Brain Tumor Detection On MR Images Through CNN

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Chapter-1: Introduction

Introduction:

Medical Image Processing has been a popular field for the research and project purpose these days. When talking about Tumor Extraction or the similar area, it has been noticed that the research is extremely active in the image processing of human brain for the successful tumor detection and analysis. Although, it becomes a challenge to rectify the critical examination of medical brain images, the newest technology and its capabilities pulls it through. In this Final Year Research Project, the main focus has been gathered on the methodology which tends the automation of analysis regarding brain tumor to become effectively possible. For this, it has been planned to utilize the latest A.I technology followed by its revolutionary technique, Deep Learning. The data for the Tumor Detection consists of MR images of brain. This dataset is available on Kaggle Datasets. After the completion of back-end process and model building, it is all about the User Interface design that would be accomplished through developing an Android & iOS Application while applying all the back-end methodologies behind it. This application has been planned to be named as "Tumor De Brain".

As the Final Year Project is on one of the most demanding domain of this era, i.e. Artificial Intelligence. The centre of attention in our project is towards the advancement in the field of Tumor Pathology of the human brain. In this project, we shall use the MRI images of the brains, half of them containing tumor, while others do not. For the related research and implementation, we are up to use one of the best and renowned Neural Network Algorithm, i.e. Convolutional Neural Network (CNN). Moreover, all the work is aimed to be done using the Python Language. For the usability of the system, there would be a proper Android and iOS Mobile Application which would be linked with an API containing our MR images' trained model. In the end, we can say that the project is a perfect combo of front-end and back-end, giving prestige to the revolutionary technologies of Artificial Intelligence as well as Flutter UI Software Development.

1.1. Background:

A brain tumor is a mass or growth of abnormal cells in your brain. It has different types and varying effects on the human body. Some brain tumors are benign i.e. they are non-cancerous while some are malignant i.e. they contain cancer. Generally, brain tumors arises in two different modes. A primary brain tumor originates initially in a human brain, whereas the secondary brain tumor (metastatic) is caused due to cancer present in other parts of your body. How quickly a brain tumor grows can vary greatly. The growth rate as well as location of a brain tumor determines how it will affect the function of your nervous system.

Primary brain tumors begin when normal cells acquire errors (mutations) in their DNA. These mutations allow cells to grow and divide at increased rates and to continue living when healthy cells would die. The result is a mass of abnormal cells, which forms a tumor.

Secondary (metastatic) brain tumors are tumors that result from cancer that starts elsewhere in your body and then spreads to your brain. Any cancer can spread to the brain, but the most common types include, Lung Cancer, Kidney Cancer, Breast Cancer, etc.

Moreover, there are two common factors due to which brain tumor can take place. One of them is exposure to radiations as these can be harmful to the entire body. The second factor is family history of genetic syndromes that increase the risk of brain tumors.

1.2. Problem Statement:

Detecting tumor in the complex and delicate organs of the human body is always a big challenge. For the tumor in human brain, the doctors and specialists have to go through deep examination of the MRI or the CT-scanned image. This surely takes too much time to get to some final conclusion. Even a tiny spot can make difference if got ignored. Through the automation process and brain tumor detection application, it would be far easier to execute the brain tumor examination.

1.3. Objectives Of Study:

- To contribute in the field of human brain pathology through developing an effective and automated tool in order to detect human brain tumor.
- Automatically detect brain tumor by MR images of a patient's brain.
- To create such an interface for the brain tumor detection system which is understandable and easily operable.

1.4. Significance and Limitations:

Artificial Intelligence has turned out to be the best guardian for the field of medical. In order to carry out different image segmentations through its sophisticated methods, Artificial Intelligence has deployed a remarkable change for the surgeries that require image guidance. As in this project, we are focusing on the brain tumor analysis and detection, the deep learning models and image segmentation techniques shall make it possible to accomplish the needs in an efficient way, thus converting the manual image analysis into effective and improved automation.

It is obvious that when we work on a certain project, there are some limitations and hurdles that can put effect in our workflow and project goals. In this project, we are facing the following:

- Limited number of dataset will be used for the project.
- The proposed model will be justified only through the Python language.

