Automated Brain Tumor Classification

Mian M. Umer Hassan Qureshi
Waleed Khalid

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Department of Computer Science
COMSATS University Islamabad
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SUPERVISOR NAME	Miss Sadia Ijaz

MEMBER NAME	REG. NO.	EMAIL ADDRESS
Mian M. Umer Hassan Khan Qureshi	CIIT/FA17-BCS-040/ATK	Umersunny9@gmail.com
Waleed Khalid	CIIT/FA17-BCS-009/ATK	Waleedkhalidwk266@gmail.com

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ATTOCK – PAKISTAN

Declaration

"No portion of the work referred to in the dissertation has been submitted in support of an application for another degree or qualification of this or any other university/institute or other institution of learning".

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Student 1 **Student 2**

Abstract

The brain is the most important organ in the human body, responsible for controlling and regulating all critical life functions for the body and a Tumor is a mass of tissue formed by the accumulation of abnormal cells, which keep on growing. A brain tumor is a tumor which is either formed in the brain or has migrated No primary cause has been identified for the formation of tumors in the brain till date. Though tumors in the brain are not very common (Worldwide brain tumors make up only 1.8% of total reported tumors), the mortality rate of malignant brain tumors is very high due to the fact that the tumor formation is in the most critical organ of the body. Hence, it is of utmost importance to accurately detect brain tumors at early stages to lower the mortality rate. In our project, we discussed the automatic classification of brain tumors by using deep learning. We made images fine and free from noise by going through pre-processing techniques. In future work, remaining steps will be done. Three most common type of brain tumors are included in the study and 3064 T1 weighted CE-MRI images are used. We are intended to develop a system that enhance and optimize the tumor diagnostic process. It will help radiologists for decision making and further surgical treatments.

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Chapter 1
Introduction

1 Introduction

Brain Tumor is one of the major causes of death in recent years and becoming life-threatening. There are multiple types of brain tumor exist and each tumor type has different structure, placement in head and different nature. Computer based systems can improve the diagnostic abilities of radiologists and physicians, optimize the accuracy. Also, it can minimize the time required for accurate results of classification of brain tumor. Correct treatment of brain tumor type can affect the planning of treatment and increase the survival rate.

The tumor type analysis is still done manually by radiologists, takes several time and effort. Therefore, the development of automatic system is needed both for physicians and patients. This work is driven by the motive to make the efficient system for better classification of the tumor. This system can be used by radiologists and healthcare specialists. There is large amount of brain tumor images to be process, multiple angles of MRI scan need to be analysed and diagnosis. The goal of our study is to accurately detect tumors in the brain and classify it through the means of several techniques involving medical image processing and computer vision.

These techniques involve pre-processing of MRI scans collected from online cancer imaging archives as well as scans obtained from several pathology labs. Images are resized and then we apply the proposed algorithms for segmentation and classification. The system is expected to improve the brain tumor screening procedure currently at use, and possibly reduce health care costs by decreasing the need for follow-up procedures. Several processing steps are required for the accurate characterization and analysis of biomedical image data.

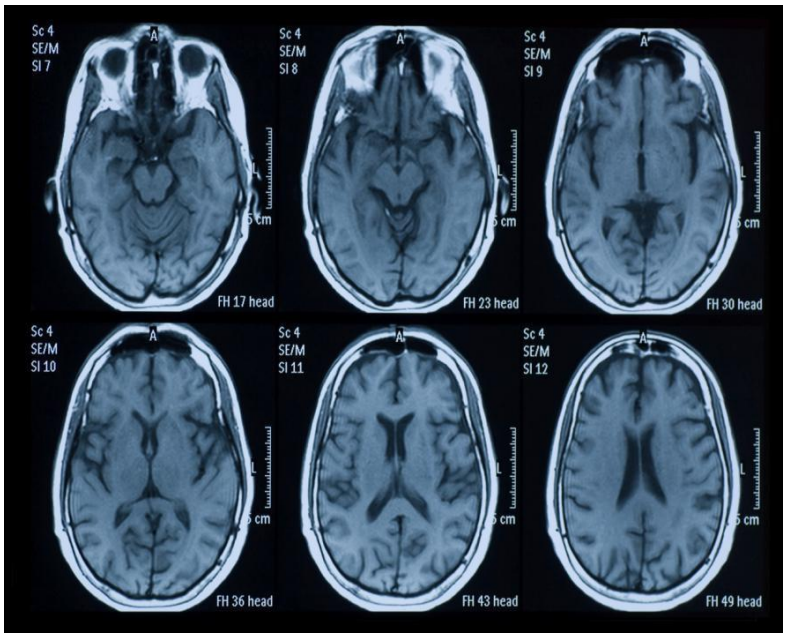


Figure 1-1 MRI Image

MRI images have different types depending on the method used to capture them, these types are called Modalities. Some tumor structures are visually clear in one modality more than the others. Also, MRI images do not produce radiations, so they are not harmful. MRI Image captured from different Angles reveals the detail areas inside the brain such as Axial, Sagittal and Coronal.

