Brain Tumor Grade Classification in MR images using Deep Learning

Eleftheria Chatzitheodoridou

Supervisor: Anders Eklund

External Supervisors: Iulian Emil Tampu

Neda Haj-Hosseini

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Overview

- Motivation
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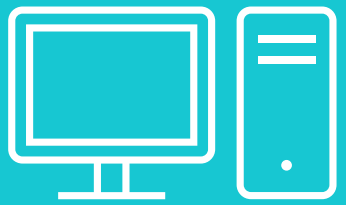
- Literature Overview



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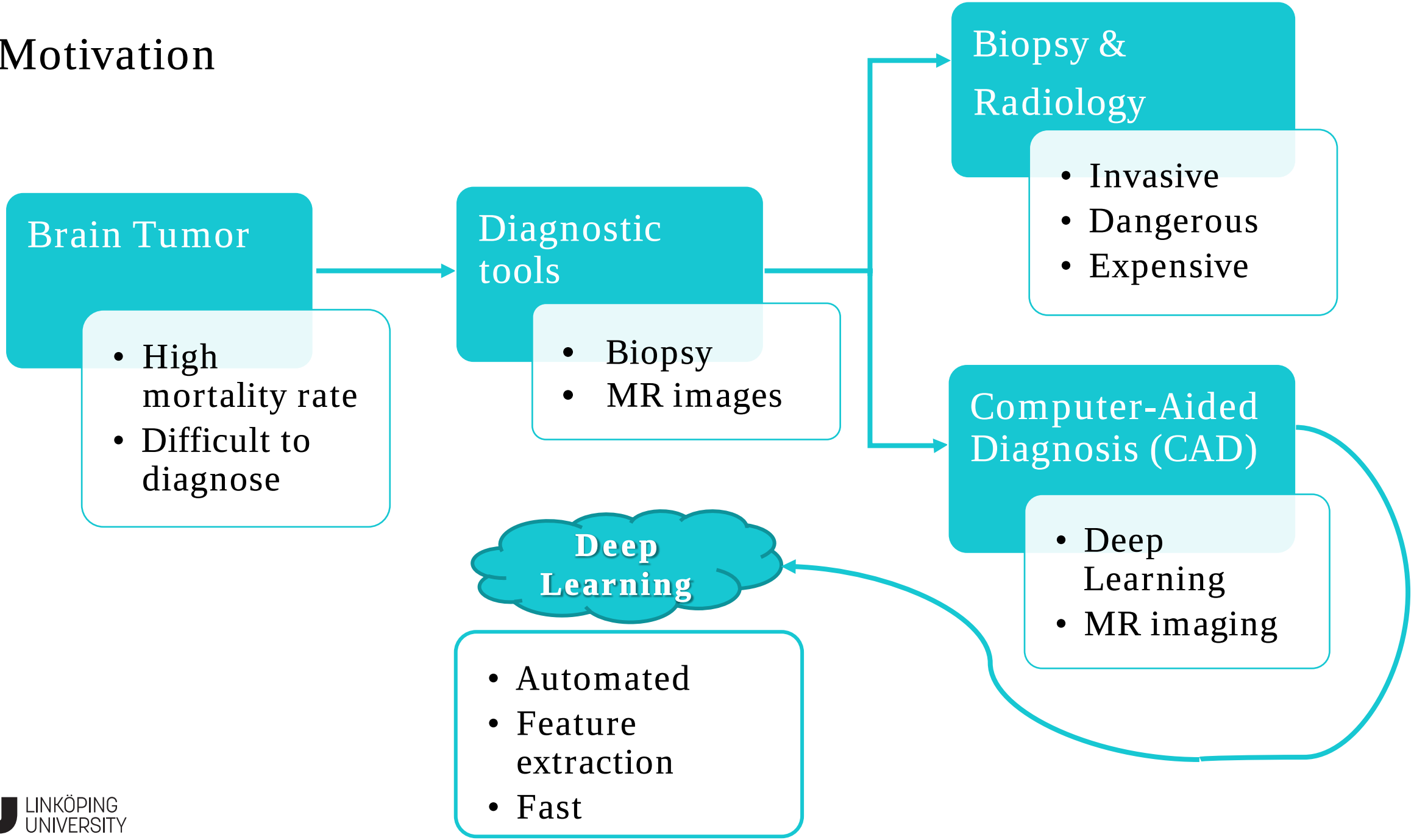
Motivation


