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BRAIN TUMOUR DETECTION WITH DEEP LEARNING USING CNN

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Abstract: Brain tumours pose significant challenges in diagnosis and treatment due to their diverse appearances and complex features. Manual interpretation by radiologists often leads to subjectivity and variability in diagnoses, while traditional machine learning approaches may struggle to capture intricate patterns from medical imaging data effectively. To address these challenges, this study proposes a robust brain tumour classification system based on the ResNet50 architecture, a deep convolutional neural network known for its effectiveness in image classification tasks. Leveraging deep learning techniques, the system automates feature extraction and learns hierarchical representations directly from brain MRI scans. By initializing the ResNet50 model with pre-trained weights and fine-tuning it on a comprehensive dataset, the system achieves high classification accuracy, sensitivity, and specificity. Extensive experimentation and validation demonstrate the system's capability to accurately distinguish between gliomas, meningiomas, and pituitary tumours, providing clinicians with a reliable tool for improved diagnosis and patient care.

Keywords: Classification system, ResNet50 architecture, Deep learning Convolutional neural network, MRI scans

I. INTRODUCTION

The human brain is a complex organ made up of many nerve tissues that control essential functions like senses, muscle growth, and movement. However, sometimes abnormal growths called brain tumours can occur. These tumours can be either benign (non-cancerous) or malignant (cancerous) and can develop anywhere in the brain or spinal cord. They can cause serious health problems and have a low survival rate compared to other types of cancer.

Identifying and classifying brain tumours is challenging because they can have different shapes, textures, and locations. Accurately analyzing these tumours early on is crucial for determining the best treatment to save the patient's life. Brain tumours are categorized into cancerous and non-cancerous types, with benign tumours growing slowly and staying in the brain, while malignant tumours can spread from other parts of the body.

Common types of brain tumours include meningioma, glioma, and pituitary cancer. Meningioma develops in the membranes surrounding the brain and spinal cord, while glioma starts from glial cells, which support nerve cells. Pituitary cancer affects a small gland at the back of the nose, impacting various bodily processes.

Deep learning methods, such as convolutional neural networks (CNNs), are now being used for object identification and classification, including in medical imaging like MRI scans.

In this study, a CNN model with fine-tuned ResNet50 architecture is developed for brain tumour classification and detection in MRIs. This model combines the strengths of different architectures to achieve high accuracy in both tasks, leading to faster and more accurate brain tumour diagnosis and better patient outcomes.

II. PROBLEM STATEMENT

This project aims to develop an accurate and automated brain tumour classification system using ResNet50, a deep convolutional neural network. By leveraging advanced deep learning techniques, the system will be trained on a diverse dataset of brain MRI scans to distinguish between different types of tumours, such as gliomas, meningiomas, and pituitary tumours.

By providing clinicians with a reliable tool for improved diagnosis and patient care, this system seeks to address the challenges of manual interpretation and limited effectiveness of traditional machine learning approaches in brain tumour classification.

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III. OBJECTIVES

1. Automate Brain Tumor Classification: Develop a deep learning-based system capable of automatically classifying brain tumors into gliomas, meningiomas, and pituitary tumors from MRI scans.

2. Facilitate Timely Treatment Planning: Provide clinicians with timely and accurate tumor classification results to facilitate personalized treatment planning and decision-making for patients.

3. Reduce Diagnostic Time: Aim to reduce the time required for tumor classification compared to traditional manual methods, thereby expediting the diagnostic process and enabling faster treatment initiation for patients.

4. Enable Remote Diagnosis: Develop the classification system with capabilities for remote access, enabling radiologists to analyze MRI scans and provide diagnostic insights from any location, improving accessibility to expert opinions.

IV. EXPECTED OUTCOMES

1. High Classification Accuracy: Achieve high accuracy in distinguishing between different types of brain tumours, ensuring reliable diagnostic results for clinical use.

2. Better Patient Outcomes: Enable clinicians to make informed treatment decisions based on accurate tumour.

V. LITERATURE SURVEY

Razia Sultana Misu's research explores brain tumour detection using deep learning, particularly ResNet50, aiming to select the most suitable transfer learning model among various architectures. Their study seeks insights into ResNet50's advantages, disadvantages, and computational efficiency compared to other models like VGG16, VGG19, DenseNet121, and YOLO V4 [1].

The introduction of SIBOW-SVM in brain tumour MRI image classification offers a novel approach by amalgamating the Bag-of-Features model, SIFT technique, and weighted SVMs. This methodology not only demonstrates computational efficiency but also addresses the scalability and parallelizability concerns often encountered with conventional CNNs [2].