1.1 Brief

The human body consists of numerous numbers of cells. When cell growth becomes uncontrollable the extra mass of cell transforms into tumor. Brain tumor is caused by abnormality in cells of brain. There are 120 type of brain tumor exists and each tumor type has different size and location. So, it is very difficult task to classify the tumor part. Brain tumor treatment depends on doctor's accurate decisions. These decisions are done by seeing and analysing the tumor location in brain, tumor shape and tumor size. Doctors interpret the MRI of patient and decide that whether the patient has a tumor or not. Human errors can mislead to wrong diagnosing of tumor type and can be misleading for planning the treatment for patients.

Diagnosis of tumor with the help of MRI image is mandatory but time-taking. This task is difficult for experts when they go for manual method. So, computer supported system are introduced for accurate disease detection from MRI images. It is problematic for radiologists to detect the tumor types manually and make decision due to variation in size, shape, and types of abnormal tissues. This system reduces the workload and avoids the mistakes that can be done by the radiologist. Therefore, these systems are playing vital role in diagnosing and detection of tumor automatically. Nowadays, the use of these systems supporting in the early detection of any type of tumor in recent years. By studying the literature, we have analysed that system's performance can be better by improving the computational speed and flexible systems for different brain datasets.

The proposed system works on Three tumor and One Non Tumor types: meningioma, pituitary glioma, and no Tumor MRI Images**.**

1.2 Relevance to Course Modules

In Artificial Intelligence course all machine learning techniques and algorithms are part of it. The topic that closely relates with my project is neural network. An artificial neuron is developed by machine learning technique to replicate the biological neuron. Neural networks comprise of technologies like machine learning concepts and deep learning and form a part of Artificial Intelligence.

In Machine Learning course we have studied about different algorithms which are used to train models to perfume task automatically after getting the training data.

In Report Writing Skills course is about learning how to write reports and other formal documentation, and, in our project, we need to write our documentation, so this course is helping a lot in this task.

A system which is interactive is easy and comfortable for the user to use the system and understand it easily and in Human Computer Interaction course is all about designing interacting system following standard rules.

1.3 Project Background

There are Main three categories of brain tumor i.e. meningioma, pituitary and glioma. Meningioma tumor is developed in thin membranes of brain like around spinal cord. Pituitary tumor is developed in pituitary gland of brain. Glioma tumor develops in the substance of brain. For examining the tumor, the brain MRI is taken to detect the tumor and to diagnose it. Radiologists must examine these MRI images and they consume a lot of their time and energy in coming up with results. If a patient has last stage tumor then it is impossible to save the life because the manual method of detecting the brain tumor takes time. To get rid of this problem, an automated system is introduced which help radiologist in early detection of brain tumor and to save the precious lives of patients.

1.4 Literature Review

Different approaches have been used in past few decades for diagnosis.

1.4.1 Machine Learning Based Approaches

Machine Learning plays an important role in Computer Diagnosis system and give promising results with improved accuracy. The machine learning also ensure the analysis of the different medical data and machine learning also provide the ability to make classy and good algorithms that help in diagnosing. For examining the bio-medical data, machine learning provides a worthy approach for making efficient algorithms. Following are the approaches that have been proposed by researchers.

Dipali M. Joshi.[2] proposed neural network approach for classification. In his work, the focus was to classify the tumor as well. He used astrocytoma tumor types for classification, using astrocytoma tumor he performed pre-processing method such as histogram, segmentation, morphological technique. His feature extraction method was Gray Level Co-occurrence Matrix (GLCM). The GLCM based features were then compared already stored features. After that, a Neuro Fuzzy method was developed for classification. Their classification approach required many steps for image pre-processing and Detection which increase the computational time. Also, high computing cost is the draw back that consumes high CPU and use of physical memory.

In the research work proposed by Hari Babu Nandpuru. [3] and Dr. S. S. Salankar, classification algorithm is done using Support Vector Machines (SVM). They proposed brain image classification that use Feature extraction by applying grey scaling and two more features like symmetrical and texture. For diagnosis, they used 50 patient's brain images with two classes such

as 'Normal', 'Abnormal'. Using on the SVM classification algorithm they classified the tumor type successfully.

[4] used KNN classifier for classification purpose by going through following steps: Determining the k value, calculating distance between the training samples and query instance and, sortation of distance based on the kth minimum distance, majority class assignment, determining the class. Both and color features textural features are being passed in classification algorithms using K-NN give the accuracy of 87.0%.Their method was evaluated on categorized data as Normal Brain Images, Primary Tumor images (or benign), Secondary Tumor Images (or Malignant).

