Low field pediatric brain magnetic resonance Image Segmentation and quality Assurance Challenge 2025

BILL & MELINDA GATES foundation

Endorsed by

RISE-MICCAI

July, 2025

The LISA 2025 challenge will be organized as a satellite event of the MICCAI 2025 conference

The participants will compete for prizes and public recognition in the following tasks:

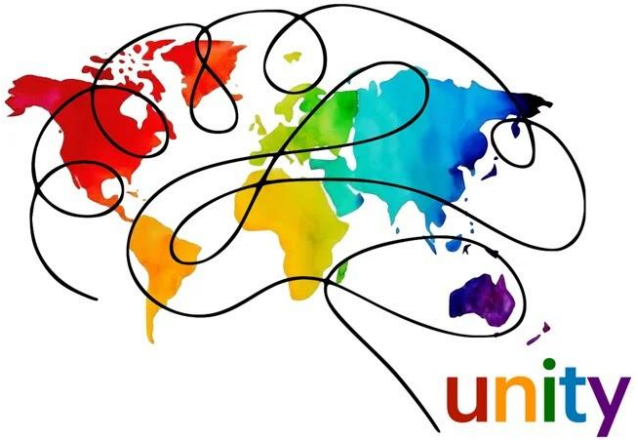
Task 1: Quality Control
Task 2a: Hippocampal Segmentation
Task 2b: Basal Ganglia Segmentation

The UNITY Project

- Funded by the Gates Foundation to improve global neuroimaging access

- Develops tools to measure and predict infant neurodevelopment especially in underserved regions

- Involves hospitals and research centers all over the world

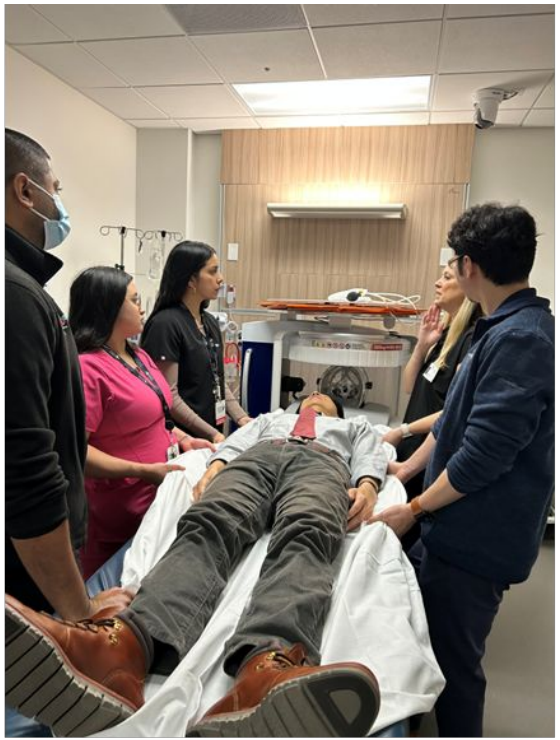


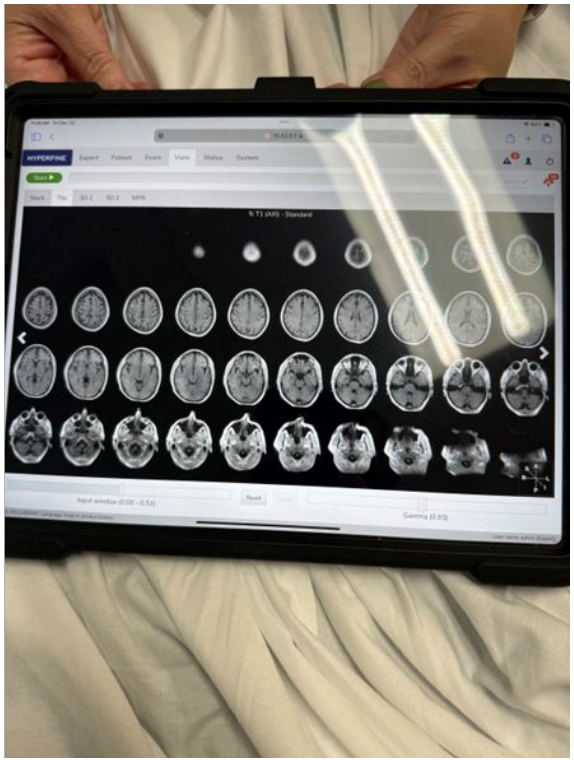
Goal: To quantify development via structural MRI in relation to environmental factors

UNITY Sites


Greenland
Iceland
Finland
Sweden
Russia
Canada
United States
Mexico
North Atlantic Ocean
Poland
Ukraine
Kazakhstan
Mongolia
France
Spain
Italy
Türkiye
China
South Korea
Japan
Iraq
Iran
Afghanista
Algeria
Libya
Egypt
Saudi Arabia
India
Thailand
Mali
Niger
Chad
Sudan
Nigeria
Ethiopia
Venezuela
Colombia
Peru
Brazil
Bolivia
Chile
Argentina
South Pacific Ocean
South Atlantic Ocean
Tanzania
Angola
Namibia
Botswana
Madagascar
Indian Ocean
Indonesia
Papua New Guinea
Australia
New Zealand

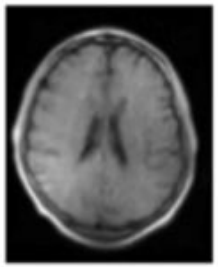
Low Field MRI



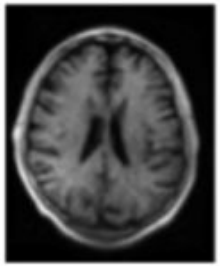


Swoop Features

- Ultra low field MRI (0.064T): lower quality than 3T MRI
- Uses as much electricity as a coffee machine
- Order of magnitude cheaper than 3T MRI
- Can be brought to the bedside

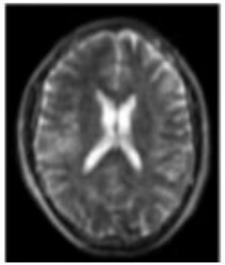


T1 (Standard)

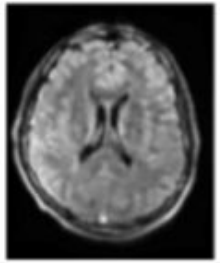


T1 (Gray/White)

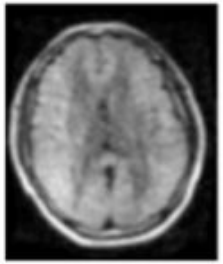
T2 (Standard)



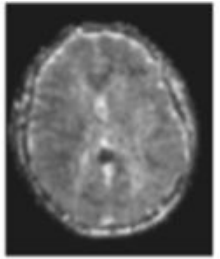
T2 (Fast)



FLAIR

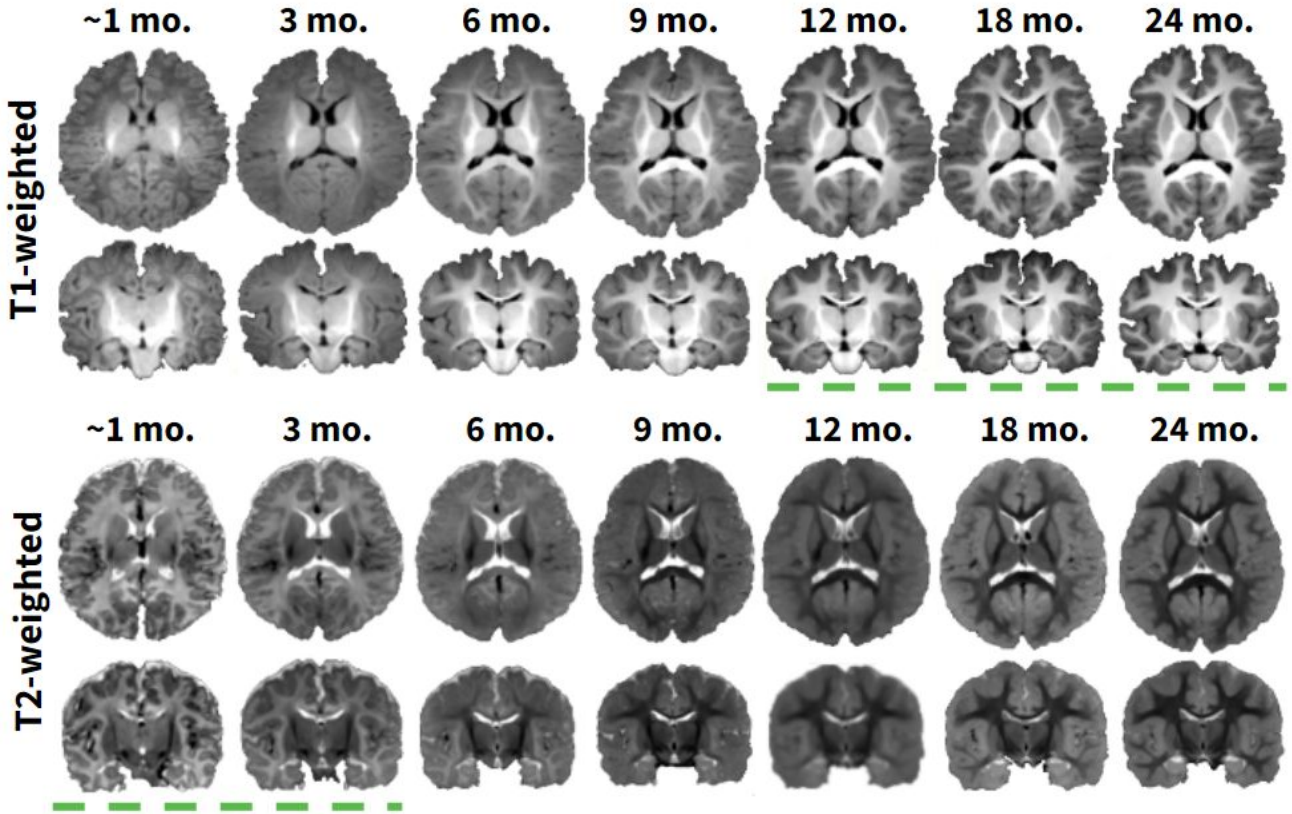


DWI



DWI+ADC

Pediatric High-Field MRI



Data Collection

University of Cape Town (UCT)

Objective:

- longitudinal research aiming to characterise and model the development of executive functions (EFs) during the first 1000 days of life

Aims:

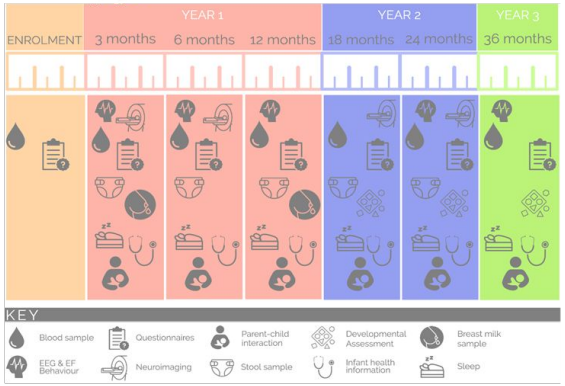
1. Understand EF-related brain network development in early childhood.
2. Quantify the impact of environmental factors on these brain networks.

Develop and validate scalable EF measurement tools for global use.

Data Collection:

321 infants in Cape Town at 3, 6, 12, 18 and 24 months.

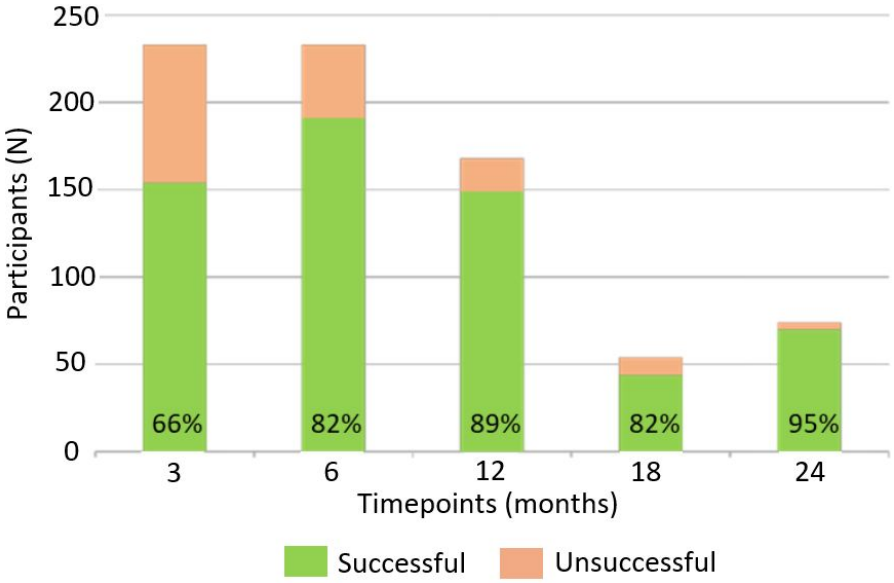
1kD The First 1000 Days
PROMOTING HEALTHY BRAIN NETWORKS



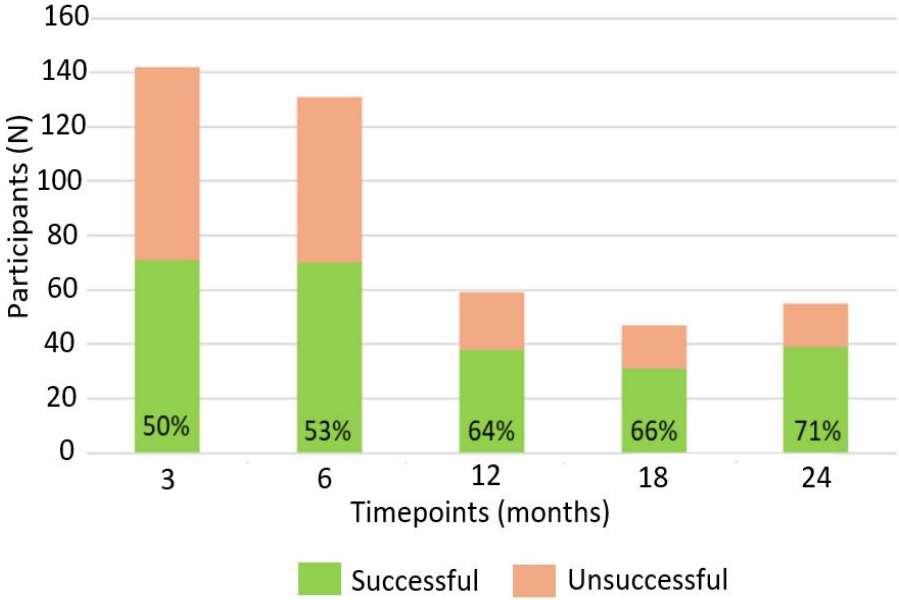
khula khula leap

UCT Data Distribution

Low field MRI data (0.064 T)



High field MRI data (>1.5T)



Aga Khan University (AKU)

Magnetic Resonance Imaging to Assess the Neurodevelopmental Impact of the Environment in the Early Years **(MINE)**

Objectives:

- Longitudinally map trajectories of brain development from early infancy (1 month) to 4 years of age using MRI and neurodevelopmental assessments.