Chapter-2: Literature Review

Artificial Intelligence, Computer Vision, and Image Processing has become a centre of innovative researches for past decades. There is a big list of domains in which the A.I Engineers have worked since many years. Focusing in the evolution of Artificial Intelligence, it was in the year 1943 as two scientists namely Warren McCulloch and Walter put forward the idea and the model of artificial neurons. This was considered as the base of Artificial Intelligence in that era. By 1950, Donald Hebb modified the idea and proposed the Hebbian Training methodology. This aimed to strengthen the approach of neurons. After couple of other proposed ideas and researches, history of Artificial Intelligence saw "A.I Winter" in which there was almost no research at all as by time, scientists thought that it is impossible to achieve even the Narrow Intelligence.

The field revived again in the late 1980s and in the year 1997, the IBM developed such an intelligent agent which won against the chess world champion of that time. The 21st century turned out to be the best era for Artificial Intelligence. Different sort of problems were being solved through newest proposed methods. The recommendation systems, smart and automated chat-bots, creation of intelligent robots, were the best contributions of Artificial Intelligence and Computer Vision. The field also contributed in security and medical studies. The evolution of secure homes and workplaces, anomaly detection, and diseases detection and their classifications developed this field especially in the last decade.

The proposed work in this project is the contribution in the field of Artificial Intelligence and Image Processing. The centre of focus is Brain Tumor Disease detection. There has been a frequent research in this domain for the last 10 to 15 years. Through machine learning and deep learning, the detection and classification of brain tumor on CT scanned images and MR images has been taken out. Besides the use of Machine Learning algorithms like SVM (Support Vector Machine) and Random Forest, there has been a recurrent adoption of Deep Learning algorithms for the detection and classification of brain tumor on MR images. Deep learning algorithms have achieved a high level performance in automated brain tumor segmentation using multi-model MRIs. The Convolutional Neural Network (CNN) is an effective image recognition and

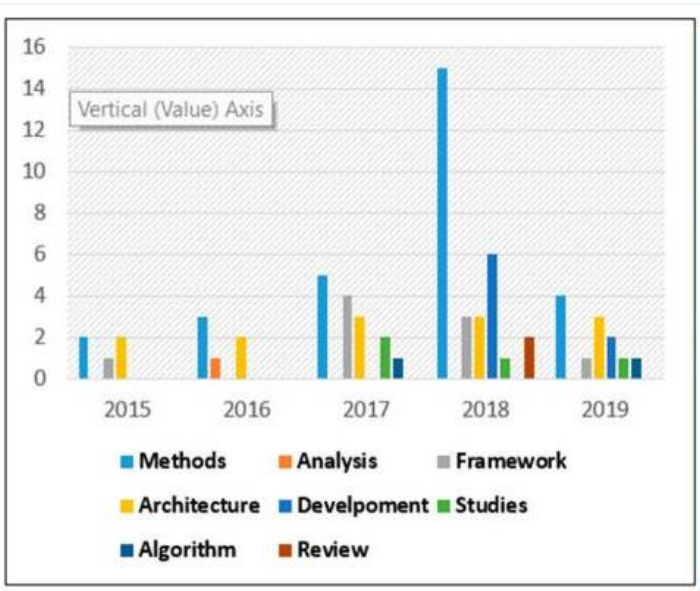
prediction algorithm. Furthermore, CNN is primarily used to segment and classify brain tumor on MR images, and also for the forecasting of patient‘s life expectancy. Stacked De-Noising Auto-encoders and Convolutional Restricted Boltzmann Machine are two more deep-learning-based techniques for tumor segmentation, classification, and prediction. But as we analyze the results and accuracies, the CNN algorithm outperforms all other deep learning techniques and approaches for brain tumor segmentation, classification, and prediction.

