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Intelligent system to detect cerebral auto-regulation and brain damages after traumatic head injury

A dissertation by

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Declaration

I hereby certify that this project report and all the artifacts associated with my own work and that it has not been submitted before, nor is currently being submitted for any degree programme.

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To my parents…

Abstract

Cerebral auto-regulation is examined only by considering the clinical signs like signs of base of skull fracture, Poor attention, Loss of consciousness, bleeding from an ear, examine the eyes, Re-examine the pupils, Examine eye movements. A change in these clinical signs will result in timely investigation and treatment of emergent problems and will help prevent secondary brain injury. It is only through clinical symptoms, that the doctors reveal that there can be secondary brain injuries or not. The severity of brain damage can vary with the type of brain injury. There can be damage to a small area or damage to several areas of the brain. Yet it doesn't solve the problem of detecting the cerebral auto-regulation and predicts the severity of the brain damage.

The main aim of this project is to detect the failing point of the auto-regulation and identify the brain damage areas and predict the severity of the damage. A literature review and an online survey of knowledge recourses were conducted to gather the requirements to design a solution.

There are two main ways of detecting the brain damages. Firstly, users can upload a CT damaged brain image and segment the damage areas using the SVM method. Secondly, the damage areas can be segmented by using thresholding process. This process will bring the vision of predicting the severity of the brain damage.

Subject Descriptors:

I.4: Image Processing and Computer Vision

I.4.3: Enhancement

I.4.6: Segmentation

Keywords:

Image Processing, Image segmentation, Thresholding, Watershed segmentation

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Table of Acronyms and Abbreviations

Acronym/ Abbreviation	Definition
TBI	Traumatic brain injuries
mTBI	Mild traumatic brain injuries
CO_2	Carbon dioxide
CT	Computer tomography
MRI	Magnetic Resonance Imaging
EEG	Electro-encephalogram
MEG	Magneto-encephalography
ANN	Artificial Neural Network
FR	Functional Requirements
NFR	Non-Functional Requirements
DICOM	Digital Imaging and Communications in Medicine
SVM	Support Vector Machine
LR	Literature Review
SRS	Software Requirement Specification
MOH	Ministry of Health
SSAD	Structured System Analyze and Design
OOAD	Object Oriented Analyze Design
GUI	Graphical User Interface
UI	User Interface

Chapter 01: Introduction

Chapter 01: Introduction

1.0 Chapter Overview

This chapter will focus on the foundation of the project by providing an introduction to its project background. It provides a brief background on the problem domain addressed in the project. This will include project aim and objectives which set at the beginning of the project. This chapter will give a preview of the main features of the proposed system, approaches taken in solving and developing the system as well as how the aim and objectives are accomplished within a given time period.

1.1 Project Background

Head injuries associated with traumatic brain injury occur with an incidence of 20–40 cases per 100000 populations per year. It is the most common cause of death in young adults (age 15–24 years) and also it is the more common in males than females (Williams.N.S, 2013). Road traffic accidents include car or motorcycle crashes, falls, sports injuries are the most common cause of traumatic brain injury.

Traumatic brain injury (TBI), also known as intracranial injury, occurs when an external force traumatically injures the brain. There is a mechanism called **Cerebral Auto-regulation** that keep and maintain cerebral blood flow and cerebral pressure in a stable value. Normal cerebral blood flow is approximately 55ml $100g^{-1}min^{-}$ (Williams.N.S, 2013). When the head is injured, the values gets vary from the constant level. If these values vary from the constant level, there is no hospital system to detect the Auto-regulation. Doctors used to identify this only by using **Clinical signs** of the patient**.**

So far this Auto-regulation is reviewed by Looking only for clinical symptoms like;

* Signs of base of skull fracture
* Poor attention
* Loss of consciousness
* Bleeding from an ear
* Examine the eyes
* Re-examine the pupils
* Examine eye movements

A change in the above clinical signs will result in timely investigation and treatment of emergent problems and will help to prevent secondary brain injury. It is only through clinical symptoms, that the doctors reveal that there can be secondary brain injuries or not.

Not only because of these head injuries, if the auto-regulation is failing, there can be **Secondary Brain Injuries** as well. In order to assess cerebral auto-regulation, one must at least continuously measure **arterial blood pressure** and **cerebral blood flow**. Because CO_2 levels are of great influence to cerebral auto-regulation, it is recommended to also continuously measure CO_2.

Secondary brain injury occurs as a result of the body's inflammatory response to the primary injury. Secondary brain injury occurs at some time after the moment of the impact and is often preventable.

Taking into consideration of the above facts, it is clear that there is no accurate way of detecting the cerebral auto-regulation. In order to prevent secondary brain damages based on the auto-regulation an intelligent system has been proposed.

Based on the Auto-regulation, in order to prevent secondary brain damages, an intelligent system has been proposed.

TBI is diagnosed by physicians based on a combination of patient reports, clinical presentation, and brain imaging studies (such as CT scans and MRIs). A form of TBI called *mild traumatic brain injury* (*mTBI*) is typically diagnosed only on the basis of the individuals report, clinical signs and symptoms. Brain imaging findings are typically normal in mTBI. Though the medical diagnosis of TBI is made by the physician, the specific deficits resulting from TBI are diagnosed and managed by an interdisciplinary team. Depending on the needs of the individual, the team often includes doctors, nurses, neuropsychologists, occupational therapists and physical therapists.

The severity of brain damage can vary with the type of brain injury. A mild brain injury may be temporary. It causes headaches, confusion and memory problems. With moderate brain injury, symptoms can last longer and be more pronounced.

There can be damage to a small area or to several areas of the brain. Sometimes the nerves are stretched throughout the brain and also there can be a collection of blood outside the blood vessels. This proposed system will identify the damage areas of the brain and it will predict the severity of the brain damage.

1.2 Aim and Objectives

1.2.1 Project Aim

The aim of this project is to research, design, develop and evaluate an intelligent system to detect cerebral auto-regulation and brain damages which enables users such as doctors, medical students and neurologists to identify brain damages and auto-regulation in order to prevent secondary brain injuries.

Further elaborating on the aim, the project will design a system to detect brain damages and predict the severity of the brain damage. This process can be done by using two methods in order to compare the accuracy of the system.

1.2.2 Project Objectives

With a specific end goal to accomplish before said points of the undertaking the accompanying objectives have been identified.

1. Conduct a background research, investigating the problems on Traumatic Head Injuries faced by patients, techniques and methods taking to prevent brain damages and prepare the TOR, which can act as the guide throughout the project lifecycle.
    1.1 Review the information gathered
    1.2 Complete the draft TOR
    1.3 Submit the draft TOR to the supervisor
    1.4 Review with the supervisor and revise the TOR
    1.5 Submission of final TOR

2. Prepare and submit a comprehensive literature survey on following areas to gain sufficient knowledge on current research area.
    - Introduction of the brain, research about traumatic head injuries and current approaches for diagnosis of auto-regulation & brain damages
    - Medical brain images conversion
    - Image segmentation technologies and algorithms
    - Frequently used methods for Image Segmentation
    - Classification of machine learning techniques

3. To decide on suitable project management, project planning, research, design and development approaches, methodologies, tools and techniques for the project to ensure that the project runs smoothly without any errors.
    - 3.1 Identifying suitable development methodologies and justify suitable development methodology
    - 3.2 Identifying suitable data gathering tools and techniques
    - 3.3 Identifying system design techniques and justify the most suitable system design techniques
    - 3.4 Monitoring the project plan
        - 3.4.1 Complete and revise the completed work breakdown structure
        - 3.4.2 Complete and revise the final Gantt chart that reflects the methodology used in the project planning and management chapter
    - 3.5 Identifying the risk factors and develops a risk mitigation plan

4. To carry out a requirement gathering survey in the form of questionnaires and interviews targeting doctors, medical student, radiologists and neurologists in order to,
    - Gain more understanding about the problem domain
    - Features and usability of existing technologies used for detecting brain damages
    - How useful the proposed system for the users
    - How accuracy of the existing system and benefits of using an intelligent system to detect brain damages
    - Functionalities that they expect from a system proposed like here

    This will analyse and prioritize the requirements identified through the literature review and the survey in order to create the requirement specification document. Furthermore, this will include both functional and non-functional requirements for the proposed system.

5. To design the proposed system that includes all the functionalities that identified during the objective number 4.
    - 5.1 Identify the design methodologies, design tools and justify the most suitable design methodology and tools
    - 5.2 Identify various design goals
    - 5.3 Design the high-level and low-level architecture of the system

6. Develop the proposed prototype of the solution that includes the main functions required by the system.

7. Conduct a detailed testing to evaluate the functional requirements of the implemented system is in an effective and efficient manner.

8. Finalise the detailed document of the project that will define all aspects of the project.

1.3 Features of the Prototype

1. Intelligent way to measure and display arterial blood pressure and cerebral blood flow of the patient
2. The system should be able to upload an image
3. Read and support DICOM medical images
4. Identify various parts of the brain
5. Identify damage areas of the brain
6. Detect the severity of the damage

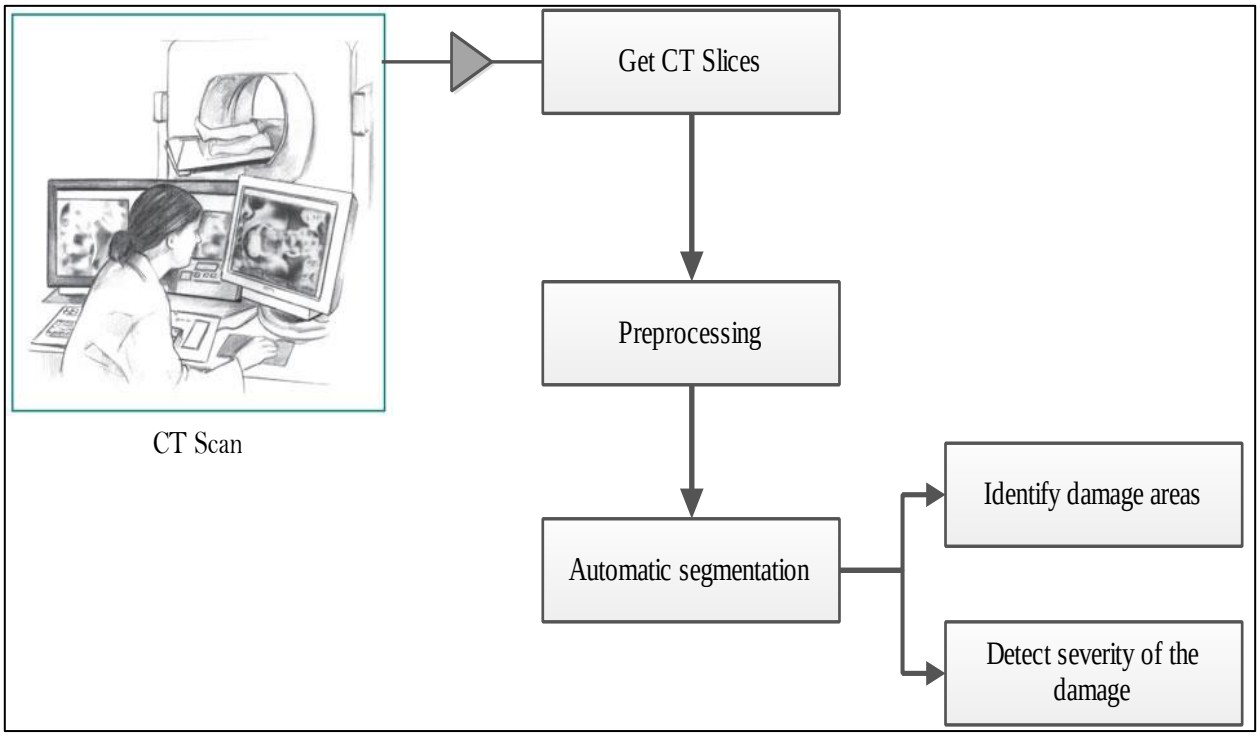


Figure 1.0: Features of the Prototype

The main features of the proposed system can be explained by using the real life example shown above in Figure 1.0

1.4 Project Deliverables

- Draft TOR
- Final TOR
- Literature Review
- Requirement Specification Document
- Interim Report
- Software Design Document
- Project Prototype Report
- Draft Project Report
- Bound Copies of the Final Project Report

1.5 Resource Requirements

Software	Hardware
Matlab 7.12.0 (R2011a)	Personal Computer
Microsoft office – Word, Excel, Project	CT Scanner – Optional
UML Software – Star UML	

Table 1.0: Software and Hardware Requirements

1.6 Chapter Summary

This chapter points out the importance of an intelligent system to detect brain damages and cerebral auto-regulation and how it can be useful to the users such as doctors, medical students and neurologists. The aim and the main objectives are identified and features of the prototype and the main deliverables of the project are also being discussed.

Chapter 02: Literature Review

Chapter 02: Literature Review

2.0 Chapter Overview

This chapter will focus on the anatomy of the brain, understanding the basic information about the brain, cerebral auto-regulation and classification of the brain damages and how it happens. This chapter also includes current approaches, techniques and technologies for diagnosis of auto-regulation and brain damages. This literature review verifies the best approach, technique and technology by comparing its advantages and disadvantages for diagnosing the brain damages.

2.1 Introduction of the Brain

The human brain is the main organ of the human sensory system which located in the head. Brain receives signals as input from the sensory organs and sends output to the muscles. Brain has same general structure as the brains of other mammals.

The largest part of the human brain is the Cerebrum. The cerebrum is made up of two main nervous tissues called gray matter and white matter. White matter carries nerve signals to the brain and spinal cord while the gray matter integrates information in the cerebrum.

The cerebral cortex is divided into four sections, called the frontal lobe, parietal lobe, occipital lobe, and temporal lobe. Figure 2.0 gives a visual representation of the cortex.

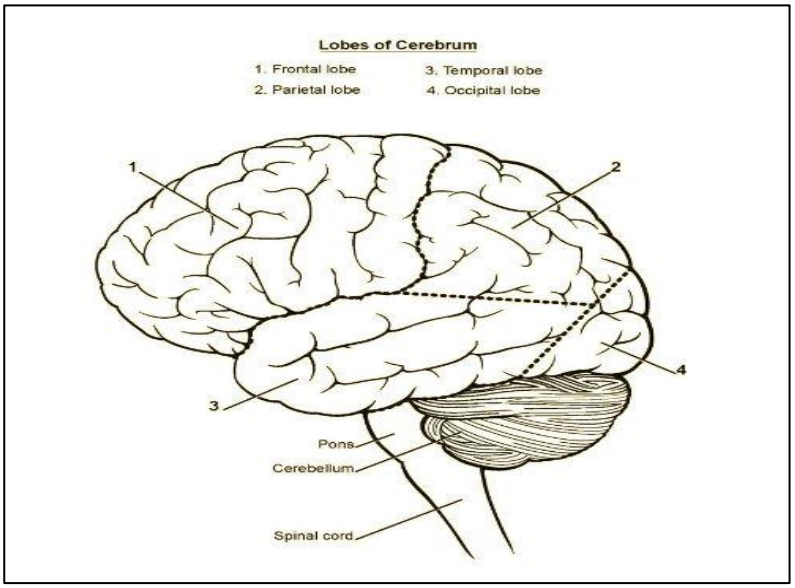


Figure 2.0: Human Brain

2.1.1 Anatomy of the Brain

There are three noteworthy divisions of the cerebrum. They are the Forebrain, the Midbrain and the Hindbrain.

- The forebrain: This is in charge of an assortment of capacities including getting and handling tactile data, considering, seeing, creating and understanding dialect, and controlling engine capacity.

- The midbrain: This area is capable in sound-related and visual reactions and also work.

- The hindbrain: This locale helps with keeping up equalization and balance, development coordination and the conduction of tactile data.

2.2 Cerebral Auto-regulation

Cerebral auto-regulation is a process which aims to maintain adequate and stable cerebral blood flow. By means of auto regulation the body is able to deliver sufficient blood containing of Oxygen and nutrients to the brain for the metabolic needs and remove Carbon dioxide and other waste products. The cerebral auto-regulation always maintains blood flow at an appropriate level during any changes in the blood pressure.

2.2.1 How Cerebral Auto-regulation Fails

The cerebral auto-regulation fails in several incidents like traumatic head injury, stroke and brain tumours. The cerebral auto-regulation can be measured by clinical signals like cerebral blood flow, intracranial pressure, and blood pressure and CO_2 level. In order to access cerebral auto-regulation, one must at least continuously measure cerebral blood flow. Cerebral blood flow can be measured non-invasively by Trans-cranial Doppler or MRI.

2.3 What is a Traumatic Brain Injury?

A rapid force applied to the head may cause a sudden damage inside the brain. Brain tissues may stretch or tear because of the rapid movement (David. M.D, 2004). This kind of an incident is declared as a brain injury. This can injure the nervous tissue of the brain directly. Most of these injuries caused by road traffic accidents including car or motorcycle crashes, falls, sport injuries and most of the victims are children and adolescents.

2.4 Secondary Brain Injuries

Secondary brain injuries cause swelling in the brain, which may lead to increase the intracranial pressure and prevent cerebrospinal fluid from draining out of the skull**.** This causes a further increase in pressure and brain damage. If this is not controlled, there can be respiratory failures and may cause of death. The only way to prevent the primary injury is to prevent the trauma. The prevention of this secondary injury is the focus of the acute medical care after injury. (David. M.D, 2004).

