Application of Deep Learning (CNN) for Classification of Brain Tumors

By

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Capstone Project

Submitted to the Panel of Reviewers

Making Data-Driven Decisions

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Summary

- *Neuroradiologic analysis of MRI (Magnetic Resonance Imaging) is the primary method of diagnosing human brain tumors.*
- *In this project a Convolutional Neural Network (CNN) was built which classifies MRI images into glioma, meningioma, pituitary tumors or no-tumors.*
- *The recalls were 97% for no-tumor, 96% for meningioma, 74% for pituitary tumor and 22% for glioma with a prediction accuracy of 75%.*
- *The response time for each test image prediction was about 15 msec compared to a best case of 20 min/MRI by a skilled neuroradiologist.*

Motivation and Importance (Health)

- *Cancer is the leading cause of death in the world*
- *People diagnosed with brain tumor have relative 5 year survival of 32.6%*
- *Rapid accurate diagnosis is crucial for better prognosis and treatment*
- *Radiologic assessment is the main diagnostic tool to even locate a tumor for eventual biopsy and diagnosis confirmation*
- *Availability of skilled neuroradiologist is a limitation in diagnosis*

Motivation and Importance (ROI)

- *A neuroradiologist can examine about 3 scans/hour at approximately $168/hr based on median compensation of $350K/year [https://pubmed.ncbi.nlm.nih.gov/29929936/]*

- *AI systems can scan more than 700 scans/hr (5 sec/scan) to classify brain MRIs*

- *While a neuroradiologists' services are very much needed, having a tool that flags scans for brain tumors will increase the efficiency as well as control for misdiagnosis or even a missed diagnosis.*

- *This increased efficiency would translate to higher return of investment for investing in development of such an artificial intelligence tool*

Project Goals

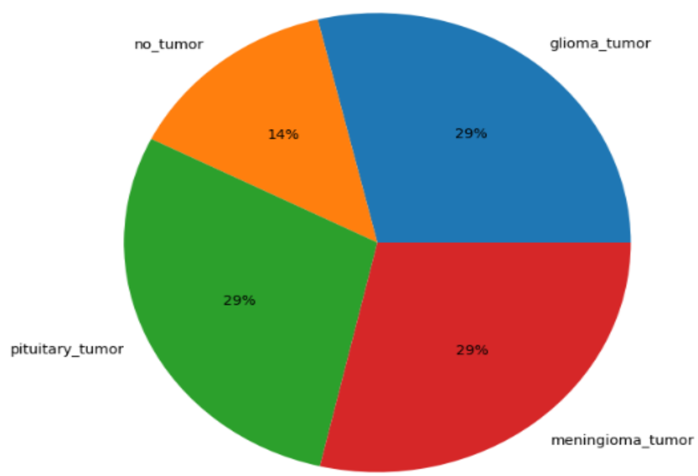
- *Develop an artificial intelligence system based on Convolutional Neural Networks (CNN) to rapidly predict the type of brain tumor in an MRI scan of head*

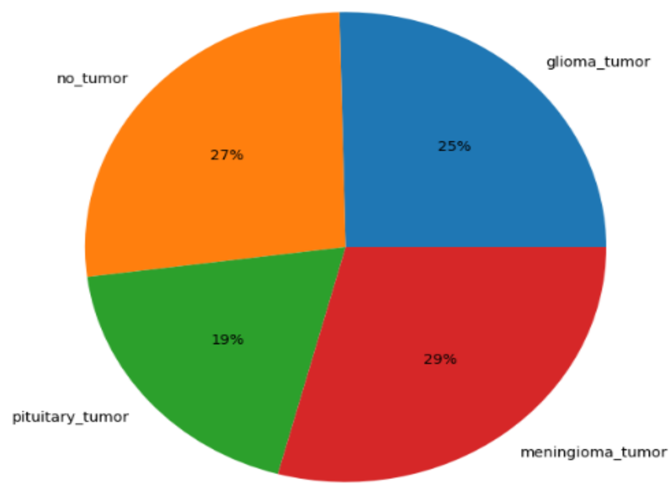
- *The system will flag brain MRIs for glioma, meningioma, pituitary or no-tumor.*

