# Decoding Brain Health

A Case Study on Machine Learning-Based Classification of Brain Tumours and Alzheimer's Disease

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# Abstract

This project focuses on developing a machine learning model to classify brain diseases, specifically Brain Tumours and Alzheimer's Disease. We utilize two datasets comprising approximately 7,100 brain images for Brain Tumour classification and 5,000 images for Alzheimer's Disease.

Our model distinguishes between four types of brain tumours (Pituitary Tumours, Meningiomas, Gliomas, and No-Tumour) and categorizes Alzheimer's Disease into four stages (Very Mild Dementia, Mild Dementia, Moderate Dementia, and Non-Demented, representing those without Alzheimer's).

The model accepts input in the form of JPEG or PNG images, such as MRI scans of the brain, and provides a classification output, indicating the type of disease the person may be suffering from.

This research represents a significant advancement in medical imaging and diagnosis, offering a valuable tool for early intervention and personalized treatment. The project's potential applications extend beyond neurology, contributing to improved healthcare outcomes and overall quality of life.

In conclusion, our project addresses the challenge of brain disease classification, enhancing early detection and care.

# Introduction

The human brain, a marvel of complexity composed of numerous neurons, stands as a vital organ within our bodies. Nevertheless, this remarkable organ is not impervious to afflictions. Brain diseases, an expansive category of disorders impacting the brain's structure or function, can inflict profound and often devastating consequences upon individuals and their families.

Brain diseases encompass a wide spectrum of conditions, ranging from neurodegenerative disorders such as Alzheimer's disease and Parkinson's disease, to mental health conditions like depression and anxiety, and extending to traumatic brain injuries and brain tumours. These diseases can affect individuals of all ages, from infants to the elderly, presenting significant challenges to healthcare systems and society as a whole.

Within this section, we will focus on the training of two specific brain diseases from this extensive range. Subsequently, we will save our model and create a .py file to evaluate the accuracy of our model.

# What is Brain Tumour?

Brain tumour is an abnormal growth of cells that occurs in the brain. Brain tumours like other tumours can be benign (not harmful in effect) and malignant(cancerous).

They are two types of brain tumours they are:

1. Primary brain tumours: Start in the brain
2. secondary brain tumours: Spread to the other brain tissues.

There are over 120 different types of brain tumours but we had discussed only 3 main types, they are:

1. Gliomas: Gliomas are a category of brain tumours that begin in glial cells.
2. Meningioma: Meningioma are the most common primary brain tumour that forms in the meninges and are usually benign.
3. Pituitary: It is an abnormal growth or mass that develops within the pituitary glands.

# What is Alzheimer?

Alzheimer's disease is a common type of dementia, a condition that affects the brain and memory. It happens because the brain develops unusual clumps of proteins called plaques and tangles. These clumps harm brain cells and make them die. It all begins in a part of the brain called the hippocampus, which is important for making new memories. This is why people with Alzheimer's have trouble remembering things.

**Alzheimer's Disease Progression**

**Mild Cognitive Impairment**

An intermediary stage between age-related forgetfulness and pronounced Alzheimer's memory deficits.

### Mild Dementia

Memory issues more discernible; individuals maintain daily functionality, socializing, and work.

### Moderate Dementia

Increased assistance needed; restlessness and potential for aggressive behaviour emerge.

### Severe Dementia

Advanced stage, physical and cognitive decline parallel; total assistance required.

# Project Components and Libraries

**1. OpenCV (Open-Source Computer Vision Library)**: OpenCV is used for image processing and plays a pivotal role in detecting the type of disease based on MRI scans. It provides a wide range of tools for image manipulation, feature extraction, and computer vision tasks.

**2. TensorFlow**: TensorFlow is employed for loading and preprocessing brain MRI images, preparing the data for feeding into the machine learning model.

**3. Pandas**: It helps organize and process datasets, making it easier to handle structured data such as metadata associated with MRI scans.

**4. NumPy**: NumPy is used for efficient numerical computations and data manipulation, particularly in array and matrix operations, which are common in machine learning.

**5. Matplotlib**: Matplotlib is employed for visualizing data, including the display of MRI images, model performance metrics, and other informative graphics in the project's reports and user interfaces.

