https://studhub.jinr.ru:8080/jjbook
https://studhub.jinr.ru:8080/books
https://studhub.jinr.ru:8080/itschool2024

A polygon for visualization of brain CT data
https://hlit-th-ct.jinr.ru

A polygon for quantum computing
https://ampere05.jinr.ru

OpenCV, pandas, jupyter, Caffe, NumPy, scikit learn, JB, theano, Keras, PyTorch, TensorFlow, CVAT, ultralytics, kornia, Cirq, Nipype: Neuroimaging in Python Pipelines and Interfaces, matplotlib, Joblib, Numba, FreeSurfer, PENNYLANE

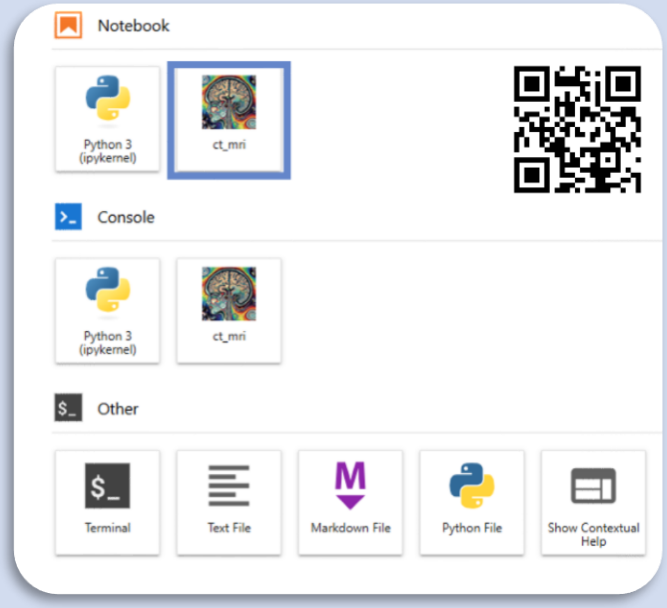
About polygon

Server Characteristics:

- 2x Intel Xeon Gold 6126, 48 core @ 2.60 GHz
- 256 GB RAM

Working in the Polygon:

hlit-th-ct.jinr.ru



Access to the Polygon is provided from the JINR network.

To getting access to the polygon's resources you need send an email to one of the administrators with your login: <aanikina@jinr.ru>, <zuevmax@jinr.ru>. In response, you will receive an email confirming access and a password to the Polygon.

The JupyterLab interface was installed on the Polygon with a configured ***ct-mri*** environment in the form of a separate "button" for working with installed Python libraries.

hlit.jinr.ru

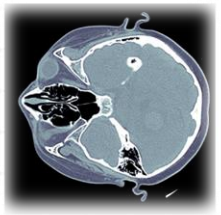
A polygon for working with CT and MRI/fMRI data of brain

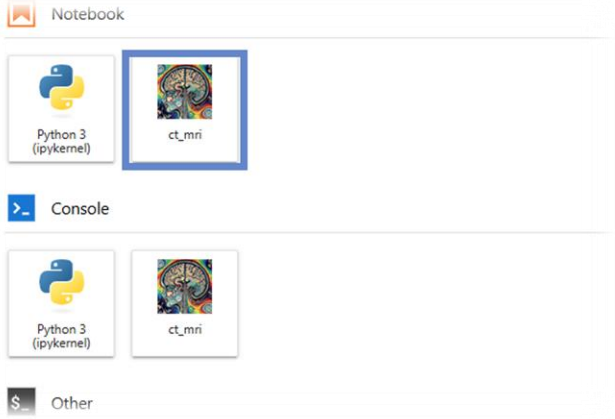
JupyterLab interface

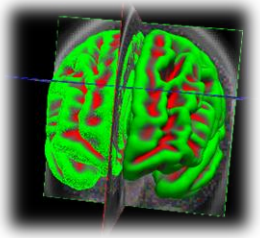
- **PyDicom** is a Python package used to read, modify, and write DICOM (Digital Imaging and Communications in Medicine) files, which are used in medical imaging.
- **Nipype** (Neuroimaging in Python - Pipelines and Interfaces) is a Python-based software package for analyze data using a variety of different algorithms.
- **PySurfer** is a Python library for visualizing cortical surface representations of neuroimaging data.