- *The system could be used for decision support as well as to control for misdiagnosis or even a missed diagnosis.*

- *The system will use precision, recall,accuracy metrics for reporting*

Exploratory Data Analysis





Training and testing datasets have 2870 and 394 MRI images respectively

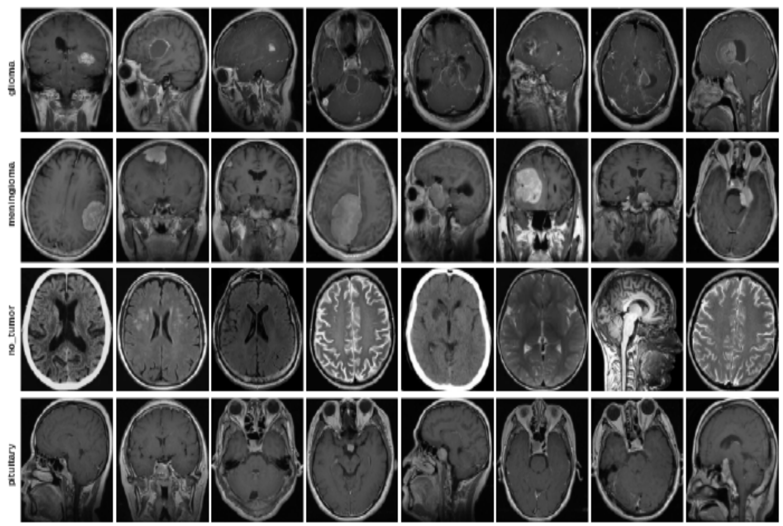
Imbalance in the distribution of tumor and non-tumor categories

Fewer no-tumor images in training(13.7%) compared to testing(28.1%)

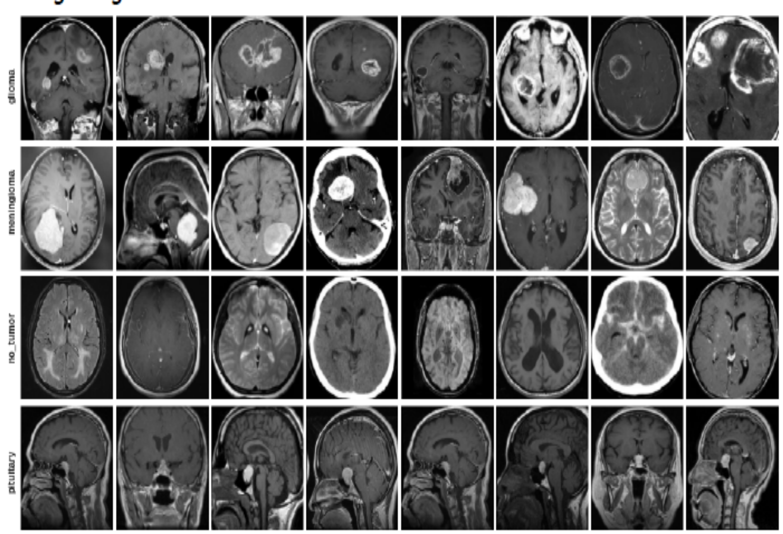
Fewer pituitary-tumor images in testing(18.4%) compared to training(28.7%)