Rahul Chauhan and colleagues delve into the practical implementation of Convolutional Neural Networks (CNNs) for image recognition and object detection, showcasing remarkable accuracies on benchmark datasets like MNIST and CIFAR-10. Their study underscores the significance of real-time data augmentation and dropout techniques in mitigating overfitting, highlighting the potential of deep learning models in addressing complex image classification tasks with precision and efficiency [3].

The paper proposes a novel 2D CNN architecture and a convolutional auto-encoder network for brain tumour detection using MRI data, achieving high accuracy and computational efficiency. It also explores the performance of six common machine learning techniques alongside deep learning networks, showcasing significant improvements in brain tumour classification [4].

Shubhangi Solanki et al. discuss various computational intelligence techniques for brain tumour detection, including deep learning and machine learning models. They compare traditional and intelligence techniques for tumour identification, covering morphological aspects, datasets, augmentation methods, and categorization among deep learning, transfer learning, and machine learning models [5].

Sarvachan Verma et al. propose a brain tumour detection system using CNN and deep learning methods, achieving high accuracy. They discuss the challenges of brain tumour segmentation and the complexity of manual segmentation processes, emphasizing the importance of automated approaches for accurate and efficient tumour identification [6].

Jonayet Miah et al. investigate the use of CNNs for brain tumour detection using MRI images, introducing a clustering method for feature extraction. They emphasize the importance of preprocessing and scaling models to larger datasets for accurate detection, highlighting the potential of deep learning in medical imaging tasks [7].

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Seema S. Kawthekar et al. discuss image processing techniques for brain tumour detection, focusing on preprocessing methods using MATLAB. They highlight the advantages of X-ray images over other modalities and the importance of preprocessing for accurate detection, demonstrating the potential of image processing in medical imaging tasks [8].

Juan Jose Augusto explores brain tumour identification and tracking using image processing techniques, achieving high accuracy in detecting patients with brain tumours. The study emphasizes the role of advanced imaging technologies and computerized techniques in accurate disease diagnosis, showcasing potential of image processing in medical science [9].

Ed-Edily Mohd. Azhari et al. propose a brain tumour detection and localization system using image processing techniques, achieving high classification accuracy. They emphasize the simplicity and efficiency of their approach, highlighting its potential for detecting various types of tumours in medical imaging [10].

Amrutha Ravi et al. propose a brain tumour detection system using image segmentation and threshold techniques, addressing challenges like noise and low contrast. They emphasize the importance of preprocessing for accurate segmentation, showcasing the potential of image processing in medical imaging applications [11].

R.Sathya et al. propose a technique for segmenting and detecting brain tumours using fuzzy clustering and machine learning classifiers. They discuss the challenges of manual segmentation and the advantages of their proposed approach for accurate tumour detection, highlighting the potential of machine learning in medical imaging tasks [12].

Naveed Akhtar et al. discuss the use of transfer learning with ResNet-50 for brain tumour classification, highlighting challenges and opportunities in applying deep learning to medical imaging tasks. They delve into the fine-tuning process, data augmentation strategies, and model evaluation techniques specific to brain tumour classification [13].

Y. Zhuge et al. propose an attention mechanism for ResNet and discuss its role in deep learning models for medical image analysis. They evaluate its impact on model performance and discuss potential future directions for research, emphasizing the importance of attention mechanisms in improving model accuracy and interpretability [14].

M. A. Salehi et al. present experimental results and discuss limitations and potential biases in using deep learning models for medical image analysis. They address issues like dataset imbalance, data preprocessing techniques, and model interpretability, offering practical insights for researchers and practitioners in the field [15].

VI. REQUIREMENT SPECIFICATION

Hardware requirements

This application is designed to run on the minimum possible configuration of hardware.

- RAM: 8GB minimum
- Processor: A processor with support for parallel computing (such as Intel Core i7 or AMD Ryzen series)
- Hard disk: compatable

Software requirements

- Platform: Android Studio, Visual Studio, Google Colab
- Programming Language: Dart, Python
- Database: Firebase
- Frontend: Flutter
- Backend: Flask

VII. SYSTEM DESIGN

The chapter on system design is an important part of the system development process that focuses on the creation of a detailed plan for building system or product. It typically performance requirements includes a comprehensive overview of the system's architecture, functionality, and components and subsystems that make up the system, as well as their interactions and dependencies.

In general, the system design chapter will outline the various dependencies. This may include information such as hardware and software requirements, communication protocols, and data structures.