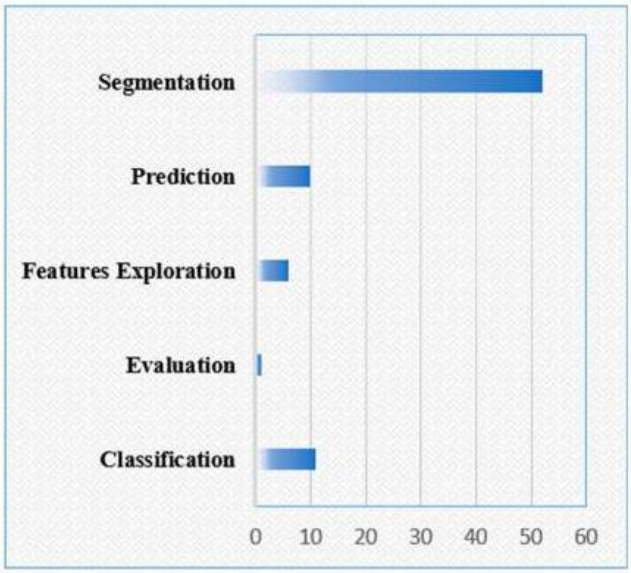
Besides these algorithms, there has also been the utilization of clustering algorithms for the analysis and detection of brain tumor. In the year 2019, the researchers of Islamic University, Bangladesh proposed a research on Brain Tumor Detection in MRI Image Using Template-Based K-Means and Improved Fuzzy C-Means Clustering. According to this particular research work, the K-means performs initial segmentation of MR image of brain and FCM performs further segmentation on the image and an approximate segmented tumor is detected by FCM technique through exact cluster selection. At first, the acquisition of the human brain MR image is done and the input image is pre-processed in addition with the enhancement of the MR image at the same time. Furthermore, the template base window has been selected and the output of the window has been segmented with the temper based K-means clustering segmentation. After that, required features are extracted. Finally, tumor is acquired by detecting with red line marked by the improved fuzzy C-means algorithm with the updated membership. This is committed through the clustered image which is automatically chosen from the image features.

Another research work on the segmentation of human brain images for brain tumor analysis has been in the list. The Iranian engineers from Isfahan University of Technology proposed Brain Tumor Segmentation Using Deep Learning by Type Specific Sorting of Images. In this contribution, automatic brain tumor segmentation technique based on Convolutional Neural Network has been focused. The researchers used three MRI views of human brain while carrying out partitioning of the images based on the direction of captured MR images. Hence, three networks have been trained separately to achieve better segmentation results. The LinkNet approach was considered as it is a light deep neural network architecture designed for performing semantic segmentation. The LinkNet Network consists of encoder and decoder blocks that arrange to break down the image and build it back up before passing it through a few final

convolutional layers. As there were three different angled MR images of brains, an individual LinkNet network has been designed for each of the three groups of images.

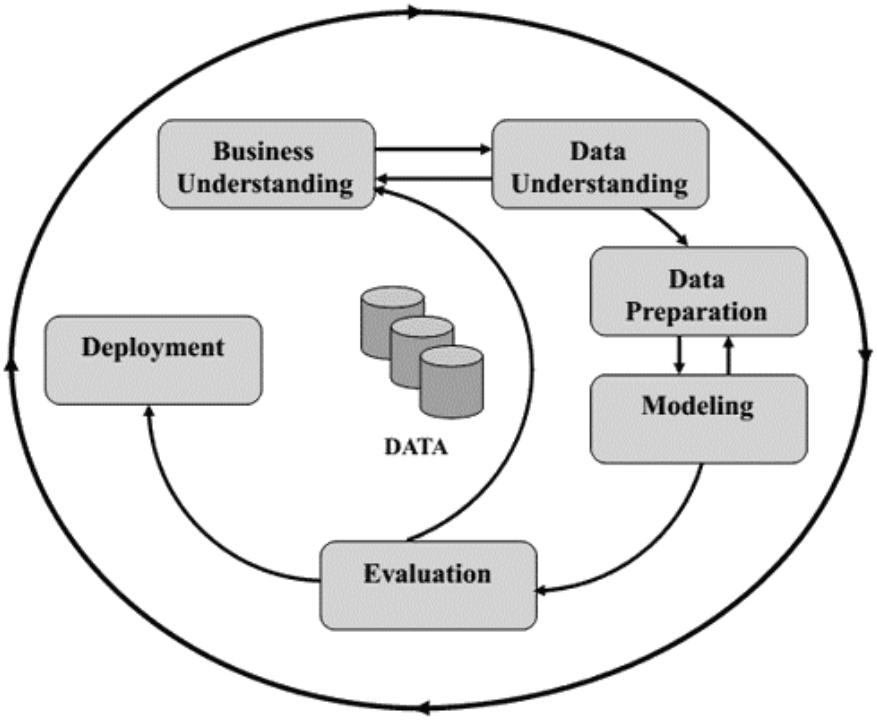
As per our literature review, Deep learning technique for brain tumor analysis was initially presented at conferences and seminars, then published as researches. From 2015 to now, the quantity of research publications has increased dramatically. This issue has now taken centre stage at a number of conferences and periodicals. Here is the illustration which shows the contributions in the context of brain tumor analysis with deep neural networks from 2015 till 2019:





Chapter-3: Project Methodology

3.1 Crisp-DM-Model:



- **Problem Understanding:**

  The problem which this project is solving is straight-forward and easy to be understood. As we know that brain tumor is a fatal disease and late diagnoses can kill a human, the deep learning methodologies help to solve this problem. This enables early diagnoses of brain tumor spots, thus, creating a bright chance for the patients to survive for a longer time.

- **Data Understanding:**

  The dataset used in this project is taken from Kaggle Datasets. It consists of MR images of human brain having tumor spots on almost halve of the dataset, whereas, there are

several images which do not have tumor spot. Here is the count of "yes tumor" and "no tumor" images in our dataset with respect to our training, testing and validation sets.

	Train Sets	Validation Sets	Test Sets
Yes Tumor Counts	120	30	5
No Tumor Counts	75	20	5

Note: These dataset counts are before the augmentation process which would be carried out in the Data Preparation phase.

- **Data Preparation:**

  It is one of the most critical step for getting accurate results for brain tumor detection. It has three sub-steps to follow.

  1) Data Normalization – As there are images having different sizes and unwanted spaces, so cropping them to their extreme points and viewing only the brain image includes in the Data Normalization Process.
  2) Data Augmentation – As the dataset is small and CNN requires large data for exceptional training, it is necessary to carry out data augmentation. This produces a bunch of images from a single image through applying the cropping, direction

reverting, and rotation of images. The dataset becomes large and the CNN model becomes stronger.

3) Data Splitting – It refers to splitting the data into train, test, and validation sets. The training sets shall be used in the CNN model training, validation sets shall evaluate the model at the time of training. After complete training of the CNN model, the test set aid in the model evaluation.

- **Modeling:**

  The main part of project is based on the model building. In this project, the CNN model has two parts, the VGG-16 pre-trained network known as base model, and the prediction model network which contains Dropout, and Dense layers. This concludes the modeling process of the project. Finally, the train and validation sets are given to this model for learning the brain tumor dataset.