1.5 Analysis from Literature Review

Deep learning has a classifier named as Deep Neural Network (DNN) classifier that classifies four types of tumor classes. The walvet transformation and feature extraction tool is used in it which yield 96% accuracy overall. The drawback of this classifier is high computation time and low accuracy. Artificial Neural Network (ANN) classifier used astrocytoma tumor types for classification, using astrocytoma tumor. Their classification approach required many steps for image pre-processing and Detection which increase the computational time. The drawback was high computing cost for consuming much memory and resources.

Support Vector Machines (SVM) method used feature extraction by applying grey scaling and two more features like symmetrical and texture. K-Nearest Neighbour (KNN) classifier also used for this problem. This algorithm using K-NN give the accuracy of 87.0% and high computing cost.

1.6 Methodology and Software Lifecycle for this project

Project methodology is an important phase of any project because it is a key element and set the overall tone. For this we must first understand the steps that are involved in project methodology. We use iterative approach to develop this application.

1.6.1 Methodology

For betterment of our system we adopted to implement iterative methodology.

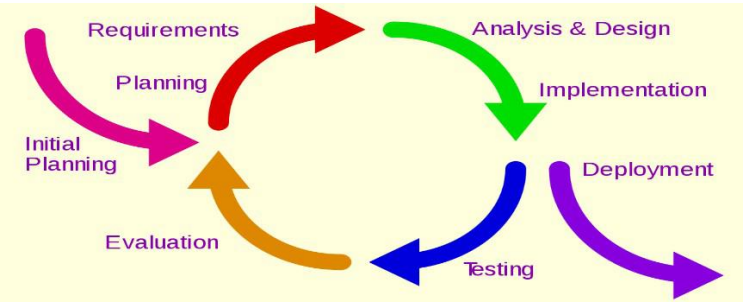


Figure 1-2 Incremental Model

1.6.2 Rationale behind selected methodology

During implementation phase we may add, remove, or modify different features. So, an iterative development will be a good approach to achieve this. Furthermore, it allows:

- Working software creates speedily and early.
- This design is more workable – less costly to adjust specifications and dimensions.
- During iteration, testing and debugging is not hard and complex.
- The cost of delivery is reduced.
- Risk management is much simpler and easier because they are identified during each iteration.

Chapter 2

Problem Definition

2 Problem Definition

2.1 Problem statement

Our study deals with automated brain tumor detection and classification. Normally the anatomy of the brain is analysed by MRI scans or CT scans. Our system aims to detect if the given MRI scan has a tumor and if found it then classifies the tumor as into its types. Our project deals with automated brain tumor classification. Normally the anatomy of the brain is analysed by MRI scans. Our system aims to detect if the given MRI scan has a tumor and if found it then classifies the tumor as meningioma, glioma, pituitary And No tumor.

Classification of Brain Tumor is needed to overcome the manual analysis, workload, improve computational time, flexibility, and the accuracy. Brain tumor is expected to become the number one cause of death in future. There is large amount of brain tumor images to be process, multiple angles of MRI scan need to be analysed and diagnosis. Sometimes human fatigue and stress can affect the process of analysis. Physicians sometime fail to detect the early signs. Existing computer aided diagnosing systems are not capable of generating efficient results in less computational time and inflexible to different brain data sets.

To accurately classify the brain type, we need accurate systems to accommodate the limitations. Solution to the problem is make software that early detect the tumor type automatically in brain. This will be helpful for radiologist and physicians for deciding the surgical treatment. Automatically classifying the tumor type whether it is meningioma, glioma or pituitary is the required solution.

2.2 Deliverables and Development Requirements

Following is the list of deliverables of our project:

First, we need MRI images of Four types of brain tumor required.

Development requirements include following software requirements:

- **IDE**
    - PyCharm
- **Anaconda**
- **Dataset based work**
- **pyTorch for Libraries**
- **Programming Language**
    - Python
- **Interface**
    - PyOt Designer

Chapter 3

Requirement Analysis

3 Requirement Analysis

System Requirements Specification (SRS) is an official statement for the application to provide functional and operational requirements. During the development process of system, it serves as contract between the developer and the customer for whom the system is being developed. The developer would be capable to build the system based on specified requirements as the enlists and necessary requirements specification for the system development is enough. SRS dependency based on functional and non-functional specifications and inclusion of use cases defining user experiences to be supported by software.

3.1 Use Case Diagram

A use case diagram is a technique utilized as a part of framework investigation to perceive and arrange framework necessities. We design UML (Unified Modelling Language) figures to model a framework in the simple and efficient way.