- To compare the image quality of high-field and low-field MRI.

- Investigate the relationships between modifiable environmental factors (e.g., early child nutrition, maternal stress) and brain structure, function, and maturing cognitive skills.

MINE Project

Study Participants high and low-field MRI will be performed on 270 participants from Low socioeconomic areas for 4 years.

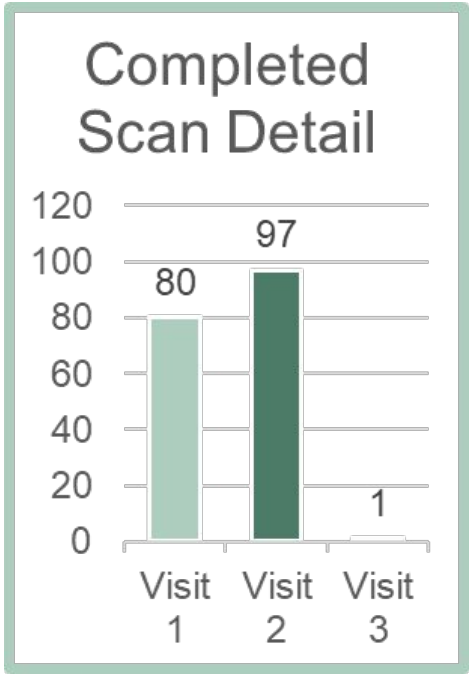
Demographics, Socioeconomic and **Anthropometric Measurements** of the mothers and children

Psychological Tools for Mothers

Global Scale for Early Childhood Development (**GSED**) to assess child development assessment.

Biological Samples include blood, stool, hair, and breast milk samples.

Study Duration from August 2022 to August 2026



Makerere University (Mak)

Rationale:

Nearly 250 million children in Low and MICs risk developmental delays, with limited data on brain development and environmental exposures

Aims:

1. Describe brain development trajectories (white, grey, and total brain volumes) in normal and low birth weight children from birth to 5 years.
2. Describe motor, cognitive, language, social-emotional development, and physical growth patterns in these children from birth to 5 years.
3. Explore prenatal/postnatal factors and associations between white matter volume and neurodevelopment outcomes, including GSED scores at 5 years.

Data Collection:

171 infants in Uganda scanned at 3 and 6 months old since March 2023

Makerere University (Mak)

Methods:

Prospective cohort study

Normal and low birth weight babies followed up to 5 years

Observe brain development (MRI), neurocognitive development, and growth

Pre/Postnatal Exposure Analysis of:

- Maternal/paternal education and occupation
- Maternal alcohol and substance abuse
- Maternal hemoglobin
- Smoking
- Body mass index
- Maternal depression
- Maternal HIV infection
- Maternal age
- Birth weight
- Birth order
- Sex
- Socioeconomic status
- Nutrition
- Illnesses

LISA Data Contributors

The Aga Khan University

Makerere University

University of Cape Town

Data Distributed from LISA 2025:
UCT, Mak and AKU

Task 1 Quality Control Data			
	Training	Validation	Testing
UCT	213	54	54
Mak	144	18	18
AKU	144	39	39
Total	501	111	111

Task 2 Bilateral Hippocampi and Basal Ganglia Segmentation Data			
	Training	Validation	Testing
UCT	47	7	7
Mak	16	2	2
AKU	12	3	0
Total	75	12	9

Task 1 Data - Quality Assurance

Why Assess MRI Quality in Pediatrics?

Pediatric Brain MRI Challenges

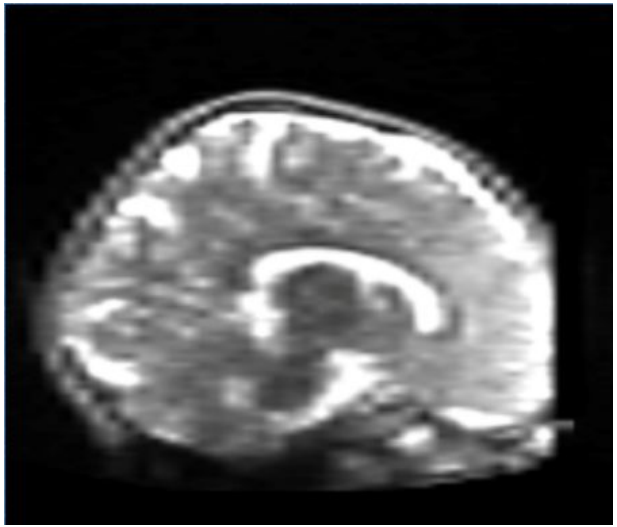
- Poor gray/white matter contrast
- High motion from infants
- Traditional QA tools are adult-centric
- Poor gray/white matter contrast in neonates

Low-Field MRI (0.064 T, Hyperfine SWOOP)

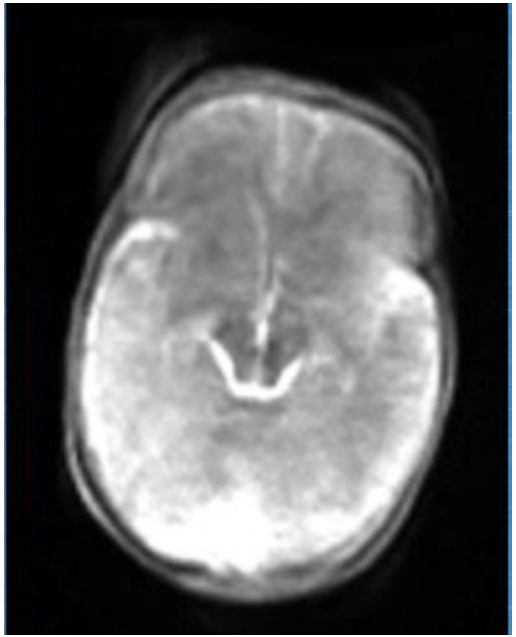
- Portable, accessible
- Lower resolution & higher artifact susceptibility
- Traditional QA methods designed for adult, high-field MRI

Existing QA methods do not translate well to pediatric low-field settings
Reliable QA is critical for diagnostic utility in resource-constrained or bedside imaging

