next_AIM GENERAL MEETING 14/02/2023

DEEP LEARNING MODELS FOR TARGETING OF TcMRgFUS FOR ESSENTIAL TREMOR

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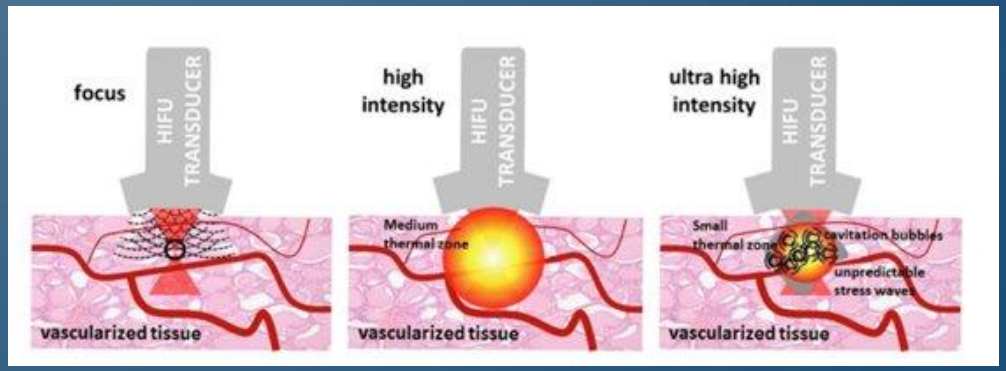
TCMRGFUS TREATMENTS



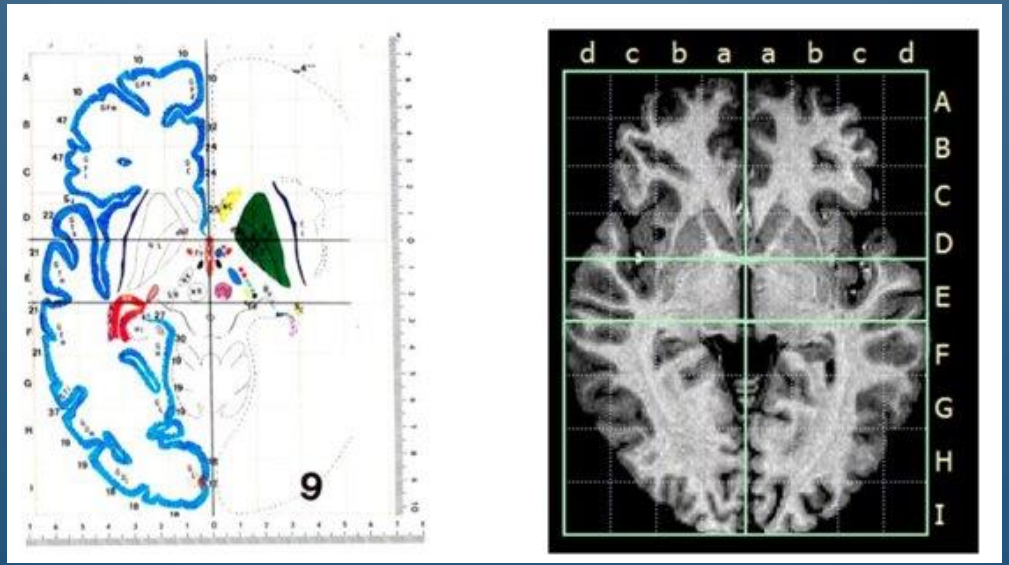
Focused Ultrasound can cause thermal ablation!

THE ESSENTIAL TREMOR

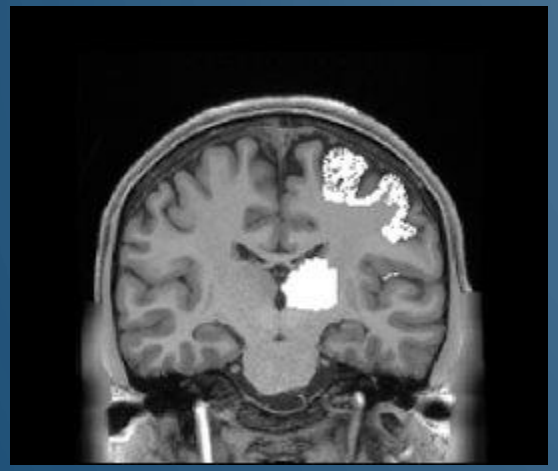
- Essential tremor is a very common disease (about 5% of general population is affected by essential tremor)
- It consists of a continuous tremor of hands, voice, legs, head, ..
- It does not affect life expectancy, but causes disability
- It can be treated with deep brain stimulation, radiofrequency ablation, gamma knife, tcMRgFUS treatments

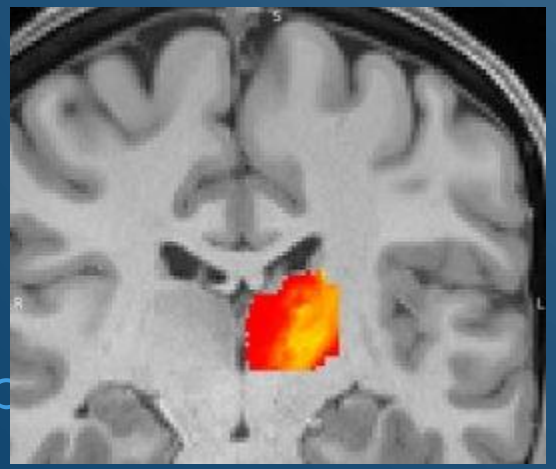
HOW TO FIND THE TARGET?

Making use of stereotactic atlases !