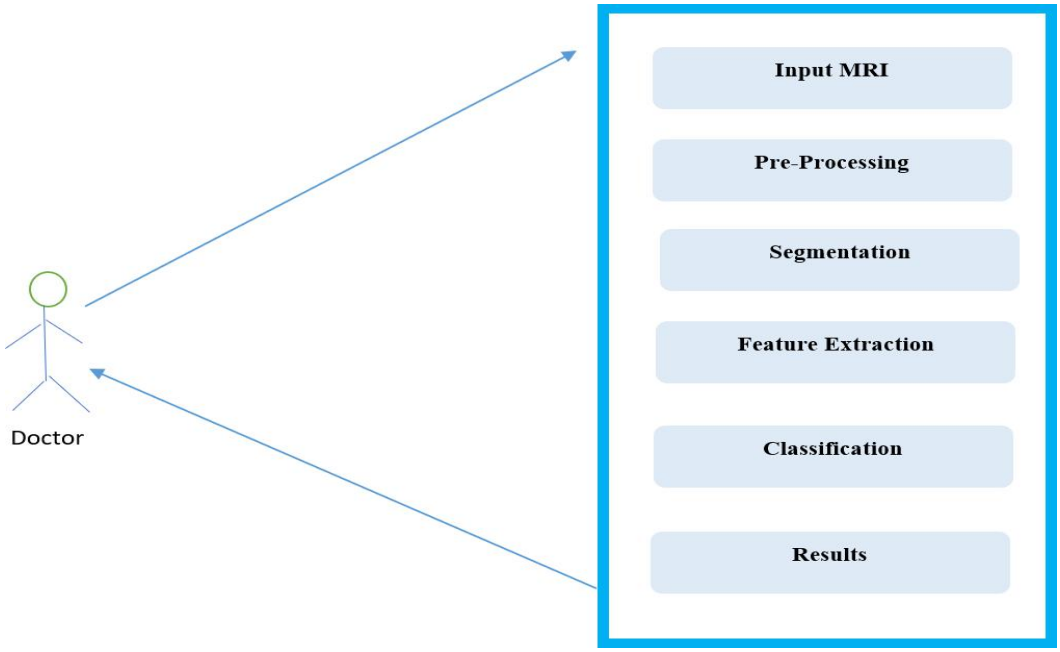


Figure 3-1 Use Case Diagram

3.1.1 Detail of Use Case Diagram

Table 3-1 Input MRI Image (Use Case Description)

Use-case name	Input MRI Image
Action	User
Description	User will input image from system directory to application as initial step to use this application.
Pre-condition	After giving an input to a system, system must start pre-processing process.
Post-condition	After giving an input to a system, system must start pre-processing process.

Table 3-2 Pre Processing (Use Case Description)

Use-case name	Pre-Processing
Action	System
Description	User will input image for pre-processing.
Pre-condition	The User will upload MRI IMAGE from directory
Post-condition	After giving an input to a system, system must start Segmentation process

Table 3-3 Segmentation (Use Case Description)

Use-case name	Segmentation
Action	System
Description	User will input image for pre-processing.
Pre-condition	The User will upload MRI IMAGE from directory
Post-condition	The segmented image will be saved on disk and passed to the next module

Table 3-4 Classifier (Use Case Description)

Use-case name	Classifier
Action	System
Description	A segmented image is sent to classifier for extracting features
Pre-condition	The User will upload MRI IMAGE from directory
Post-condition	After classification on 70% training and 30% testing, the labels are classified.

Table 3-5 Result (Use Case Description)

Use-case name	Result
Action	System
Description	After classification of each rice plant disease class, each disease label is classified with promising accuracies and yield output.
Pre-condition	The labels must classify correctly
Post-condition	Result is displayed after correct classification of rice plant disease classes along with their labels and accuracies.

3.2 Functional Requirements

Functional requirement describes the predictable behaviour of the framework. These are main framework requirement and without applying any of these requirements the framework should be fragmented.

- The system will take the input image and perform pre-processing.
- The system will segment the image.
- Based on the segmentation, the system will classify the segments.

3.2.1 Input Image

Table 3- 6 FR-1 Input Image

Identifier	FR-1
Title	Input image
Requirements	The system take image
Dependencies	None

3.2.2 Pre-processing and Enhancement

Pre-processing and enhancement techniques are used to improve the detection of the suspicious

region from Magnetic Resonance Image (MRI). This section presents the gradient - based image enhancement method for brain MR images which is based on the first derivative and local statistics. The pre-processing and enhancement method consists of two steps; first the removal of film artifacts such as labels and X - ray marks are removed from the MRI using tracking algorithm. Second, the removal of high frequency components using weighted median filtering technique It gives high resolution MRI compared to median filter, adaptive filter, and spatial filter.

Pre-processing is the first and essential part of the framework. Data cleaning is the basic step to refine data from noise, missing values, or irrelevant data. It is required for the removal of unwanted noisy data in the lesion image. We apply elements of pre-processing like, image scaling, color space transformation, contrast enhancement, image restoration and noise removal.