Brain Tumor
• High mortality rate
• Difficult to diagnose
Diagnostic tools
• Biopsy
• MR images
Biopsy & Radiology
• Invasive
• Dangerous
• Expensive
Computer-Aided Diagnosis (CAD)
• Deep Learning
• MR imaging
Deep Learning
• Automated
• Feature extraction
• Fast

Aim

To classify the grade of brain tumor in MR images of different modalities from adult patients using deep learning

Source: https://www.philips.se/healthcare/solutions/magnetic-resonance

Background

- **Magnetic Resonance Imaging**: uses non-ionizing radiation during scan, offers superior soft-tissue resolution, has the ability to acquire different images sensitive to intrisic tissue parameters + contrast-enhanced agents

- **Gliomas**: most prevalent type of brain tumor, classified into 4 grades (WHO 2021)

- 1 ➡ Benign tumor
- 2, 3 } Low-Grade Glioma
- 4 } High-Grade Glioma

Malignancy

Background

- DL algorithms use an arrange of multiple layers of non-linear processing identities for feature extraction. Output of each sequential layer is input of next one -> ease of data abstraction
- **Convolutional Neural Networks (CNNs)**: subclass of DL, used with great success in analysis of images, require minimal preprocessing, can achieve great levels of abstraction with little prior knowledge
- **Architecture**: input layer (entry point), convolutional layer (feature extractors through small filters), activation layer (output responses pass through an activation function), pooling layer (downsampling), fully-connected layer (the classifier)

Data Overview

- **Source**: The Cancer Genome Atlas (TCGA) ➡ Grade 2, 3

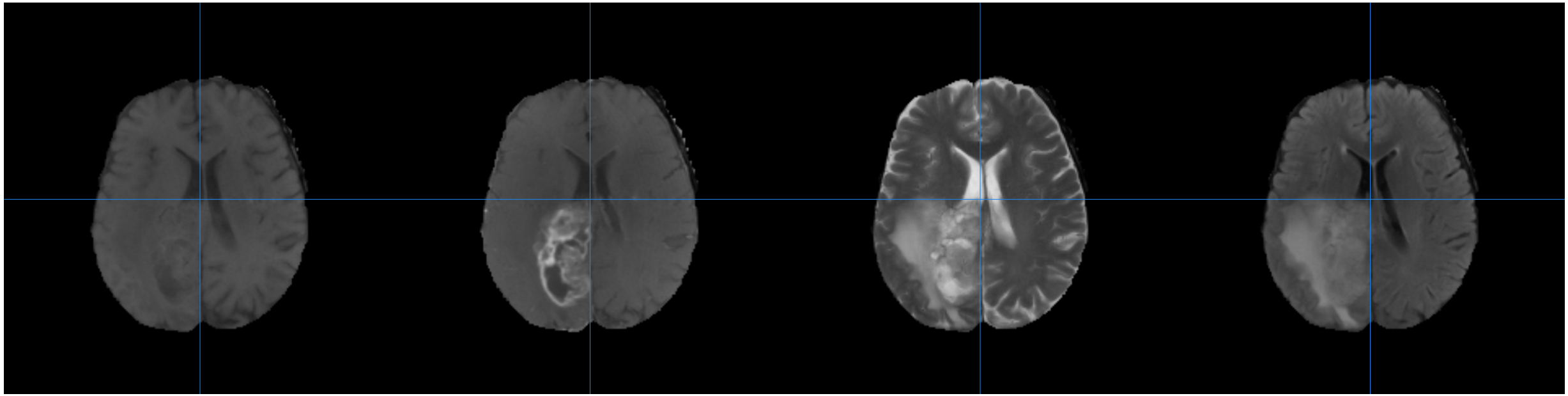
  Brain Tumor Segmentation (BraTS 2020) ➡ Grade 4