Secondary Injury Includes:

- Intracranial haemorrhage (bleeding inside the skull)
- Brain swelling
- Increased intracranial pressure (pressure inside the skull)
- Brain damage associated with lack of oxygen
- Infection inside the skull, common with penetrating trauma
- Chemical changes leading to cell death
- Increased fluid inside the skull

2.5 Mechanisms of Injury

Following mechanisms are the highest causes of brain injury.

- ✓ **Open head injury :**

  Penetration of the skull.

- ✓ **Closed head injury:**

  Resulting from a slip or fall from a vehicle.

- ✓ **Stroke :**

  If there is bleeding in or over the brain because of a tear in an artery or vein, loss of blood flow and injury to the brain tissue by the blood will also result in brain damage.

- ✓ **Hematoma:**

  If blood flow is blocked through a cerebral vascular cell there can be clotted blood within the tissues.

Hematoma is common in traumatic brain injuries. Brain Hematoma is caused due to a sudden Injury in brain and blood leaks out from the blood vessels in the brain. CT scan is the preferred method to determine these kinds of head injuries.

2.6 Effects of TBI

TBI is classified into two categories as Mild TBI and Severe TBI.

- ✓ **Mild TBI** can be classified as mild if loss of consciousness is shorter than 30 minutes. The mild TBI individual has cognitive problems such as headache, difficulty thinking, memory problems and attention deficits.

- ✓ **Severe TBI** is associated with loss of consciousness for more than 30 minutes and memory loss after the injury.

The effects of TBI can be profound. Individuals with severe injuries can be left in long-term unresponsive states. For many people with severe TBI, long-term rehabilitation is often necessary to maximize function and independence. It is very same with mild TBI.

Unresponsive states or depression is a common problem after TBI. The risk of depression after a TBI increases whether the injury is mild, moderate, or severe. Researchers cannot say if age, gender, the part of the brain that was injured, or the type of injury makes depression more likely.

Researchers don't know when depression is well on the way to happen after TBI. Some individuals experience discouragements directly after their damage, while others create misery a year or all the more later. It is critical to the specialist about any side effects of discouragement that might be having regardless of the fact that it has been a while since the head damage.

2.7 Depression after TBI

Depression status of a head injured person can be predicted using set of EEG data. A predictive model can be develop find the depression level of the patient. For this it required EEG data signal of head injured patients. This study shows that EEG analysis can be used as a tool to identify and assesses brain related injuries and depression status of a patient.

2.8 Current Approaches for Diagnosis of Auto-regulation & Brain Injuries

Following is a comparison of the current methods used for diagnosis of auto-regulation and brain injuries.

2.8.1 CT Scanner

A computerized tomography (CT) scan is a combination of X-ray images. These images are taken from different angles and uses computer processing to create cross-sectional images of soft tissues inside our body.

Advantages of CT Scanner	1. Common imaging system in hospitals for head injured unconscious patients 2. CT is a non-invasive technique that gives images of each part of the brain 3. A CT scan can show the structure of the brain, blood vessels, other tissues and any abnormality within the skull 4. Fast scanning method (Sharma & Venugopalan, 2014) 5. Superior contrast in the images (Sharma & Venugopalan, 2014)
Disadvantages of CT Scanner	1. Fail to access the magnitude of the accumulated brain damage

Table 2.0: Advantages and Disadvantages of CT scanner

2.8.2 MRI Scanner

MRI stands for Magnetic Resonance Imaging. MRI is also one of the neuroimaging techniques for identifying brain damages.

Advantages of MRI Scanner	1. MRI is unique in its applicability to study both structure and function 2. High resolution in the image 3. Brain areas can be localized with millimetre(mm) spatial resolution (Liu et al, 2006)
Disadvantages of MRI Scanner	1. Compared to CT, EEG and MEG, it is a high cost scanner (Liu et al, 2006) 2. Comparing to other methods, number of machines is less 3. Fail to access the magnitude of the accumulated brain damage

Table 2.1: Advantages and Disadvantages of MRI Scanner

Electro-encephalogram (EEG) and Magneto-encephalography (MEG) brain imaging techniques has become an important tool in neuroimaging.

2.8.3 EEG

Electro-encephalogram (EEG) data have been used to study TBI patients' severity of injury, level of awareness, unconsciousness, and to predict patient's outcome.

Advantages of EEG Scanner	1. Highly sensitive in identifying in traumatic brain injuries (McBride et al, 2013) 2. It uses to study the severity of the damage 3. Non-harmful diagnostic tool for quantifying brain injurie

Disadvantages of EEG Scanner	1. By doing EEG it is difficult to find the exact location of the injury 2. Do not produce a visual image of the brain(Goel et al, 1996)

Table 2.2: Advantages and Disadvantages of EEG Scanner

2.8.4 MEG

Magneto-encephalogram has a remarkable merit of high temporal resolution at sub millisecond scale, capable of detecting the rapid changes of neurophysiologies processes. MEG is a common neuroimaging technique for identifying structures and function of the living human brain.

Advantages of MEG Scanner	1. MEG is a Non-invasive functional 2. Highly sensitive to abnormal slow wave signals
Disadvantages of MEG Scanner	1. By doing MEG, it is difficult to find the exact location of the injury **2.** Do not produce a visual image of the brain (Goel et al, 1996)

Table 2.3: Advantages and Disadvantages of MEG Scanner

2.8.5 The Best Approach

Currently in medical fields, the most common methods of diagnosing TBI are CT, MRI, EEG and MEG scanning, in addition to the history and physical examination. A research has been carried out of these methods to find out which tool is the best to use for the brain damage detecting system.

Comparing CT, EEG, MEG and MRI images, MRI is the most frequently used way of imaging in the brain. But MRI is a high cost scanner and there is only less number of machines in the hospital systems when compared to the other approaches. CT scan is the best approach when comparing to the other approaches because of its extensive availability, less cost, fast scanning and superior contrast.

2.9 CT Brain Images

It is useful to understand the availability of CT scan images are higher than the other scanning images and also acquiring a CT image is cheaper than other scanning images. These images are in the form of Digital Imaging and Communications in Medicine (DICOM) files. These medical images need to be converted into a general image file before detecting the brain damages or the severity of the brain damage.

2.10 Image Segmentation

Image segmentation can separate objects and identify background sharing similar characteristics. This could help to identify the number of objects in a complex image as well as to segment brain cells in the brain images to determine whether the lesions exist or not. However, due to the variety and complexity of images, image segmentation is a difficult task and the influence factors include the contrast, size, colour, illuminates and even to the noises of the images.

The purpose of image segmentation is to divide the image into several parts for the characteristics of consistency and non-overlapping regions, It is the basis of the of the image analysis. (Hui-jie, 2015)

2.10.1 Image Segmentation Technologies

Image segmentation is a process where image segmentation is divided into several non-overlapping regions and different characteristics in per region. Several methods can be used to segment images.

There are three image segmentation methods.

1. Image segmentation method based on region
2. Image segmentation method based on boundary
3. Image segmentation method based on the theory

Image Segmentation Methods		
Image Segmentation Based on Region	**Image Segmentation Based on Boundary**	**Image Segmentation Based on Theory**
Threshold Value	Hough Transformation	SVM
Split Consolidation	Surface Fitting	Rough Set Theory
Region Growing	Differential Operator	Fuzzy Theory
Clustering Method		

Table 2.4: Image Segmentation Methods

Image segmentation methods and its examples are clearly manifested in the table 2.4.

Following methods and techniques are used to segment images.

- Fuzzy C-means Clustering Methods
- K-means Clustering Methods
- Edge Detection Methods
- Region Growing Methods
- Watershed Transformation
- Histogram Thresholding
- Graph Partitioning Methods
- Level Set Methods
- Grey Level Co-occurrence matrix
- Support Vector Machine
- Genetic Algorithms

2.11 Frequently Used methods for Image Segmentation

Current methods use for image segmentation.

2.11.1 Thresholding

Thresholding is frequently used for image segmentation.

Thresholding is an essential procedure in the picture division process. The essential thought of programmed thresholding is to consequently choose an ideal dim level edge esteem for parceling pixels in the pictures into item and foundation in light of their dark level appropriation.

In this method, for an input colour image or gray image, the proposed technique transfers it to be a gray-level image, and then to observe the peaks and valleys of the gray-level histogram to determine the number of thresholds, after that to determine each threshold range from the histogram. In the end, to find the segmentation threshold can get the bi-level image or multilevel image. The method of finding peaks and valleys in the gray-level histogram is the most important objective in this method.

2.11.2 Edge Detection Methods

Picture edge recognition is a viable picture preparing device that gives fundamental picture edge data and qualities. Therapeutic picture edge location is a critical step towards object acknowledgment of the human organs, for example, cerebrum delicate tissues, and other distinctive organs. It speaks to a fundamental pre-preparing work in medicinal picture division.

Agaian and Almuntashri (2009) assess the execution of a few edge discovery systems and the Canny technique has ended up being better over large portions of the accessible edge identification calculations and along these lines was picked generally for constant usage and testing. The assessed calculations are Sobel, Roberts, Prewitt, Laplace, LOG and Canny calculation.

The vast majority of these applications are produced in light of CT pictures, a wide assortment of neural system sorts have been received for their investigation, and reported exploration results demonstrate to a great degree promising results for both picture division and edge location. Some ANN can decrease the impact of commotion in the picture and consequently make the division

more strong, settling on them a decent decision where picture clamor is a critical issue. (Jiang et al, 2010)

2.11.3 Watershed Transformation

The watershed change is a prominent division technique originating from the field of numerical morphology. "In this change the picture is think about as a topographic alleviation, where the tallness of every point is straightforwardly identified with its dim level, and consider rain bit by bit falling on the landscape, then the watersheds are the lines that different the "lakes" (really called catchment bowls) that shape" (Grau et al, 2004). For the most part, the watershed change is processed on the slope of the first picture, so that the catchment bowl limits are situated at high angle focuses. (Grau et al, 2004).

According to Grau et al, the watershed transform has been widely used in many fields of image processing, including medical image segmentation, due to the number of advantages that it possesses:

- Simple and intuitive method
- Fast and can be parallelized
- Produces a complete division of the image in separated regions, even if the contrast is poor

The watershed transform exist below drawback;

- Over segmentation
- Sensitivity to noise
- Poor detection of significant areas with low contrast boundaries
- Poor detection of thin structures

2.11.4 Fuzzy C-means Clustering

Fuzzy C-means clustering is a technique which has been effectively applied to feature analysis, clustering, classifier design in various fields and also in image segmentation. Using fuzzy C-means algorithm an image can be segmented grouping similar data points into clusters.

According to Muthukannan & Moses (2010) fuzzy clustering techniques have been effectively used in image processing, pattern recognition and fuzzy modelling. Grouping includes the assignment of separating information focuses into homogeneous classes or bunches so that things in the same class are as comparable as could reasonably be expected and things in various classes are as divergent as could be allowed. Bunching can likewise be considered as a type of information pressure, where countless are changed over into a little number of delegate models or groups. Contingent upon the information and the application, distinctive sorts of comparability measures might be utilized to distinguish classes, where the similitude measure controls how the bunches are shaped.

2.12 Selected Image Segmentation Methods

The selected approach for the use in the project is thresholding and watershed segmentation. In the threshold technique the image is segmented into similar areas on the basis of connected pixel values. Each of the pixels in a region is similar with respect to some characteristics or computed property such as color, intensity and/or texture. The Thresholding and watershed method is also classified as the pixel based image segmentation technique.

2.13 Classification of Technologies

The aim of this project is to develop an intelligent system to detect cerebral auto-regulation and brain damages after traumatic head injury. Artificial neural network and Fuzzy logic are some technologies found after several researches in the area of artificial intelligence which consist of several intelligent techniques for developing an intelligent detecting system.

2.13.1 Artificial Neural Network

An ANN is a scientific representation of the human neural design, mirroring its "learning" and "speculation" capacities. Therefore, ANNs have a place with the field of computerized reasoning. ANNs are generally connected in examination since they can show profoundly non-straight frameworks in which the relationship between the variables is obscure or exceptionally unpredictable. (Amato et al, 2013)

As indicated by Amato et al (2013) a neural system is framed by a progression of "neurons" or "nodes" that are sorted out in layers. Every neuron in a layer is associated with every neuron in the following layer through a weighted association. The structure of a neural system is framed by an "information" layer, one or more "concealed" layers, and the "yield" layer.

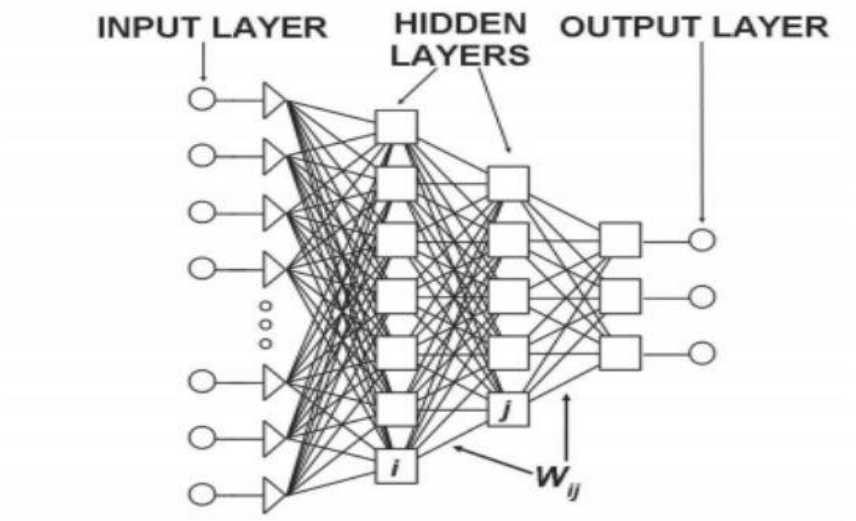


Figure 2.1 General Structure of a Neural Network with Two Hidden Layers (Amato et al, 2013)

The general scheme of a typical three-layered ANN architecture is given in Figure 2.1

ANNs represent a powerful tool to help physicians perform diagnosis and other enforcements. In this regard, ANNs have several advantages including:

1. The ability to process large amount of data
2. Reduced likelihood of overlooking relevant information

3. Reduction of diagnosis time ANNs have proven suitable for satisfactory diagnosis of various diseases
4. In addition, their use makes the diagnosis more reliable and therefore increases patient satisfaction (Amato et al, 2013)

2.13.2 Fuzzy Logic

Fuzzy logic provides a method to make definite decisions based on imprecise and ambiguous input data. Fuzzy logic is widely used for applications in control systems, since it closely resembles how a human make a decision but in a faster way**.** Fuzzy logic is a strong system for decision making programs, for instance structure classification systems and expert systems. Fuzzy set theory has already been used in some medical expert system. (Dagar et al,2015)

Fuzzy logic allows making definite decisions based on imprecise or ambiguous data, whereas ANN tries to incorporate human thinking process to solve problems without mathematically modelling them. Even though both of these methods can be used to solve nonlinear problems, and problems that are not properly specified, they are not related. (Dagar et al,2015)

In contrast to Fuzzy logic, ANN tries to apply the thinking process in the human brain to solve problems. Further, ANN includes a learning process that involves learning algorithms and requires training data. Using artificial intelligence will help in prompting better diagnosis results with the time period of training the system. It is always better to use neural network since there can be done vase training using a huge number of data set.

2.14 Chapter Summary

This chapter fully focused on literature review of this project. This will cover almost all the area of the project topic. The main objective of this literature review is to get the knowledge of all existing systems and researches.

This research area has covered by giving an introduction to the brain, looking anatomy of the brain, looking cerebral auto-regulation, traumatic brain injuries, currently available approaches, currently available technologies and techniques.

Classification of various techniques will explain the best approach in detecting brain damages. Imaging is an essential tool of the medical science to visualize the anatomical structures of the human body. Medical image analysis for identification and classification is an important task for many applications. In this literature review, it has mentioned the image segmentation methods that are available and have discussed about which imaging tool is suitable to analyse the brain damages.

Even there are several researches already exist, still this is an open research topic. All the imaging tools discussed in the literature review help to get knowledge in that area for further development process. This research helps to identify the best techniques and technologies that can apply for this project.

Chapter 03: Project Planning and Management

Chapter 03: Project Planning and Management

3.0 Chapter Overview

This chapter will focus on Software methodology techniques and tools and also each stage in the software development life cycle will be discussed with some examples. Furthermore, the different development process models will be explained and will give a justification of the best development process model that suitable for this project by comparing the advantages and disadvantages of each model. Identification of risks will be documented along with the risk mitigation plan. Further apart work breakdown structure and the Gantt chart will be documented well in the appendix.

3.1 Development Process Model

A development process model is an abstract representation of a process. It presents a description of a process from some particular perspective. Few development process models are listed below.

- ✓ Waterfall Method
- ✓ V Model
- ✓ Rapid Application Development
- ✓ Agile Method
- ✓ Spiral Model

3.1.1 Waterfall Method

In this methodology, all the stages follow an order. Every stage must be completely finished before the following stage starts. At the end of each phase a review takes place to determine the projects right paths and failures. The testing starts only after the development is complete. In **the** waterfall method phases do not overlap.

Advantages	Disadvantages
• Simple method that can understand and use easily.(Natalia,2012)	• Less flexibility. (Natalia,2012)

• Easy to manage and implement. (Natalia,2012)	• Required more time. (Natalia,2012)
• Phases are processed and completed one at a time.	• If there is a small change in any previous stage can cause big problems for subsequent phases as all phases are depending on each other
• Work well for small projects. (Natalia,2012)	• Going back a phase or two can be a costly affair

Table 3.0 Advantages and Disadvantages of Waterfall Method

3.1.2 V Model

V Model Stands for Verification and Validation model. It is same as the waterfall method. In this model each phase must be completed before the next phase begins. Testing is planned in parallel with a corresponding phase of development.