Low Field Artifacts

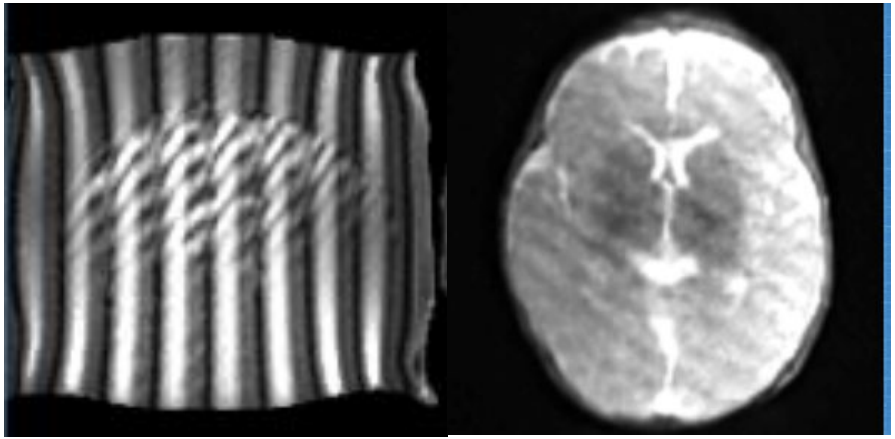


Positioning: parts of brain and neurocranium missing

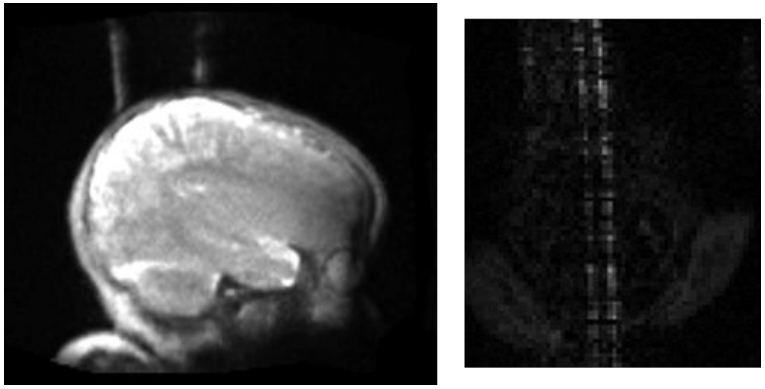


Motion: blurry or ghosted edges

Low Field Artifacts



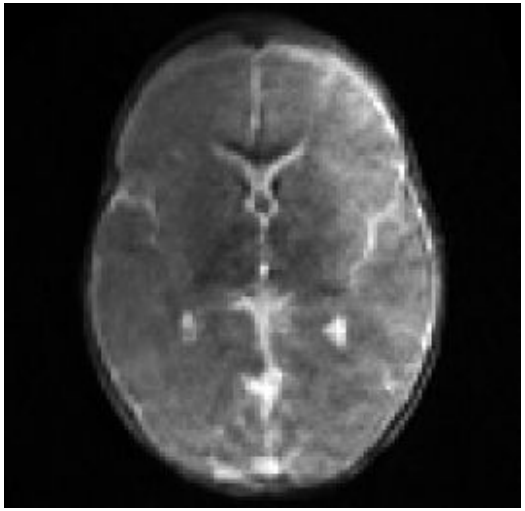
Banding: periodic stripes in the image



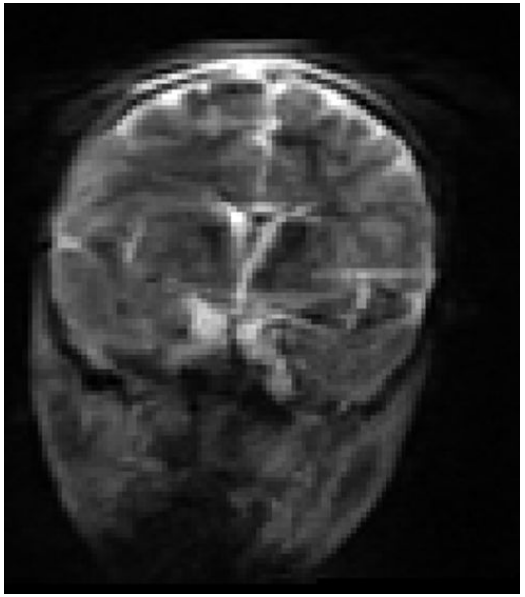
Zipper: high frequency noise lines

Low Field Artifacts

Noise: random graininess or speckling



Contrast: reduces visibility of structures

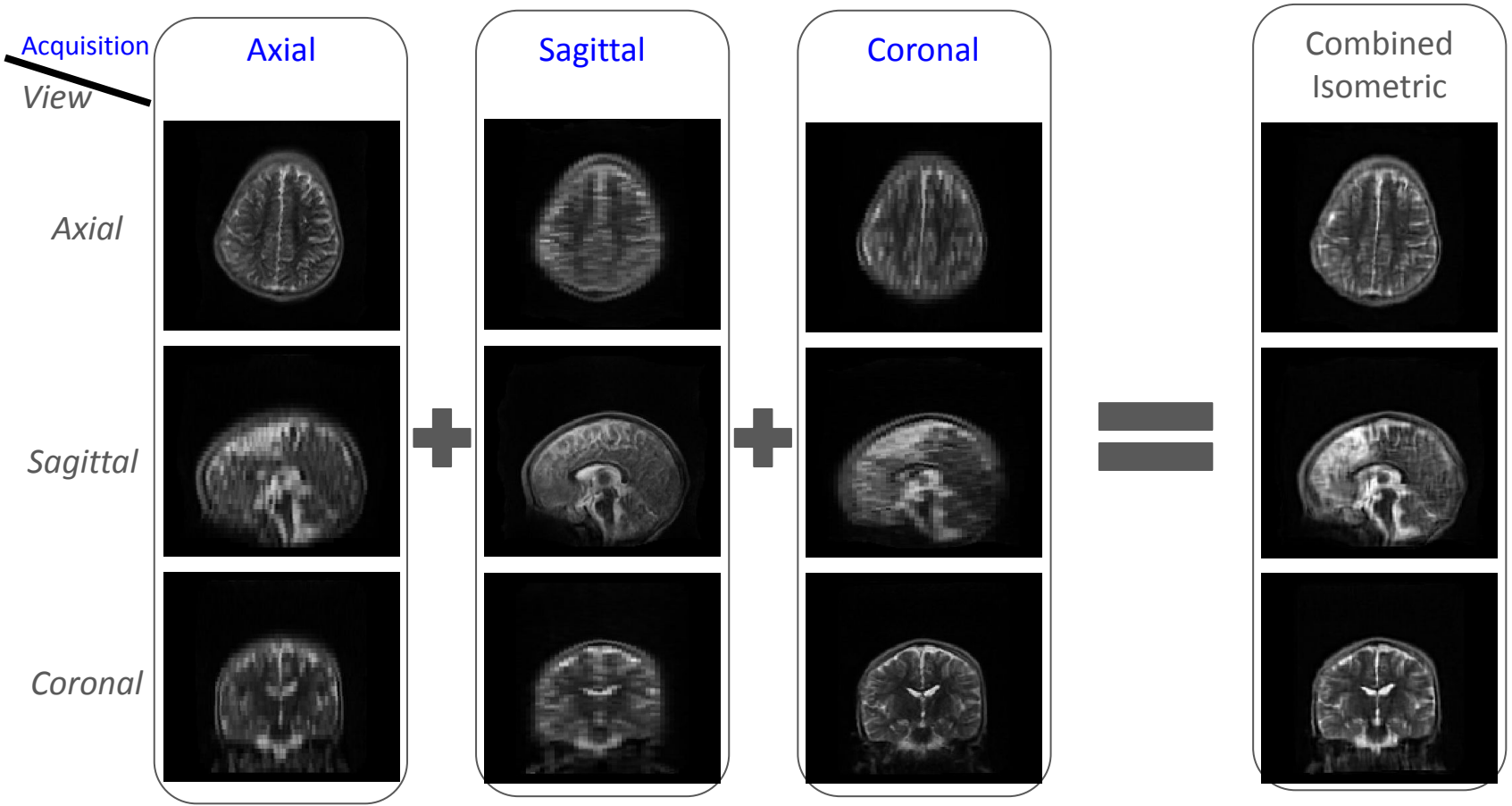


Distortion: geometric warping of brain structures

QA Goals and Broader Impact

- Detect unusable scans early to enable re-scanning
- Improve downstream segmentation and diagnostic reliability
- Reduce radiologist workload
- Critical for low-resource and bedside settings

Task 2 Data Pre-processing : Combined ISOmetric (Low field images)

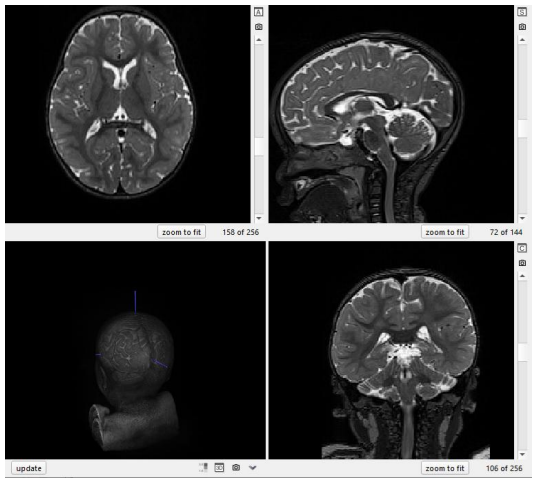


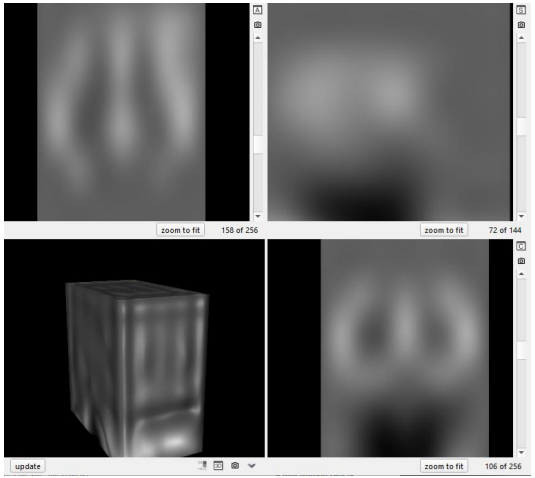
Task 2 Data Pre-processing : N4 Bias Field Correction

