AUTOMATIC ANALYSIS OF TRAUMATIC BRAIN INJURY CT SCANS

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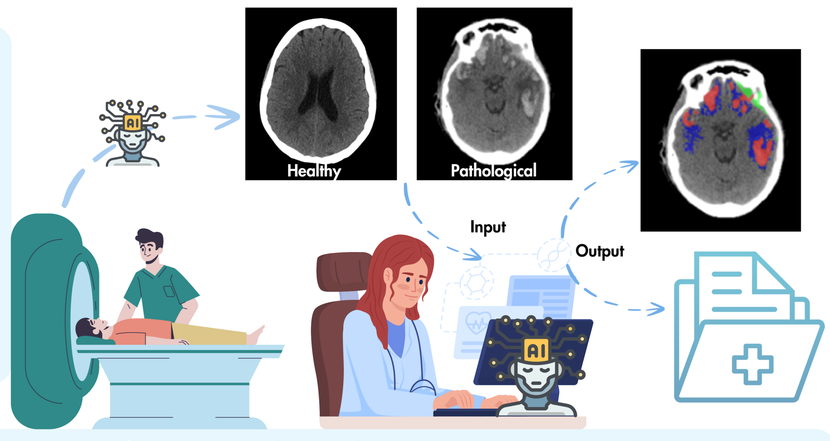
CONTEXT

Traumatic Brain Injury (TBI) is a damaging medical condition, major cause of mortality and disability, including cognitive and physical deficits.

- TBI lesions are monitored with CT imaging, but qualitative processing and interpretation may provide inconsistent analysis
- Image quality varies according to machine and image reconstruction approaches impacting AI image processing
- Artifacts may also have an impact on AI image processing
- Multimodal data from the imaging and medical record may enhance TBI analysis and therapy by improving patient's condition comprehension



GOAL

Create a robust semi-automatic triage tool of pathological brain scans from a large collection of routine clinical scans, to create diagnostic tools for pathological subjects, taking into account the variability of the scans

TOOLS

BLAST-CT: Brain Lesion Analysis and Segmentation Tool for Computed Tomography: AI used to automatically segments four types of TBI lesions on CT images. Radiomic metrics refer to the process of extracting quantitative features from an image in order to accurately represent tissue damage in a quantitative manner.

Segmentation of the brain in three regions of interest (ROIs) : White Matter (WM), Grey Matter (GM) and Cerebrospinal Fluid (CSF) for two purposes:

- Using FLS's FAST segmentation tool to detect artifact scans
- Using an Atlas for the Variability detection

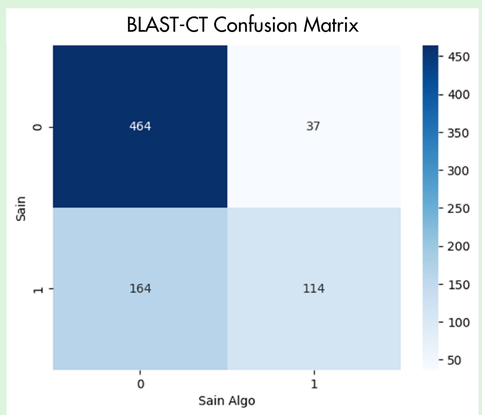
1029 CT scans

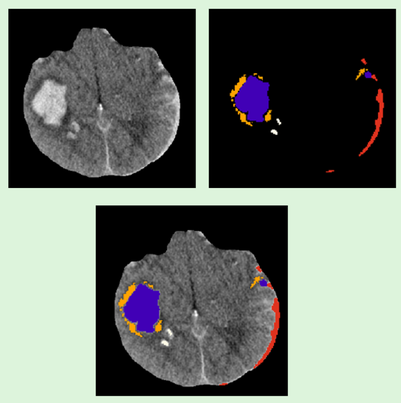
All patients went through Shock Treatment to assess whether they had traumatic brain injuries or not

Imaging was conducted using different scanners with distinct protocols

At the beginning of the thesis, there were no available medical records to determine whether a CT Scan was healthy or not