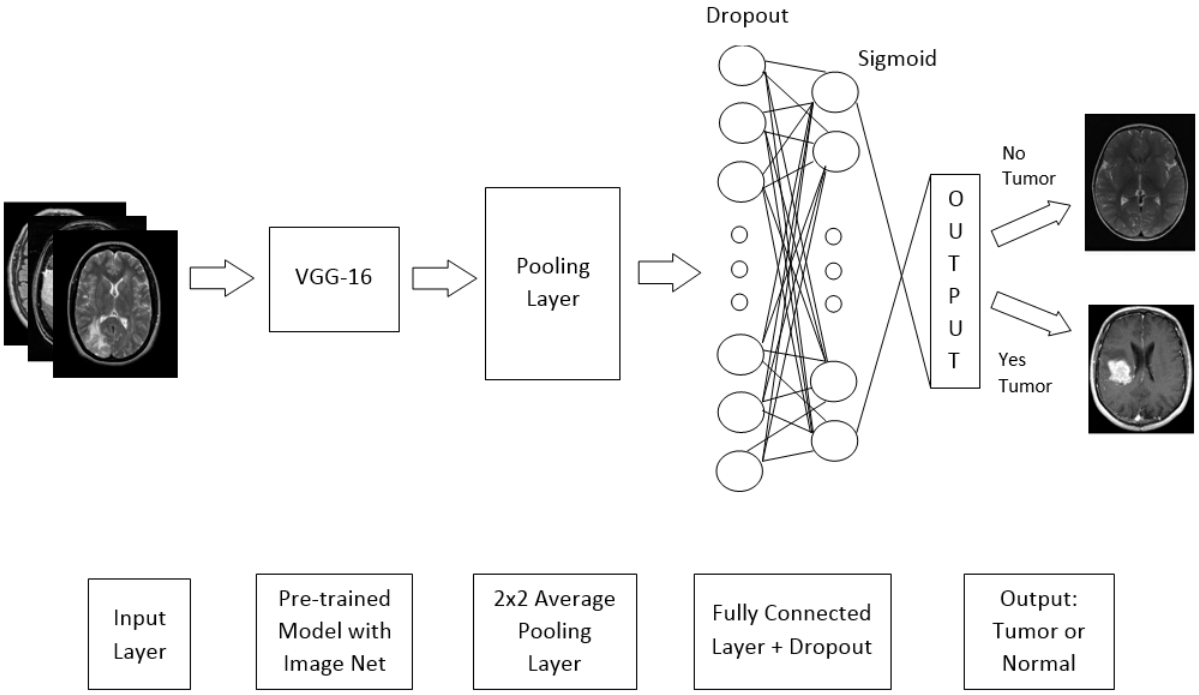
- **Evaluation:**

  Evaluation is the next step in the project. It defines the model performance. The test sets play a vital role for model evaluation as accuracy is returned as a result. The good accuracy shall lead to the deployment of the brain tumor detection CNN model over the Google Cloud in the form of REST API. If precision is not as per the expectation or isn't high, the reverse execution shall occur, and problem understanding step shall be executed again to analyze the issues and solve them.

- **Deployment:**

  The last phase according to Crisp model is Deployment. It includes the conversion of model into REST API, and finally, the deployment of the brain tumor detection model over the Google Cloud. In the end, this REST API shall be integrated with the Flutter based Mobile Application to conclude the project in whole.