SSH-access

- **MRI Convert** for converting the NIFTI file from the original set of DICOM files;
- **FreeSurfer** for NIFTI file processing;
- **FreeView** (viewer from the FreeSurfer package) for building images after NIFTI file processing.
- **FSL**, alternative package for NIFTI file processing;
- **FSLeyes** (viewer from the FSL package) for building images after NIFTI file processing

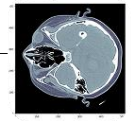




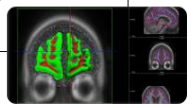


1 Mathematical modeling
- Ecosystem ML/DL/HPC
- SC Govorun

2 Visualization
- Pydicom
- Nipype
- PySurfer

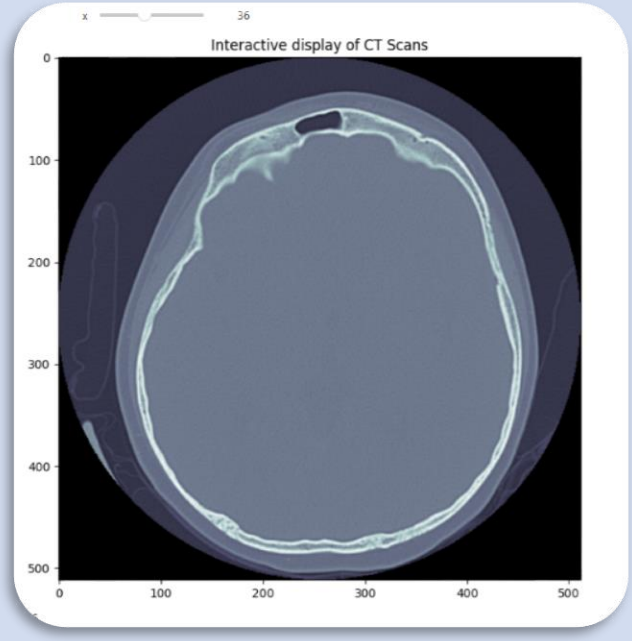


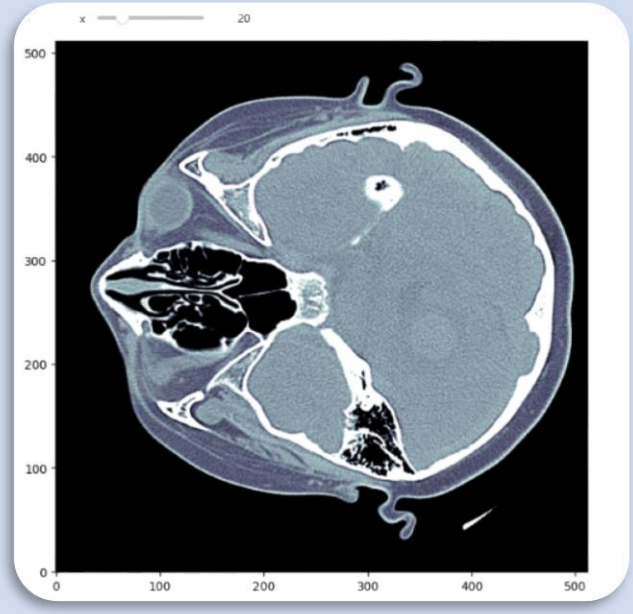
3 Software developer
- MRI Convert
- FreeSurfer
- FreeView



Anikina A., Andreev G., Andreev V., Anikin I., Belyackov D., Grigorov G., Kokorev A., Sharipov Sh., Streltsova O., Zuev M. Polygon for visualization of brain computed tomography data. Phys. Part. Nuclei (sent to review).

Visualization of medical data





Data source: https://www.kaggle.com/datasets/trainingdatapro/computed-tomography-ct-of-the-brain

Conclusions

For the visualization of medical computed tomography data, the polygon based on heterogeneous platform “HybriLIT “ has been developed. The main purposes of polygon are

1) CT and MRI/fMRI data storage;
2) the visualized work with data in web-browser thanks for the possibility to work within JupyterLab interactive environment ;
3) the visualization of results using the special software;
4) the software development;
5) mathematical modeling.

In the further work, after implementation of new mathematical methods, visualization and medical data analysis the polygon has to help for the restoration of images. This is the principal goal which should minimize the blurred zones of images and the X-ray radiation of patients.

Thank you for attention!