Exploratory Data Analysis

) Training Images



Testing Images



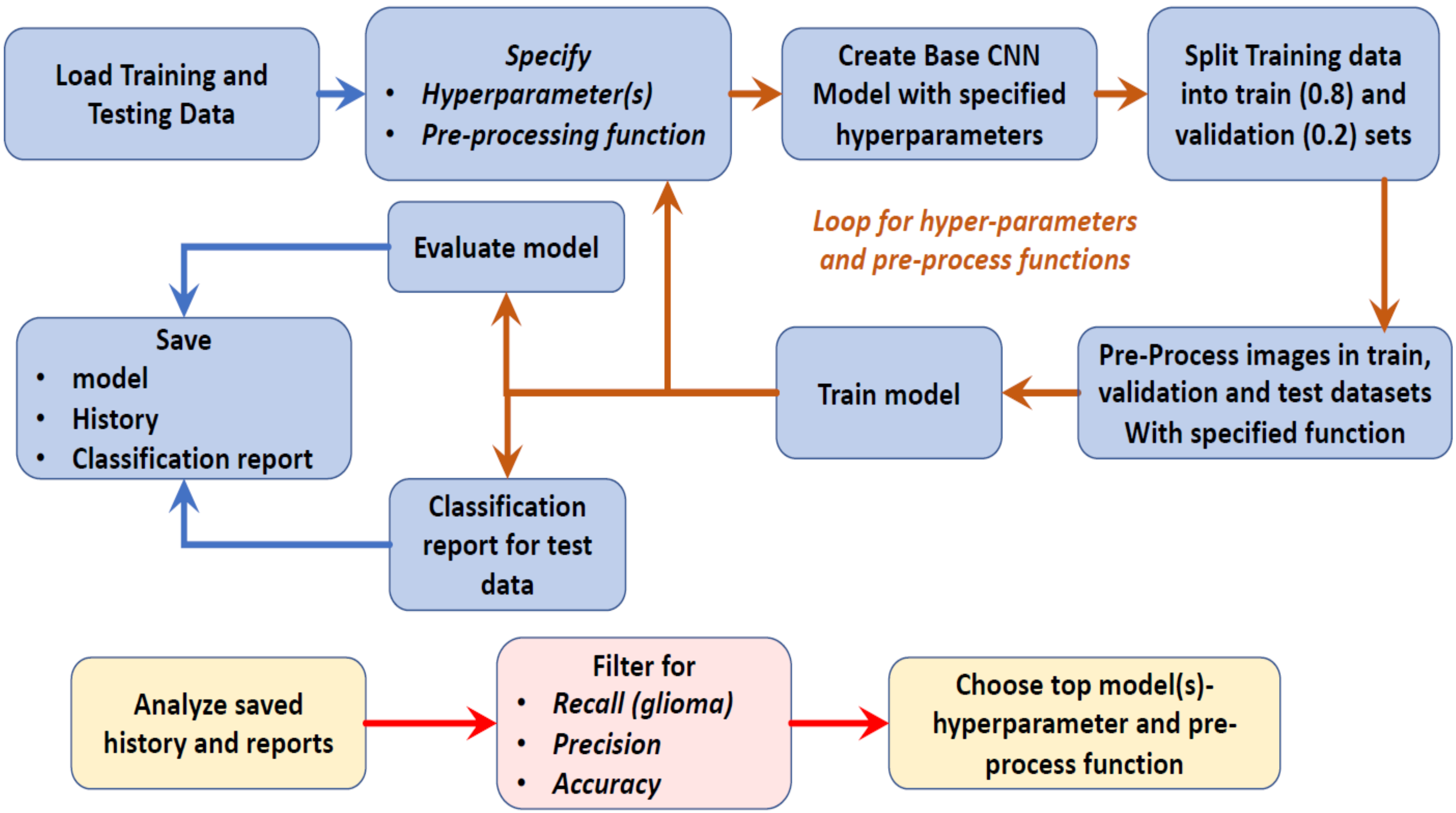
Variation in following can be seen in both training and testing datasets:

- *Contrast*
- *Brightness*
- *Rotations*
- *Slice orientation*

Tumors in testing images appear more prominent than in training images

No bounding boxes for the tumors

Model Training Workflows



Final Model

EfficientNetB0 base model had been used and it was important to use a callback for adjusting the learning rate.
This study recommends a CNN model which focuses on non-tumor recall.
Metrics used for recommendations:

- *Accuracy = (TP + TN) / (TP + TN + FP + FN)*
- *Recall(sensitivity) = TP/(TP + FN)*
- *Precision = TP / (TP + FP)*

Time taken to predict for 394 test images 5.92s. Response time 0.015s/images