Pre-processing and enhancement techniques are used to improve the detection of the suspicious region from Magnetic Resonance Image (MRI). This section presents the gradient - based image enhancement method for brain MRI images which is based on the first derivative and local statistics. The pre-processing and enhancement method consists of two steps; first the removal of film artifacts such as labels and X - ray marks are removed from the MRI using tracking algorithm. Second, the removal of high frequency components using weighted median filtering technique [12]. It gives high resolution MRI compared to median filter, adaptive filter, and spatial filter. The performance of the proposed method is also evaluated by means of peak single - to noise - ratio (PSNR), Average Signal - to - Noise Ratio (ASNR).

3.2.3 Segmentation

Term Image segmentation refers to the portioning of an image into groups of pixels which are homogenous with respect to some criteria. The objective of segmentation is to extricate as well as change the portrayal of an image into more significant easy to examine.

Image segmentation is the primary step and the most critical tasks of image analysis. Its purpose is that of extracting from an image by means of image segmentation. The mechanization of medical image segmentation has established wide application in diverse areas such as verdict for patients, treatment management planning, and computer - integrated surgery. We will apply segmentation on pre-processed images by following techniques: Threshold method, Watershed Algorithm and Region-Based method.

Edge detection is the approach used most frequently for segmenting images based on abrupt change in intensity. The canny edge operator works in a multistage process. Canny algorithm was the only procedure capable of yielding a totally unbroken edge for the posterior boundary of the brain.

Otsu’s thresholding is a non - linear operation that converts a grayscale image into a binary image where the two levels are assigned to pixel those that are below or above the specified threshold

value. The two levels in a binary image are assigned to pixels below or above the threshold. It is based on threshold range by statistical calculations. Otsu suggested minimizing the weighted sum of within - class variances of the object and background pixels to establish an optimum threshold

3.2.4 Feature Extraction

Feature extraction is process of extracting quantitative information from an image such as color features, texture, shape, and contrast. Here, we have used discrete wavelet transform (DWT) for extracting wavelet coefficients and gray-level co-occurrence matrix (GLCM) for statistical feature extraction.

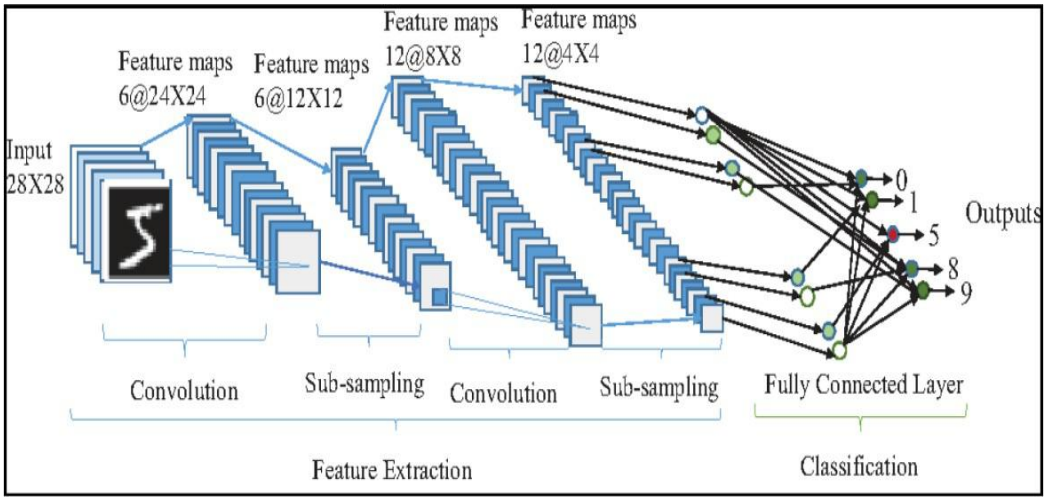
Feature defines the behavior of image. To determine the subset of initial features is known as feature selection. Feature extraction refers to extraction of features based on pixels. To save the computational cost, take the tumor region and extract its features and interpret them. This is done to isolate desired portion from an input image.

3.2.5 Classifier

SVM is one of the classification techniques applied on different fields such as face recognition, text categorization, cancer diagnosis, glaucoma diagnosis, microarray gene expression data analysis [15]. SVM utilizes binary classification of brain MR image as normal or tumor affected. SVM divides the given data into decision surface, (i.e. a hyper-plane) which divides the data into two classes. The prime objective of SVM is to maximize the margins between two classes of the hyper-plane [16]. Dimensionality reduction and precise feature set given as input to the SVM on the duration of training part as well as during the testing part. SVM is based on binary classifier which employs supervised learning to provide better results.

In classification tasks, there are often several candidate feature extraction methods available. The most suitable method can be chosen by training neural networks to perform the required classification task using different input features (derived using different methods). The error in the neural network response to test examples provides an indication of the suitability of the corresponding input features (and thus method used to derive them) to the considered classification task.