- 142 subjects (47 × G4, 45 × G2, 50 × G3)
- All images are: anonymized, registered to T1-weighted image, skull-stripped, bias-field corrected
- 3D volumes of 240 × 240 × 155 voxels with $1mm^3$ isotropic resolution
- 155 slices for each subject
- Each subject has images of 4 MRI modalities (T1-weighted, T1-weighted post-contrast, T2-weighted, Fluid Attenuated Inversion Recovery (FLAIR))

TCGA dataset: https://portal.gdc.cancer.gov

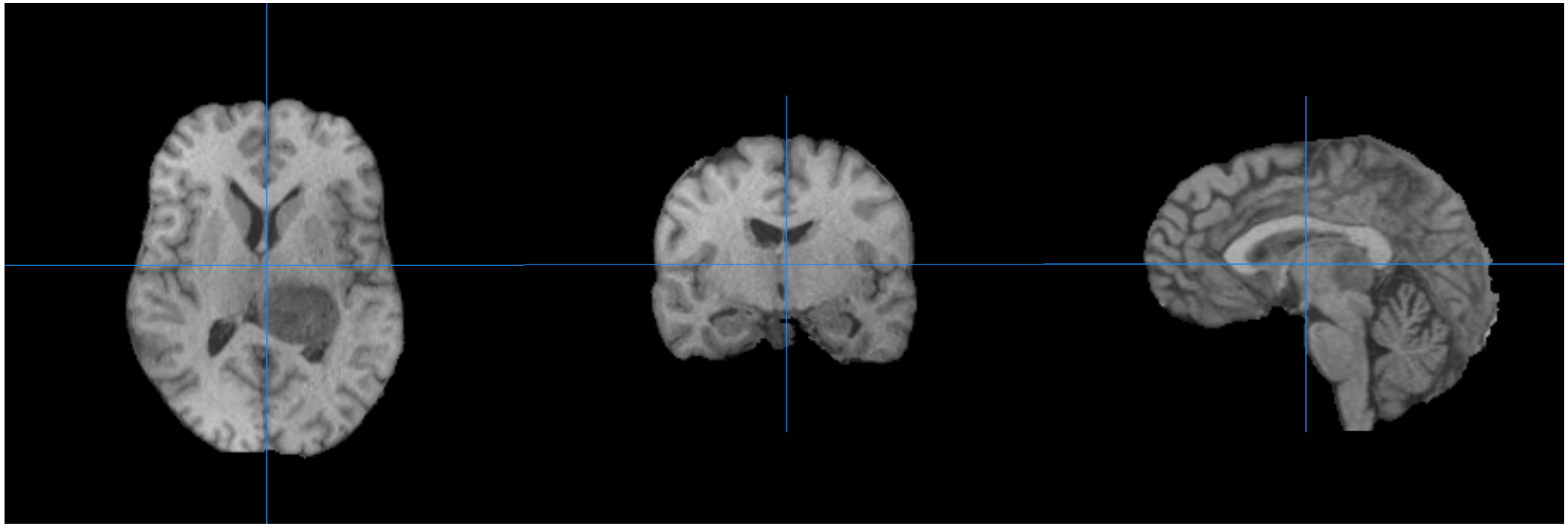
BraTS 2020 dataset: https://arxiv.org/abs/1811.02629

Data Example – Grade 4 (axial view)