Advantages	Disadvantages
• Simple and easy to use. (Natalia,2012)	• Less flexible. (Natalia,2012)
• Avoids the downward flow of the defects.	• Software is developed during the implementation phase, so no early prototypes of the software are produced. (Natalia,2012)
• Works well for small projects where requirements are easily understood. (Natalia,2012)	• If any changes happen in midway, then the test documents along with required documents has to be updated. (Natalia,2012)

Table 3.1 Advantages and Disadvantages of V Model

3.1.3 Rapid Application Development

In this model all the components and functions are developed in parallel as considering them as small projects. The developments are time boxed, delivered and then assembled into a working prototype.

Advantages	Disadvantages
• Reduced development time. (Verma.P,2015)	• High dependency on modelling skills. (Verma.P,2015)
• Increases reusability of components. (Verma.P,2015)	• Requires highly skilled developers. (Verma.P,2015)
• Quick initial reviews occur. (Verma.P,2015)	• Inapplicable to cheaper projects as cost of modelling and automated code generation is very high. (Verma.P,2015)

Table 3.2 Advantages and Disadvantages of Rapid Application Development

3.1.4 Agile Method

Agile development model is also a type of Incremental model. Software is developed in incremental, rapid cycles.

Advantages	Disadvantages
• Working prototype is testing frequently. (Haunts.S, 2014)	• The project can easily get taken off track if it is not satisfied with the outcome. (Natalia,2012)
• Continuous attention to technical excellence and good design. (Haunts.S, 2014)	• There is a lack of emphasis on necessary designing and documentation. (Natalia,2012)

• Late changes in requirements are acceptable. (Haunts.S, 2014)	• Potential for scope creep. (Haunts.S, 2014)
• Focus more on the application rather than documenting things. (Natalia,2012)	• Agile processes are applicable for products where reliability is not very critical. (Natalia,2012)
• Daily meetings and discussions help to determine the issues well in advance and work on it accordingly. (Natalia,2012)	

Table 3.3 Advantages and Disadvantages of Agile Method

3.1.5 Spiral Model

The spiral model is similar to the incremental model. The spiral model mainly has four phases including planning phase, risk analysis phase, engineering phase and evaluation phase. A software project repeatedly passes through these phases in iterations. This model best in use for projects which has a large scope that required more management and planning.

Advantages	Disadvantages
• Good for large and mission critical projects. (Natalia,2012)	• Does not work well with small projects. (Natalia,2012)
• Strong approval and documentation control. (Natalia,2012)	• Risk analysis requires highly specific expertise. (Natalia,2012)
• Additional Functionality can be added at a later date .(Natalia,2012)	• Project success is highly dependent on the risk analysis phase. (Natalia,2012)
• This model is a very flexible model. (Natalia,2012)	• Spiral model is much customized for every project.(Natalia,2012)
• Software is produced early in the software life cycle. (Natalia,2012)	

Table 3.4 Advantages and Disadvantages of Spiral Model

3.1.6 Methodology Selections

For this project the software development process model that was selected was spiral model. This was selected by considering all the project information. The main reason for choosing this methodology is that this methodology incorporates further changes to the requirements. Additional functionalities can be added later. In a research project requirements change with the development of the project. So this methodology provides the ease of changing the prototype along with growth of the project.

Also another main advantage of this methodology is that the Software is produced early in the software life cycle and can test the prototype accordingly. When compared with the other development process models this model has a strong approval and documentation control. All are well documented.

3.2 Work Breakdown Structure

See Appendix 7

3.3 Gantt Chart

See Appendix 8

3.4 Risk Identification

Following will be the major risk that can be identified during the project life cycle.

1. Changes in the Software Requirements
2. Workload of other modules
3. Lack of knowledge in the IDE
4. Lack of knowledge in the language
5. Some technologies may have unseen difficulties during implementation
6. Hardware failure

3.5 Risk Mitigation Plan

	Risks	Likelihood of Occurrence	Impact	Risk Owner	Mitigation Plan
1.	Changes in the Software Requirements	Low	Medium	K.A.Ayani Nethma	Schedule late changes accordingly with the timeline
2.	Workload of other modules	Medium	Medium	K.A.Ayani Nethma	Allow for contingency time when planning
3.	Lack of knowledge in the IDE	Medium	Medium	K.A.Ayani Nethma	Follow online tutorials available in the internet
4.	Lack of knowledge in the language	Medium	Medium	K.A.Ayani Nethma	Research into the language and get help from experts in the industry
5.	Some technologies may have unseen difficulties during implementation	Medium	Medium	K.A.Ayani Nethma	Research into these technologies at the start of the project
6.	Hardware failure	Medium	Medium	K.A.Ayani Nethma	Follow suitable weekly backup methods

Table 3.5 Risk Mitigation Plan

3.6 Chapter Summary

This chapter fully focused on software development process model which was used to do the project. Detail description of multiple process models was included and justified the best development process model which work well for this project. A Work breakdown structure is produced in order to fulfill the project objectives and the final Gantt chart is also produced with the help of the work breakdown structure. Finally, the Risk for this project is identified and documented along with a risk mitigation plan.

Chapter 04: Software Requirement Specification

Chapter 04: Software Requirement Specification

4.0 Chapter Overview

This chapter will mainly focus on stakeholders, stakeholder roles, different elicitation techniques to gather requirements and different analysis models. Stakeholder analysis onion model will help to identify the stakeholders that interact with the system. This SRS review and verifies the best elicitation techniques to gather requirements by comparing the advantages and disadvantages of them and also this chapter will focus main functional and non-functional requirements of the system.

4.1 Identify Stakeholders

A stakeholder is a person or a legal entity in a development project that can influence the requirements of the system.

The aim of this project is to research, design, develop and evaluate an intelligent system to detect cerebral auto-regulation and brain damages after traumatic head injury. The following stakeholders have been identified in the system.

- ✓ Doctors
- ✓ Patients
- ✓ Medical Students
- ✓ Neurologists
- ✓ Radiologists
- ✓ Hospital Board of Directors
- ✓ CEO/ Shareholder
- ✓ Government
- ✓ Ministry of Health
- ✓ Competitors (Existing products)
- ✓ Developer
- ✓ Project Supervisor

4.2 Stakeholder Roles

The role of each stakeholder and their view point is clearly depicted in the below Table 4.0.

Stakeholder	Stakeholder Role	View Point
Doctors	Normal Operator Functional Beneficiary	This stakeholder wants the system to be functional
Medical Students	Normal Operator Functional Beneficiary	Wants to analyse MRI images to improve their academic and clinical skills
Neurologists	Functional Beneficiary	This stakeholder wants the system to be functional
Radiologists	Functional Beneficiary	This stakeholder wants the system to be functional
Patients	Functional Beneficiary	This stakeholder wants to get medical treatments to get into better condition
Hospital Board of Directors	Financial Beneficiary	Wants it to be a good return on investment and to obtain profits
Government	Political Beneficiary	Wants to gain financial profits
CEO/Shareholder	Financial Beneficiary	Wants it to be good return on investment and to obtain profits
Ministry of Health	Regulatory	Wants system to comply with rules and regulations / Want system to be run effectively and safely
Competitors(Existing Products)	Negative	Wants to find faults on the system
Developer	Expert : Software Opinion	Wants to market the developed product
Project Supervisor	Expert : Advisory	This stakeholder wants to guide the development of the system

Table 4.0: Stakeholders and Their Roles

4.3 Onion Model

Stakeholders of this project is analyzed and depicted on the following diagram.

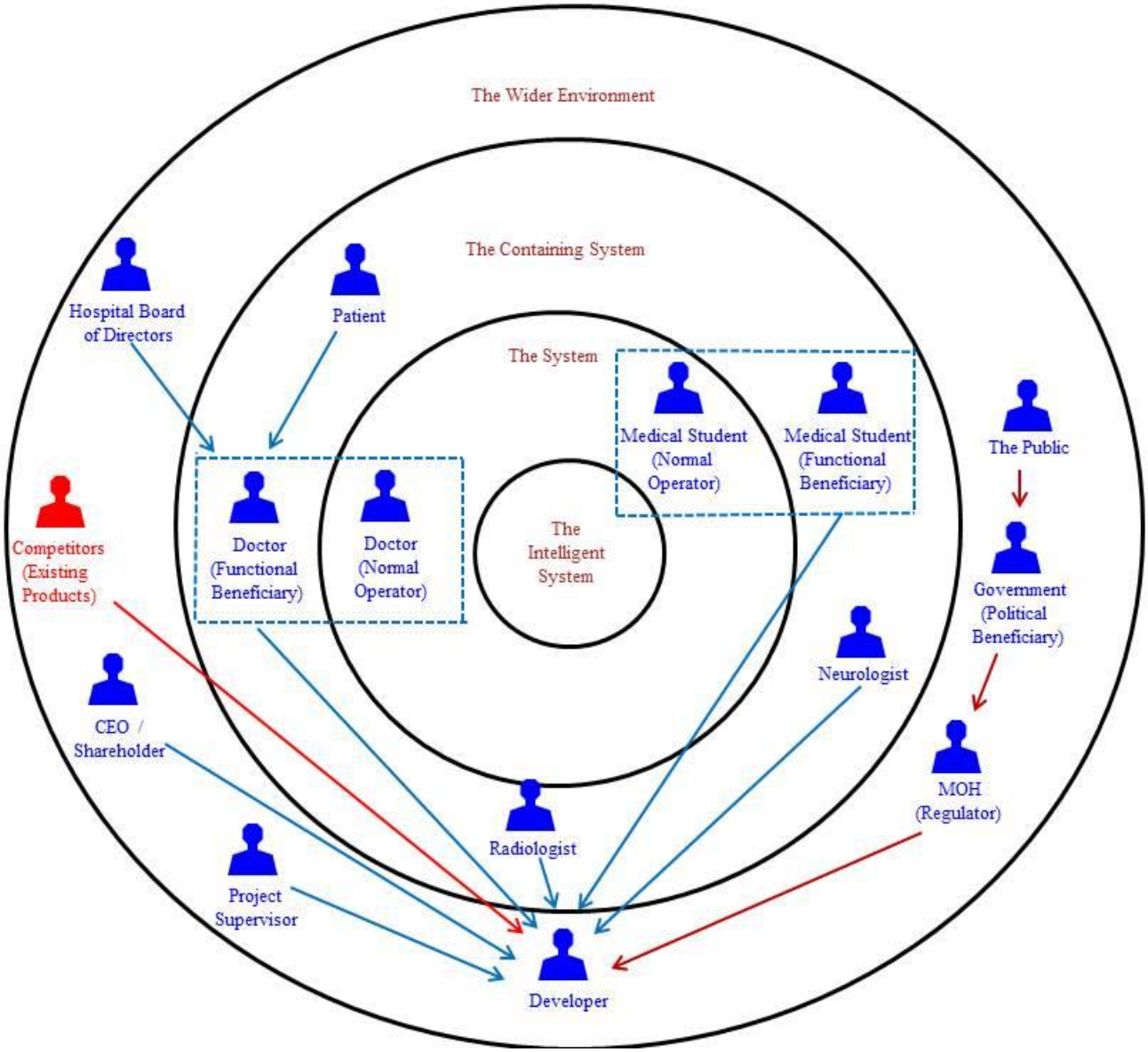


Figure 4.0: Onion Model Showing the Stakeholders of the System

4.4 Requirement Gathering Techniques

Following requirement gathering techniques are used to find out people's points of view and to learn what really happens in each execution.

1. Interviews
2. Apprenticing
3. Observation
4. Questionnaires
5. Brainstorming

Each of these techniques is compared below by giving advantages and disadvantages.

4.4.1 Interviews

Interviews are one of the most popular requirement elicitation techniques. They can be used to verify facts, engage end users, identify requirements and solicit opinions and ideas. An interview is a conversation with stakeholders to elicit needs and requirements. An interview may include one or more stakeholders. The interview should be planned of time based on the type of requirements that need to be identified. There are many good ways to plan the interview, but generally you want to ask open-ended questions to get the interviewee to start talking and then ask probing questions to uncover requirements. (Mochal.T, 2008)

Advantages of Interviews	1. Generally easy. It can be done with minimal preparation 2. Interviews require less planning and scheduling 3. Able to clarify or explore topic in more detail 4. Can be Formal or informal 5. Interviews provide an opportunity for the analyst to ask follow-up questions 6. Interviews allow the interviewee to respond freely and openly to questions ("Interviews.")
Disadvantages of Interviews	1. Interviews can be time consuming and inefficient if there is large number of stakeholders involved in the project

	2. Conflicts are unresolved as stakeholders do not get to hear each other's' points of view (Dieste et al.,2008) 3. Interviews can also be costly especially where stakeholders have to be interviewed one at a time or where the analyst has to travel to another geographical location to interview stakeholders 4. Quality of data by interviewer. The quality of data that gather will often depend on the ability of the interviewer. Some interviews have the natural ability to interview. Some people have very low interviewing skills (Wyse.S.E, 2014)

Table 4.1: Advantages and Disadvantages of Interviews

4.4.2 Observation

This involves in observing or studying stakeholder's work environment. This technique can also be used to verify requirements and deliver requirements.

Observation should be planned to ensure that all the required data elements are pre-determined beforehand. This will reduce uncertainty during the observation session and ensure that the analyst can focus on the task of observing without wondering which event should be recorded and which should not.

Observation involves looking at the actual work environment that the end user experiences every day. This technique is used when attempting to document an existing process or when a project's goal is to improve a process. Observation is a great way to understand what the end user goes through in their job and can provide some instant requirements for how a process can be improved (Pious.K, 2013).

Advantages of Observation	1. Better in discovering practical issues 2. Elicits details of informal communication and ways people actually work around the system that may not be documented anywhere
Disadvantages of Observation	1. Time consuming 2. May not observe all possible scenarios

Table 4.2: Advantages and Disadvantages of Observation

4.4.3 Questionnaires

Questionnaires are much more informal, and they are good tools to gather requirements from stakeholders in remote locations or those who will have only minor input into the overall requirements. Questionnaires can also be used to gather input from dozens, hundreds, or thousands of people (Mochal.T, 2008). A questionnaire is a technique that uses to gather information from many people, anonymously, in a relatively short time. A survey may comprise open-ended questions that allow users to provide answers in their own way or closed questions where users provide answers from a range of options.

Advantages of Questionnaires	1. Large amounts of information can be collected from a large number of people in a short period of time and in a relatively cost effective way (Rupesh, 2010). 2. Can be administered remotely 3. Can collect attitudes, beliefs, characteristics, features for the proposed system 4. They can be completed easily and quickly (Rupesh, 2010) 5. They should be simple and quick for the respondent to complete (Rupesh, 2010)
Disadvantages of Questionnaires	1. There is no way to tell how truthful a respondent is being 2. Lacks validity 3. The respondent may be forgetful or not thinking within the

	full context of the situation 4. Some people may not be willing to answer the questions (Rupesh, 2010)

Table 4.3: Advantages and Disadvantages of Questionnaires

4.4.4 Brainstorming

Brainstorming is used in a wide variety of ways, whether it is one person on their own or many people working together it can always be of some help. It is a cheap and easy way of getting ideas on how to solve problems. There are some projects the requirements are not discovered well. In this type of projects simple brainstorming can be used. Then the appropriate subject matter experts get together and start creatively brainstorming about the solution. After all the ideas are generated, the participants prioritize the best solutions for the problem. The best idea is used for the requirements (Mochal.T, 2008).

Advantages of Brainstorming	1. Brainstorming costs little to nothing to work 2. Doesn't require much resources 3. Not a very hard technique to understand 4. Helps provide widespread involvement throughout the group. 5. Good way to get over obstacles that are slowing the development of the problem solving(Sarah, 2010)
Disadvantages of Brainstorming	1. Can take a long time to work out the kinks if the group is not organized properly 2. Can be hectic, leading to people being afraid to speak their opinion 3. Can go into too much detail that some things may not be used 4. Can have repeats of opinions if people aren't paying close enough attention 5. May not end up with usable solutions (Sarah, 2010)

Table 4.4: Advantages and Disadvantages of Brainstorming

4.4.5 The Best Elicitation Technique

Comparing Interviews, Observation, Questionnaires and Brainstorming, Interviews is the most accurate way of gathering requirements. When comparing to other techniques conducting interviews is easy and it can be done with minimum preparation. This technique was used to gather requirements for this project as it's able to clarify or explore topic in more detail with the experts. Can ask open ended questions from the interviewee and get covered the requirements.

At the same time by conducting an online survey can quickly collect information from large number of people in the research community. When comparing with brainstorms and observation both the techniques consuming much time than questionnaires. It takes a long time to collect resources. Online questionnaires can be administrated remotely and can collect individual's beliefs, comments and feedbacks for the proposed system.

As this is a medical research project, interviewing and online questionnaires were selected to gather requirements by comparing its advantages and disadvantages.

4.5 Execution of Suitable Requirement Gathering Techniques

Requirements were taken from multiple sources and techniques to ensure wider coverage and impartiality of requirements. Following requirements elicitation techniques were used to gather requirements for the proposed system.

1. **Literature Review**

   A literature review was conducted to discover and focus on the anatomy of the brain, understanding the basic information about the brain, cerebral auto-regulation and classification of brain damages and how it happens. Through this review was able to gain a wide understanding of a majority of techniques and technologies used to detect cerebral auto-regulation and brain damages.