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System Flow diagram

A flowchart is a diagram that depicts a process, system or computer algorithm. They are widely used in multiple fields to document, study, plan, improve and communicate often complex processes in clear, easy-to-understand diagrams. Flowcharts use rectangles, ovals, diamonds and potentially numerous other shapes to define the type of step.

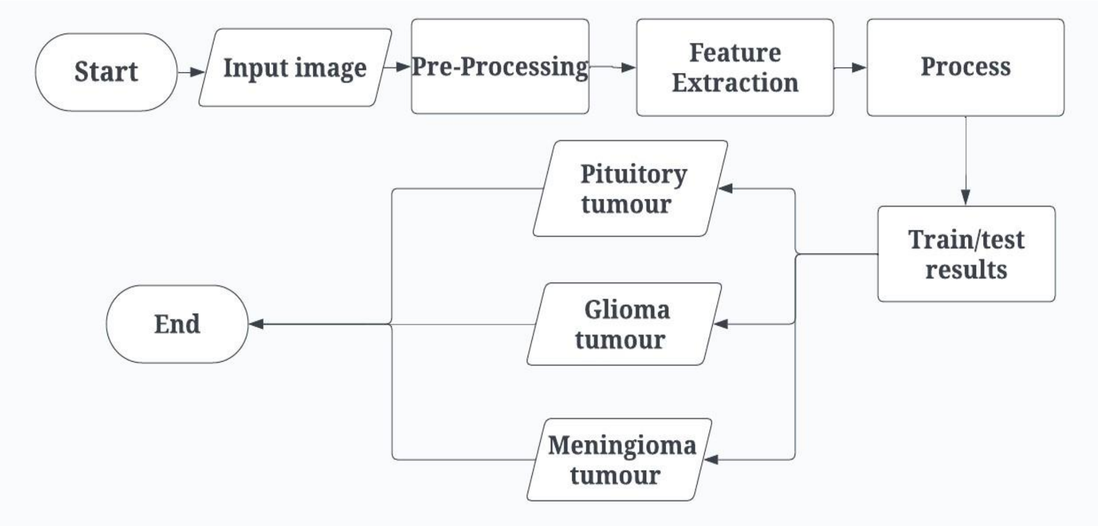

Figure 6.1 Flowchart representing the stages involved in the Detection of Brain

The above Figure 6.1 describes the complete workflow of the model that involves different stages involved in the detection of brain tumour with deep learning using CNN. The input images are given to the model which in later stage is pre-processed. After pre-processing the feature extraction is carried out. Immediately, after the processing the result data is split into training data and testing data. The model then classifies the brain tumour based on its types. The types are to be classified are Pituitory tumour, Glioma tumour and Meningioma tumour.

Sequence Diagram

A sequence diagram is a type of interaction diagram in UML (Unified Modeling Language) that depicts the interactions and message exchanges between objects or components in a system over time. It illustrates the flow of messages between different parts of a system, showing the sequence of events and the order in which interactions occur.