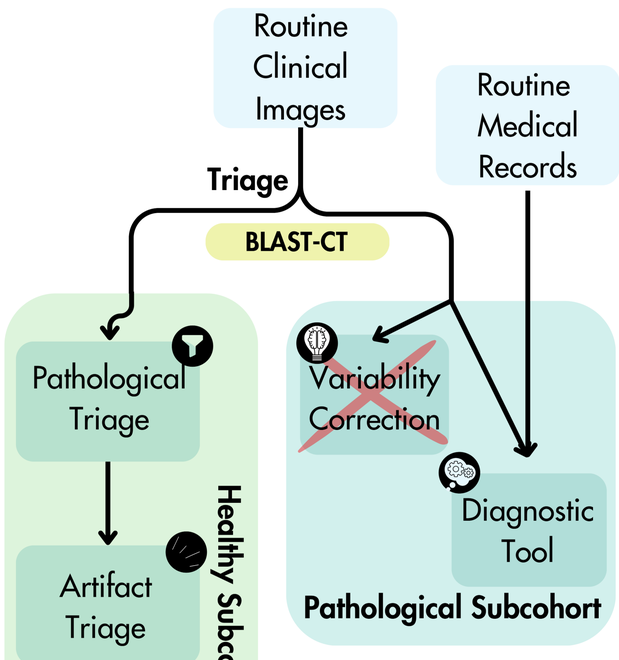
AI TRIAGE OF PATHOLOGICAL SCANS



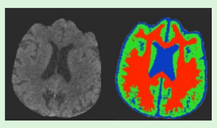


74% precision

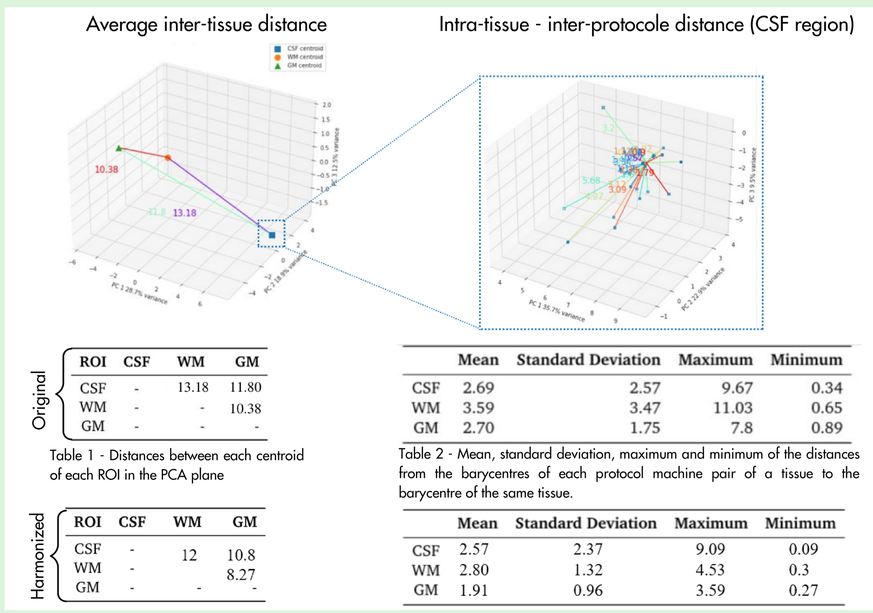
Four TBI lesions were segmented using the BLAST-CT AI tool, allowing to sort pathological from healthy brain scans.



VARIABILITY EVALUTATION



Separation of the brain into three different segmentations. In blue the CSF, in red the WM and in green the GM.



Original

ROI	CSF	WM	GM
CSF	-	13.18	11.80
WM	-	-	10.38
GM	-	-	-

Table 1 - Distances between each centroid of each ROI in the PCA plane

	Mean	Standard Deviation	Maximum	Minimum
CSF	2.69	2.57	9.67	0.34
WM	3.59	3.47	11.03	0.65
GM	2.70	1.75	7.8	0.89

Table 2 - Mean, standard deviation, maximum and minimum of the distances from the barycentres of each protocol machine pair of a tissue to the barycentre of the same tissue.

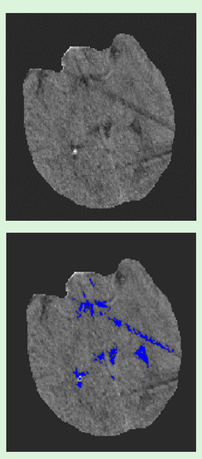
Harmonized

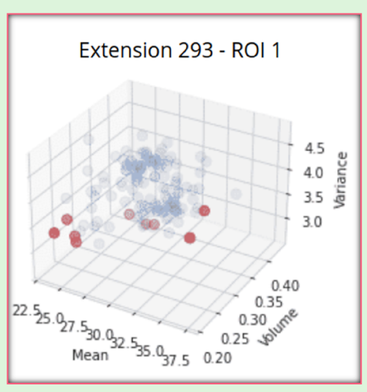
ROI	CSF	WM	GM
CSF	-	12	10.8
WM	-		8.27
GM	-	-	-

	Mean	Standard Deviation	Maximum	Minimum
CSF	2.57	2.37	9.09	0.09
WM	2.80	1.32	4.53	0.3
GM	1.91	0.96	3.59	0.27

The variability within a tissue is comparable in magnitude to the variability between different tissues.