3.1.1. Proposed Project:

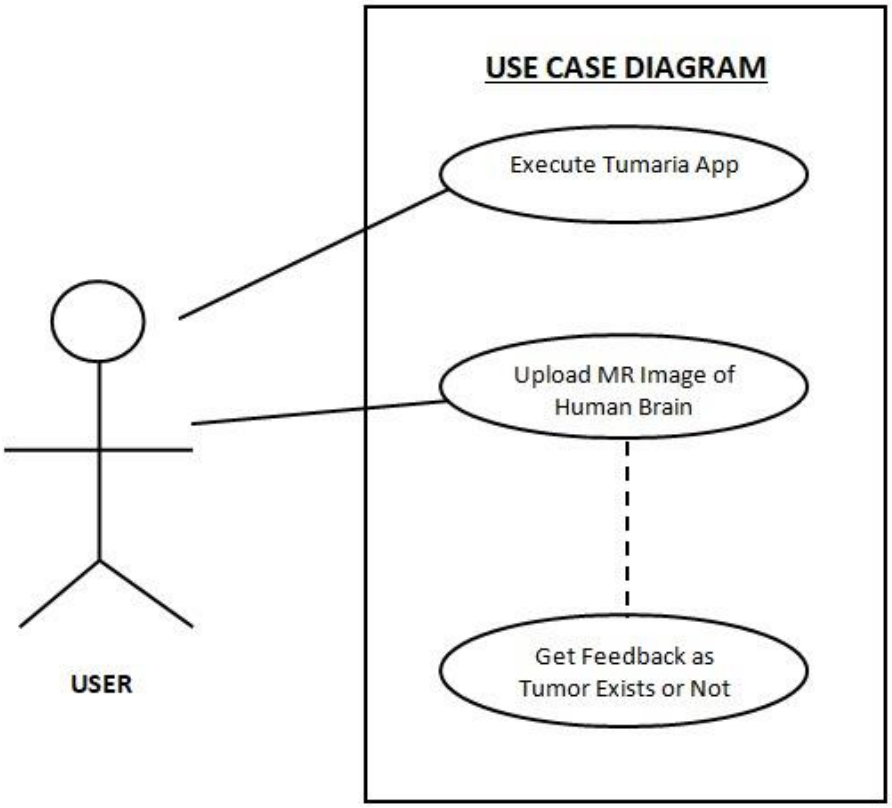


The above figure shows the interior workflow of the proposed project. As it could be noticed that the hierarchy of this architecture is from left to right. This architecture sum up the workflow of the Deep Learning CNN model utilized. It is a supervised learning procedure in which there are MR images with the labels of “Yes” and “No”. These labels identify whether tumor is present or not. There are training layers in CNN models as shown in the figure. At first, there is VGG-16 pre-trained model which acts as a base layer or base model. The MR images go through the VGG-16 layer and generate parameters as well as layer outputs. These outputs are then caught by the Pooling layer which reduces the image size through fetching useful features. Finally, the next outputs go through prediction portion having Fully-Connected Dropout layer and Sigmoid. The Sigmoid activation function predicts that whether tumor is present or not. As a result of training, the model learns the dataset and the edges of the tumor spots. While predicting the test sets over the final prepared model, it shall be concluded that how accurate the brain tumor detection is. In the end, the final CNN model is built by continuous parameter tuning and evaluations.

Chapter-4: Design And Tools

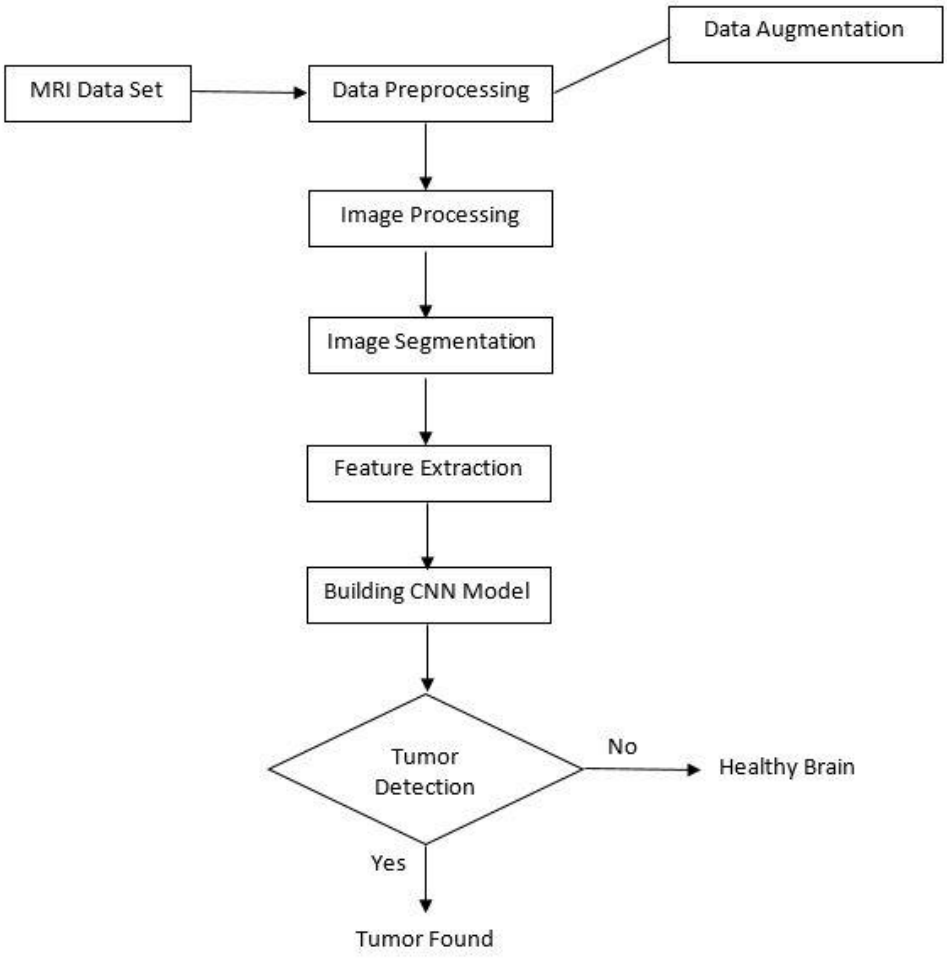
4.1. Project Design (Fully dressed UML and Flowchart):