Convolutional Neural Networks (CNNs) have proven to be very successful frameworks for image



recognition. In the past few years, variants of CNN models achieve increasingly better performance for object classification

Figure 3-2 CNN Working

Table 3-7 FR-2 Classifier CNN

Identifier	FR-2
Title	Classifier CNN
Requirements	The system performs the classification and predict the rice plant disease label
Dependencies	FR-1

3.2.6 Results/Output

Table 3-8 FR-3 Output

Identifier	FR-3
Title	Output
Requirements	The classifier predicts the rice plant disease label and displays the accuracy
Dependencies	FR-2

3.3 Non-Functional Requirement

3.3.2 Performance

Performance of our system is efficient, and it takes very less time to perform the action. Our CAD system saves the time.

3.3.3 Capacity

Our system must meet the agreed capacity.

3.3.4 Availability

The system will be available into any hospital or clinic.

3.3.5 Reliability

Our system is 100% reliable and generates an accurate result.

3.3.6 Maintainability

With the time and needs our system will be maintained properly and any feedback from the user is our priority while performing maintenance.

3.3.7 Efficiency

This system is efficient as it does not require any kind of effort to use it and does not take much time.

3.3.8 Flexibility

The system provides the user to load the image easily.

Usability

This system is very easy to use by radiologist and pathologist. The designed interface is very easy to understand.

Chapter 4

Design and Architecture

4 Design and Architecture

After gathering all requirements, the next step is to start planning that how we are going to develop our project, how much resources, costs, time, benefits, and other items are required. After planning we move to the designing and architecture phase that which techniques and methods we can use and how we are going to develop our project. It is the most challenging phase of project development.

4.2 System Architecture

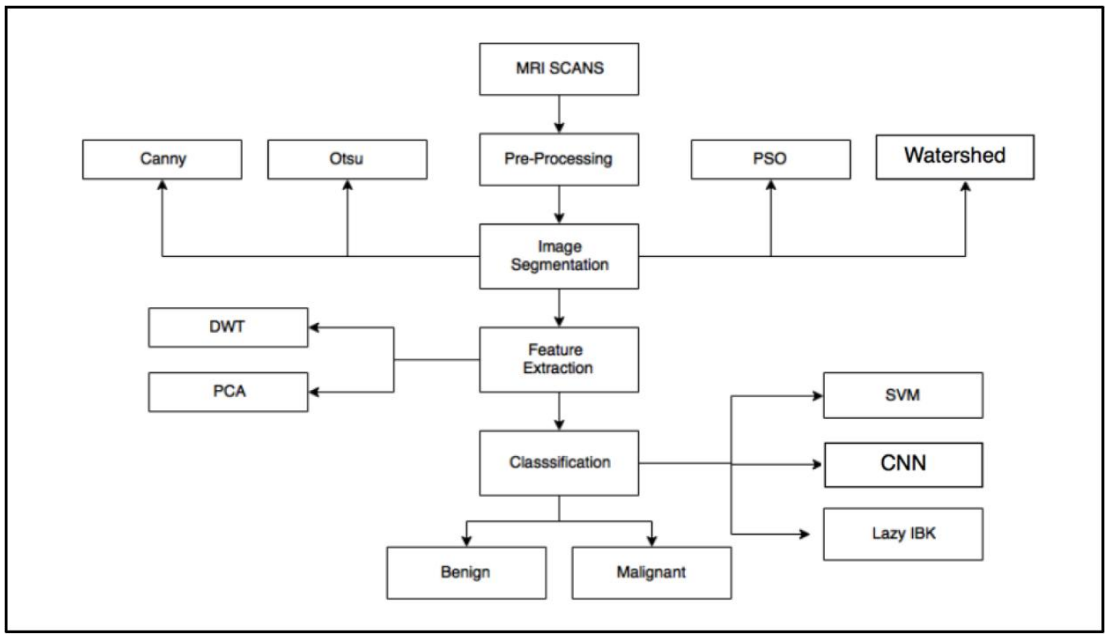


Figure 4-1 System Architecture

4.3 Process flow (Representation)

4.3.2 Data Flow Diagram

A data flow diagram is graphical interpretation of information move from a data framework is called data flow diagram. A DFD is used for basic step to create an overview of the system without going into great aspect, which can later be elaborated.