AN INNOVATIVE TECHNIQUE TO IDENTIFY THE TARGET





The target is identified through **probabilistic tractography**:

- A seed area and a target area are selected
- A kind of anisotropic **random walk** is performed based on the diffusion tensor information
- A **probability distribution** is obtained as output defined within the thalamus
- The neuroradiologist uses **areas with the highest probability** to **search for the target**
- Advantage: the estimate of the target **is relative to the subject**
- Disadvantage: the process takes up to **20 hours** for each subject

THE REPOSITIONING PROBLEM

- The images on which the tractography is carried out are acquired **several days before the treatment**
- Repositioning during the treatment can significantly **increase treatment time**

METHODS ABLE TO REBUILD APPROXIMATED TRACTOGRAPHY MAPS IN A VERY SHORT TIME COULD PROVIDE A SOLUTION TO THE PROBLEM

SOLUTION: AI METHODS !

THE DATASET

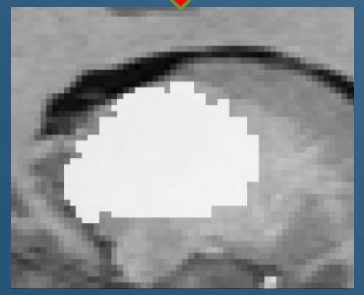
The Human Connectome Project (HCP) is a five-year project sponsored by National Institutes of Health.
The goal of the Human Connectome Project is to build a "network map" (connectome) that will shed light on the anatomical and functional connectivity within the healthy human brain, as well as to produce a body of data that will facilitate **research into brain disorders such as dyslexia, autism, Alzheimer's disease, and schizophrenia.**

- The dataset contains structural and functional MRI images of **1200 subjects.**
- The amount of data is approximately **30 GB per subject !**

THE TARGET IMAGES

Thalamus mask

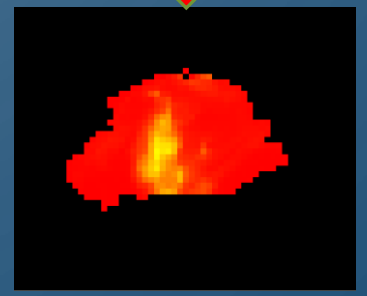
Freesurfer



Classification Task

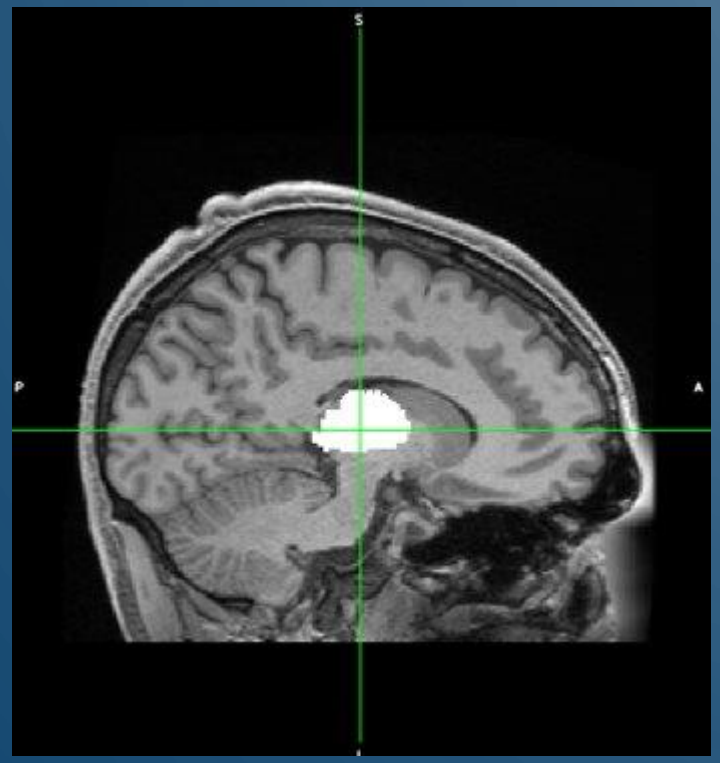
PDF of the target

ProbtrackX



Regression Task

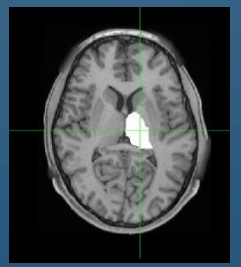
BOUNDING BOX



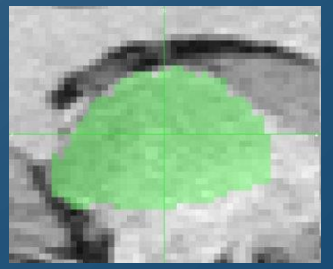
3D processed images have
256x256x256 voxels

Volume of the thalamus: 8500 voxels ~ 0.05%

BOUNDING BOX !