TRIAGE OF ARTIFACT SCANS WITH FSL'S FAST





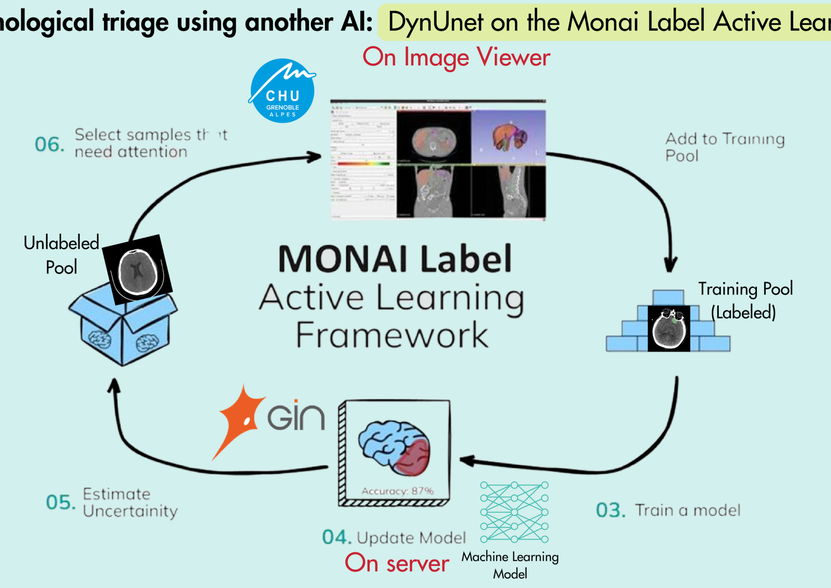
This diagram depicts in red the artifact images detected with the metrics extracted from the CSF region.

FIRST CONCLUSIONS

Our internal data and cohorts show no difference pre- and post-harmonization.
Thus, we decided to proccess the images without correcting variability.

PERSPECTIVES: IMPROVEMENT OF THE AI LESION SORTING TOOL WITH DYNUNET AND ENHANCEMENT OF THE DIAGNOSTIC TOOL WITH AI RATCHET

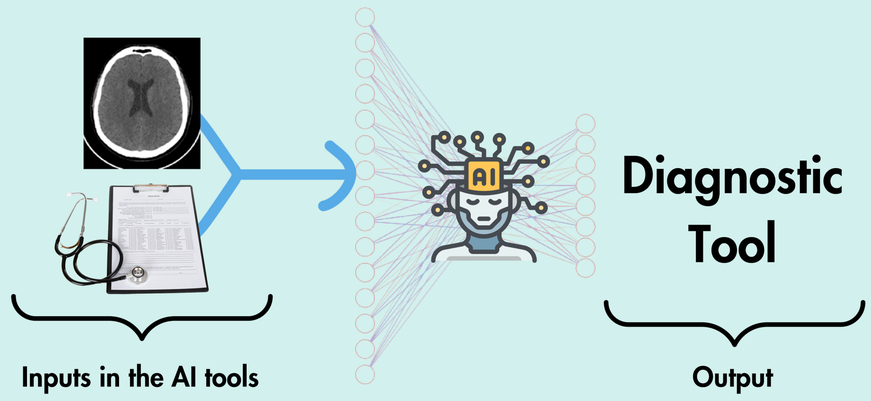
Improving pathological triage using another AI: DynUnet on the Monai Label Active Learning Framework [3]



Enhancement of the diagnostic tool:

The RATCHET [4] AI tool consists in creating thoracoscopic X-ray examination reports with an AI Transformers architecture.

We plan on tayloring this tool to generate TBI medical report from the CT scans.



[1] Orlhac et al., (2019). Validation of a method to compensate multicenter effects affecting CT radiomics. Radiology, 291(1) :53–59
[2] M. Monteiro et al., « Multiclass semantic segmentation and quantification of traumatic brain injury lesions on head CT using deep learning: an algorithm development and multicentre validation study », Lancet Digit. Health, vol. 2, no 6, p. e314-e322, juin 2020, doi: 10.1016/S2589-7500(20)30085-6
[3] Diaz-Pinto, Andres, et al. MONAI Label: A Framework for AI-Assisted Interactive Labeling of 3D Medical Images. 2, arXiv, 2022, doi:10.48550/ARXIV.2203.12362.
[4] Hou,, et al. RATCHET: Medical Transformer for Chest X-Ray Diagnosis and Reporting. 2, arXiv, 2021, doi:10.48550/ARXIV.2107.02104.