2. **Online Survey**

   An online survey with 15 questions was released to the research medical community. It was distributed among Doctors, Medical Students, Radiologists, Neurologists and people who are in the medical field. Over 16 days from 07.12.2015 to 22.12.2015, 34 respondents have given their feedback to the survey. It was valuable since it provides some comments and feedback from

some experience set of researchers and experts in the medical industry. The online survey questionnaire is shown in the Appendix 1.

3. Interview

An interview was conducted by two individuals who are experts in the medical industry. (See Appendix 5) This was conducted with a neurologists and a radiologist and it was a 15 minutes interview. Interviews were used to obtain in-depth information about the problems faced by doctors, radiologists and neurologists. It facilitated to understand the problems in different perspectives without solely making conclusions based on the responses received from the questionnaire. Interview questions are shown in the Appendix 5.

Medical researchers were keen on the methodology used to develop the automation process as they expect a system which will do a huge difference in a doctor's routine mainly by saving time. As time is the most important thing for a doctor and a patient, an automated detection tool as in this project will be a success in the medical field according to the interviewed researchers. Medical experts also agreed with the researchers when interviewed about imaging techniques and the impact that will occur by an automated detection system.

It is important to conclude that the interviewed personals were interested and very bright minded when they were asked about the introduction of such a system to them. Also they elaborated on the right requirement gathering part and the implementation area as it is very important to acutely focus on such areas due to the complexity of the research project.

4. Email Correspondences with Experts

From the beginning of the project was able to stay in touch with the research community and the authors of research papers to understand their viewpoints. Email and building up connections with the foreign research expertise is a great way of gathering requirements. The email correspondences between one such individual who helped me in finding test data sets and giving valuable feedback on the project are shown in the Appendix 3.

4.6 Analysis Phase

4.6.1 Design Approach

According to David Hay, 1999 Structured programming led to structured design, which in turn led to structured systems analysis. Structured design is mostly interacts with data flow diagrams rather than using objects. Object Oriented Modelling is based on objects rather than data. Object oriented design approach is selected to perform the analysis models of the system as it based on objects rather than data. Selection of the best design approach is clearly discussed in the next chapter.

4.6.2 Analysis Models

Key components related to the guide of questionnaire and the identified fundamental and main functionalities are demonstrated in this segment.

4.6.2.1 UML Use Case Diagram

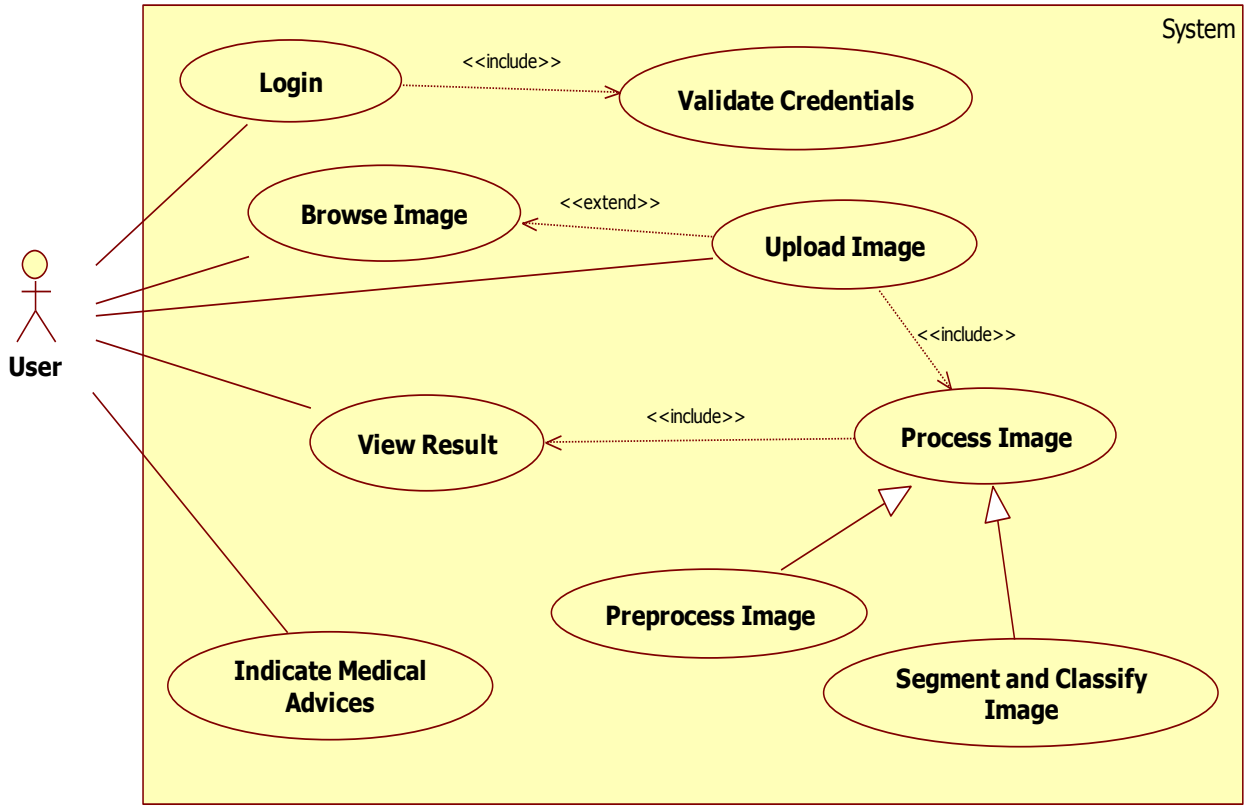


Figure 4.1 Use Case Diagram of the System

Identified functional requirements are modelled in the above figure 4.1 using UML use case diagram.

4.6.2.2 UML Class Diagram

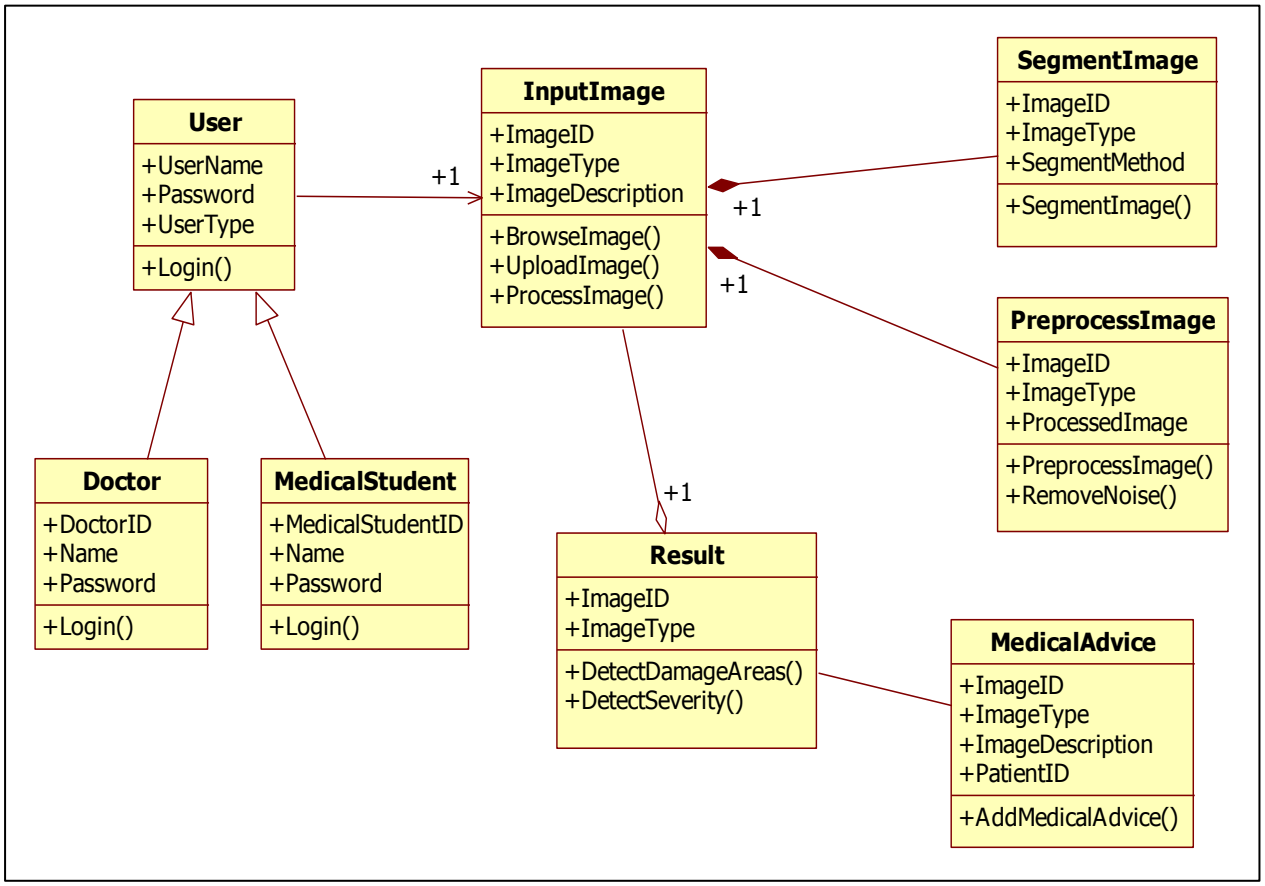


Figure 4.2 Class Diagram of the System

Above figure 4.2 shows the UML classes that interacts with the system.

4.6.2.3 UML Domain Model

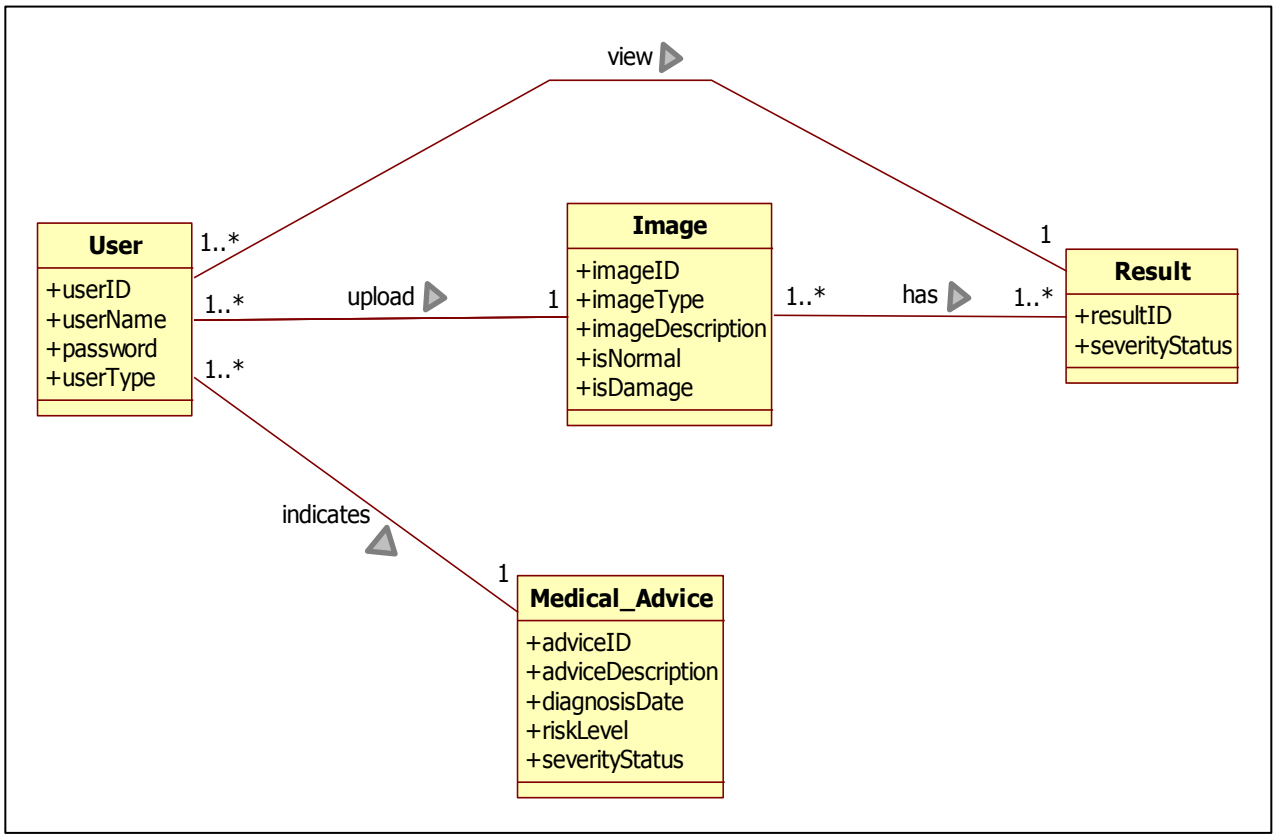


Figure 4.3: Domain Model of the System

4.6.2.4 Use Case Descriptions

Priority:	High
Use Case Name:	Upload Image
Summary:	The user logins to the system to read and analyse the damages of the brain image
Actors:	User (Doctor, Medical Student, Radiologist, Neurologist)
Pre-condition:	User must have been logged in to the system
Triggering events:	User selects 'Upload Image' option on the home window
Main flow of events	

Actor	**System**
2.User clicks 'Upload Image' button	1.System displays home window 3.System navigates to the brain images folder

4. User browse images 5. User selects an damage brain image to upload 10.User clicks 'View Result' option	 6.System displays the uploaded image 7.System pre-process the image by improving image quality 8.System segment image by using various segmentation methods 9.System displays the filtered images with damages
Alternative flow of events 1	
Actor	**System**
1. User clicks 'Upload Image' button	At 3: Displays an error message "Images folder is empty" Go back to 1
Alternative flow of events 2	
Actor	**System**
	At (2) System displays an error, "Please log into the system" when the user is not logged in to the system. 3. Perform Login use case
Exceptional flow of events	
At 3: System shows an error message , " System Unexpectedly Close, Please Try Again Later " After 3: At any point system shows an error message , "System Not Responding, Please Try Again Later"	
Post condition:	User can process (pre-process, Segment and Classify) the image in order to detect damages and predict the severity of the brain damage
Inclusions:	Process Image
Extensions:	Browse Image

Table 4.5: Use Case Description for Upload Image Use Case

4.6.2.5 Functional Requirements

The main functional requirements of the system are specified below in Table 1.1.

(E = Essential, D = Desirable, L = Luxury)

ID	Functional Requirements	Description	Priority
FR1	User should be able to login to the system	Doctors, Medical student, Radiologists and Neurologists are able to login to the this system	E
FR2	The system should be able to read and support DICOM medical images	All the MRI images are in DICOM / MNC format. This system should be able to read these images	E
FR3	Should be able to upload CT brain images to the system	MRI images will be stored in a folder and user should be able to load the image to the system	E
FR4	Preprocess the CT images	System should improve image quality by manipulating the parameters of image	E
FR5	Should be able to segment and classify the CT images	Classify types of brain injuries that include image processing, principal component analysis and identification	E
FR6	System should display the damage areas of the brain	System should be able to indicate the damages areas of the brain	L
FR7	The system should detect the severity of the brain and display the status	Once the processes is completed the system should state the severity (Brain injury: Light, Medium or Heavy) of the brain damage of all given images.	E
FR8	Should be able to enter risk factors emerged by the patient	There should be an option for the user to state the risk factors that found after processing the brain image.	D
FR9	Should be able to enter required medical advices	User should be able to enter the medical advices after examine the medical image using the proposed	D

		system	
FR10	System should save entered records	Once the user completed entering, the system should be able to save the entered records	D
FR11	System should be able to measure and display arterial blood pressure and cerebral blood flow of the patient	System should be able to measure the patients arterial blood pressure and cerebral blood in order to find the failing point of auto-regulation	L

Table 4.6: Functional Requirements

4.6.2.6 Non Functional Requirements

NFR1: Performance

Performance requirements are the facts that the system must perform as what every user expects. There should not be any delays in actions, such as loading the image, browsing an image, opening a window, saving the records. The database should be able to handle a minimum of 300 records of images. And also this system should support use of multiple users at a time.

NFR2: Safety

The database may get crashed at any certain time due to virus or operating system failure. Therefore, it is required to take the database backup. In case of a potential breakdown on the database the backup database can be used.

NFR3: Accuracy

Accuracy The system should have a very high accuracy of results. As these results are very crucial to the patient, it is very important to have a system that is very accurate.

NFR4: Availability

It is a must to check that the system always has something to function. When the user perform an invalid function make sure the system always popup error messages in order to warn the user. In this case error messages appear when something goes wrong.

NFR5: Reliability

The system should be reliable as it is a medical application, many doctor prefer to give fully accurate feedback to their patients. Due to this the application should make sure that the output is as accurate as possible.

NFR5: Usability

Checking the system whether it's easy to handle and navigates without any delays. This will check how easy to navigate windows in the system. There should be user-friendliness throughout the system. User should be able to browse and upload images without any delays.

4.7 Chapter Summary

This chapter begins with stakeholders and their roles. Then the stakeholders of this project are analyzed and depicted using the onion model. After identifying the stakeholders and their roles, this chapter reviews with a detailed description of the different requirements elicitation techniques. Advantages and disadvantages of each technique are clearly discussed in the above topics. Literature review, Online Survey, Interviews has been used to gather requirements for the proposed research project. The online survey provided valuable information about the problem and further the feedbacks from those experts helped to fix the scope of the project.