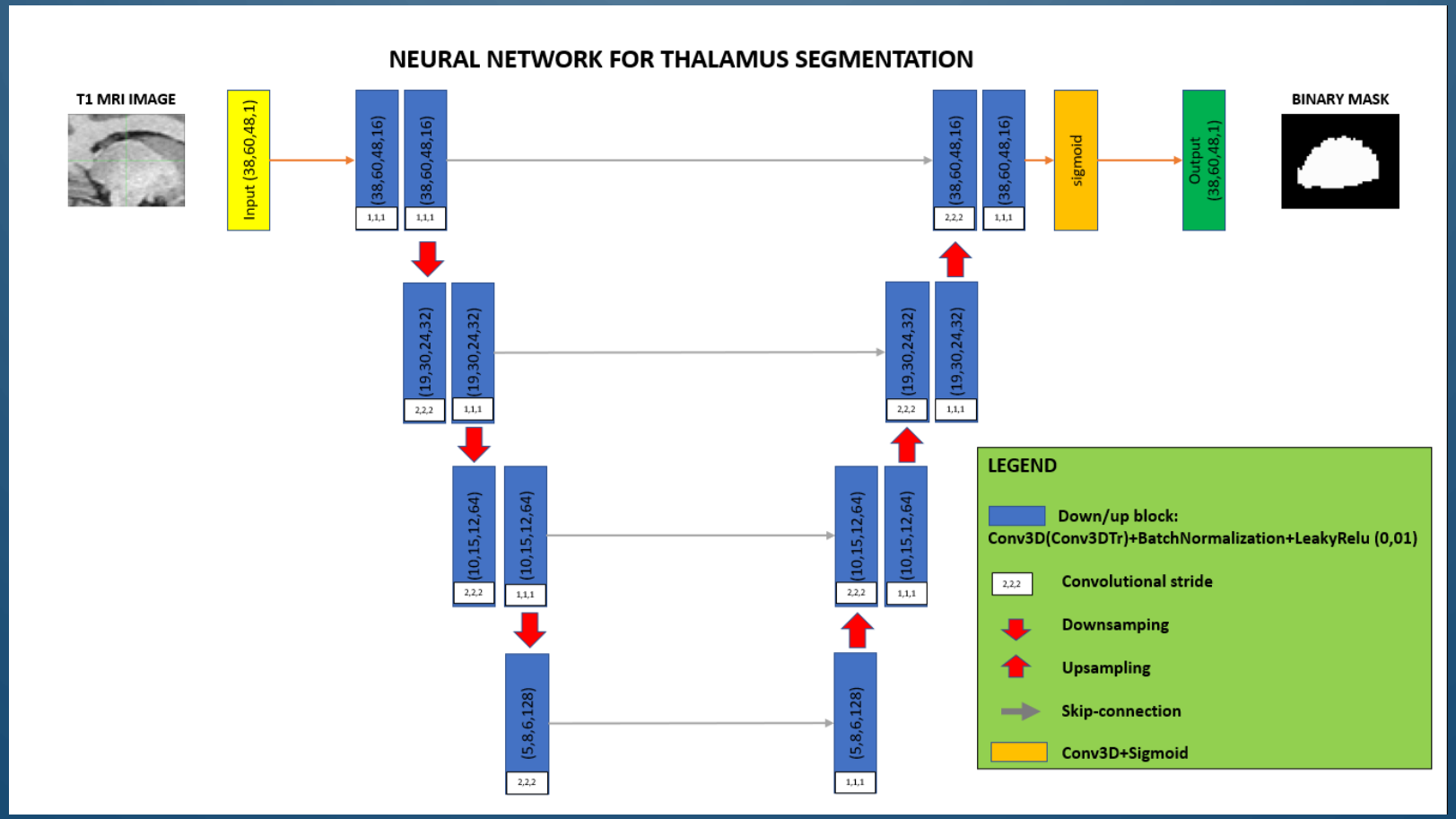


256x256x256



38x60x48

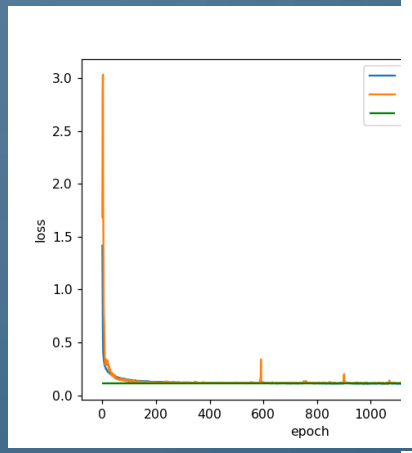
THE CLASSIFICATION TASK: THE NETWORK

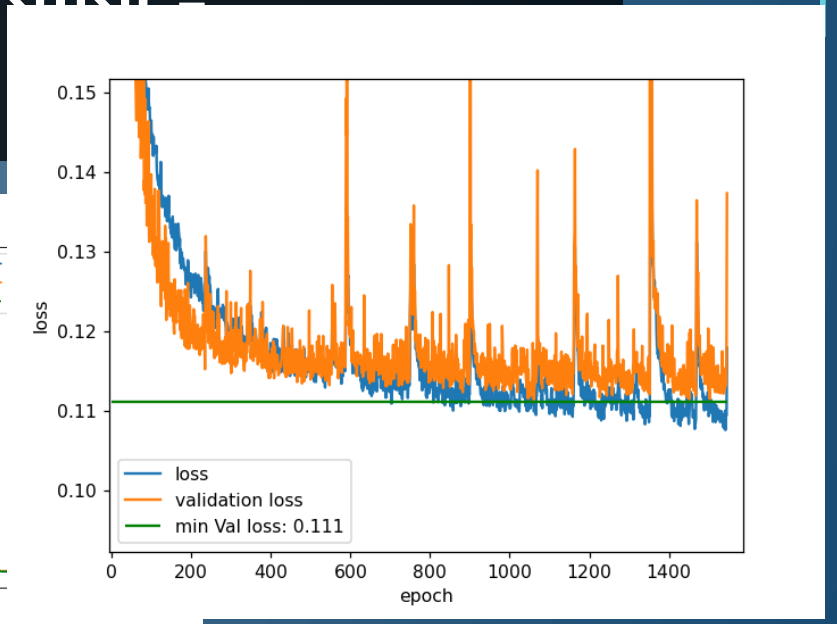


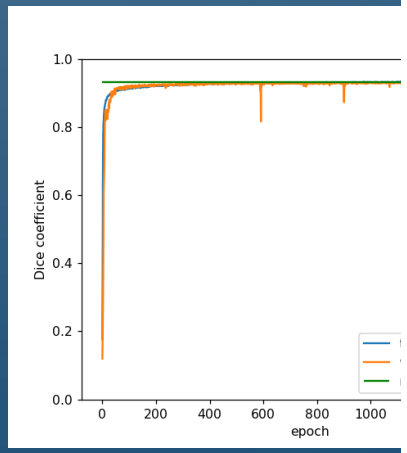
THE CLASSIFICATION TASK: THE TRAINING

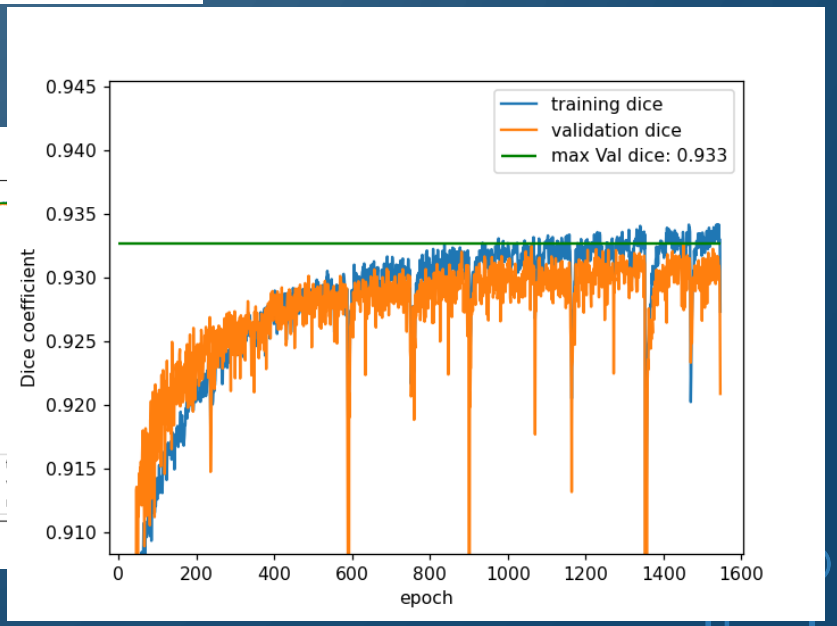
Training data:

- Network: params **1.462.817** (trainable 1.461.409)
- 1081 data, **881 train** and **200 test**
- Optimizer: **Adam**
- Loss: **crossentropy + dice loss**
- 1 validation folder **176** data
- 5000 start epochs, **early stop** with patience of **500 epochs** on real dice index
- Batch size: **64**
- Learning rate: **0.001**
- Data augmentation: **translation, rotation, scaling, flipping, gaussian noise.**
- Training duration (performed on servers with NVIDIA RTX A5000 24GB): about **11 h**