- **Fully Dressed Use Case:**



There is a single user at a time for the execution of the Brain Tumor Detection App. A user shall open the application and he just have to upload the MR image of brain. Then, he shall tap on the "Predict" button on the screen. The application shall enforce its prediction on that particular image. As a feedback, the user shall know that Brain Tumor exists or not.

- **Flowchart:**



The above flowchart shows the step by step workflow of the Brain Tumor Detection methodologies. From importing dataset as input to the tasks that shall be carried out are being furnished in this diagram. Finally in the end, a perfect Brain Tumor Detection model shall be finalized through continuous parameter tuning of the CNN model.

4.2. Tools and Techniques:

Operating System:

An operating system is also known as a system software which is use to manage the system hardware and application softwares. Windows 8.1 is the Operating System that we have worked on.

Python3:

Python3 is a type of high level language. It is a powerful language which is use to create web applications, for mathematical computing. Python3 is also used to create a graphical interface. The syntax of this language is easy to understand and can be used easily.

Jupyter Notebook:

Jupyter Notebook is an open source client application platform which is use for editing and running documents through web browser. This app can also be use locally to execute notebooks.

Tensorflow:

Tensorflow is an open source framework which is use for machine learning and deep learning. It can be used to perform various tasks but usually focus on training and inferences of deep neural network.

NumPy:

NumPy, (Abbreviated as Numerical Python), is another fast and robust Python library used to deal with multi-dimensional arrays and numeric data. It possesses large-scale mathematical functions that include in different domains like Linear Algebra, Matrices, Fourier Transform, Fourier Series, Statistics, etc. Furthermore, this Python library also contains such special

functions that aid in creating charts and graphs with visualization libraries in Python. Hence, we can consider it the second to none package for array manipulations.

Pandas:

Pandas is an important data preprocessing library written for the Python language. It is an effectual tool to create and manipulate Data Frame objects. In addition, we can also load the in-memory data files with different formats into the Python development environment. For the preprocessing of data, Pandas is sufficient to carry out data cleaning, data alignment, visualization and even handling of the missing data. It is surely the best data representation tool with the benefit to write less and gain more.

Matplotlib:

Matplotlib is a data visualization library integrated with the Python language. It contains numerous packages from which the mostly used is the pyplot package. We can produce many graphs according to the nature of our data. These different charts and graphs include line plots, scatter plots, bar graphs, pie charts, etc. It deals with both types of plots, 2D, as well as 3D plots.

Convolutional Neural Network:

A Convolutional Neural Network is a type of Deep learning Algorithm which takes an input image, assign learnable weights and biases) to different objects in the image and be able to differentiate one from the other.

Another component of CNN has been utilized which is a pre-trained network, namely VGG-16. It consists of layers which are trained with thousands of different image datasets and can be used in almost any of the deep learning, detection, and classification projects. The main goal to use VGG-16 is to reduce the time complexity as well as exceptions that may occur while the heavy training of the brain MR images dataset.

Flask:

Flask is an open source Python web framework, it is a third-party Python library which is used for developing web applications. The web application can be web pages, blog or may be a web-based calendar application or an e-commerce website. For making REST-API, Flask has a vital role

REST-API:

Representational State Transfer Application Programming Interface is set of rules which defines that applications and devices can communicate with each other. It is also considered as the standard protocol for Web APIs.