Now Data flow diagram can be drawn to show the different levels of abstractions. Levels in DFD are numbered as 0, 1 and so on

4.3.2.1 Level 0 DFD

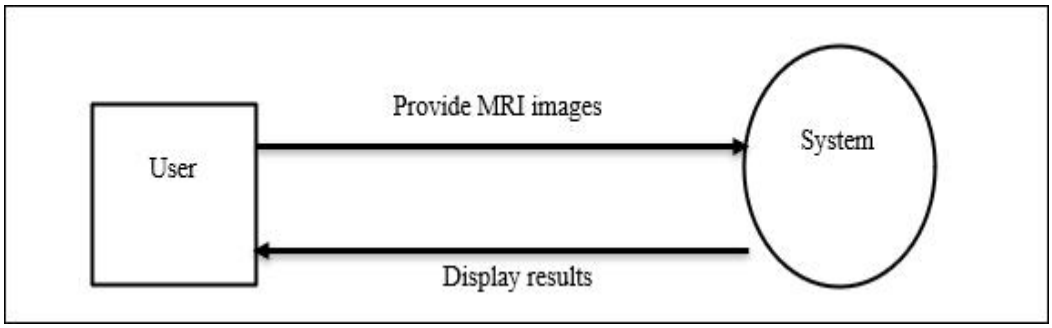


Figure 4-2 Level 0 DFD

4.3.2.2 Level 1 DFD

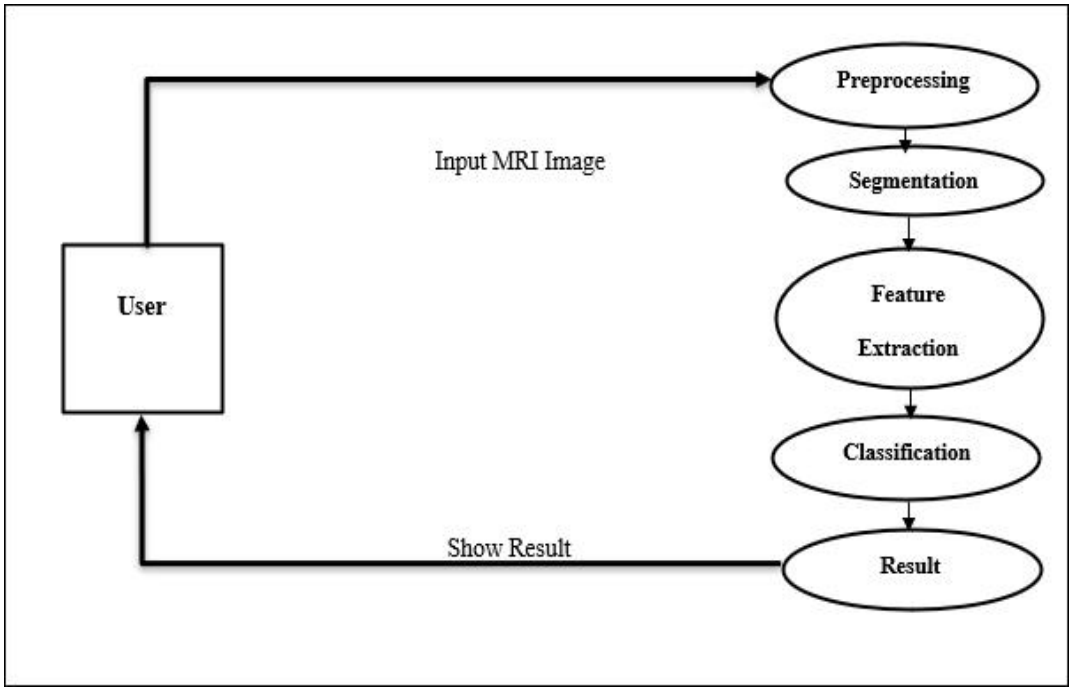


Figure 4-3 Level 1 DFD

This chapter presents the complete design of our project. Project design is an important part for developing a graphical view of requirement based on the detailed functional and non-functional requirements in the previous chapter. Project design is only acceptable and marked as good after understanding the requirements of the project provided for development. It is always good practice to start from making a high-level design and then move it to low-level design phases.

4.3.3 Activity Diagram

An activity diagram is depicting the dynamic component of the framework. An activity diagram is essentially a flowchart to speak from one action to another movement. The movement may be relating to an operation of the framework. This diagram is used to explain the dynamic features of the system. It is more like a flow chart because it shows the flow of data from one activity to other.