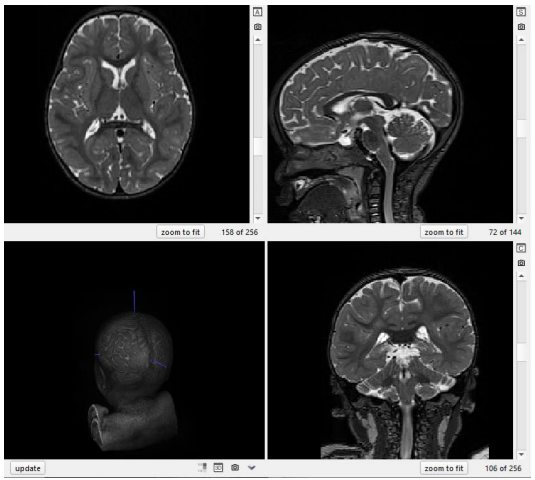
Original Image

Bias Field

Bias Field Corrected Image

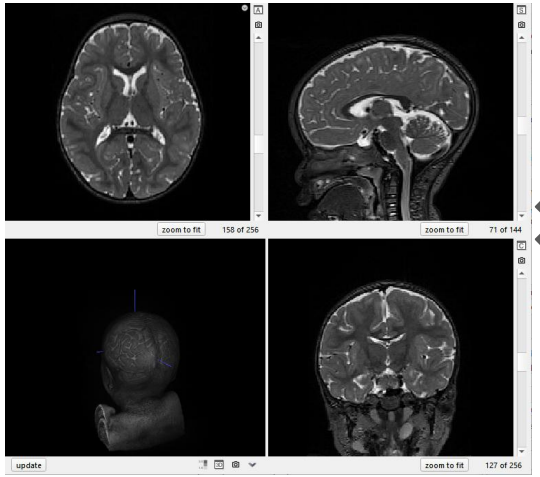




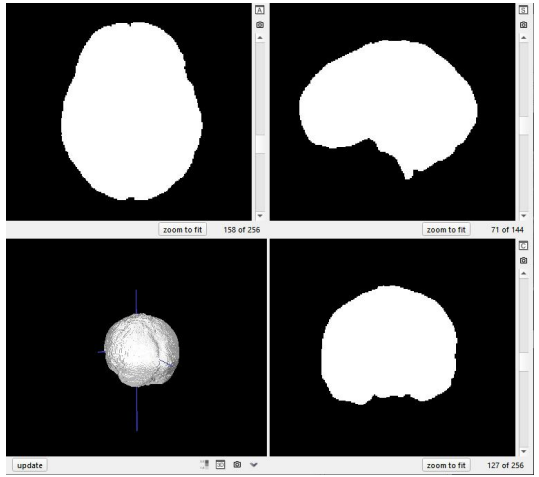


Task 2 Data Pre-processing : Skullstripping

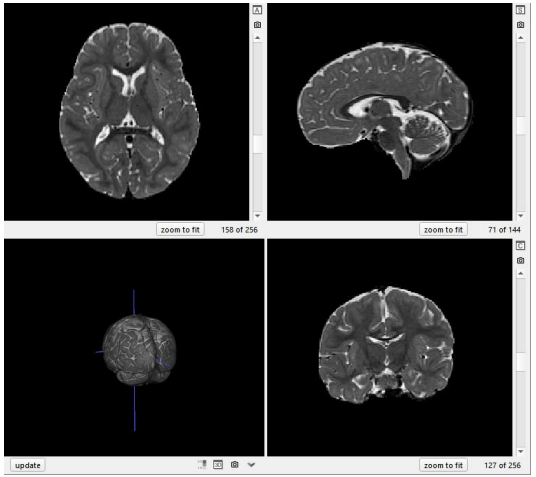
Bias Field Corrected Image



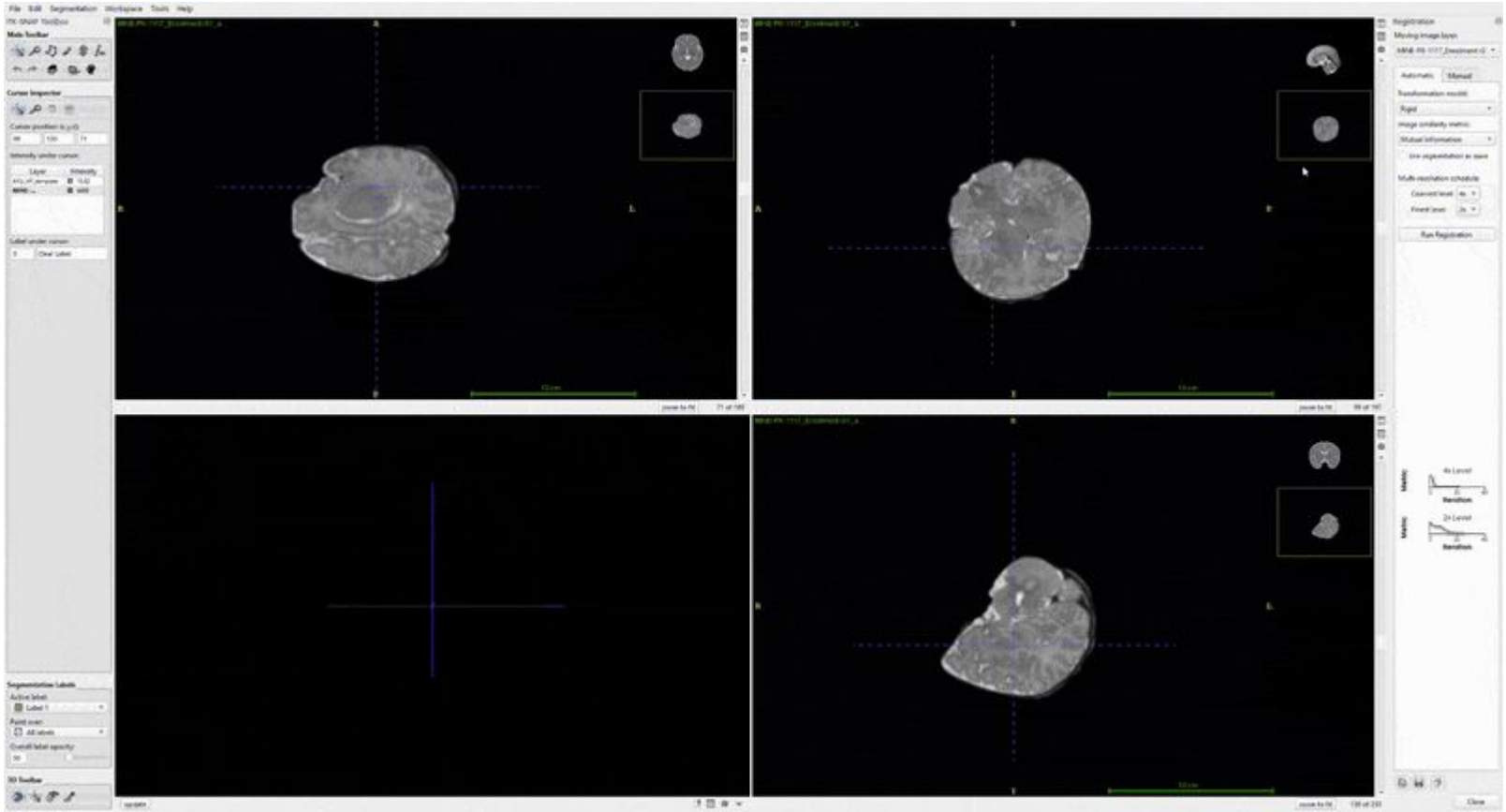
Skull mask



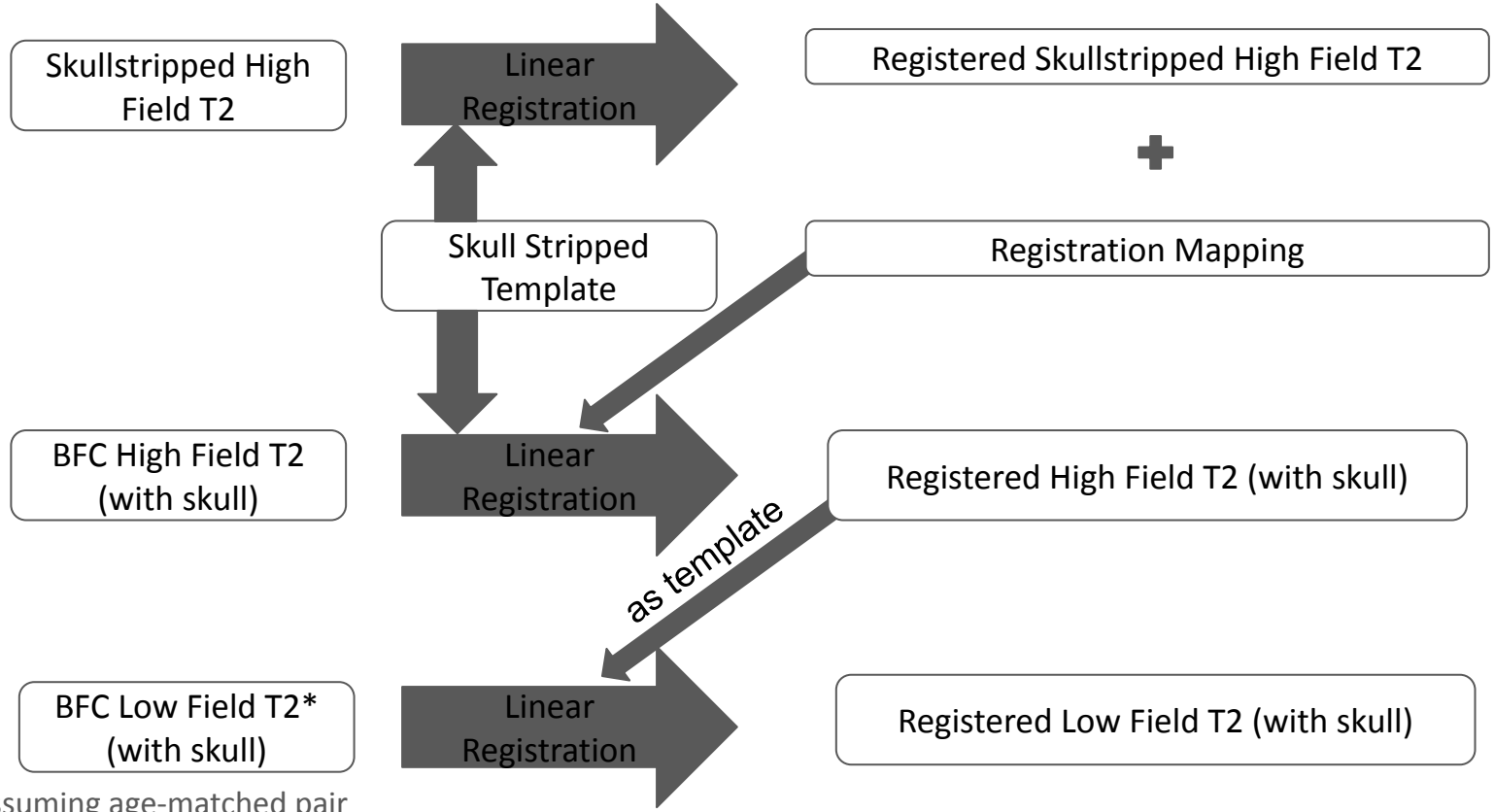
Skullstripped Image



Task 2 Data Pre-processing : Linear Registration - example



Task 2 Data Pre-processing : Linear Registration

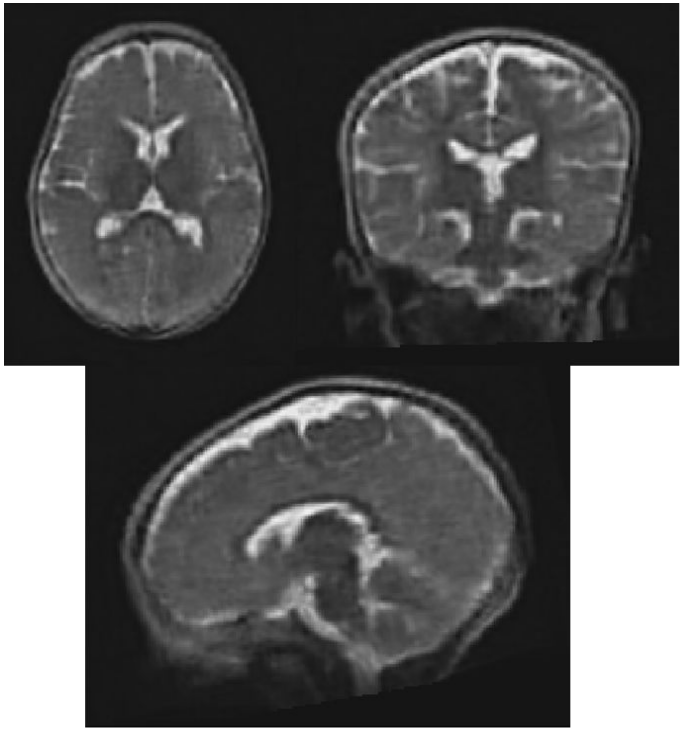


*assuming age-matched pair

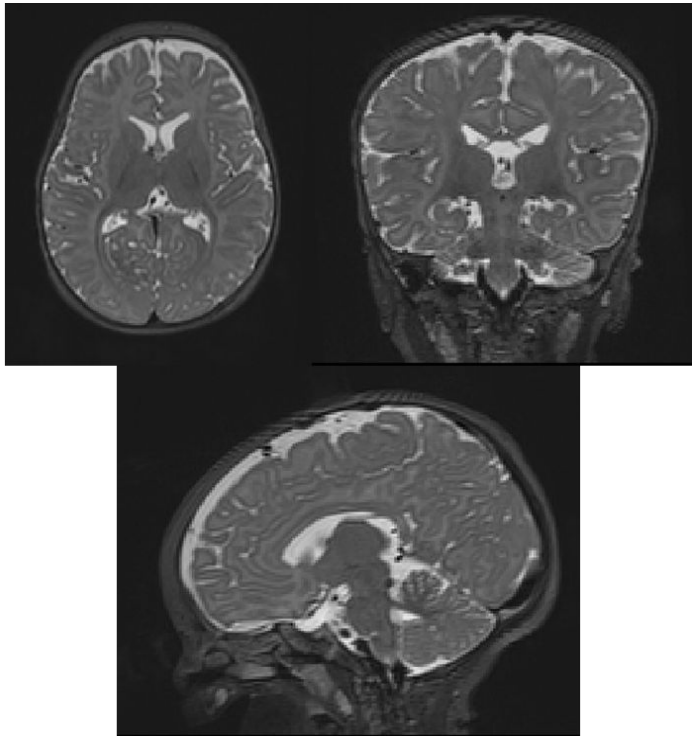
Task 2 Data Pre-processing : Linear Registration

Paired Example

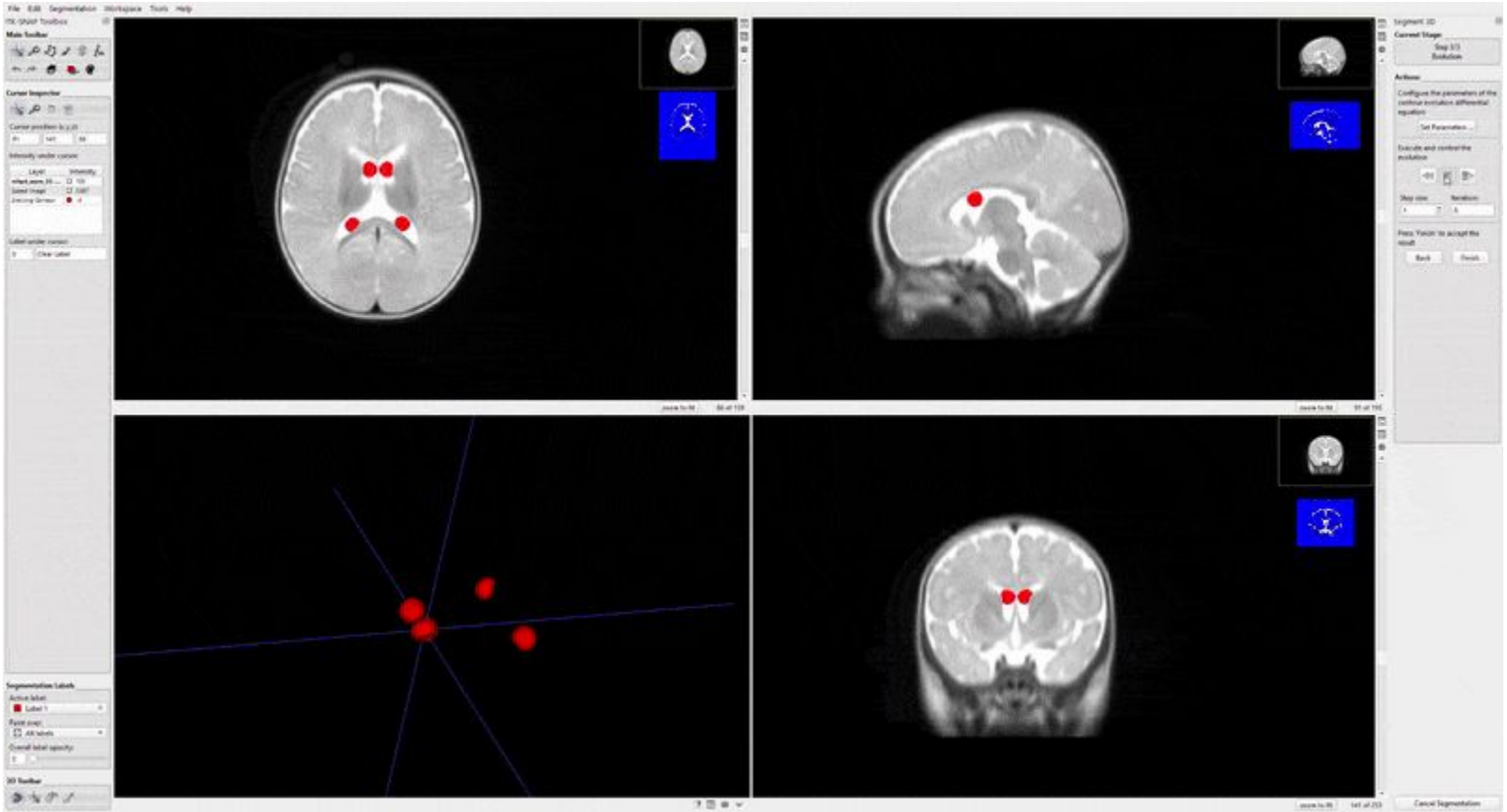
uLF MRI



HF MRI

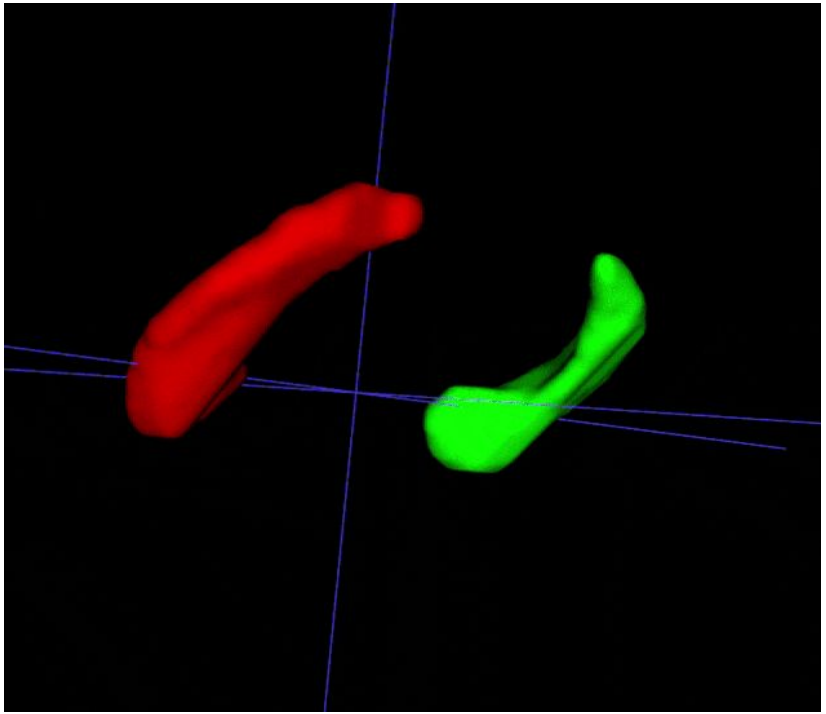


Task 2 Data Pre-processing : Segmentation Process Example

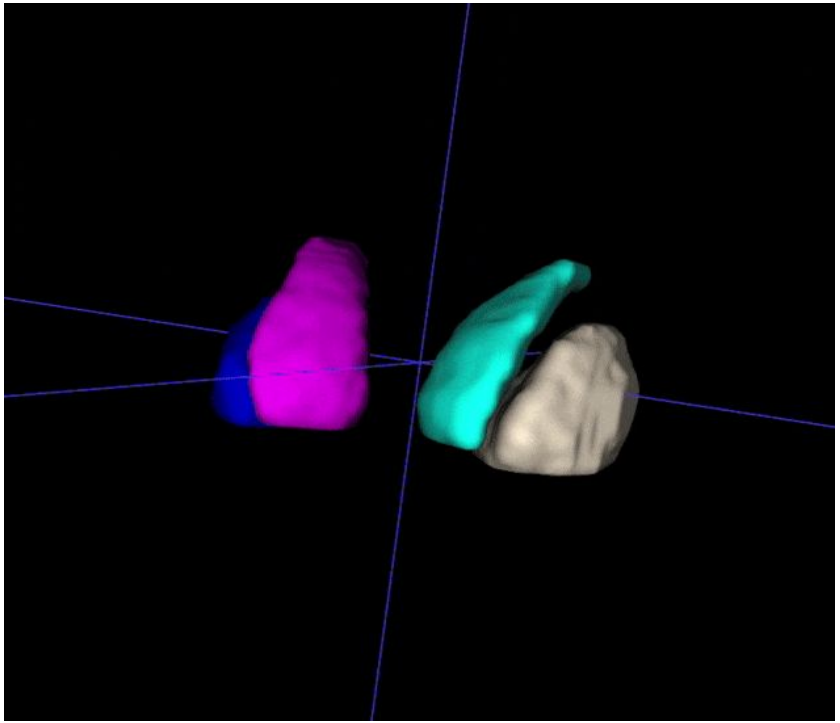


Task 2 Data Pre-processing : Segmentation

Task 2a - Hippocampus



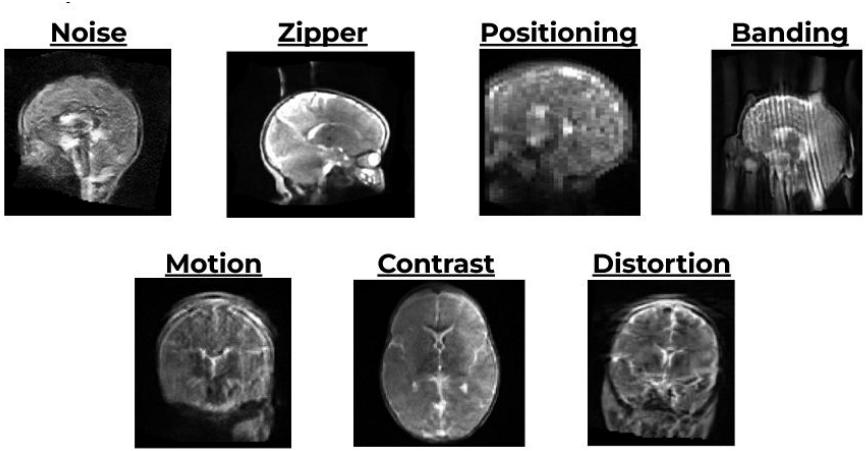
Task 2b - Basal Ganglia



Task 1: Quality Assessment in Low-Field Neonatal MRI

Problem Statement:

- Evaluate quality of 0.064T Hyperfine SWOOP scans from 3 sites
- Quality assessment is based on the visibility of 7 artifact categories



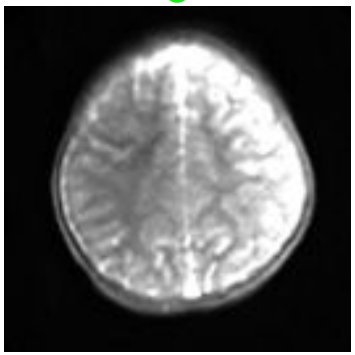
Task 1: Quality Assessment in Low-Field Neonatal MRI

Task 1 Goal: Assign classification label for all artifacts for each scan

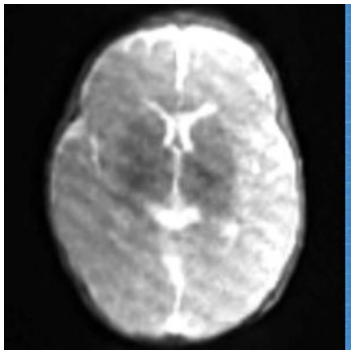
Labels:

- 0 = No visible artifact
- 1 = Artifact with mild impact on neural structure visibility
- 2 = Severe artifact impairing neural structure distinction

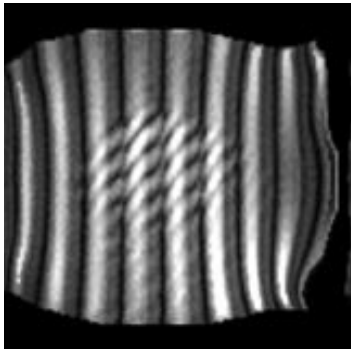
0



1



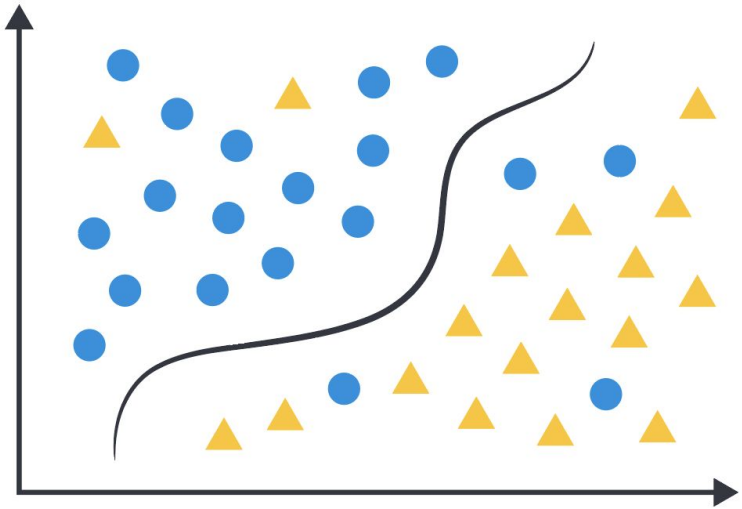
2



Classification Task

- A learning technique used to categorize data into predefined classes or categories.

- It involves training a model on labeled data so it can predict the class of new, unseen data points.



Shapes in the following graph can be differentiated and classified as "circles" and "triangles"

Figure: https://www.elastic.co/docs/explore-analyze/machine-learning/data-frame-analytics/ml-dfa-classification

Types of Classification Problems

1. Labels:
   a. Binary (two labels)
   b. Multi-label (label overlap)
   c. Multi-class (0/1/2 - LISA Task 1)
2. Data:
   a. Supervised (LISA Task 1)
   b. Unsupervised
3. Imbalanced vs balanced

Approaches for Classification

1. Deep Learning Models
2. Ensemble Approaches (combination of different models)
3. Random Forest/Decision Trees
4. Clustering
5. Support Vector Machines

Commonly Used Metrics

1. Accuracy: measures the proportion of total predictions that are correct
2. Precision: correctness of positive predictions per class
3. Recall: coverage of actual positives per class
4. F1-score: harmonic mean of precision and recall, balancing the two.

LISA Task 1 Setup

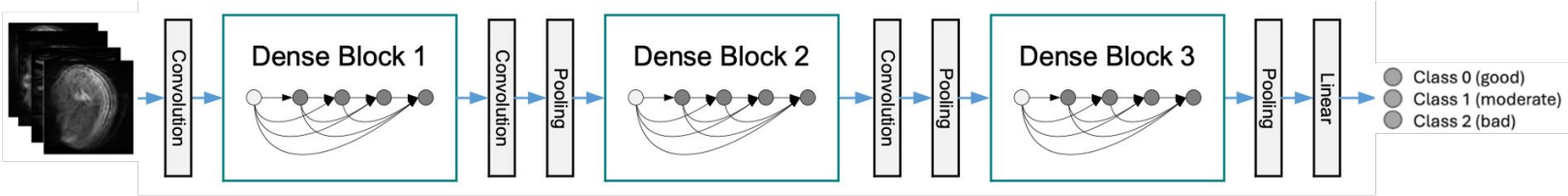
- **Input to the models:**
  - **Images:** 3 orthogonal images (Axial, Sagittal, Coronal) taken from the same patient
  - **Ground truth labels:** manual assessment scores of the quality of those images.
- **Model output:** quality label for each artifact that is predicted by your model

Best Practices for Classification

1. Data augmentation:
   a. avoid intensity based transformation that change the quality of the image
   b. rotation, cropping etc can be used
2. Metrics:
   a. use F1, recall, precision etc to select the best performing models as accuracy can be misleading if there is a class imbalance
3. Consider cross-validation and monitor for overfitting

Baseline Model (Task 1)

- DenseNet architecture:



Huang, G., et al., IEEE CVPR, 2017

- Inputs: Trio-orthogonal images
- Outputs: A csv file including the labels
- For 7 artifact categories, 7 separate models were trained.
- https://github.com/LISAChallengeOfficial/2024Task1

Task 2 - Segmentation

The process of partitioning an image into distinct regions by grouping together neighborhood pixels based on a predefined similarity criterion

The criterion can be determined using specific properties or features of pixels representing ‘objects’ in the image

Task 2 - Segmentation

Benefits of Low-Field MRI

Portability and reduced clinical costs

Reduced sedation for young patients

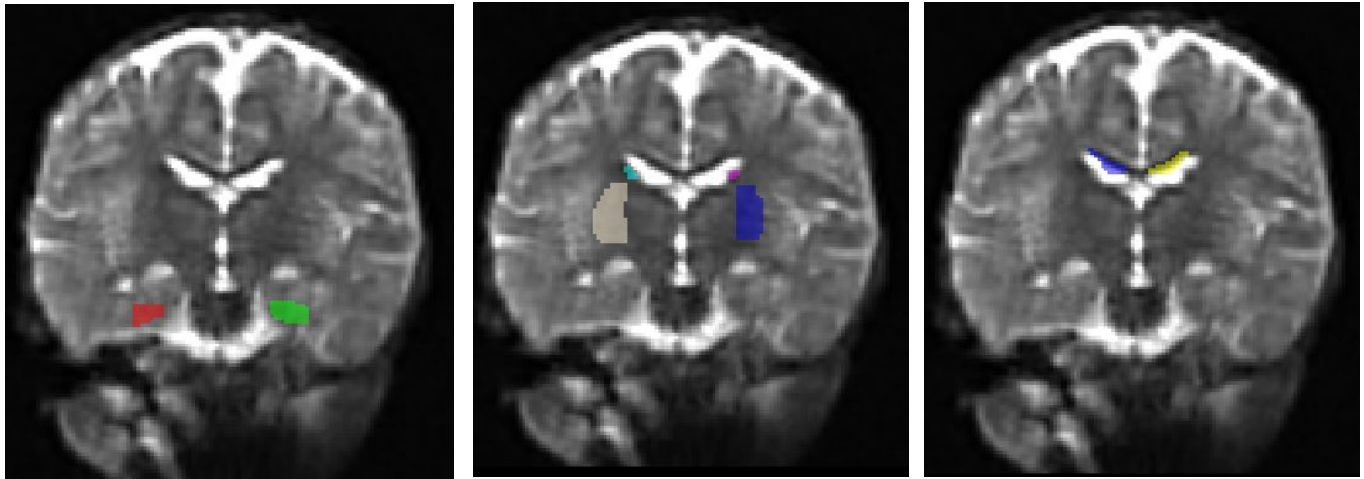
Challenges of Automatic Segmentation in Low-Field MRI

Lower resolution in systems like the 0.064T Hyperfine scanner complicates structural delineation.

Task 2 - Segmentation

Target Objects for this Challenge

1. Hippocampus (Task 2a)
2. Basal Ganglia (Task 2b)
3. Ventricle

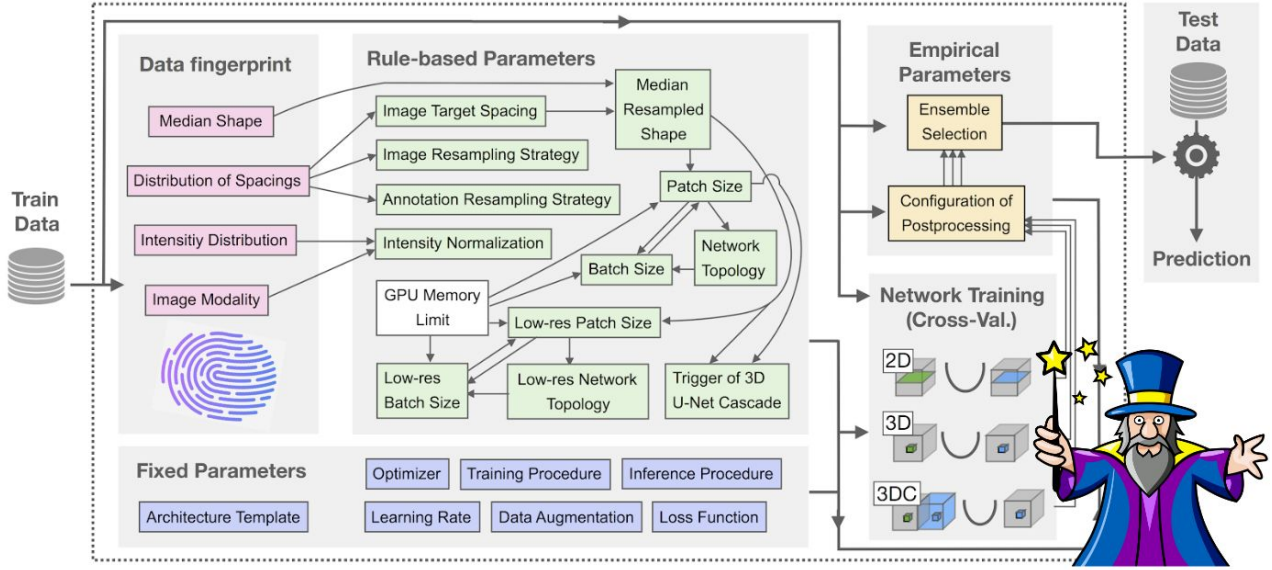


Task 2 - Segmentation

Presented segmentation results using nnU-Net on the first fold of cross-validation training.

Inputs are:
CISO Images

Outputs are:
Segmentations



nnU-Net: Isensee, F., et al., Nature Methods, 2021

Task 2 - Segmentation

Simple Approach: nnU-net for semantic segmentation

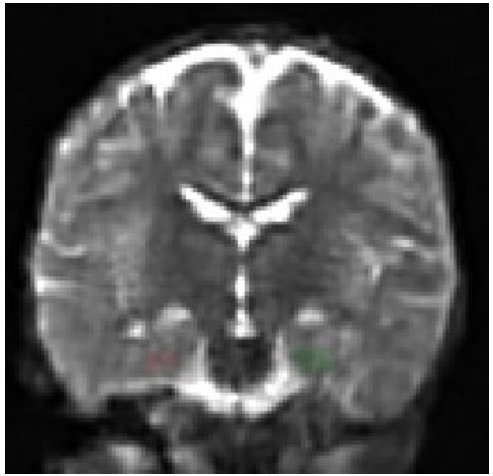
We have a basic repository from last year's challenge
https://github.com/LISAChallengeOfficial/2024Task2

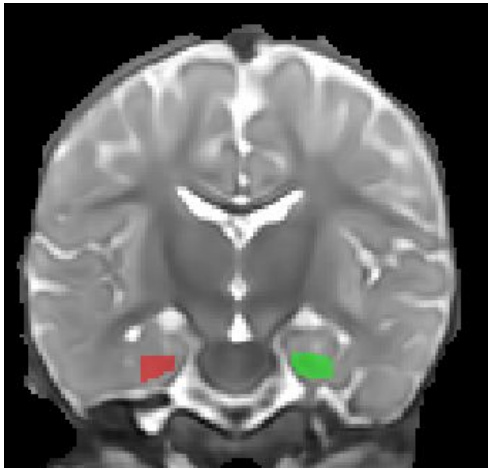
1. Follow the installation instructions for nnU-Net
2. Download the data from LISA
3. Place the data into nnUNet_raw/Dataset999_LISA
4. Run nnU-Net as instructed

Task 2 - Segmentation

To make objects more apparent, try enhancing your images before training your network for segmentation