Flutter:

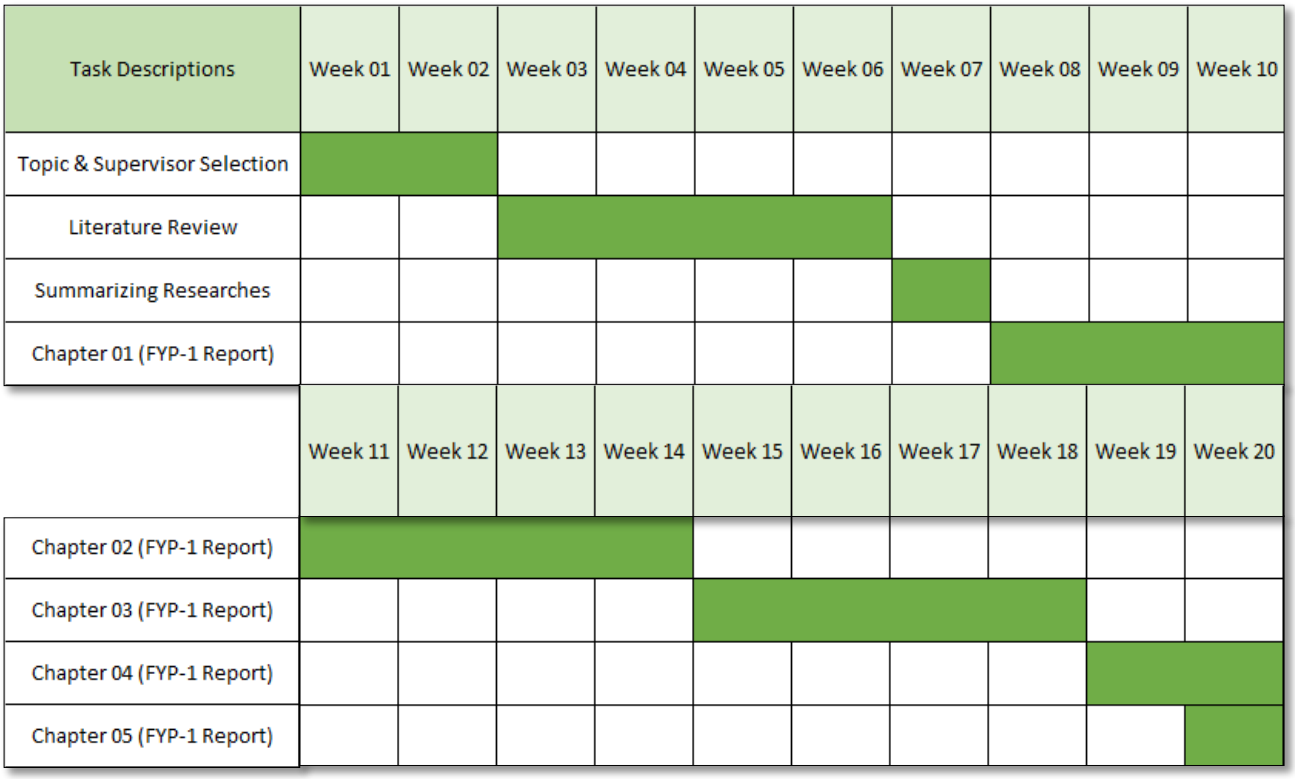
It is an open source framework which is created by Google. It helps to create a native mobile application with only one codebase.

Google Cloud:

It is a public cloud computing service that is offered by Google. It has a range of web hosted services for computing, storage and application development which runs on google hardware.

Chapter-5: Timeline And Conclusion

5.1 Gantt Chart:



5.2 Conclusion:

The FYP-1 report shows all the prerequisites required for the implementation of this project. Total details including literature review, problem statement, objectives, significance, limitations, and workflow of the Brain Tumor Detection through CNN have been discussed. Furthermore, the proper flowchart, use-cases, and model architecture have also been attached. Moreover, the tools and techniques for this project execution are also put forward. At last, it can be concluded that the above proposed project could work well. The integration of model with the Flutter UI would add up to the better usability of the complete project in the form of a mobile application.