T1-weighted | T1-post_contrast | T2-weighted | FLAIR

Data Example – Grade 4 T1-weighted view

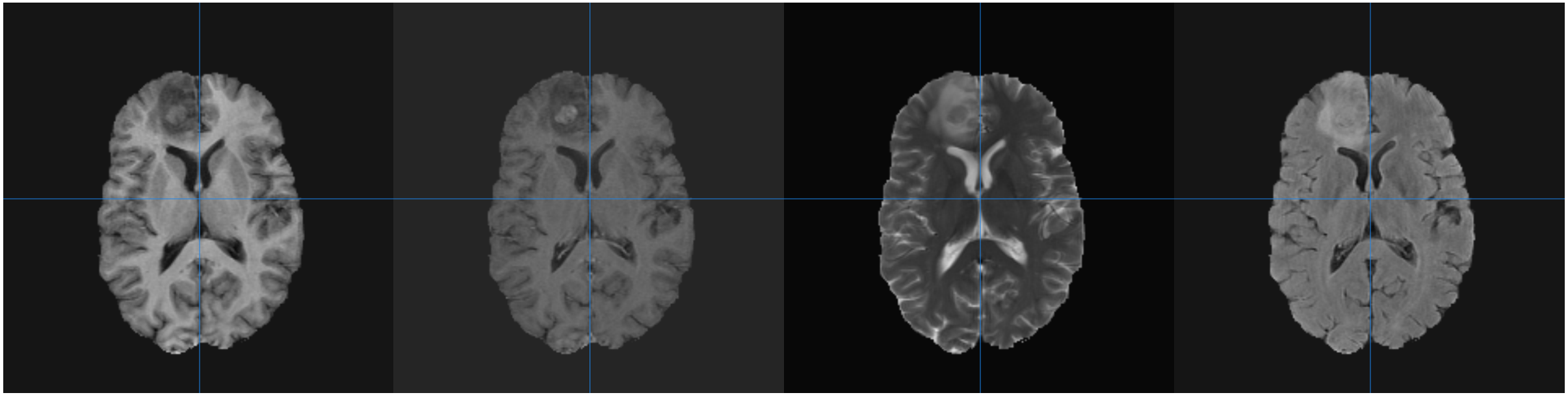


Axial view

Coronal view

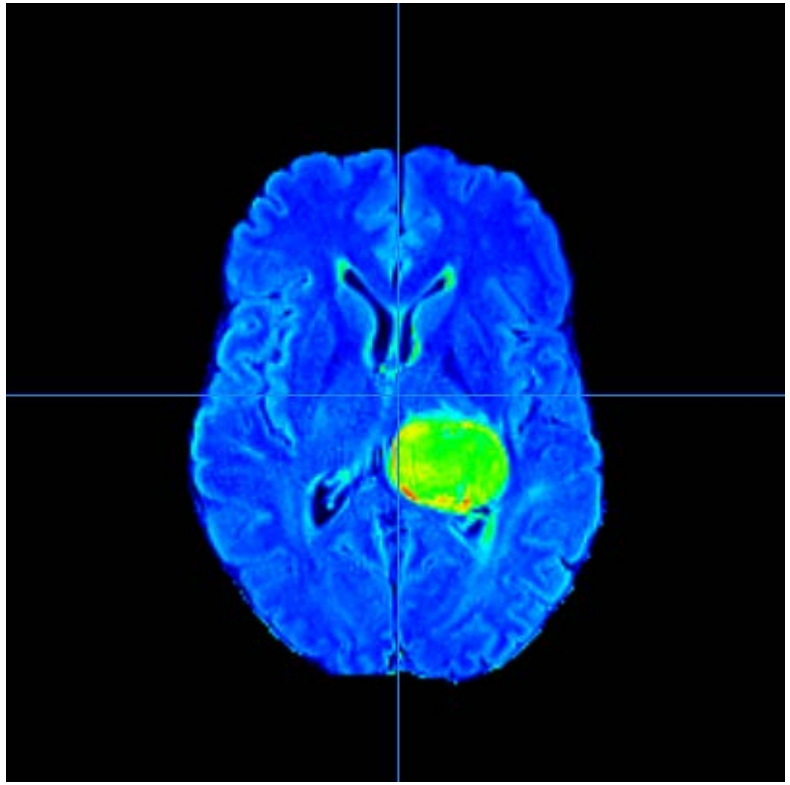
Sagittal view

Data Example – Grade 2 (axial view)