1. Deep learning
2. Basic Sharpening
3. Alt: Pretraining

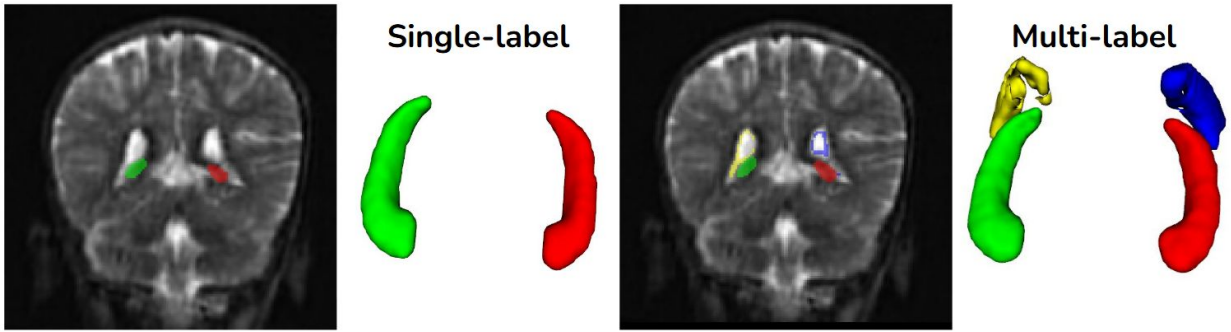




Task 2 - Segmentation

To make boundaries more defined, utilize a multi label approach

1. Ventricles support boundaries
2. All objects at once
3. Ensembling



Task 2 - Segmentation

Goal is to achieve best scores across all categories

1. DSC - Overlap of two structures, best score is 1
2. HD - Max distance between boundary points of objects
3. HD95 - distance at the 95th percentile, not maximum
4. ASSD - average distance for corresponding surfaces
5. RVE - difference in volume between GT and prediction

Task 2 - Segmentation

Using all the enhancement techniques can improve results

		Model		
Metric	**Structure**	**uLF nnU-Net**	**SF nnU-Net**	**SF ML nnU-Net**
DSC ↑	Left Hippocampus	0.57±0.29	0.68±0.24*	**0.68±0.23***
DSC ↑	Right Hippocampus	0.65±0.25	0.74±0.13	0.75±0.11
DSC ↑	Average	0.61±0.27	0.71±0.17	**0.72±0.16***

Task 2 - Segmentation

Regardless of your strategy:

- Submit early and often (there is no limit)
- Ask for help if you are stuck
- Share ideas and approaches in the discussion forum

Participation Information (LISA 2024)

Participants:

- 35 Teams
- 9 Countries
- 4 Continents

LISA 2025 Timeline:

Upcoming LISA 2025 Key dates:

July 1: Validation phase opens
July 24: Validation phase ends
July 25: Submission deadline of short papers; testing phase opens (only for participants who submitted short papers)
August 9: Testing phase ends (submission deadline of Dockers)
August 29: Evaluation of models as Dockers on test data
September 1: Final results and rankings available; top performing participants contacted to begin preparing oral presentations
September 23: In-person presentation of the challenge at MICCAI 2025; top teams present their work live at MICCAI 2025
Late October: Camera-ready paper submission of extended papers for inclusion in associated workshop proceedings

Participating in LISA 2025 offers the opportunity to:

- Present your methods live at MICCAI 2025
- Have them published in the LISA 2025 proceedings

LISA at RISE-MICCAI Key dates:

July 14 Start of the competition
July 21 Validation phase opens
August 24 Validation phase ends
August 25 Submission of models as Dockers
September 1 Top performers contacted
September 27 Announcement of the final top 3 ranked teams at LISA satellite session

- Training and validation data are available at the LISA 2025 website: https://www.synapse.org/Synapse:syn68633106/wiki/633379

Password for participation in LISA at RISE-MICCAI Summer School: **321_RISE**

Evaluation (Task 1)

- The received methods are evaluated based on metrics of: F1-score, F2-score, Precision, Recall and Accuracy.

- Due to the imbalance cohorts for Task 1, metrics were calculated in with a macro, micro and weighted scoring system.

- Final ranking: Average of all the metrics above are considered.

https://github.com/LISAChallengeOfficial/2025EvaluationMetrics

Evaluation (Task 2)

- The received methods are evaluated based on metrics of: DSC, HD, HD95, ASSD and RVE.

- Metrics were computed for both left and right hippocampal structures and all the four regions of the basal ganglia.

- The average of the metrics (1-DSC, HD, HD95, ASSD and RVE) are considered for final ranking.

https://github.com/LISAChallengeOfficial/2025EvaluationMetrics

Final Scores (Task 1), LISA 2024

Rank	Team	F1 Score weighted	F2 Score weighted	Precision weighted	Recall weighted	Accuracy weighted	AVG
	vaanu	0.795	0.799	0.804	0.804	0.804	**0.801**
	ZYY101	0.781	0.803	0.752	0.820	0.820	0.795
	wooks527	0.785	0.796	0.771	0.804	0.804	0.792

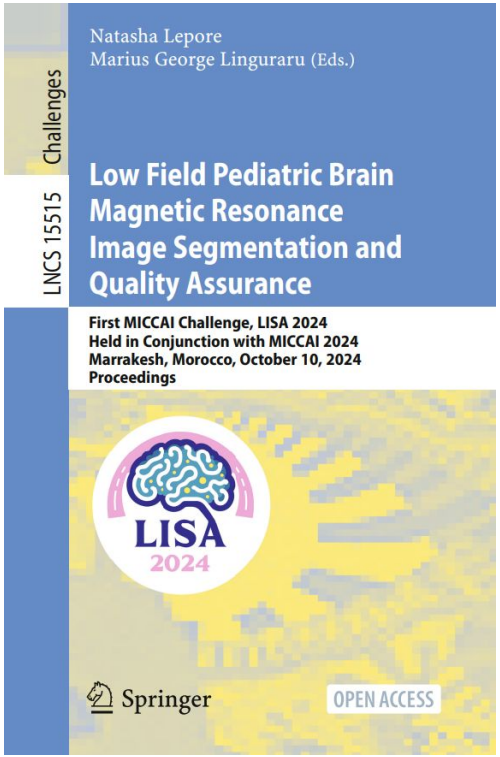
The average of all the metrics in weighted scoring will also be considered for the final ranking at LISA 2025.

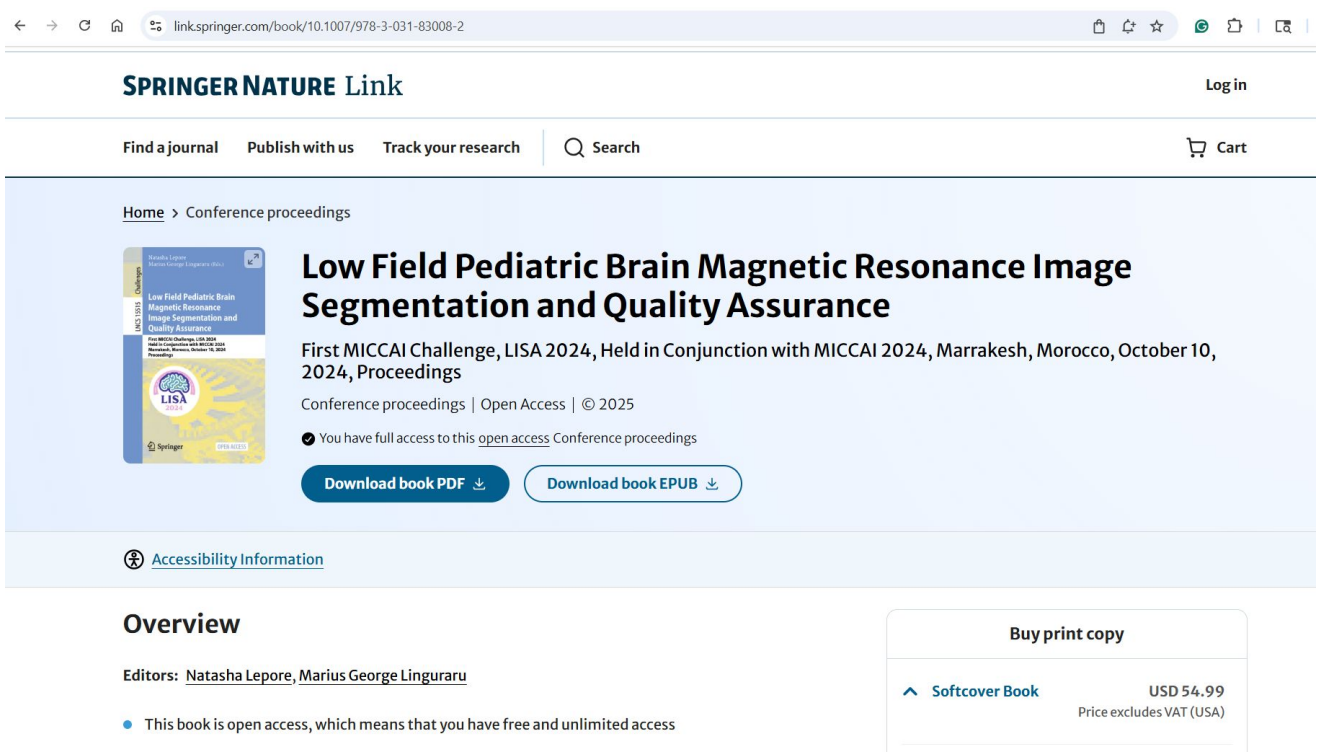
Final Scores (Task 2), LISA 2024

Rank	Team	Dice Similarity Coefficient Left	Dice Similarity Coefficient Right	Dice Similarity Coefficient AVG	Hausdorff Distance AVG	95 Hausdorff Distance AVG	Average Symmetric Surface Distance	Relative Volume Error AVG	AVG
	wooks527	0.61±0.19	0.62±0.18	0.61±0.18	4.31±2.11	2.77±1.62	0.91±0.52	0.34±0.47	**1.744**
	hap	0.63±0.18	0.61±0.19	0.62±0.18	4.57±2.19	2.98±1.75	0.90±0.52	0.39±0.47	1.844
	wanziya	0.61±0.19	0.58±0.20	0.60±0.18	4.77±1.99	2.90±1.51	0.94±0.51	0.34±0.39	1.870

The average of the metrics (1-DSC, HD, HD95, ASSD and RVE) will also be considered for the final ranking at LISA 2025.