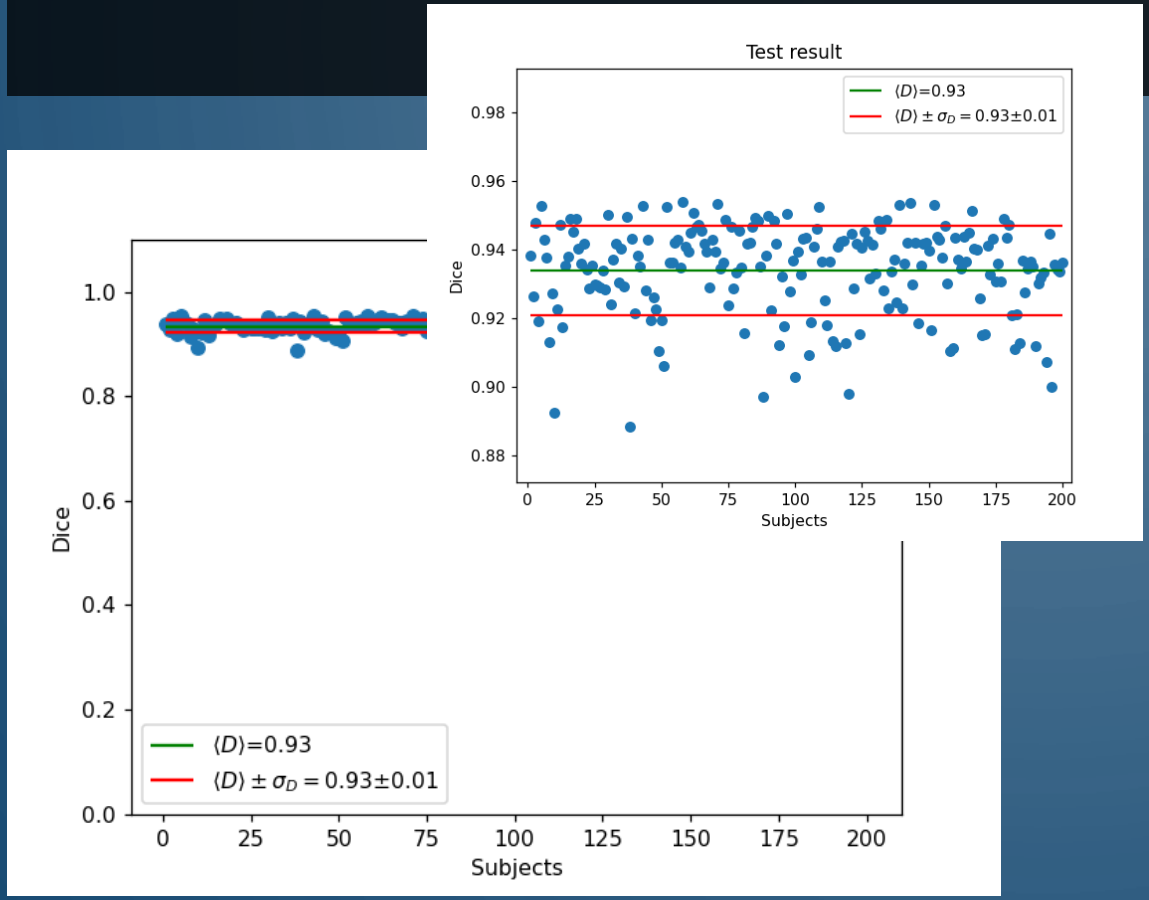








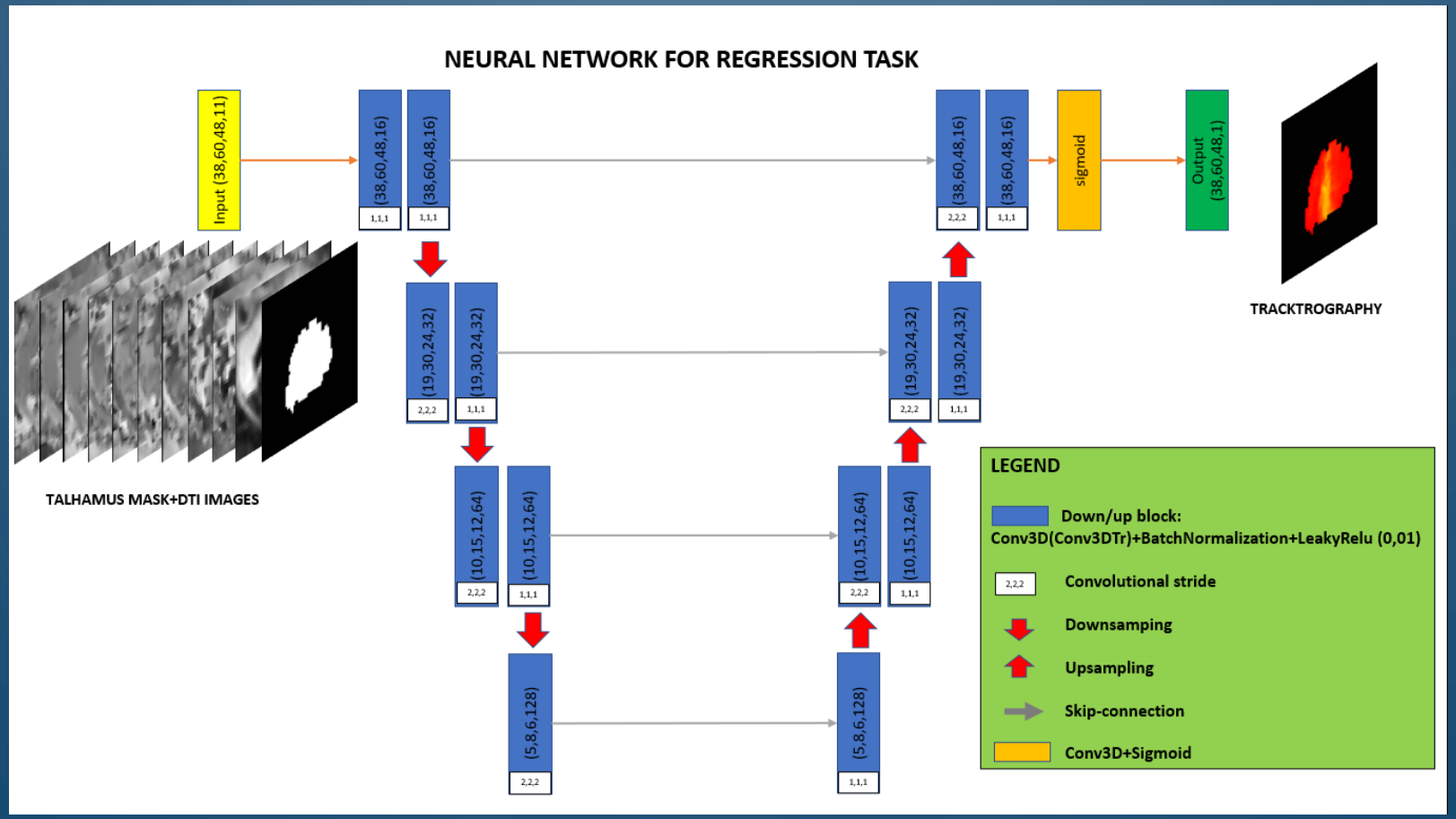
THE CLASSIFICATION TASK: RESULTS



Mean Dice	STD
0,93	0,01

Green: predicted ROI; red: ground truth

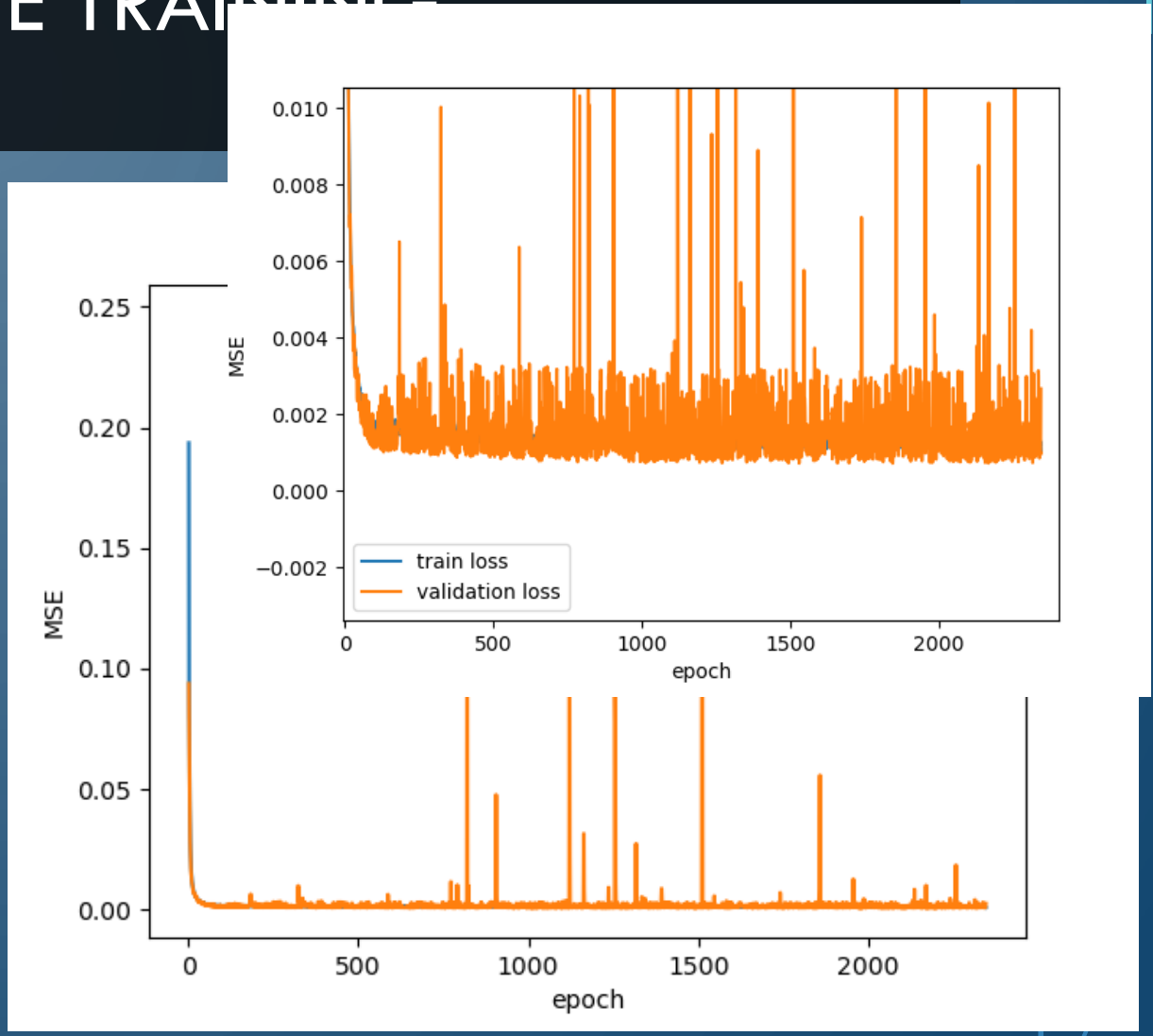
THE REGRESSION TASK: THE NETWORK



THE REGRESSION TASK: THE TRAINING

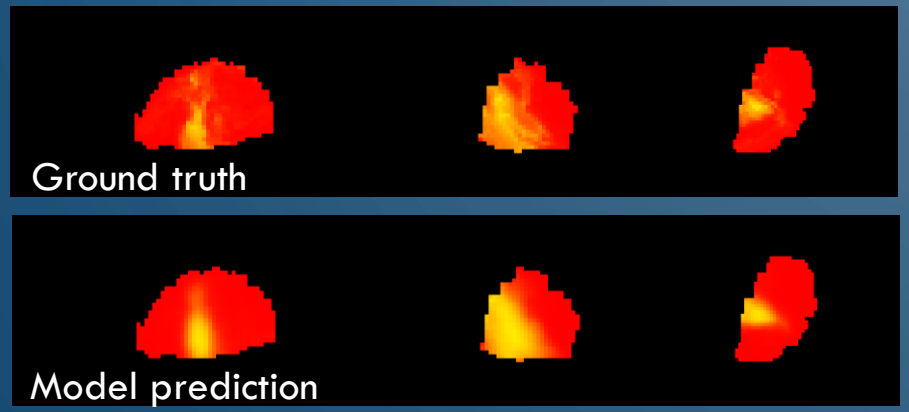
Training data:

- Network: params **1.467.137** (trainable 1.465.729)
- 293 data, **200 train** and **93 test**
- Optimizer: **Adam**
- Loss: **mean squared error**
- 1 validation folder **40** data
- 5000 start epochs, **early stop** with patience of **500 epochs** on real dice coefficient
- Batch size: **8**
- Learning rate: **0.001**
- Data augmentation: **translation, rotation, scaling, flipping, gaussian noise.**
- Training duration (performed on servers with NVIDIA RTX A5000 24GB): about **11 h**



THE REGRESSION TASK: EVALUATION

How much are they different?