Object oriented design approach is then provided. Use case diagram and use case descriptions are provided to identify the main functionalities of the system. UML Class diagram and the Domain model are provided in order to identify the interactions with the system.

A comprehensive discussion on the functional and non-functional requirements is then provided. Finally the scope refinement is also described in this chapter.

Chapter 05: Design

Chapter 05: Design

5.0 Chapter Overview

The first section of this chapter will discuss about the various design methodologies and it will select the best design methodology that is suitable for this project. Next will discuss about the various design tools and the justification for choosing the most suitable design tool for this project. The next section will discuss about the design goals and the high level architecture of the system that form the foundation of the design and implementation of the solution. Finally, this chapter will discuss about the low level design models including Class diagrams, Component diagrams, Deploy diagrams and Sequence diagrams.

5.1 Design Methodology

A methodology is a procedure for determining the issues of the present system or for building another one. There are numerous methodologies for the outline and improvement of data frameworks which include, Structured Systems Analysis and Design, Rapid Application Development (RAD), and Object-Oriented Analysis and Design. Following will include a discussion of Structured Systems Analysis and Design and Object-Oriented Analysis and Design respectively.

5.1.1 Structured System Analysis Design

Structured Systems Analysis & Design methodology (SSAD) is a structure of exercises and assignments that should be expert to build up a data framework. This strategy as said already is known as the waterfall model as every real period of the system streams descending into the following stage. Therefore, this approach is a methodology comprising of different strategies, devices, documentation and errands that should be incorporated so as to build up the system. The SSAD depends on the idea of practical deterioration where the expert separates the framework into the fundamental procedures that make it up and afterward separates these into smaller ones, thus on until the examiner sees all the crucial parts of the system being researched.

Advantages of structured system analyse design	1. SSAD is relatively simple and easy to understand (Kenneth.P, 2008) 2. This methodology is very well known and established methodology in the industry (Kenneth.P, 2008) 3. SSAD is very visual, it makes it easier for programmers to understand (Kenneth.P, 2008)
Disadvantages of structured system analyse design	1. Since SSAD is process-oriented, it ignores the non-functional requirements (Kenneth.P, 2008) 2. SSAD does not always address the user's requirements (Kenneth.P, 2008) 3. SSAD is non-iterative, so that requirements changes would mean restarting the entire process (Kenneth.P, 2008)

Table 5.0: Advantages and Disadvantages of Structured System Analyse Design

5.1.2 Object Oriented Design

Object oriented analysis is the procedure of building up an object oriented model of the issue area where the underlying items speak to the elements and strategies identified with the issue that should be determined. In Object Oriented Modelling, code and data are merged into a single unbreakable thing, called an object. Object oriented design is the procedure of building up an item arranged model of the system important to meet the predefined necessities.

Advantages of object oriented design	1. Easy to understand 2. OOAD significantly simplifies the development of the system compared to SSAD (Kenneth.P, 2008) 3. OOAD improves the quality of the system due to program reuse(Kenneth.P, 2008) 4. OOAD methods make code more maintainable 5. This method reduce the development time and cost

Disadvantages of object oriented design	1. In OOAD, it is difficult to decide all the important classes and objects required for a system 2. In OOAD the initial designs for the system may be too simplified to be adequate (Kenneth.P, 2008)

Table 5.1: Advantages and Disadvantages of Object Oriented Design

5.1.3 Best Design Methodology

An examination between Structured System Analyse Design and Object Oriented Design is given below.

Structured System Analyse Design	Object Oriented Design
Process oriented design approach	Object oriented design approach
Main focus is process	Main focus is data or objects
High risk in using this methodology	Low risk in using this methodology
Reusability is low	High reusability
Suitable for well-defined projects with stable user requirements	Suitable for risky large projects with changing user requirements

Table 5.2: Comparison between Structured Systems Analyse Design and Object Oriented Design

Object Oriented Design methodology was selected as the suitable design methodology for this project by considering its advantages and disadvantages. Table 5.2 illustrates a clear comparison of the two main methodologies. Object Oriented Design methodology was selected as it is very easy to understand and it mainly focuses on data and objects. That was a major reason for selecting OOD as the design approach.

Although the Structured Systems Analyse Design methodology provides many benefits, it does not resolve all the issues associated with the project. This intelligent system is mainly focused on data and creation of objects.

Thusly, the advantages and points of interest picked up from utilizing the new OOAD strategy can be much greater and more remunerating for the association in the long term than utilizing the conventional SSAD methodology.

5.2 Design Tools

5.2.1 Star UML

Star UML is an open source UML demonstrating application authorized under a modified version. Since the objective of star UML is to contend with the business UML displaying applications like Microsoft's Visio and Rational Rose, star UML gloats a complete arrangement of UML modelling features. Following is a list of key features of star UML.

- Open source designing tool.
- Easy online access.
- Supports the vast majority of the diagrams determined in UML.
- Very rich feature set and formatting options.
- Ability to create source code from the UML diagram.
- Reverse engineer the existing code into UML diagrams.
- Supported languages like C, C# and Java.
- Fast load time/execution time contrasted and other UML tools.
- Supports exporting diagrams into JPG / XMI formats.

5.2.2 Rational Rose

Rational Rose is an object-oriented Unified Modeling Language (UML) programming outline instrument proposed for visual displaying and segment development of big business level programming applications. Rational rose has following key features.

- It is not an open source tool. Rational rose is licensed.
- Rational rose is extensible.
- High cost compared to star UML.
- Ability to give iterative advancement

For this project the designing tool that was selected was Star UML, since it pursued its advantages when compared to the other designing tool. Start UML would benefit this project as it is an open source designing tool and easy online access.

5.3 Design Goals

The design should be flexible and extensible, ensure the reusability for the next phase of the development. The architectural goals for this project are listed below in the table 5.3.

Constraint	Description
Availability	The stage ought to be up and running 24x7. Any disappointments of a segment ought not to trade off the entire system. Such disappointments will be taken care of smoothly.
Usability	The system should be easy to use for the user.
Efficiency	The system should be highly efficient when fully implemented. It should not have any crash in other technical fault.
Extendibility	As the system is particular, it will effectively bolster including new components, features and extensibility. It will be implicitly, such a route, to the point that future advances can be effectively utilized by the system with least revise to the code.
Performance	Performance requirements are the facts that the system must perform as what every user expects. There should not be any delays in actions.
Scalability	The system ought to scale well when the information volume and number of exchange increments.
Portability	This system should be portable across operating systems.

Table 5.3: Architectural Goals

5.4 High Level Architecture

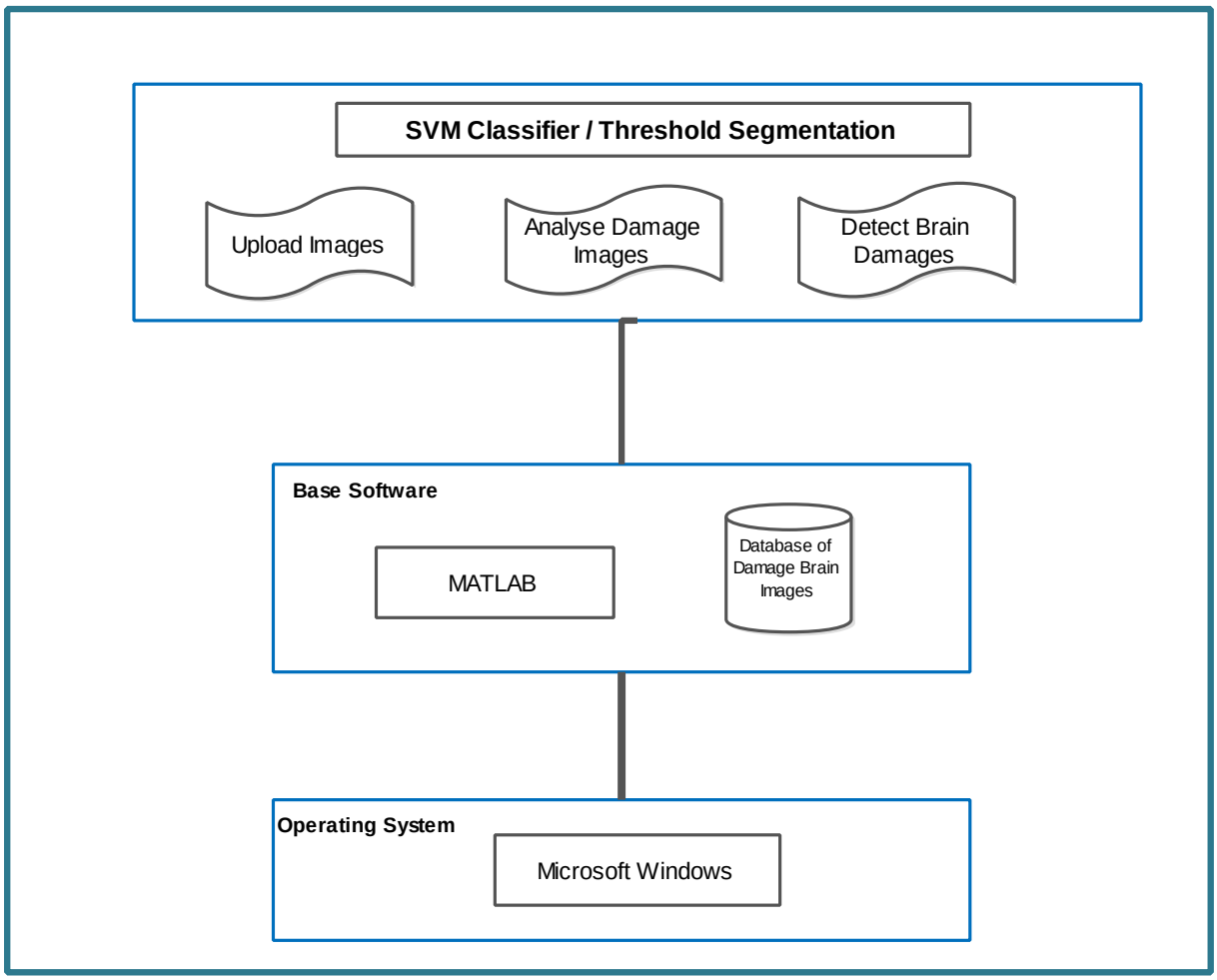


Figure 5.0: High Level Architecture of the System

Figure 5.0 above clarifies the information move through the system. Users can upload a damage brain image from the image database. The system will then prompt the user to select a suitable method to segment the images. Method selection is done by the user. Additionally, the system can save patient data with necessary treatment advices.

5.5 Low Level design Model

5.5.1 Class diagram

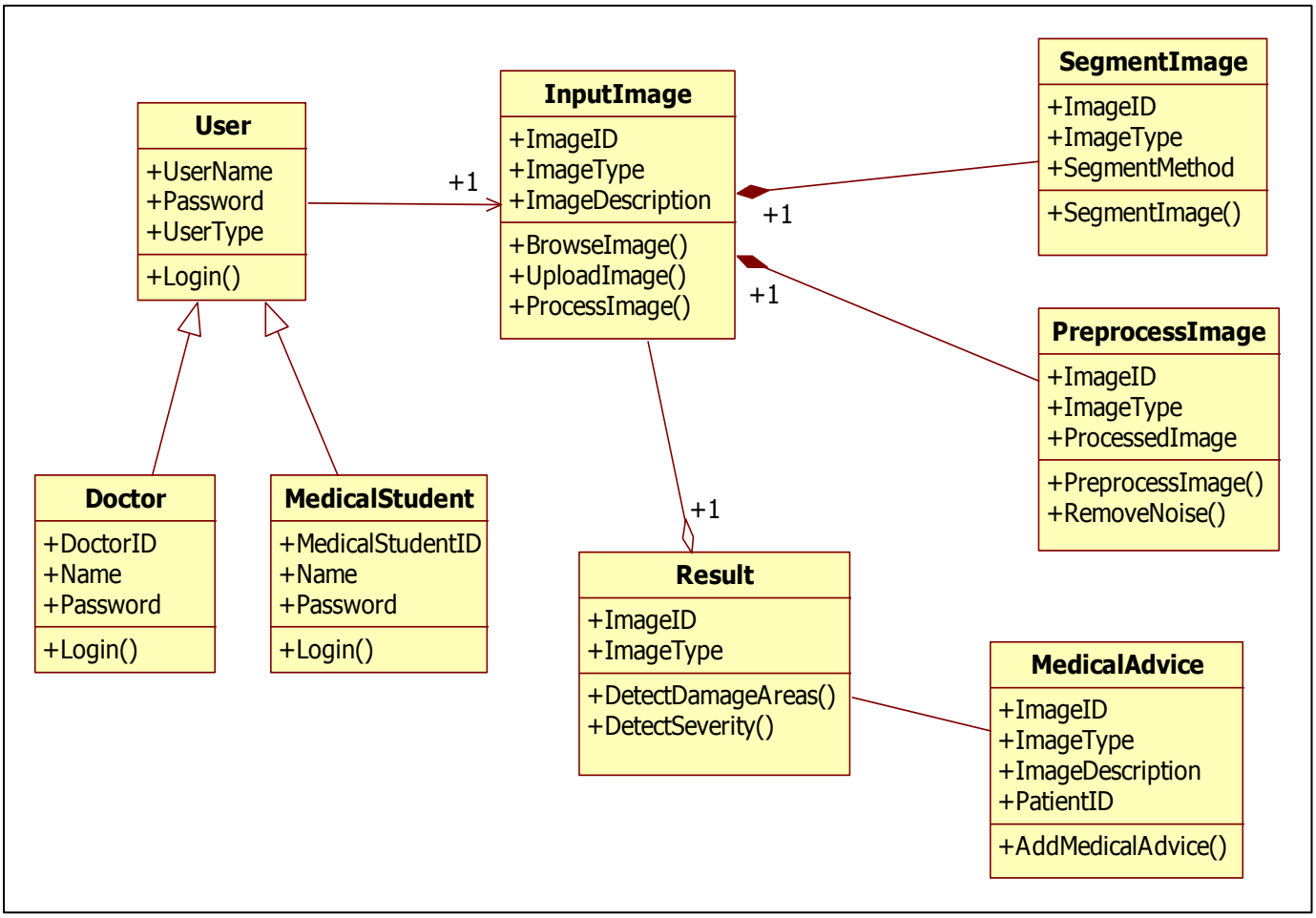


Figure 5.1: Class Diagram of the System

5.6 Chapter Summary

This chapter gave an important perspective of the outline of the intelligent system and justified the establishment whereupon the system will be executed. First the main design methodologies were presented to the reader. Object Oriented Design and structured system analyse design were presented with advantages and disadvantages. The justification of the best design methodology was then presented by comparing its advantages and disadvantages.

Design tools are then explained with the extensive use of advantages and disadvantages. Start UML and Rational Rose were compared and Star UML was chosen as the best design tool for this project. Design goals were presented and a high level architecture was then illustrated using a rich picture to give the user a superior comprehension of the project. High level architecture was designed in order to support design goals.

Next a low level design model was presented. Class diagram, component diagram, deploy diagram and sequence diagrams were illustrated under the low level design model.

The next section will depict how the functionality of the system was implemented; furthermore, it talks about the difficulties confronted amid usage.

Chapter 06: Implementation

Chapter 06: Implementation

6.0 Chapter Overview

This chapter will discuss how the development of the prototype and how each feature was carried out. This section plans to describe how each functionality of the system distinguished in the prerequisites gathering stage is implemented utilizing the skeleton of the system illustrated in the design chapter. Firstly, it will include the high level architecture of the technology stacks, technology selection and justifying tool selection. It will give the method of reasoning for selecting the programming language, programming tools, operating system and the development environment. Then the development of each core functionalities and features will be described with suitable code segments and UI screenshots. Finally, it will include an account of problems encountered during the implementations. The solutions that were found to fix those problems will be discussed in details at the end of this chapter.

6.1 Programming Technology and Tool Selection Process

6.1.1 Operating System

Selection of Operating System affects many implementations. As this is a system related to the medical field Microsoft windows was chosen as the operating system by considering the users of this system. Most of them will be from the medical field and they are much familiar with windows operating system rather than using a new operating system.

6.1.2 Programming Environment

MATLAB is selected as the programming IDE for this project, which is a fourth generation programming language that provides various toolboxes which can be used to implement different functions. MATLAB was used for implementation as it has very good documentation and this was used in most existing segmentation systems. MATLAB also provides efficient functions for image processing.

MATAB allows testing algorithms immediately without recompilation and also this is a desktop environment which allows working interactively with data sets and helps to keep track of files and

variables and simplifies common programming tasks. Therefore, MATLAB is selected as the programming IDE for this project.

6.1.3 Technology Selection

To produce a successful system it is important to carefully select the technologies and focus on their technical aspects of the system. Technology selection was primarily done by focusing on the research carried out in the literature survey and also by considering the requirements of the system.

6.1.3.1Image Processing and Segmentation

Image processing should be carried out on the image before performing any other actions because images will consist of noise. Noise should be removed in order to achieve a clear image, which can be processed further for the system requirement. Noise removal in the system is mainly carried out by applying the SVM and Threshold function. Then the images can be segmented to detect the damages.

6.1.4 Programming Tools

6.1.4.1 Image Processing Toolbox

Using this toolbox can perform image analysis, image segmentation, image enhancement, noise reduction and geometric transformations. Image Processing Toolbox supports a diverse set of image types, including high dynamic range, resolution and tomographic. The toolbox underpins workflows for processing, displaying, and navigating large images.