**6. Flask**: In the context of this project, Flask is used for deployment. It allows us to create a web-based interface through which users can interact with the model. Users can upload MRI scans, and the Flask application processes the input and returns classification results. Flask also facilitates the integration of the machine learning model with a user-friendly front-end.

# Model Preparation and Data Processing

In this section, we'll explore the steps we took to get our machine learning model ready and how we managed the data for our brain disease classification project, mainly centered around Brain Tumours and Alzheimer's Disease.

## Data Collection and Preprocessing

Our project's success heavily relies on the quality and quantity of data we employ. We've meticulously gathered two distinct datasets for this purpose:

1. **Brain Tumour Dataset:** Comprising approximately 7,100 brain images, this dataset includes a diverse range of images featuring three different types of brain tumours: Pituitary Tumours, Meningiomas, Gliomas, and a category denoting the absence of tumours (No-Tumour). These images have been sourced from various medical institutions and databases.
2. **Alzheimer's Disease Dataset:** With over 5,000 brain images, this dataset facilitates the classification of Alzheimer's Disease into three distinct stages: Very Mild Dementia, Mild Dementia, Moderate Dementia, and Non-Demented, representingindividuals without Alzheimer's. This dataset has been meticulously curated to encompass a wide spectrum of disease progression.

## Data Preprocessing:

To ensure consistency and suitability for our model, we performed essential preprocessing steps. This involved resizing all images to a uniform dimension, converting them into a suitable format (JPEG or PNG), and scaling pixel values to fall within a specific range.

## Model Architecture

Our machine learning model leverages convolutional neural networks (CNNs) for its architecture. CNNs have proven exceptionally effective in image classification tasks. The model comprises multiple layers, including convolutional layers for feature extraction, pooling layers for down sampling, and fully connected layers for classification.

## Training and Validation

We divided our datasets into training and validation sets to train and assess the model's performance. Extensive hyperparameter tuning and cross-validation were conducted to optimize the model's accuracy and prevent overfitting.

## Model Evaluation

Our model's performance was evaluated using various metrics, including accuracy, precision, recall, and F1-score. It underwent rigorous testing on both the Brain Tumour and Alzheimer's Disease datasets to ensure its reliability and robustness in disease classification.

## Conclusion

In this section, we have outlined the critical steps involved in preparing our machine learning model and processing the data for brain disease classification. The integration of two distinct datasets, rigorous preprocessing, and the utilization of CNNs demonstrate our commitment to creating a robust and reliable tool for early disease detection. This project holds substantial potential for revolutionizing medical imaging and diagnosis, with applications that extend far beyond neurology, ultimately contributing to improved healthcare outcomes and enhanced quality of life. Our project represents a significant stride forward in addressing the challenges of brain disease classification and enhancing early detection and care in the field of medical research.

# Deployment

In the deployment phase of our project, we took the necessary steps to make our machine learning model accessible and functional to users through a web-based interface. Here's a breakdown of the deployment process:

**1. Flask Web Application:**

We built a web application using Flask, a Python web framework, to create a user-friendly interface for our machine learning model. This web app served as the bridge between the user and the model, allowing users to interact with it effortlessly.

**2. Amazon Web Services (AWS) and S3 Bucket:**

To host our web application and make it accessible online, we utilized Amazon Web Services (AWS). AWS provides a robust cloud computing platform that enabled us to deploy our application securely and efficiently.

We stored essential components of our web app, such as the index.html for the webpage structure and style.css for designing the website, in an AWS S3 (Simple Storage Service) bucket. This allowed us to efficiently manage and serve these static files to users while keeping our application lightweight.

**3. Dataset Storage:**

In addition to hosting our web app files, we also stored our dataset, which consists of brain images, in the same AWS S3 bucket. This ensured that our machine learning model had seamless access to the data it needed for predictions.