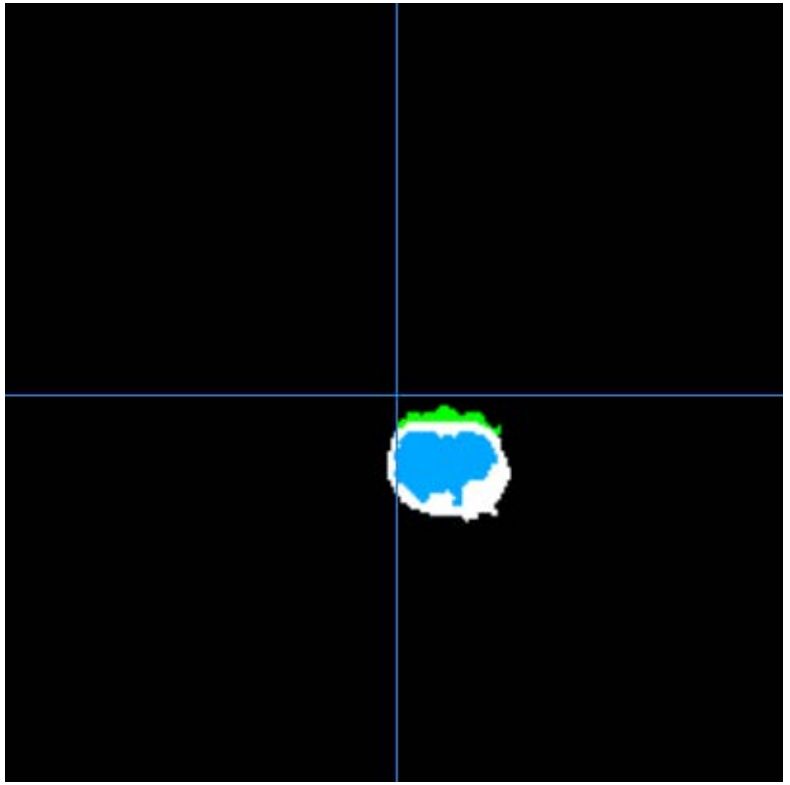


T1-weighted | T1-post_contrast | T2-weighted | FLAIR

Data Example – Grade 4 annotated (axial view)