6.1.4.2 Statics and Machine Learning Toolbox

The toolbox gives supervised and unsupervised machine learning calculations, including support vector machines (SVMs), k-means, hierarchical clustering and Gaussian mixture models.

SVM is in the field of machine learning and have utilized as a part of the advancement of this project. The advantages of SVMs incorporate high accuracy, exquisite numerical tractability, and direct geometric translation. As of late, numerous enhanced SVMs have become quickly, among

which the kernel SVMs are the most well-known and effective. Kernel SVM work extremely well and have been amazingly effective in such different fields as regular dialect arrangement. In this way this machine learning method was chosen.

6.2 Implementation of Core Functionalities

This section will explain what set of functional requirements is implemented in the prototype from the requirements discovered in Chapter 3.

6.3.1 User /Operator Login

```
76      % --- Executes on button press in Login_Button.
77      function Login_Button_Callback(hObject, eventdata, handles)
78      % hObject    handle to Login_Button (see GCBO)
79      % eventdata  reserved - to be defined in a future version of MATLAB
80      % handles    structure with handles and user data (see GUIDATA)
81
82 -    ID = get(handles.edit1,'string');
83 -    PW = get(handles.edit2,'string');
84
85 -    if strcmp(ID,'admin') && strcmp(PW,'admin')==1
86 -    msgbox('Login Succesfull!!');
87      % close current figure
88 -    closereq;
89 -    Main_Menu;
90
91 -    set(handles.figure,'Visibility',false);
92 -    else
93 -    errordlg('Invalid Username or Password');
94 -    end
```

Code Snippet 1: User Login

Above code snippet depicts the development of the login user interface. Users can login to the system by providing their username and the password. A successful login will then prompt for the main menu of the system. Main menu consists of two damage segmentation methods and users can select either one of them to detect the brain damages.

6.3.2 Uploading a CT Brain Image to the System

Below are the user interface and the code snippet of uploading a CT brain image to the system. The user can click on the 'Load Image' button to insert a damage brain image. Then it will prompt a window to browse for an image. Then the user can browse for a suitable damage image and can upload into the system in order to detect damage.

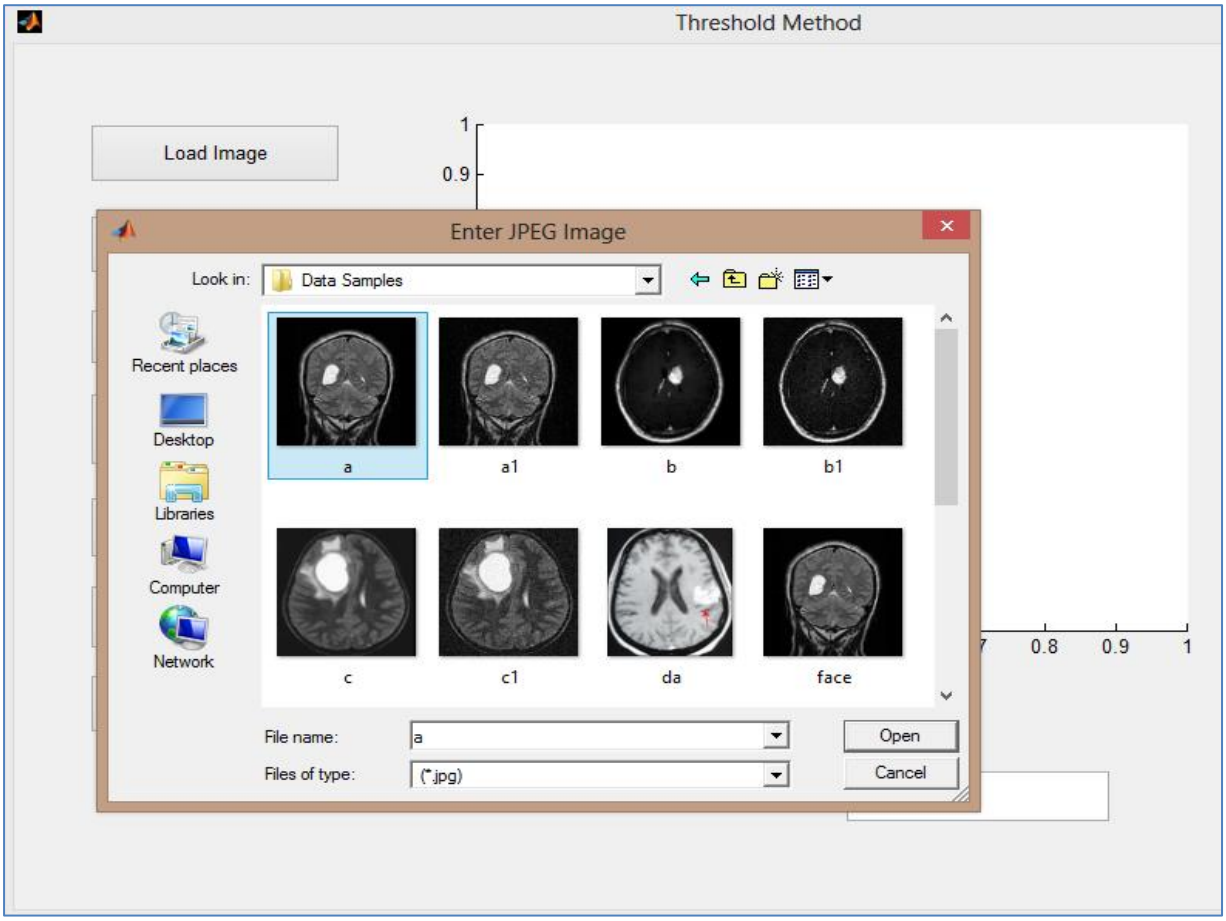


Figure 6.0: Uploading a CT image to the System

```
76      % --- Executes on button press to upload an image to the system.
77      function pushbutton1_Callback(hObject, eventdata, handles)
78      % hObject    handle to pushbutton1 (see GCBO)
79      % eventdata  reserved - to be defined in a future version of MATLAB
80      % handles    structure with handles and user data (see GUIDATA)
81
82 -    [fname path]=uigetfile('*.jpg','Enter JPEG Image')
83 -    fname=strcat(path,fname);
84 -    im=imread(fname);
85 -    [x y z]= size(im);
86 -    if( z>1)
87 -        im=rgb2gray(im);      % To convert a color RGB image to grayscale, use 'rgb2gray'.
88
89 -    end
90 -    im=imresize(im,[256,256]);
91 -    imshow(im),title('Actual Image');
92 -    save imageD im
93
94 -    im = imresize(im,[256,256]);
95 -    imshow();
```

Code Snippet 2: Uploading an Image to the System

6.3.3 Remove Noise and Preprocess the CT images

```
110     %---- Image Filter ----------
111     function pushbutton3_Callback(hObject, eventdata, handles)
112     % hObject    handle to pushbutton3 (see GCBO)
113     % eventdata  reserved - to be defined in a future version of MATLAB
114     % handles    structure with handles and user data (see GUIDATA)
115
116 -   load imageD;
117 -   im=imresize(im,[512 512]);
118 -   [r c]=size(im);
119 -   imggray=im;
120 -   b=zeros(r,c);
121 -   fil=[-1 2 -1;0 0 0;1 -2 1]; % filtering
122 -   b=imfilter(imggray,fil);
123 -   M=max(max(b));
124 -   b1=double(b)./double(M);
125 -   b1=b1*255;
126 -   imshow(uint8(b1)),title('Median Filtered Image');
127 -   save imageD b im r c imggray
128
```

Code Snippet 3: Image Filter

According to the above code segment filtering of the image use a multidimensional array imggray with the multidimensional filter file. Imfilter function is used to remove noise and filter the image. Below UI screenshot depicts the above.

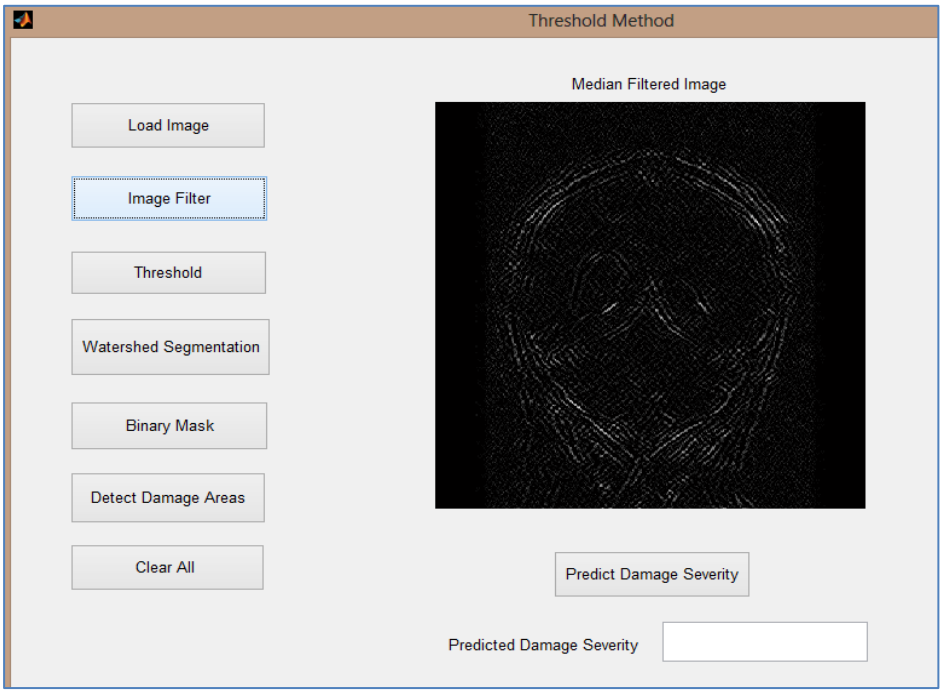


Figure 6.1: Filtering the Uploaded Image

6.3.4 Applying Threshold and Watershed Segmentation

```
131      %---- Image Threshold ----------
132      % --- Executes on button press in pushbutton4.
133      function pushbutton4_Callback(hObject, eventdata, handles)
134      % hObject    handle to pushbutton4 (see GCBO)
135      % eventdata  reserved - to be defined in a future version of MATLAB
136      % handles    structure with handles and user data (see GUIDATA)
137 -    load imageD
138 -    c1=c;
139 -    c=b+imggray+25;
140 -    c=medfilt2(c);
141 -    imshow(c),title('median filtered result');
142 -    save imageD b im r c imggray c1
143
144
145      %---- Watershed Segmentation ----------
146      % --- Executes on button press in pushbutton5.
147      function pushbutton5_Callback(hObject, eventdata, handles)
148      % hObject    handle to pushbutton5 (see GCBO)
149      % eventdata  reserved - to be defined in a future version of MATLAB
150      % handles    structure with handles and user data (see GUIDATA)
151 -    load imageD
152 -    wg=watershed(c);
153 -    imshow(wg),title('watershed segmentation')
154 -    save imageD b im r c imggray c1 wg
155      % enhanced image
```

Code Snippet 4: Applying Threshold and Watershed Segmentation

Above is the code segment for thresholding and watershed method. Image thresholding is a simple, yet effective, way of partitioning an image into a foreground and background. This image analysis technique is a type of image segmentation that isolates objects by converting grayscale images into binary images. Thresholding is use to extract pixels from the image and segment the image.

```
%---- Detect Damage Areas ----------
% --- Executes on button press in pushbutton7.
function pushbutton7_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

load imageD
[r2 c2]=size(bw3);        %imposing identified tumor location on to the input image
newImg=zeros(512,512,3);
newImg(:,:,1)=imggray;
newImg(:,:,2)=imggray;
newImg(:,:,3)=imggray;
for i=1:1:r2
    for j=1:1:c2
        if bw3(i,j)==1
            imggray(i,j)=255;
            newImg(i,j,2)=255;

        else
            imggray(i,j)=imggray(i,j)*0.5;
        end;
    end;
end;
```

6.3 Problem Encountered and Solutions Found

There were several problems that identified during the implementation of this system. These problems are clearly documented below with its solutions.

- Lack of data sets

  Lack of data was a huge problem to test the system. It was difficult to get normal and damage CT images of the brain. With the help from international researchers and found some useful websites to get data sets.

- Lack of knowledge in image processing

  The project's main module was image processing and the absence of knowledge in this section was a huge challenge in the beginning. This was overcome by reading lots of research work on image processing and doing tutorials available online.

- Lack of knowledge in the IDE and language used in the project

  At the beginning of the project, it was very hard to work with MATLAB due to the lack of knowledge about it. MATLAB tutorials were done with the help of MATLAB documentation. With this the language and the IDE became familiar.

- Lack of knowledge in the neural network

  Damage areas were identified and could not implement how to predict the severity of the brain damage. This was identified as a major risk because it is one of the main functions of the system.

6.4 Chapter Summary

This section points of interest the execution of features found in the requirement analysis chapter. Firstly, it depicted the high level architecture of the technology integration. Secondly, it justified the selection of windows as the main operating system and MATLAB as the main programming environment. It also showed how the technology was selected and the technologies used in the project were also listed and discussed.

The implementation of the core features of the prototype is then documented. The implementation of the login process of the system is described using code samples and UI screenshots. The functionalities of each image segmentation method use in the system are explained well in detail. Furthermore, each method is explained in detail with appropriate screenshots. Segmenting damage is clearly depicted using UI screenshots.

Finally, it contains a discussion of problems that were encountered during the project time. It will also contain the solutions that were found in order to overcome the problems. The next chapter contains the testing of the prototype and it will provide the test cases carried out and results obtained from the system.

Chapter 07: Testing

Chapter 07: Testing

7.0 Chapter Overview

Previous chapter provided an overview to the implementation phase of the project prototype. This Chapter provides an overview of the testing phase of the system prototype. Since testing is the main stage of a successful system, it should be thoroughly tested before handing over. The testing of the system will be done according to the functional testing criteria. The appropriate test plans and test cases will be presented.

7.1 Objectives and Goals of Testing

The testing of the system has kept in mind the end goal to confirm the complete working of the system in admiration to the normal results identified in the requirements. The main objectives for the testing of the system is,

- To verify the functioning of the core features of the system.
- To identify the functioning of the sub functionalities of the system.
- To recognize existing bugs and mistakes in the system so that the bug and error count in the final system can be reduced.
- To identify new enhancements and apply them to the system.

7.2 Testing Criteria

There are several types of testing that should be done on a large scale software system. At least some of these test types should be carried out in a project to maintain its success rate. These test types are conducted within various stages of the development lifecycle to accomplish the desired standard. The testing criteria include unit testing, integration testing, module testing and black box testing. These are the functional aspects of testing. Non-functional testing includes performance, accuracy and security.

7.2.1 Unit Testing

This testing involves testing software units or groups of the whole project. This encourages developers to modify the source code without immediate concerns about how such changes might affect the functioning of other units or the program as a whole. Once all of the units in a program have been found to be working in the most efficient and error free manner possible, larger components of the program can be evaluated by means of integration testing. Unit testing can be time consuming. (Rouse.M, 2007)

7.2.2 Module Testing

It is also called as module testing. The basic difference between the unit testing and component testing is in unit testing the developers test their piece of code, but in component testing the whole component is tested.

7.2.3 Integration Testing

Integration testing is testing combined software component to evaluate the integration between them. Integration testing is a logical extension of unit testing. Components and back-end components can be combined and tested alongside each other.

7.2.4 Black-Box Testing

This testing is only aware of what the software is supposed to do, not how it is done. So this allows the quality assurance personnel to examine the application's functionality with internal implementation. In a black box test on software design knows only the inputs and what the expected outcomes should be and not how the program arrives at those results. During the testing, it does not ever examine the programming code and does not need any further knowledge of the program other than its specifications.

7.3 Selection of Testing Tools

Even though integration testing is a major testing technique, it was not carried out in this prototype testing since the front and the back-end was not integrated. For this prototype the testing criteria selected was unit testing and black box testing.

7.4 Test Cases

Functional testing of the system is carried out in order to identify how well the implementations of the system's features are functioning. Here, the test cases covering all the functional requirements are defined along with the expected result. The test cases were carried out respectively and the results were documented.