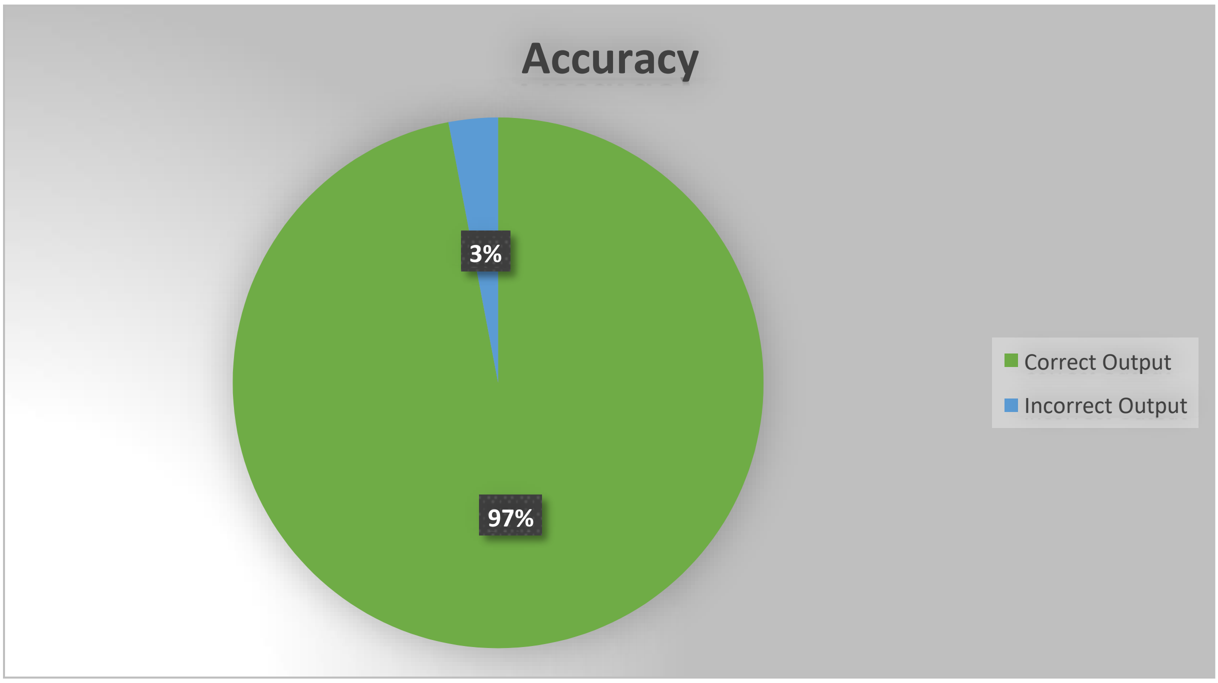
**4. Flask Code (app.py):**

Our Flask application code, contained within the app.py file, served as the backbone of our web application. It handled user requests, interacted with the machine learning model for inference, and presented the results to the user.

## 5. Testing on Amazon Linux:

Before making our deployment public, we rigorously tested our application on an Amazon Linux environment to ensure that it worked seamlessly. This step was crucial for identifying and resolving any potential issues before the application went live.

# Model Accuracy




## Observations:

### 1. High Accuracy:

- Our model achieved an impressive accuracy rate exceeding 97% during testing.

### 2. Challenges with Complex or Inadequate Images:

- Complex or poorly captured test images occasionally led to incorrect outputs.

### 3. Acknowledging Model Limitations:

- While highly effective, the model may encounter challenges with atypical or inadequately representative data. Users should exercise caution in such cases.

# References


1. BrainLine - "Brain Imaging: What Are the Different Types?" :
   This resource explains various types of brain imaging techniques, shedding light on the technology behind brain scans, making it useful for understanding the basis of our project.

2. Omega PDS - "MRI Can Help Diagnose Alzheimer's Disease":
   This source discusses the role of MRI in diagnosing Alzheimer's disease, offering insights into the importance of neuroimaging in early disease detection, which aligns with our project's objectives.

3. International Journal of Emerging Trends & Technology in Computer Science - "Image Processing Techniques for Brain Tumor Detection" :
   This academic paper discusses image processing techniques for brain tumor detection, which informed our approach to processing brain images for classification, enhancing our model's performance.

4. Nature Scientific Data - "Alzheimer's Disease Neuroimaging Initiative (ADNI) Database Data Up To 2018"
   This data descriptor provides access to valuable Alzheimer's disease neuroimaging data, which is crucial for training and validating our machinelearning model for disease classification.