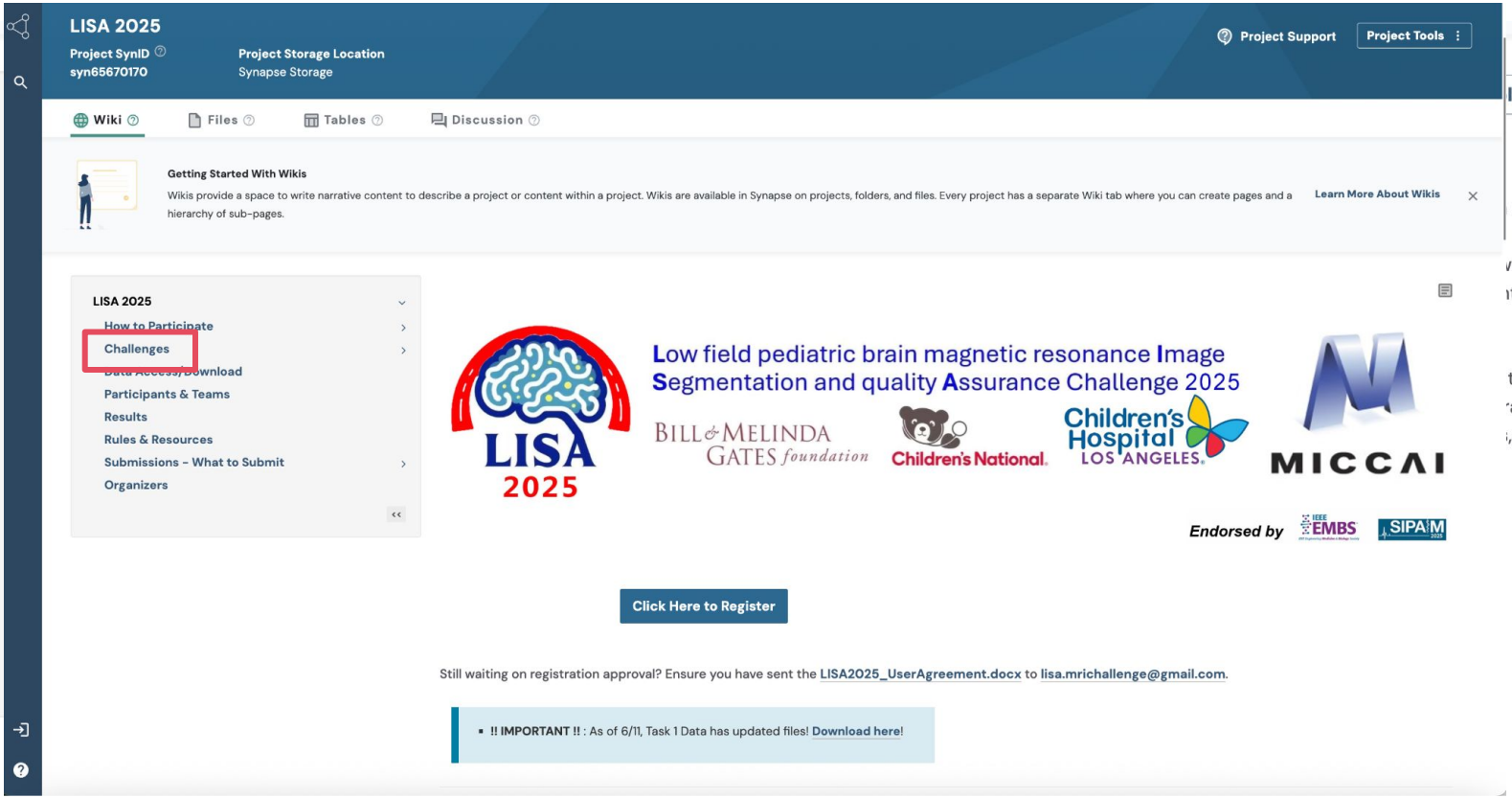
LISA 2024 Proceeding Paper





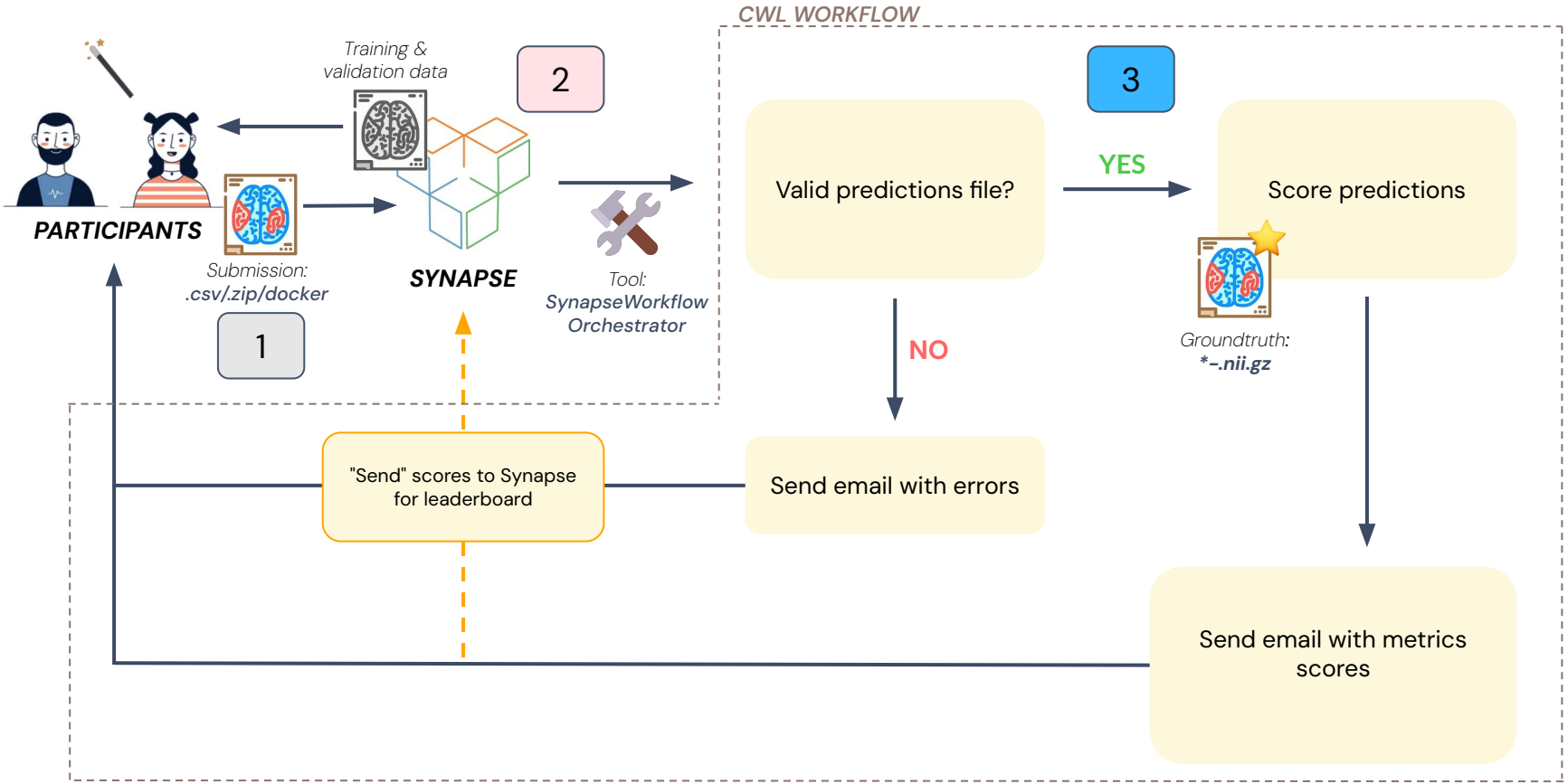
https://link.springer.com/book/10.1007/978-3-031-83008-2

LISA 2025 Tasks



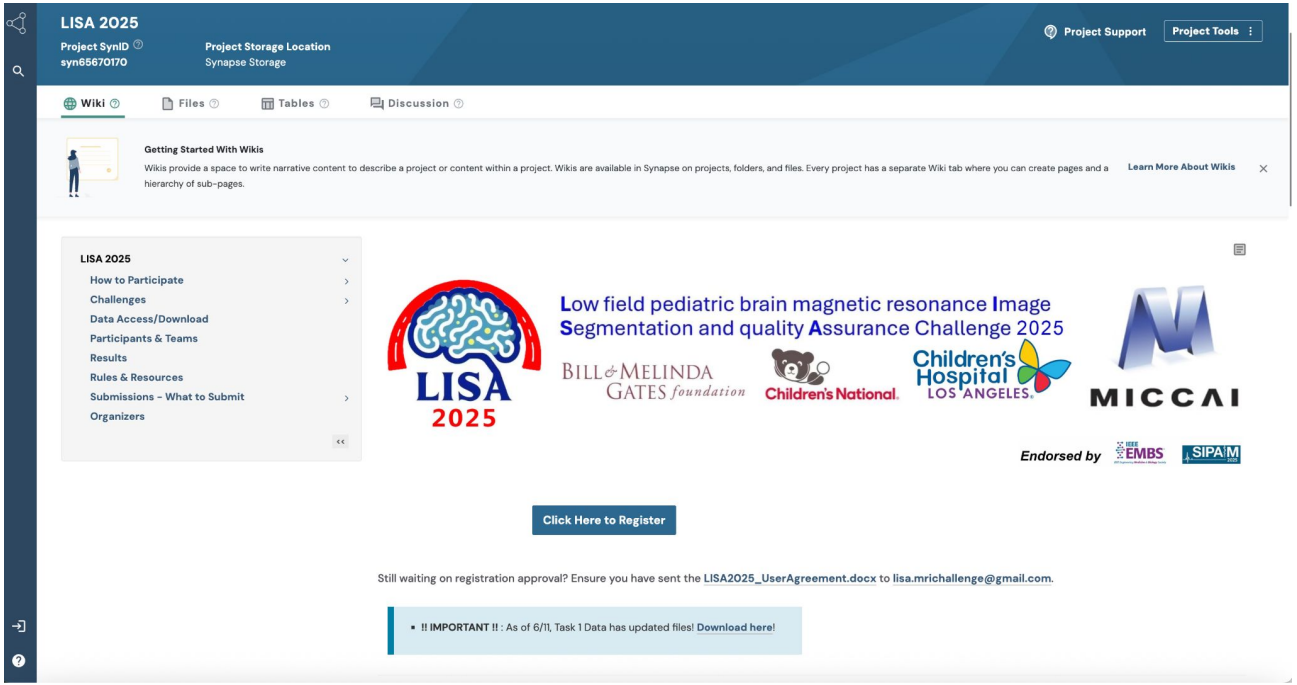
https://www.synapse.org/Synapse:syn65670170/challenge/

Workflow visual



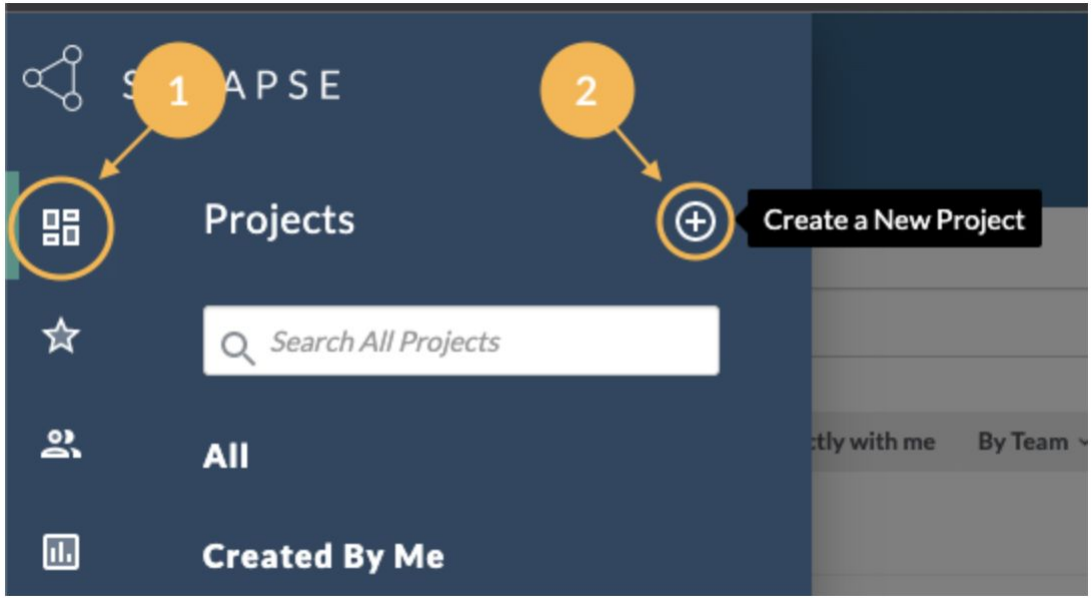
STEP 1: Register the Challenge

- Go to Wiki → 'Click Here to Register'
- Sign and Submit your Data Agreement Form to **lisa.mrichallenge@gmail.com**
-



STEP 2: Create a Synapse Project

- Go to Synapse → Projects → 'Create a New Project'
- Name it descriptively: LISA 2025 <Your Team Name>
- Share project with your team via 'Project Tools → Sharing Settings'
- Ensure all members are Certified Users (required to upload files)



INPUT

Task 1 – Quality Control:
Each case includes ultra-low-field (ULF) MRI brain scans in 3 orientations:

Axial (LF_axi)
Coronal (LF_cor)
Sagittal (LF_sag)
File format: .nii.gz

Prefix: LISA_XXXX_LF_*.nii.gz or LISA_VALIDATION_XXXX_LF_*.nii.gz

Task 2 – Segmentation:
Each case includes:

A single low-field brain scan (LISA_XXXX_ciso.nii.gz)

Segmentation masks for:

Hippocampus (LISA_XXXX_HF_hipp.nii.gz)

Basal Ganglia (LISA_XXXX_HF_baga.nii.gz)
Total: 79 cases per subtask

OUTPUT

Per case: one or more NIfTI files with labeled brain structures (e.g., hippocampus, basal ganglia)

Task 1: a .csv file containing predicted quality scores per image

Task 2: predicted NIfTI masks, matching the original image size and naming

SUBMISSION

Validation Phase:

Task 1:

Submit a .csv file with predicted quality control scores.

Task **2:**

Submit a compressed folder (.zip or .tar.gz) containing predicted NIfTI masks:

One per structure (hippocampus & basal ganglia)

Naming: LISA_XXXX_HF_hipp.nii.gz, LISA_XXXX_HF_baga.nii.gz

Test Phase:

Submit a Docker container that performs inference and outputs predictions

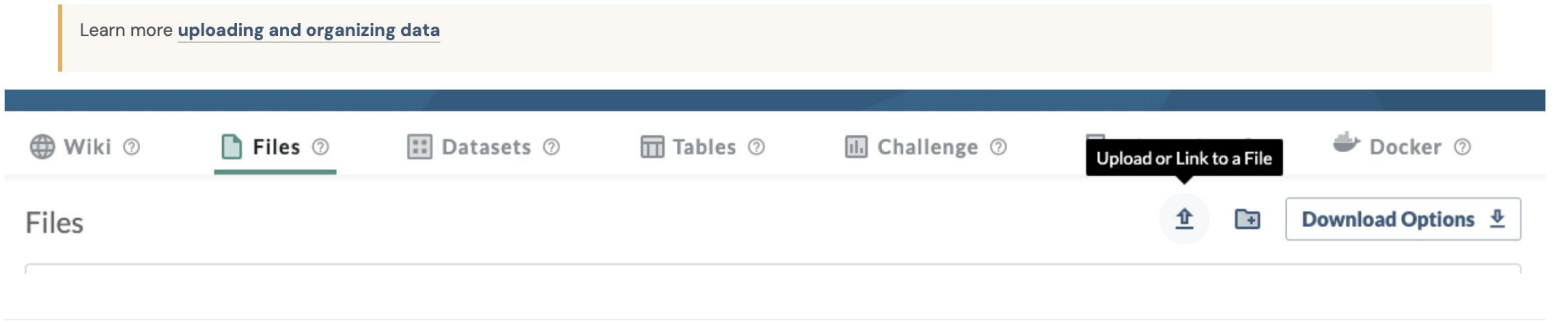
(for both segmentation & QC tasks)

STEP 3: Prepare Prediction Files

- Task 1 (Quality Control): submit a .csv file (if participating in main challenge)
- Task 2a: submit segmentation masks for hippocampus
- Task 2b: submit segmentation masks for basal ganglia
- File naming: LISA_XXXX_HF_hipp.nii.gz, LISA_XXXX_HF_baga.nii.gz