7.4.1 Public User Interface Testing

ID	Test Description	Possible Inputs	Expected Output	Actual Output	Status
1	Verify that all the button links work	Click on each button	Load the relevant window into the system	Load the relevant window	Passed
2	Verify spellings of method 1 UI content	N/A	No spelling mistakes	No spelling mistakes	Passed
3	Verify spellings of method 2 UI content	N/A	No spelling mistakes	No spelling mistakes	Passed
4	Verify method 1 button links are aligned to the left	N/A	All the buttons should be aligned to the left	Buttons are aligned to the left	Passed
5	Verify method 2 button links are aligned to the left	N/A	All the buttons should be aligned to the left	Buttons are aligned to the left	Passed

Table 7.0: Test Cases for Public User Interface Testing

7.4.2 User Login Testing

ID	Test Description	Possible Inputs	Expected Output	Actual Output	Status
1	Verify spellings in the login screen	N/A	No Spelling mistake	No spelling mistake	Passed
2	login with an invalid Username and Password	N/A	Display error “Invalid Username or Password”. Do not allow login	Display error “Invalid Username or Password”. Do not allow login	Passed
3	Enter correct credentials for User login	Correct Credentials	Login and load the main menu panel with two selection methods	Login and load the main menu panel with two segmentation methods	Passed
4	Keep username blank and enter	N/A	Display message “Please enter the Username” Do not allow login	Display error “Invalid Username or Password”. Do not allow login	Failed
5	Keep Password blank and enter	N/A	Display message “Please enter the Password” Do not allow login	Display error “Invalid Username or Password”. Do not allow login	Failed
6	Keep both password and username blank and enter	N/A	Display error “Invalid Username or Password”. Do not allow login	Display error “Invalid Username or Password”. Do not allow login	Passed

Table 7.1: Test Cases for User Login Testing

7.4.3 Upload Image

ID	Test Description	Possible Inputs	Expected Output	Actual Output	Status
1	Navigate to the file chooser window after upload image button is clicked	N/A	Open a window to choose the image to upload	Open a window to choose the image to upload	Passed
2	Select an image of .JPG format from the computer to upload into the system	Brain image with jpg format	Jpg format image will be visible to be selected and uploaded to the system	View the jpg format images in the window to be selected and uploaded to the system	Passed
3	Select an image of png format to upload into the system	Image with png format	png format image should be rejected from the system	Image is rejected from the system	Passed
4	Select an image of gif format to upload into the system	Image with gif format	gif format image should be rejected from the system	Image is rejected from the system	Failed

Table 7.2: Test Cases for Upload Image

7.4.4 General Testing

ID	Test Description	Possible Inputs	Expected Output	Actual Output	Status
1	Remove noise	Brain image	Uploaded image should be remove noise and filter	Filter the image by removing noise	Passed
2	Apply threshold to the damage image	Filtered brain image	Threshold should be applied to the image	Threshold will be successfully applied	Passed
3	Apply watershed segmentation	Processed brain image	The processed regions should be segment	The required region is successfully segmented	Passed
4	Detect the damage area	Processed brain image	The damage areas should be display in the system	Successfully detect the damage areas of the image	Passed
5	Apply SVM classifier	Filtered brain image	Indication of the damage areas	Indication of the damage areas using a bounding box	Passed

Table 7.3 General Test Cases

7.5 Chapter summary

This chapter discussed about the testing of the system in detail. This gives a detailed description about the testing criteria. Unit testing and black box testing were selected as the testing tools for this system. Testing was carried out under each functionality and those test cases are clearly documented in the body of the report along with the corresponding results.

Chapter 08: Evaluation

Chapter 08: Evaluation

8.0 Chapter Overview

The previous chapter provided a detailed explanation of how the testing process was carried out. This chapter focuses on the evaluation of the project concept and the overall project quantitatively and qualitatively. The evaluation is done by using external evaluators by providing a questionnaire. Finally, a critical evaluation is done by the author. Aim, Objectives and completion of functional and non-functional requirements are also evaluated.

8.1 Quantitative evaluation

Quantitative analysis is carried out in the previous chapter. Please refer the testing chapter (Chapter 07) for this. Test cases, test execution and test result analysis is carried out in the above chapter.

8.2 Qualitative Evaluation

Qualitative evaluation can carry out by experts in the area, evaluate by end user survey, and compare features with the other solutions.

8.2.1 Evaluation Methodology

The project evaluation can be done mainly in two stages.

- Evaluation by external evaluators
- Self-evaluation

8.3 Evaluation by External Evaluators

The first the project is evaluated using qualitative and quantitative methods. The initial survey result (Appendix 2) validated the project concept. The main focus of this section is a qualitative analysis of the whole project done by using an evaluation survey at the end of the project. The prototype was demonstrated to a group of experts in the medical field and asked to support the questionnaire. The questionnaire can be found in Appendix 6. The main tool used for external evaluation is a qualitative questionnaire.

The questionnaire respondents are shown below in Table 8.0.

The Questionnaire Respondents	
Name	**Designation**
Dr.S.H. Egodage	Consultant Radiologist , Military Hospital Narahenpita
Dr.S. Wijekoon	Consultant Physician & Senior Lecturer in Medicine, Colombo South Teaching Hospital Kalubowila
Dr.Umesha Herath	Intern Trainee Doctor, gampola Base Hospital
Nimesha Dilanthi	Medical Student, Faculty of Medicine Ragama
Rashmi Haniska	Medical Student, Faculty of Medicine karapitiya

Table 8.0: Evaluator Details

8.3.1 Evaluation Feedback from the Respondents

The aim of this section is to provide a commentary on the feedback received from the experts for each question. The genuine remarks for every question can be found in Appendix 8. The evaluation feedback analysis will begin with the question 3 in the survey.

"3. What is your opinion on using an intelligent system to detect brain damages?"

Several respondents have pointed out that by using an intelligent system user can minimize the mistakes and help to give better readings. One respondent also pointed out that this is an interesting idea as long as the system gives accurate results. Others too agreed with the idea as this system can be used as a learning material for the students like medical students.

"4. Out of the two segmentation methods what method will give a satisfactory output?"

A majority of respondents agree that segmentation method 2 is the best way to detect the damage area as well as some agreed on both methods. It is also noted that the method 1 gives less satisfactory results when compared to the method 2.

"5. How easy to identify the damage area using the system? Does it have any indication to the damage area?"

Respondents have compared the both segmenting methods and suggested to have a visible indicator to show the damage area. Other respondents are satisfied with the indication used in the both methods.

"6. What are your comments on the general flow of the system?"

The main comments mentioned by respondents are listed below.

- Flow is maintained well. Easy to navigate through the system.
- The system seems to be well maintained.
- General flow is fine.
- The flow is good.

"7. What is your opinion on the performance and usability of the intelligent system?"

A majority of respondents agree that this system has extremely good usability factors, especially considering that this is a prototype.

"8. How accurate is the system in detecting brain damages?"

According to the feedback from the respondents, it is clear that the system will produce accurate results. Some experts did not agree with the accuracy because they said there can be some technical issues when using an automated system.

"9. Do you think that the proposed system is flexible in detecting the severity of the brain damage"

The majority of the respondents agree that the proposed system is flexible and that is easy to cooperate. One of the respondents expresses concern about the detecting the severity status of the damage. Moreover, it is agreed that the system can be used in many domains.

"10. In what kind of situations do you think that the detection of brain damages are most useful in?"

The idea of the respondents is to use the system at any given situation. But they mostly say it is useful to use the system when the reading amount of CT images is high. If there are more than 15 or 20 CT scans, they would like to go for an automated system. Some respondents say that they can

use the system during emergency situations, when there is lack of expertise to read the scanning through naked eyes.

"11. In your opinion what are the main benefits of the system regarding the detection of the brain damages?"

The response shows that the majority of the respondents agree with reducing the mistakes while reading as well as some says time saving is a main benefit from the system. Other respondent says it will be useful for anyone who is new to read CT scanning and get a best practice from the system. They discussed it as a major benefit from the system.

"12. What do you suggest as future enhancements for this system?"

According to the feedbacks from the respondents, the following are some of the most important future enhancements proposed.

- Try to determine the presence or absence of a brain damage and give the severity status of the damage.
- Improve the system for both CT and MRI images.
- Improve identifying the severity status of the damage.
- Try to identify the affected brain area with the damage.

8.4 Self Evaluation

Through the self-assessment it expects to identify the strengths and the shortcomings of the thesis. This will enhance the value of the project.

A comprehensive research was conducted to identify the main problem of the project. During the primary research it was able to identify the need for an intelligent system to detect brain damages. The solution for this was a segmentation of damages and predicting the severity. With this idea a comprehensive literature review was conducted. Through the literature survey, it was able to propose new technologies and techniques that can be used for this system. Detail researches about the existing solutions were carried out and it has been found that a detailed study of these areas would have helped in developing the system.

Next an online survey was conducted in order to gather requirements for the solution. This was distributed among experts in the medical field, including radiologists, neurologists, general doctors and medical students. This was answered by these representatives was able to gain a better understanding about the problem through their responses. The survey contains questions about the auto-regulation and brain damages. If there were more questions to investigate how to detect the severity status of the damage, it could have been used to develop some of the features.

After gathering the requirements through the online survey and the literature review was able to formalize the design of the system. All the functional and non-functional requirements were identified by that time. The design stage includes a detailed specification of the intelligent system. Main design goals are mentioned clearly in the design chapter with the high level architecture. Some of the low level design models were not identified and the design stage would be more complete if these models were identified at the design stage.

The design was then used as the blueprint in developing the prototype. This provides a complete implementation of some core functionalities and non-functionalities. However, it does not provide a neural network that can predict the severity status of the brain damage. If this functionality was also implemented as part of the system, it would have been a full accurate and useful system for the users.

Lastly, the project was assessed and evaluated qualitatively using a questionnaire. The choice of respondents from the medical field gives a good feedback on the prototype.

8.5 Evaluation of the Objectives

The following are the evaluations of the main objectives that declared in the first chapter of the project.

- Literature Survey

  Writing the literature survey can be known as the foundation of the project. It has given the greater part of information and certainties to build this project. A comprehensive literature survey was carried out on image processing and segmentation methods. That helped in many ways to succeed the project.

- Project Planning and Management

  This helped in selecting the best development process model. Agile methodology was selected and the project was planned accordingly with the time plan. This objective was successfully achieved by identifying possible risks and to come up with risk mitigation plans.

- Software Requirement Specification

  The surveys and interviews carried out for the requirements specification helped in identifying the scope and major requirements of the project. It can be said that the requirements analysis is successfully given as it processed many survey findings before any vague conclusions on the requirements. A valid set of functional and non-functional requirements were identified.

- Software Design

  A good design is an essential objective as it is the bridge between the requirements specification and the implementation. The design facilitated the flow of the project and also the implementation process and the testing process.

- Implementation

  The implementation was focused on the major requirements of the system. The main features were implemented and evaluated by the experts. Some features were not implemented due to the problems encountered during the project. It could not achieve the detecting part of the damage severity. Apart from that, experts agree with the techniques used for the other methods.

- Testing

  Another most important objective of the project is testing. Testing was carried out using test cases to ensure the functionality of the prototype. According to the evaluation given by experts, testing can be improved in order to get more descriptive test results.

8.6 Completion of the Functional and Non- Functional Requirements

The status of all functional requirements is stated below in Table8.0.

(C = Critical, D = Desirable, L = Luxury)

ID	Functional Requirement	Priority	Status
FR1	User should be able to login to the system	E	Completed
FR2	The system should be able to read and support DICOM medical images	E	Completed
FR3	Should be able to upload CT brain images to the system	E	Completed
FR4	Preprocess the CT images	E	Completed
FR5	Should be able to segment and classify the CT images	E	Completed
FR6	System should display the damage areas of the brain	L	Completed
FR7	The system should detect the severity of the brain and display the status	E	Future Enhancements
FR8	Should be able to enter risk factors emerged by the patient	D	Future Enhancements
FR9	Should be able to enter required medical advices	D	Future Enhancements
FR10	System should save entered records	D	Future Enhancements
FR11	System should be able to measure and display arterial blood pressure and cerebral blood flow of the patient	L	Future Enhancements

Table 8.1: Achievement of Functional Requirement

From Appendix 6, it is agree that the non-functional requirements of usability, performance, flexibility and accuracy are all satisfactorily fulfilled by the prototype implementation.

8.7 Chapter Summary

In this chapter the project was evaluated using qualitative and quantitative methods. The system was thoroughly evaluated using an expert evaluation questionnaire. An expert evaluation questionnaire has been given after a demonstration of the system to the experts in the medical field. Through the expert feedback, it was proven that the implemented features are performing well and users are satisfied with the solution. In the self-evaluation, it has discussed about the whole projects with its strengths and weaknesses.

Evaluations of the objectives were discussed in this chapter with a detail description. Future enhancements were also discovered through the questionnaire. Completion of the Functional and Non- Functional Requirements were also discovered. This chapter has provided a detailed analysis of the thesis from project initiation through analysis and design to implementation. The next chapter will conclude the thesis by taking a look at the problems encountered, objectives achieved, learning outcomes and finally, the future work to be carried out in the thesis.

Chapter 09: Conclusion

Chapter 09: Conclusion

9.0 Chapter Overview

The previous chapter contained a complete assessment of the project. This part expects to give a rundown of the proposal by experiencing the limitations and advantages of the solution, the main problems and challenges faced during the project, achievements, and future enhancements. This gives a retrospection of the entire task beginning from the underlying stages and proposition to the accomplishment of project aims and objectives. Furthermore, this gives the primary learning results of the final year extend and finishes up the thesis by remarking on the future extensibility of the thesis.

9.1 Limitations and Advantages of the Solution

Limitations	1. The significant constraint of the present system is that the identification of the brain damages does not work 100% for the noisy unclear images. As scan will not always perfect, it considered as an extreme disadvantage.
Advantages	1. System present with a user friendly graphical user interface. 2. System will detect the damage areas using two different methods.

Table 9.0: Limitations and Advantages of the Solution

9.2 Achievement of project Aim

The aim of this project was successfully achieved by completing a comprehensive literature survey, designing, implementing and testing the intelligent system. This system achieved to enable users such as doctors, medical students and neurologists to identify brain damages in an effective manner.

9.3 Achievement of project Objectives

The initiation of the project is done by formulating a Terms of Reference which is the introduction chapter (Chapter 01) and a time plan for the entire project (Appendix 8). The main objective of creating a Terms of Reference was to conduct a background research, investigating the problems of patients who, faced with Traumatic Head Injuries and identifying the main aims and objectives.

An intensive literature survey (Chapter 2) of related work in the auto-regulation and brain damages after traumatic head injury was directed next. The principle point of the literature survey was to assemble learning about the anatomy of the brain, understanding the basic information about the brain, cerebral auto-regulation and classification of brain damages and how it happens. The main aim of the literature survey was to gather knowledge on different techniques and technologies for diagnosis of auto-regulation and brain damages and selecting the possible approaches. This survey gave a strong establishment of learning on top of which the research was based.

The next objective was to select suitable project management, project planning, research, design and development approaches, methodologies, tools and techniques for the project to ensure that the project runs smoothly without any errors (Chapter 3). Agile was selected as the development methodology. Comprehensive literature survey, online survey, interviews and emails with experts were used as the main data gathering techniques.

System requirement specification (Chapter 4) was conducted after the chapter project planning and management. An online survey (Appendix 1) of knowledge experts in the medical field in order to gain a better understanding of the problems and solutions was conducted. The survey was successfully answered by the target user groups. Interviews with knowledge experts in the medical field and the literature survey helped in identifying the main stakeholders and requirement of the project. The functional and the non-functional requirements were analysed and presented in this chapter.

After gathering all the requirements, the next objective was to select appropriate techniques and tools to create the designing of the system (Chapter 5). Suitable design methodology and design tools were selected and high level architecture of the prototype was built along with the low level design diagrams. Design goals were presented in order to come up with a good high level architecture.

Using the created design the implementation of the prototype was successfully done (Chapter 6). Technology selection, main functionalities, problems encountered and solutions found is documented in this chapter. The prototype understands the core functionalities and certain features which were distinguished in the requirement analysis stage.

Extensive testing was carried out to identify the errors in the current system (Chapter 7). This was carried out and documented with selecting testing tools and technology, test cases, test execution, and test result analysis. Finally the evaluation done by the experts and the author is presented in the eighth chapter (Chapter 8). A questionnaire presented for a set of selected expert evaluators from the medical field. Moreover, a basic self-assessment of the project was carried out by the author together with the evaluation of the objectives.

Finally, it can be concluded that it was able to comprehensively document all the aspects of the project from every undertaking stage. The project has effectively accomplished the greater part of the destination, it had embarked to satisfy.

9.4 Problems and Challenges Faced During the Project

The main problems faced during the project are listed below in Table 9.0.

Problem	Description
Scope of the project	A few necessities were excessively immeasurable and subsequently it had, making it impossible to be downsized significantly due to time constraints.
Late changes in software requirements	There were some changes in the requirements and had to change the literature survey and software requirement specification respectively according to the changes.
Some technologies may have unseen difficulties during implementation	Used various types of new technologies and had to research into these technologies throughout the project to select the most viable technology.
Time management	Another problem faced is managing time. There were course works went parallel to the final year project. Sometimes it was difficult to manage time on a particular task.

Lack of data sets for testing	It was difficult to find an image data set of damage brain images.

Table 9.1: Problems faced during the projects

9.5 Lesson Learnt from the Project

During this project period, had the chance to gather a lot of information in an assortment of ranges, such as project management, requirement engineering, design and architecture, prototyping and critical evaluation.

Recorded beneath are some of the significant learning results.

- How to deal with a project from start to end.
- Time management and multitasking.
- Undertaking risks.
- How to carry out a scientific research.
- How to apply knowledge gain from different course contents.
- Comprehensive knowledge about Requirement gathering, elicitation and formalization techniques.
- Improved critical evaluation skills.
- Problem resolving under tight due dates.

9.6 Academic Objectives

During this project period was able to gain a huge knowledge in a variety of areas and also was able to profit immensely from the course substance of different modules. The knowledge picked up was important in the effective completion of the project. Was able to achieve the below academic objectives throughout the project.

- Improve communication skills.
- Work efficiently with colleagues and academic staff in a variety of task.
- Improve research technology skills.
- Apply course contents in an appropriate manner.
- Improve critical thinking skills and documentation skills.
- Improve programming skills and techniques.

- To acquire good result for the thesis and the project.

9.7 Module Contribution to the Project

This section concentrates on how the modules in the degree program contributed for the effective fulfilment of the research project. The knowledge gained was invaluable in the successful completion of the project.

- The Requirements Engineering module was helpful to learn the problem definition, the process of eliciting, presenting requirements and critical thinking and writing. Furthermore, Modelling in Information Systems and Object Oriented Design proved to be very useful in modelling the requirements into UML diagrams as well as it helped in drawing the Onion diagram to identify the stakeholders of the project.