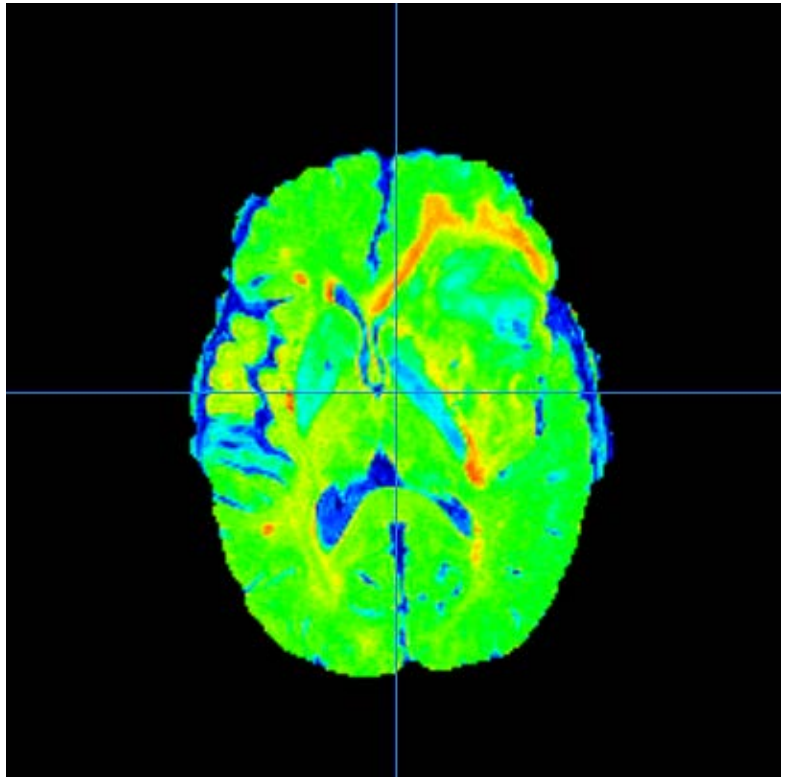


FLAIR

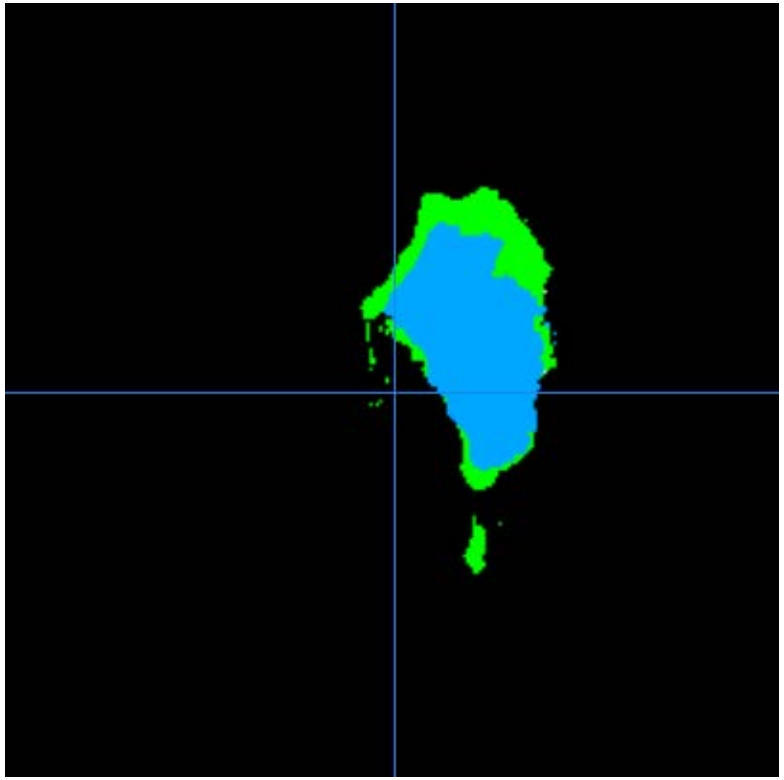


Segmented ROI

Data Example – LGG Segmented (axial view)



FLAIR



Segmented ROI

Research Questions

1. Which of the proposed CNN models performs best for brain tumor grade classification on the available dataset?

2. Which combination of MRI modalities yields the best results for classification?

Challenges:

- Little data available ➡ need for data augmentation
- Images come from 19 different institutions ➡ need for intensity normalization
- Classification of grades as relatively new concept ➡ not many experiments conducted, little supporting literature

Proposed Methods

Preprocessing

- Tumor extraction (nnUnet framework)
- Histogram Equalization
- Normalization

Data augmentation

- Horizontal & Vertical flip
- Rotation

Models

- VGG19
- ResNet50

Training

- Different MR modalities
- With + w/o Data augmentation
- Transfer learning

Evaluation

- Evaluation metrics
- ROC curves
- Hypothesis testing (?)

Literature Review

- Deep Learning for Multigrade Brain Tumor Classification in Smart Healthcare Systems: A Prospective Survey (Khan et al., 2021)
- Multi-Classification of Brain Tumor Images Using Deep Neural Network (Sultan et al., 2019)
- An enhanced deep learning approach for brain cancer MRI images classification using residual networks (Ismael et al, 2020)
- Multi-grade brain tumor classification using deep CNN with extensive data augmentation (Khan et al., 2019)
- Brain Tumor Detection and Classification from Multi-Channel MRIs using Deep Learning and Transfer Learning (Banerjee Subhashis, 2017)
- MRI based medical image analysis: Survey on brain tumor grade classification (Mohan et al., 2017)
- Brain tumor segmentation and grading of lower-grade glioma using deep learning in MRI images (Naser et al., 2020)
- Automated glioma grading on conventional MRI images using deep convolutional networks (Zhunge et al., 2020)
- Deep Radiomics for Brain Tumor Detection and Classification from Multi-Sequence MRI (Banerjee et al., 2019)

Literature Review

- Multimodal Brain Tumor Classification Using Deep Learning and Robust Feature Selection: A Machine Learning Application for Radiologists (Khan et al., 2020)
- Brain Tumor Segmentation Based on Deep Learning's Feature Representation (Aboussaleh et al., 2021)
- Multi-classification of Brain Tumor MRI images Using Deep Convolutional Neural Network with Fully optimized Framework (Irmak Emrah, 2021)
- A Survey on Image Data Augmentation for Deep Learning (Shorten et al., 2019)
- Brain Tumor Type Classification via Capsule Networks (Parnian et al., 2018)
- Capsule Networks for Brain Tumor Classification based on MRI images and Course Tumor Boundaries (Parnian et al., 2018)
- The 2016 World Health Organization Classification of Tumors of the Central Nervous System: A Summary (Louis et al., 2016)
- Brain and Other Cancer Statistics: https://seer.cancer.gov/statfacts/html/brain.html

Thank you!

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