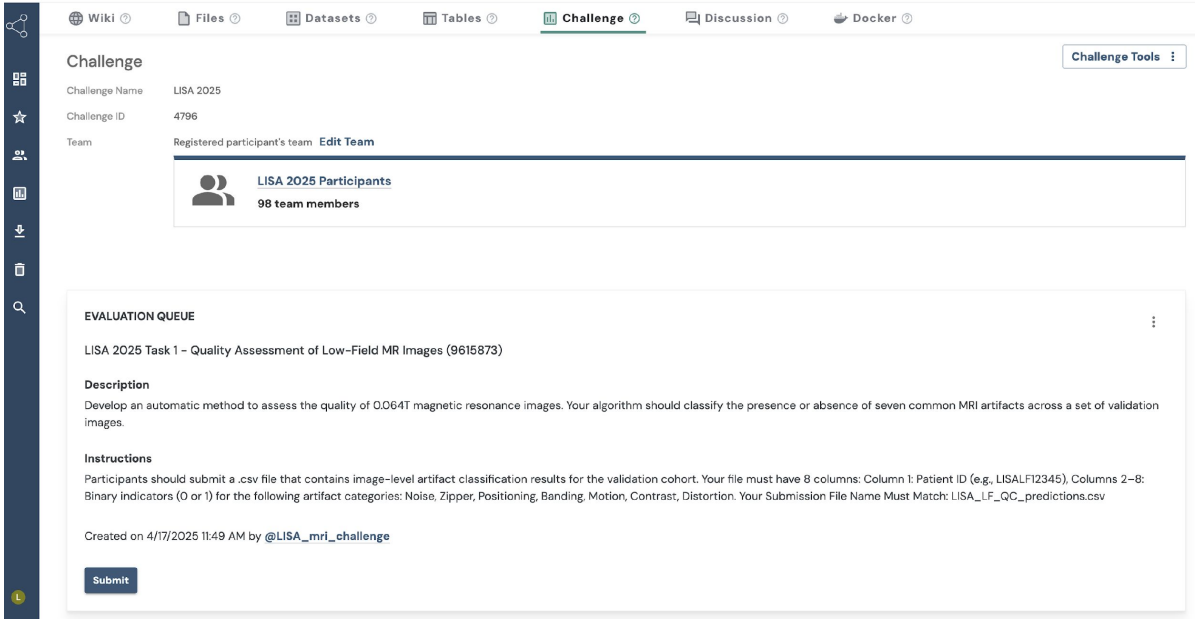
STEP 4: Upload to Synapse

- Navigate to your Synapse Project → Files tab
- Click the Upload icon (top right)
- Ensure correct file structure and naming

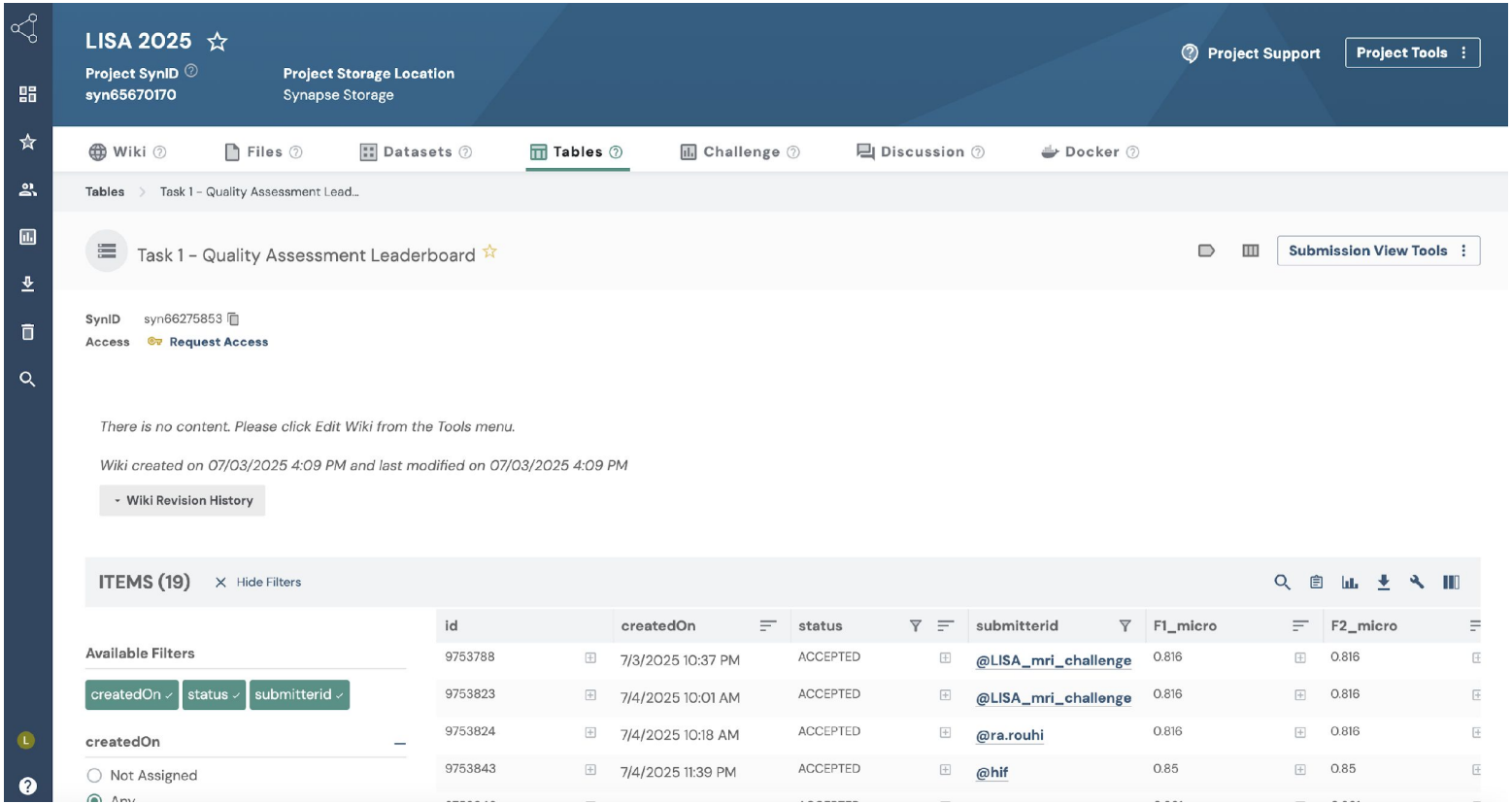


STEP 5: Submit Your Predictions

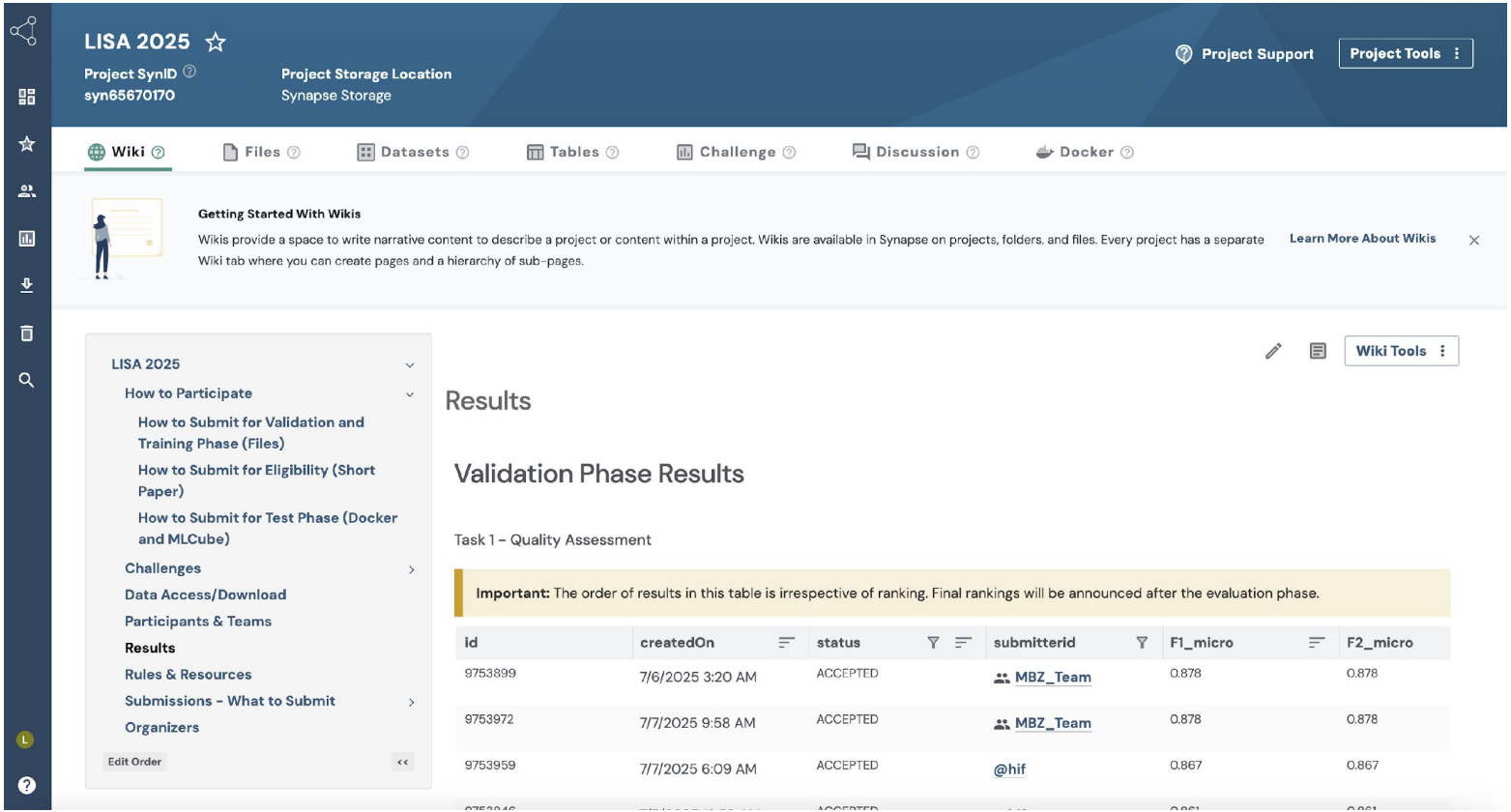
- Use Synapse Web to submit your files
- Only the submitter can monitor status in the Submission Dashboard
- All submissions must be in by 11:59 PM UTC on the deadline date



STEP 6: Check Your Results



STEP 6: Check Your Results



Test Phase – Docker Submission Overview

🎯 Why Docker?

- Ensures reproducibility and fair benchmarking
- Participants submit models as Docker containers
- Organizers run containers in secure, offline compute environment

LISA Evaluation Inputs & Outputs

💡 Model Requirements

- Must generate output automatically when container is run
- Must not rely on internet access

Expected to generate:
predictions.csv/.zip in /output folder
Based on data from /input folder

Command Line Interface Dockerfile Guidelines

🛠️ Key Commands in Your Dockerfile

```
FROM python:3.9-slim
RUN pip install -r requirements.txt

COPY run_model.py /usr/local/bin/

COPY model.pt /usr/local/bin/
ENTRYPOINT ["python", "run_model.py"]
```

- COPY – Bring in your model & code
- ENTRYPOINT – Define what runs inside the container

🛠️ Build Locally

```
docker build -t
docker.synapse.org/syn12345/my-model:v1.0 .
```

- syn12345: Your Synapse project ID
- my-model: Your image name
- v1.0: Optional tag (recommended)

Push to Synapse Docker Registry

- Login to registry: docker login docker.synapse.org
- Push image: docker push docker.synapse.org/syn12345/my-model:v1.0 .
- Check image under your Synapse project → Docker tab

Submit Docker Image to LISA Challenge

- On Synapse, click 'Docker → 'Submit to Challenge'
- Choose correct queue: Task 1, Task 2a, Task 2b
- Only submitter can see status in Submission Dashboard

https://help.synapse.org/docs/Synapse-Docker-Registry.2011037752.html

LISA 2025 Prizes

LISA 2025 Prizes:

For each task (**Task 1**, **Task 2a** and **Task 2b**), participants will have the opportunity to win the following cash prizes:

- **First Prize:** $1,000
- **Second Prize:** $500
- **Third Prize:** $250

LISA 2025 Prizes at RISE-MICCAI:

For each task (**Task 2a** and **Task 2b**), participants will have the opportunity to win the following cash prizes:

- **First Prize:** $200
- **Second Prize:** $100
- **Third Prize:** $50

- In addition to the monetary rewards, the **top three teams in each task will receive certificates of achievement**.
- Prizes will be distributed in accordance with U.S. laws.

Acknowledgments

We would like to thank all the audiences.

This work was funded by the Gates Foundation grant #INV-005798, #INV-087131, #INV-047887 and #INV-018164.


Natasha Lepore


Marius George Linguraru


Sean Deoni


Jeffrey Tanedo


Rahimeh Rouhi


Austin Tapp


Krithika Iyer


Di Fan


Kirsty Donald


Victoria Nankabirwa

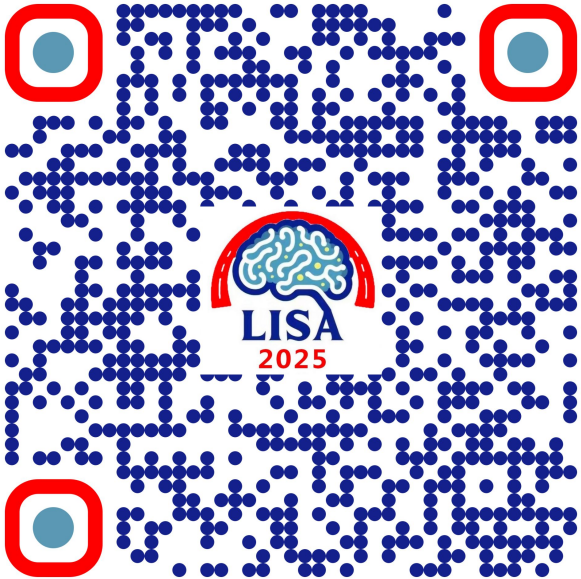

Sidra Kaleem


Sadia Parkar


Salman Osmani

Thank you for listening! Any questions?

Main LISA 2025 Challenge Info



RISE-MICCAI LISA 2025 Challenge Info