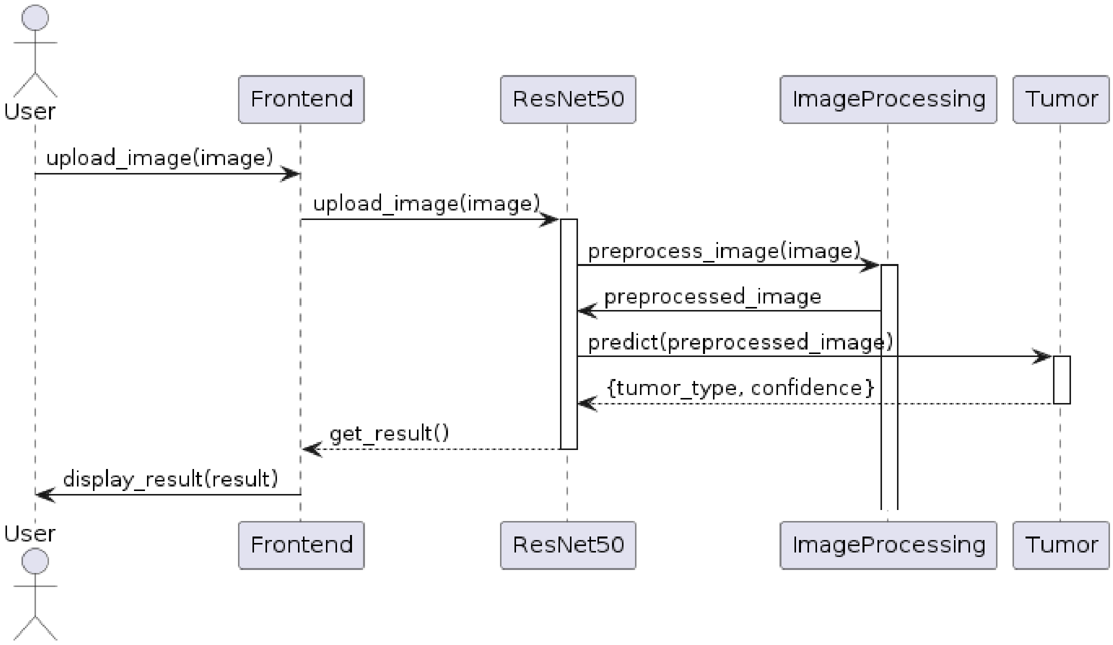

Figure 6.2 Sequence Diagram

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Figure 4.3 depicts sequence diagram which illustrates the process of analyzing an image to detect the presence and type of a tumor. The user initiates the process by uploading an image through the Frontend component. The ResNet50 component receives the image and preprocesses it using the ImageProcessing component. The preprocessed image is then passed to the Tumor component, which uses a machine learning model to predict the type of tumor present, if any, along with a confidence score. The prediction result is sent back to the ResNet50 component, which returns it to the Frontend, where it is displayed to the user. This system provides an automated way to analyze medical images for potential tumor detection.

VIII. RESULTS

Result analysis refers to the process of examining and evaluating the outcomes of a project against its planned goals and objectives. The analysis also include both frontend and backend snapshots.

Frontend Snapshots
We used Flutter to create our app's frontend, making it look great and run smoothly on both phones and the web.

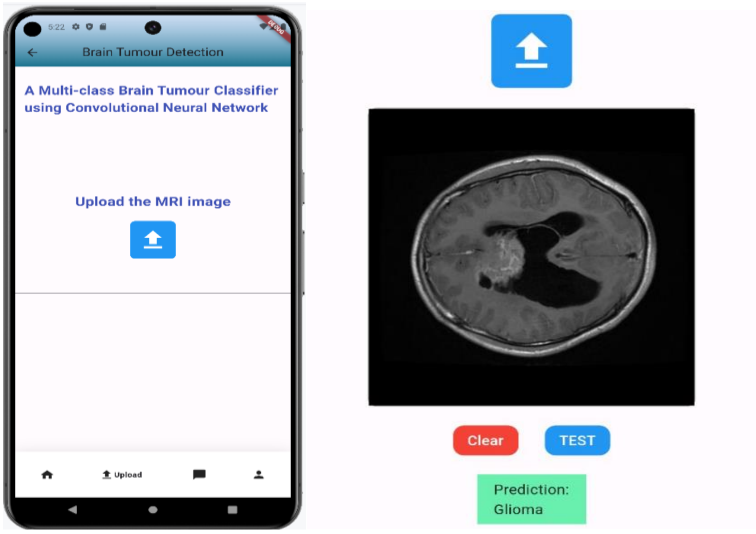

Figure 7.1: Upload MRI Image

Figure 7.1 depicts the Interface to upload the MRI image and once uploaded it will predict whether it belongs to Glioma, pituitary, meningioma.

Backend Used
We aim to develop a mobile application called Brain Care using Flutter as the frontend framework and Firebase as the backend platform. User authentication is implemented using Firebase Authentication and Real-time Data Synchronization Firestore's real-time database capabilities enable seamless data synchronization between the Flutter frontend and Firebase backend allowing users to access the latest information instantly.

XI. CONCLUSION

In conclusion, our study demonstrates the efficacy of utilizing deep learning techniques, specifically CNN ResNet50, for the detection of brain tumors in medical imaging data. By leveraging the advanced capabilities of ResNet50 in feature extraction and classification, we achieved high accuracy and robustness in identifying brain tumors from MRI scans. The integration of ResNet50 into our deep learning pipeline underscores its effectiveness in handling complex medical image data and extracting relevant features crucial for accurate diagnosis. Furthermore, the development of the frontend using Flutter offers a user-friendly interface for medical professionals and patients to interact with our brain tumor detection system. The seamless integration of Firebase for data storage ensures secure and efficient management of medical imaging datasets, facilitating data access and retrieval for model training and evaluation. Additionally, the use of Flask as the backend framework enables smooth communication between the frontend and the deep learning model, allowing for real-time inference and feedback.

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