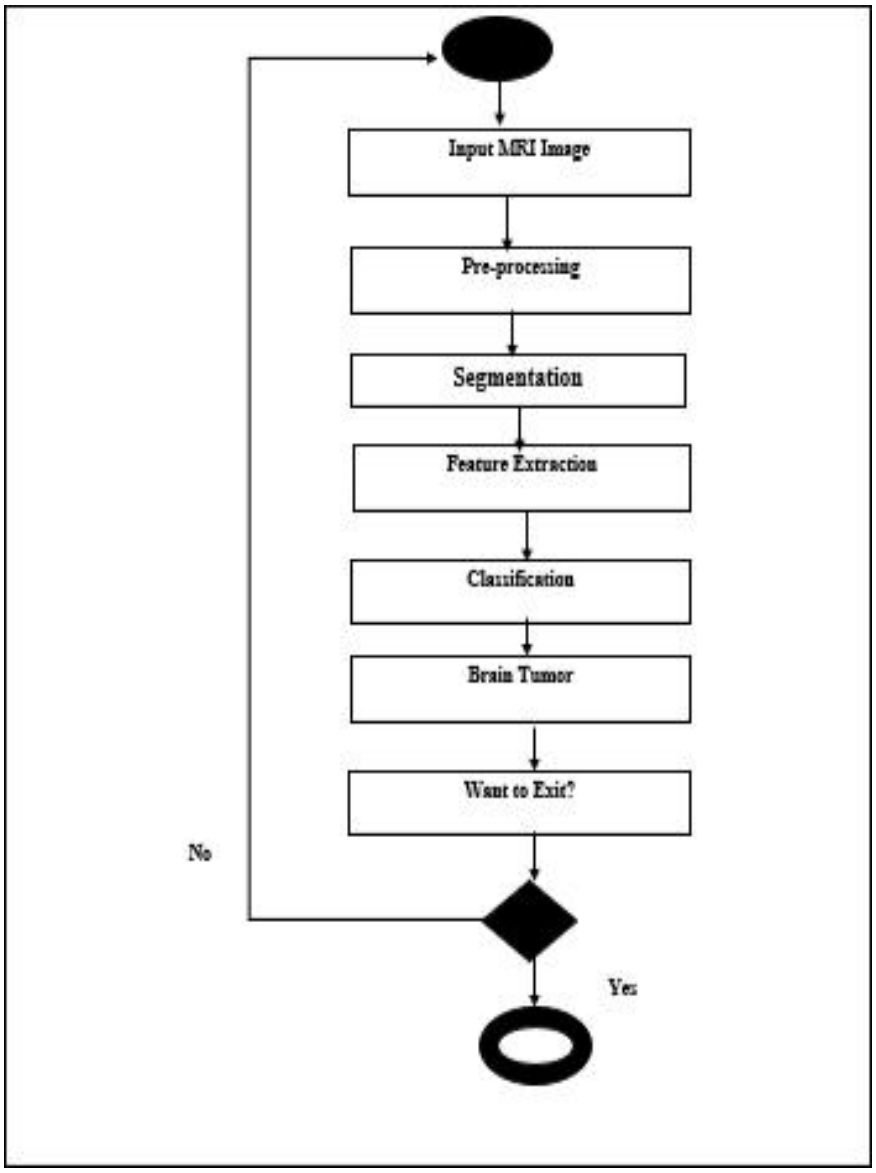


Figure 4-4 Activity Diagram

4.4 Design Models

4.4.2 Sequence Diagram

A cooperation graph that shows how objects work with each other and in what request is called sequence diagram. It is built up of message arrangement outline.

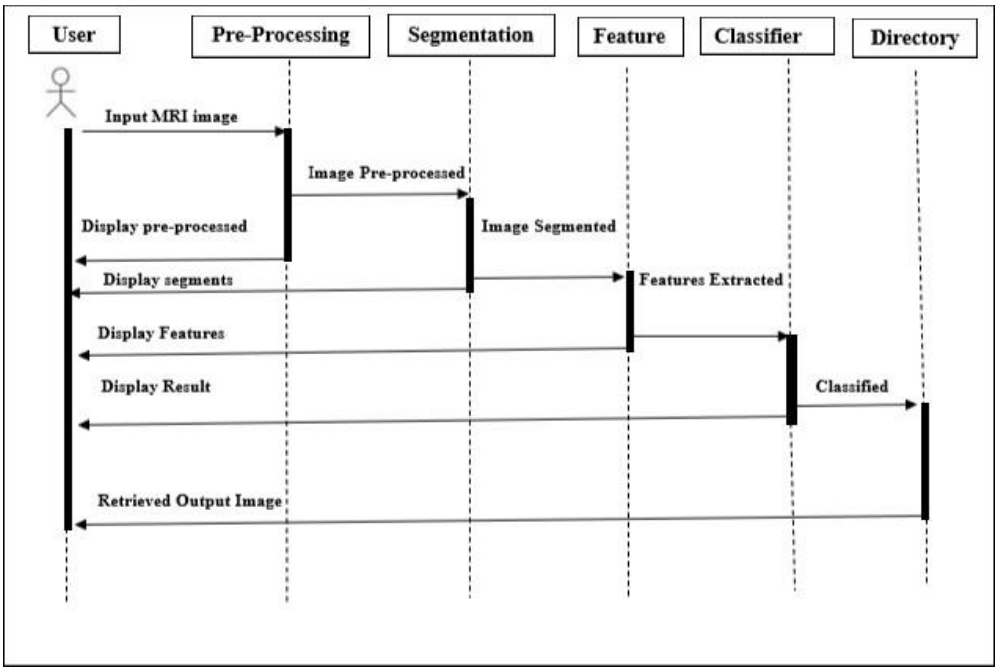


Figure 4-5 Sequence Diagram

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