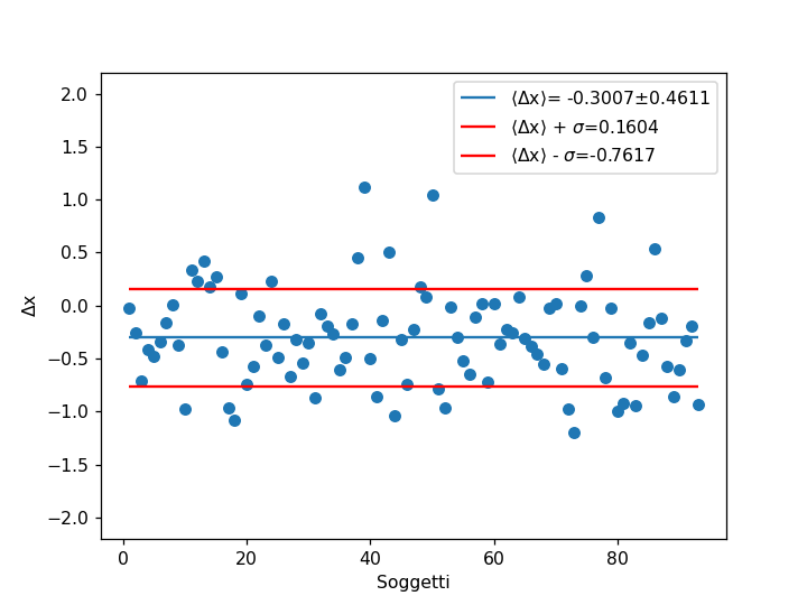
Although, the MSE is useful for training it can't help properly for model evaluation!

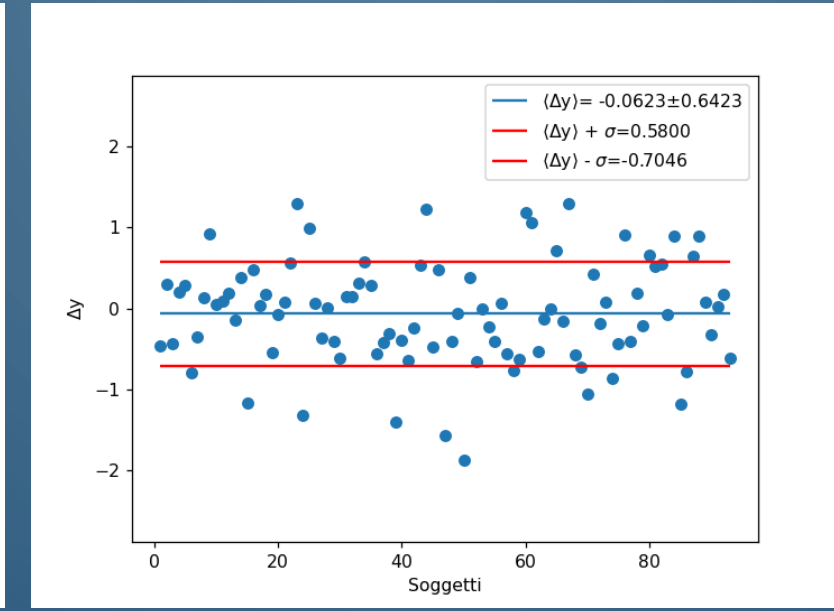
FOR THIS RAGION WE USED TWO EVALUATION CRITERIONS:

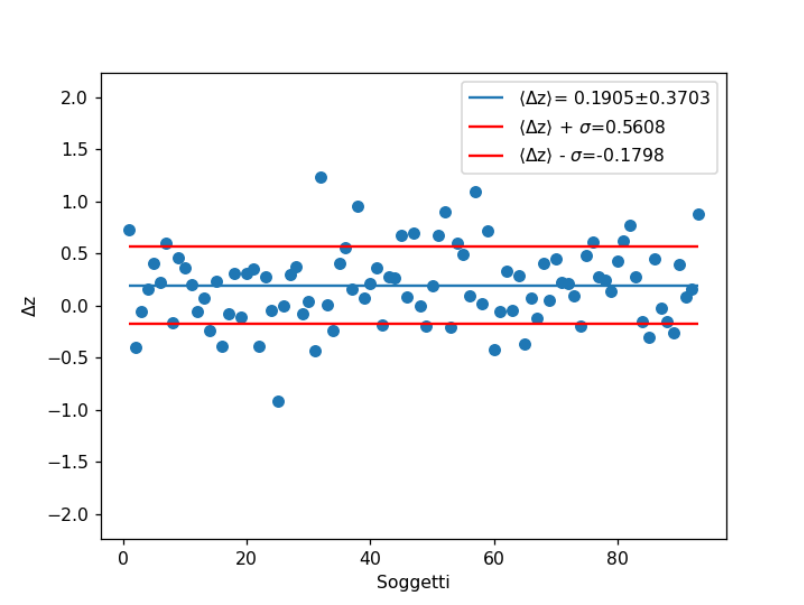
One based on the **distance between the centres of mass** of the predicted and the true PDFs

One based on the **dice index** calculated between ROIs of the predicted and the true PDFs

THE REGRESSION TASK: EVALUATION

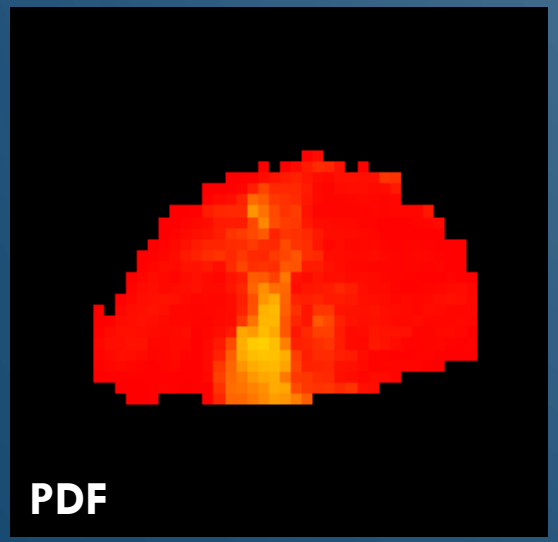






Δx (mm)	σ_x (mm)	Δy (mm)	σ_y (mm)	Δz (mm)	σ_z (mm)	Δr (mm)	σ_r (mm)
-0,3	0,5	0,06	0,6	0,2	0,6	0,4	0,5

