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Detection of Brain Tumour MRI Images using Convolutional Neural Networks and Traditional Machine Learning Algorithms

A Project in Machine Learning in Synthetic Biology

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Introduction

A brain tumour is an abnormal outgrowth of the cell in the brain, usually the human brain (Pedada *et al.*, 2023). It arises from an imbalance in the number of cell growth and death in the brain and can be classified into two major types: benign and malignant brain tumours. Benign tumours are mild that can be removed by surgery but if left untreated can lead to death. Malignant tumours, on the other hand, are cancerous brain tumours that are characterized by uncontrollable cell growth and division which evades the whole brain cell (Kareem *et al.*, 2023).

The detection and diagnosis of brain tumours is a difficult process due to the intricacies of their structure (shape and size), their location and their appearance in the brain. Early detection and treatment of benign tumours and malignant tumours can play a vital role in increasing the survival rate of affected patients (Saeedi *et al.*, 2023). Similarly, the detection usually involves the use of biopsies and high-resolution imaging from CT scans, Magnetic Resonance Imaging (MRI), and X-rays and the final diagnosis lies in the hand of experts who may perform a series of medical tests and image segmentation analyses to confirm the presence or absence. This is rather time-consuming (Borole and Nimbhore, 2015; Saeedi *et al.*, 2023). As a result, an automatic and fast technique is needed for the early detection and treatment of brain tumours before they spread throughout the affected tissue (Ari and Hanbay, 2018).

Various advanced techniques such as deep learning models have been applied to fast-track and automate the process through the use of raw tumour image scans, for example, MRI scans, without the need to manually extract pixels or obtain information from experts to use as input features to aid in classification. One method that has revolutionalised this is the *Convolutional Neural Networks* (CNNs) which can segment image pixels by automatically extracting them (Pedada *et al.*, 2023; Saeedi *et al.*, 2023).

Aim

In this project, we aim to classify brain tumour MRI scan images into four classes: No tumours, glioma tumours, meningioma tumours and pituitary tumours using traditional and modern machine learning (CNN) models. The results will be compared to observe which is superior to the other. Also, to improve the performance of the deep learning model, transfer learning using the VGG pre-trained model will be used (Kim *et al.*, 2022).

Dataset

The dataset will be obtained from the research from Saeedi *et al.*, 2023 which was downloaded from Kaggle. It contains 3624 MRI scans of a healthy brain (500), glioma tumour (926), meningioma tumour (937) and pituitary tumour (901) images. The dataset will be split into two sets: A train (80%) and a test (20%) dataset. The train data is used to develop models while the test will be used for evaluating the model's performance. The performance of models will be based on accuracy and the area under the receiver's operating characteristics curve (AUROC) for multiclass classification.

Methodology

The model architectures to be used will be adapted from the research of Saeedi *et al.*, 2023 with slight modifications.

Two traditional machine learning models: K-nearest neighbours and logistic regression, will be used. Image pixels from MRI scans of diseased and healthy brains will be manually extracted and used as features for image classification. Due to the high dimensionality of the features, the Principal

Component Analysis (PCA) feature reduction technique will be applied (Jollife and Cadima, 2016). Next, a sequential 2-dimensional convolutional neural network (CNN) architecture (a deep learning model) will be used. Due to the requirement of CNNs for a sizable number of input images for improved performance, data augmentation methods (rotation) will be applied to the training data to manually generate synthetic copies of the available images for each tumour type (Saeedi *et al.*, 2023). Transfer learning using VGG pre-trained model will be used to extract pixel features to aid in improving model performance.

Results of model performance on held-out test data will be used to compare the performance of the models used.

Expectation

From the result, it is expected that the accuracy matches or performs better than the result obtained by (Saeedi *et al.*, 2023) on a similar dataset.

Challenges

Challenges to encounter include computational cost since CNNs or generally, deep learning models require huge amounts of computational resources. Another is the problem of overfitting, hence data augmentation and layer regularization methods such as *dropout* will be applied to mitigate it.

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https://www.kaggle.com/datasets/sartajbhuvaji/brain-tumor-classification-mri (Link to dataset)