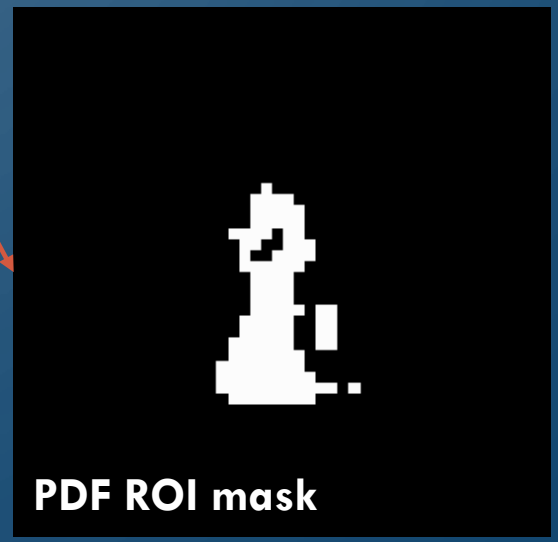
THE REGRESSION TASK: EVALUATION



PDF

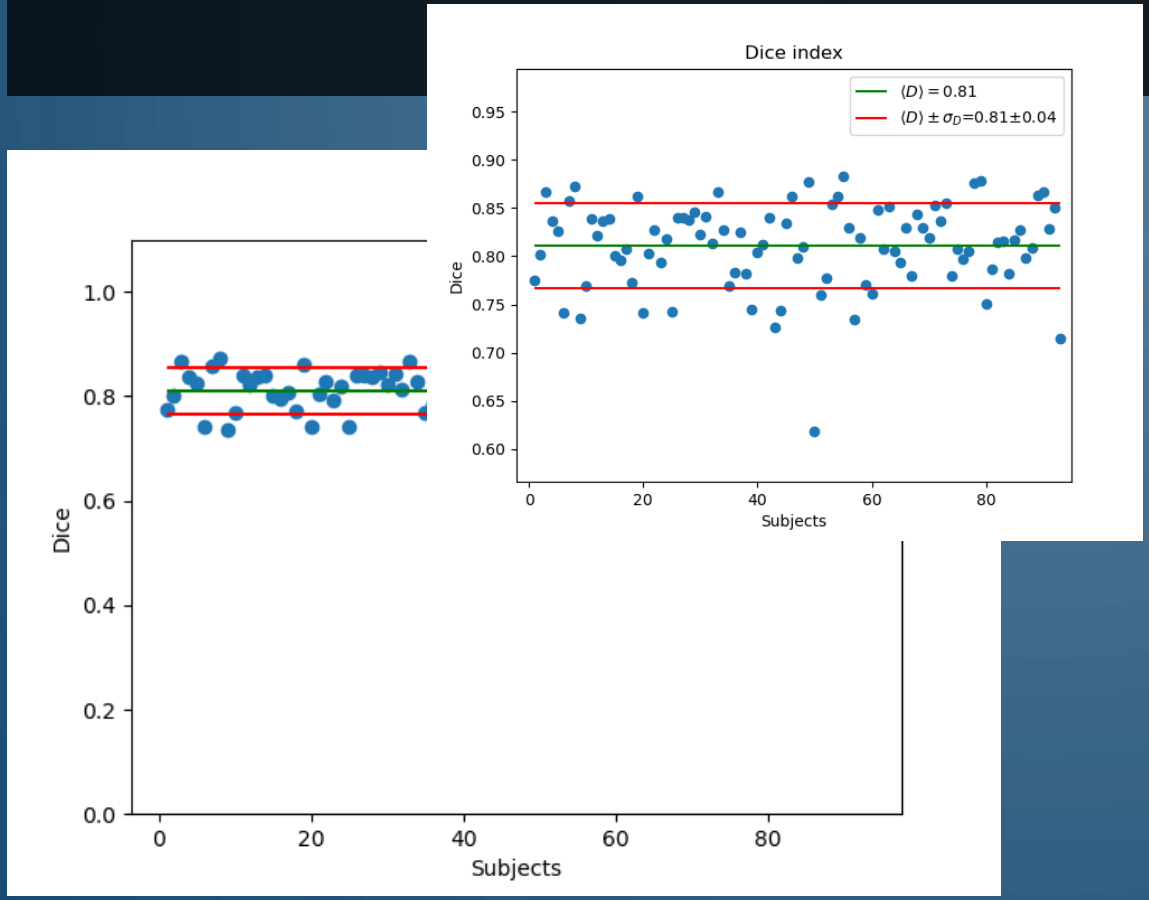
OTSU THRESHOLDING ALGORITHM

Thresholded PDF



PDF ROI mask

THE REGRESSION TASK: RESULTS



Mean Dice	STD
0,81	0,04

Green: predicted ROI; red: ground truth

NEXT TASKS

- Test of the AI models on clinical data of Policlinico P. Giaccone of Palermo, comparing the post surgery data too;
- Investigation of tractography maps using radiomic approaches;
- Investigation of possible application in the oncology field, where the brain fiber tractography can be helpful in surgery planning;
- Abstract submitted to the AIFM conference in June.
- Manuscript to be submitted soon

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thank you
danke
謝謝
ngiyabonga
teşekkür ederim
gracias
merci
obrigado
спасибо
Баярлалаа
рахмат
bedankt
dziękuję
hvala
sukriya
kop khun krap
go raibh maith agat
mochchakkeram
tapadh leat
arigatô
dakujem
grazie
terima kasih
감사합니다
ありがとう
мерси
хвала
dank je
sağolun
takk
taiku
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