- Software Quality and Performance Testing module were very helpful in the testing phase of the research project as the module had given a good comprehension on all the testing criteria present.

- Object Oriented Development module gave a good foundation on all concepts of objects oriented design and development. The knowledge gained from this module was put to use during the design and implementation stages of the project.

9.8 Future Enhancements

Because of time imperatives just the fundamental features of the model were implemented. This leaves a great deal of space for future upgrades and extensions. Recorded in beneath in Table 9.1 are some of the primary ones. A large number of these have been a piece of the underlying extension yet were reduced because of time requirements

Requirement	Proposed Enhancement
Detect the severity of the brain and display the status	This was not implemented due to the time constraints. This should be implemented to complete the full approach. Make the system to display the state of the severity (Brain injury: Light, Medium or Heavy) of the brain damage of all processed images.
Enter risk factors emerged by the patient	Create an option for the user to state the risk factors that found after processing the damaged brain image.
Enter required medical advices	Create an option for users to enter the medical advices after examine the CT image.
Measure and display arterial blood pressure and cerebral blood flow of the patient	This was not implemented as it was removed from the prototype scope due to time constraints. This should be implemented to complete the full intelligent system. Measure the patient's arterial blood pressure and cerebral blood in order to find the failing point of auto-regulation.
Building a predictive model Using EEG data	Implementing a predictive model to detect depression using collected EEG data.

Table 9.2: Future Enhancements

9.9 Concluding Remarks

This project was an outstanding accomplishment as it has accomplished the aims and objectives and contributed enormously to the author's knowledge.

This thesis has given a complete record of how the methodology was built from requirement elicitation to tools, technologies and methodologies used in the design and implementation. Moreover, issues, confinements and difficulties are likewise talked on the course of this research. It has also specifies the future work that was identified by the author and as well as the expert evaluators.

This will bring a significant competitive advantage to the users and would even go so far to reduce the effort of manually reading CT images of patients. This thesis addresses all the aspects the research project from the initial stage to the final stage. In conclusion, this project has become a usable system that providing a simple and elegant solution to the detecting brain damages.

References

References

(Amato et al, 2013)

Artificial neural networks in medical diagnosis . 2015. Artificial neural networks in medical diagnosis .[ONLINE] Available at: http://www.sciencedirect.com/science/article/pii/S1214021X14600570. [Accessed 22 October 2015].

(Dagar et al,2015)

IEEE Xplore Abstract - Medical diagnosis system using fuzzy logic toolbox . 2015. [ONLINE] Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7148370. [Accessed 22 October 2015].

(David Lenrow, M.D., 2004)

TBI | Traumatic Brain Injury | Traumatic Brain Injury Resources | Brain Injury Support | Brain Injury Information. 2015. [ONLINE] Available at: http://www.traumaticbraininjury.com. [Accessed 22 October 2015].

(Dieste, Juristo, and Shull 2008)

Dieste, O., N. Juristo, and F. Shull. “Understanding the Customer: What Do We Know about Requirements Elicitation?” *IEEE Software* 25, no. 2 (March 2008): 11–13. doi:10.1109/MS.2008.53.

(Goel et al, 1996)

IEEE Xplore Abstract - Dominant frequency analysis of EEG reveals brain's response during injury and recovery . 2015. [ONLINE] Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=541250. [Accessed 22 October 2015].

(Grau et al, 2004)

IEEE Xplore Abstract - Improved watershed transform for medical image segmentation using prior information . 2015. [ONLINE] Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1281998. [Accessed 22 October 2015].

(Haunts.S ,2014)
Haunts, Stephen. “Advantages and Disadvantages of Agile Software Development.” *Stephen Haunts { Coding in the Trenches },* December 19, 2014. https://stephenhaunts.com/2014/12/19/advantages-and-disadvantages-of-agile-software-development/.

IEEE Xplore Abstract - Medical Image Conversion with DICOM . 2015. [ONLINE] Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4232675. [Accessed 22 October 2015].

IEEE Xplore Abstract - Classification of hematomas in brain CT images using neural network . 2015. [ONLINE] Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6781250. [Accessed 13 October 2015].

IEEE Xplore Abstract - Classification of Traumatic Brain Injury Severity Using Informed Data Reduction in a Series of Binary. 2015.[ONLINE] Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6249788. [Accessed 14 October 2015].

Inhaled nitric oxide reduces secondary brain damage after traumatic brain injury in mice. 2015. [ONLINE] Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3564204/. [Accessed 13 October 2015].

(Kenneth.P, 2008)
Using object-oriented analysis and design over traditional structured analysis and design.. 2016. [ONLINE] Available at: http://www.freepatentsonline.com/article/International-Journal-Business-Research/190463129.html. [Accessed 15 April 2016].

(Liu et al, 2006)
IEEE Xplore Abstract - Integration of EEG/MEG with MRI and fMRI . 2015. [ONLINE] Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1657787. [Accessed 22 October 2015].

(McBride et al, 2013)

IEEE Xplore Abstract - Scalp EEG-Based Discrimination of Cognitive Deficits After Traumatic Brain Injury Using Event-Relate... . 2015. [ONLINE] Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6328249. [Accessed 22 October 2015].

(Mochal.T,2008)

Things, Tom Mochal | in 10, January 2, 2008, and 2:01 Am Pst. “10 Techniques for Gathering Requirements.” *TechRepublic*. Accessed April 26, 2016. http://www.techrepublic.com/blog/10-things/10-techniques-for-gathering-requirements/.

Muthukannan & Moses (2010)

IEEE Xplore Abstract - Color image segmentation using k-means clustering and Optimal Fuzzy C-Means clustering . 2015. [ONLINE] Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5738735. [Accessed 22 October 2015].

(Natalia, 2012)

Blog, Natalya’s QA. “The Differences between Life Cycle Models- Advantages and Disadvantages.” *Natalya’s QA Blog*, June 10, 2012. https://narbit.wordpress.com/2012/06/10/the-differences-between-life-cycle-models-advantages-and-disadvantages/.

Neuroimaging after mild traumatic brain injury: Review and meta-analysis . 2015. [ONLINE] Available at: http://www.sciencedirect.com/science/article/pii/S221315821300168X.[Accessed 13 October 2015].

(Pious.K, 2013)

Pious, Kevin. “Techniques for Eliciting Quality Requirements – Observation.” Captech Consulting, Inc. Accessed April 26, 2016. http://www.captechconsulting.com/blogs/techniques-for-eliciting-quality-requirements--observation.

(Rouse.M,2007)

“What Is Unit Testing? - Definition from WhatIs.com.” SearchSoftwareQuality. Accessed April 24, 2016. http://searchsoftwarequality.techtarget.com/definition/unit-testing.

(Rupesh, 2010)

Cam91175, Rupesh. "Research Methods - Surveys & Questionnaires: The Advantages & Disadvantages of Questionnaires & Surveys." Research Methods - Surveys & Questionnaires, November 24, 2010. http://orangegrouprsmet.blogspot.com/2010/11/advantages-disadvantages-of.html.

(Sarah, 2010)

Sarah. "Requirements Engineering: Brainstorming Elicitation Techniques." *Requirements Engineering*, November 2, 2010. http://blogforrequirements.blogspot.com/2010/11/brainstorming-elicitation-techniques.html.

(Sharma & Venugopalan, 2014)

IEEE Xplore Abstract - Classification of hematomas in brain CT images using neural network . 2015. [ONLINE] Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6781250. [Accessed 22 October 2015]

TBI, Traumatic brain injury(TBI).2015. [Online] Available at:http://www.mayfieldclinic.com/PE-TBI.htm. [Accessed 13 October 2015].

(Verma.P,2015)

Verma, Priya. "SOFTWARE TESTER GUIDE : What Is RAD Model- Advantages, Disadvantages and When to Use It?" *SOFTWARE TESTER GUIDE*, April 22, 2015. http://testerguidezone.blogspot.com/2015/04/what-is-rad-model-advantages.html.

Williams.N.S.(2013). 25th edition [surgery book] Bailey & Love-SHORT PRACTICE of SURGERY1

(Wyse.S.E, 2014)

Wyse, Susan E. "Advantages and Disadvantages of Face-to-Face Data Collection." Snap Surveys Blog, October 15, 2014. http://www.snapsurveys.com/blog/advantages-disadvantages-facetoface-data-collection/.

Bibliography

Bibliography

Cerebral autoregulation-PubMed-NCBI.2015[Online] Available at: http://www.ncbi.nlm.nih.gov/pubmed/2201348. [Accessed 11 October 2015].

Cerebrum - Brain. 2015. Cerebrum - Brain. [ONLINE] Available at: http://www.innerbody.com/image_nerv02/nerv41-new.html. [Accessed 22 October 2015].

Difference Between Fuzzy Logic and Neural Network. 2015.[ONLINE] Available at: http://www.differencebetween.com/difference-between-fuzzy-logic-and-vs-neural-network/. [Accessed 22 October 2015].

Garg, N., P. Agarwal, and S. Khan. "Recent Advancements in Requirement Elicitation and Prioritization Techniques." In *Computer Engineering and Applications (ICACEA), 2015 International Conference on Advances in*, 237–40, 2015. doi:10.1109/ICACEA.2015.7164702.
"Interviews: Requirements Elicitation Technique." *Business Analyst Learnings*. Accessed December 27, 2015. http://businessanalystlearnings.com/ba-techniques/2013/7/18/interviews-requirements-elicitation-technique.

Human Brain: Facts, Anatomy & Mapping Project. 2015 [ONLINE] Available at: http://www.livescience.com/29365-human-brain.html. [Accessed 22 October 2015].

IEEE Xplore Abstract - Image segmentation algorithm based on swarm intelligence technology . 2015.[ONLINE] Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7111540. [Accessed 22 October 2015].

Images:
2015 [ONLINE] Available at: http://img.medscapestatic.com/pi/meds/ckb/15/12015.jpg. [Accessed 21 October 2015].

RSNA Publications Online. 2015. [ONLINE] Available at: http://pubs.rsna.org/doi/figure/10.1148/radiology.211.3.r99ma07781. [Accessed 22 October 2015].

"starUML and argoUML – Compared." Accessed April 15, 2016. http://veerasundar.com/blog/2008/11/staruml-and-argouml-compared/.

Subacute Pain after TBI is Associated with Lower Insular N-Acetylaspartate Concentrations. - PubMed - NCBI . 2015. [ONLINE] Available at: http://www.ncbi.nlm.nih.gov/pubmed/26486760. [Accessed 22 October 2015].

TBI: Definitions of Traumatic Brain Injury. 2015. TBI: Definitions of Traumatic Brain Injury. [ONLINE] Available at: http://www.traumaticbraininjury.com/understanding-tbi/definitions-related-to-tbi/. [Accessed 22 October 2015].

TBI: Effects of Traumatic Brain Injury l Effects of Brain Injury l Causes of Brain Injury. 2015.[ONLINE] Available at: http://www.traumaticbraininjury.com/understanding-tbi/what-are-the-effects-of-tbi/. [Accessed 22 October 2015].

"Tips For Developing Questionnaires & Surveys." *Business Analyst Learnings*. Accessed December 27, 2015. http://businessanalystlearnings.com/ba-techniques/2015/3/16/tips-for-developing-questionnaires-surveys.

"Using the Observation Technique for Requirements Elicitation." *Business Analyst Learnings*. Accessed December 27, 2015. http://businessanalystlearnings.com/ba-techniques/2013/5/16/using-the-observation-technique-for-requirements-elicitation.

Appendix

Appendix 1: Online Survey

Intelligent Way to Detect Cerebral Auto-regulation & Brain Damages After Traumatic Head Injury

I am Ayani Kapugama Arachchi an undergraduate student following the BEng (Hons) Software Engineering degree program at Informatics Institute of Technology, which affiliated with the University of Westminster.
For my final year i need to carry out a research project. Below is a survey conducted as a part of my research project which focused on detecting cerebral auto-regulation and brain damages using artificial intelligence.
I would truly be grateful if you could spare few minutes of your valuable time to fill out the questionnaire below.

Head injuries associated with traumatic head injury occur with an incident of 20-40 cases per 100000 populations per year. Road traffic accidents, falls, sport injuries are the most common cause of traumatic head injury. This is project is about developing an intelligent system to detect cerebral auto-regulation and brain damages.

The proposed system is used to predict the type of brain injury, (Light, Medium, and Heavy) that pattern recognition system based on neural networks CT scan results, by using image processing techniques, converted into digital form that can be processed using analysis methods.

1. Designation

- ☐ Neurologist
- ☐ Doctor
- ☐ Radiologist
- ☐ Medical Student
- ☐ Other: ○

2. How do you identify the cerebral auto-regulation of a head injured patient?

- ○ Using clinical signs of the patient
- ○ Using a special hospital system
- ○ There is no proper way to detect auto-regulation
- ○ Other: ○

3. What are the major clinical signs that can be identified in a head injured patient?
(Specify at least 3 clinical signs)
◉

4. What could be the immediate actions taken when the cerebral auto-regulation fails in a head injured patient?

- ☐ Continuously measure arterial blood pressure
- ☐ Continuously measure pulse rate
- ☐ Maintaining Glasgow Coma Scale (GCS)
- ☐ Other:

5. Do you think is it appropriate to detect cerebral auto-regulation and predict secondary brain damages using clinical signs of a head injured person?

- ○ Yes
- ○ No

6. Would you like to have an intelligent system to detect cerebral auto-regulation without using individual's clinical signs?

- ○ Yes
- ○ No

7. How do you detect brain damages of a head injured patient?

- ○ Clinical Signs
- ○ CT Scanning
- ○ MRI Scanning
- ○ ECG Scanning
- ○ MEG Scanning

8. How do you read CT images normally?

- ○ Naked Eye
- ○ Automated System
- ○ Other:

9. Based on the above opinion, how would you rate the method of reading/ analyzing CT images?

- ○ Very Effective
- ○ Moderately Effective
- ○ Somewhat Effective
- ○ Not Effective
- ○ Other:

10. Is it possible to predict the severity of the brain damage by analyzing a CT image?

- ○ Yes
- ○ No

11. If it is over 50 to 100 CT images are done per day, how would be the accuracy and the effectiveness of the outcome of the results?

- ○ Highly Accurate
- ○ Moderately Accurate
- ○ Somewhat Accurate
- ○ Not Accurate
- ○ Other:

12. Would you prefer to have an automated intelligent system to detect brain damages and predict the severity of the damages?

- ○ Yes
- ○ No
- ○ Other:

13. If yes what kind of features would you like to have on this automated system?

- ☐ Read and Analyse CT images
- ☐ Identify damage areas of the brain
- ☐ Indicator to show the damage areas of the brain
- ☐ Detect the severity of the brain damage (Light, Medium, Heavy)
- ☐ Other:

14. Would you be interested in an automated system proposed?

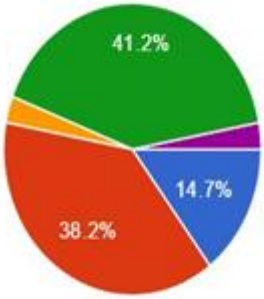
- ○ Definitely
- ○ May be
- ○ Not at all
- ○ Other:

15. Any other suggestions, comments or feedback on the proposed system?

Appendix 2: Analysis of the Online Survey Results

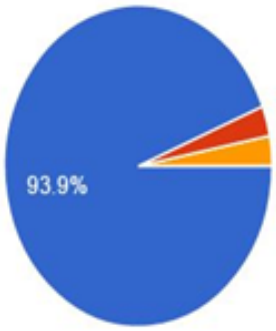
This questionnaire will take approximately 10 minutes to complete.

1.Designation



Neurologist	5	14.7%
Doctor	13	38.2%
Radiologist	1	2.9%
Medical Student	14	41.2%
Other	1	2.9%

2. How do you identify the cerebral auto-regulation of a head injured patient?



Using clinical signs of the patient	31	93.9%
Using a special hospital system	1	3%
There is no proper way to detect auto-regulation	1	3%
Other	0	0%

93.9% of the respondents stated that the identification of cerebral auto-regulation of head injured patient is using the clinical signs of the patient. 3% of the respondents state that they use a special hospital system to identify cerebral auto-regulation and other 3% state that there is no proper way to detect cerebral auto-regulation.

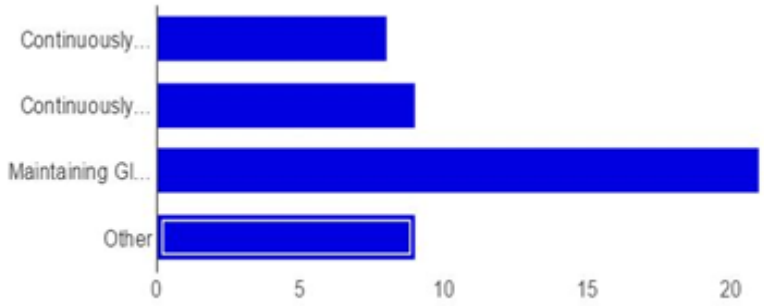
3. What are the major clinical signs that can be identified in a head injured patient?

Number of respondents answered this question :	28
Papilledema, bradicardia, hypertension	
Bradicardia, hypotension, unequal pupils	
Severe headache, Vertigo Dizziness Somnolence, Nausea, Loss of consciousness	
Headache, nausea, Status of the cerebral nerves	
pupillary reflex GCS blood pressure/ pulse rate	
Bleeding , Unconscious, Bradycardia	
Hypotension Tachycardia Papilledema Reduced volume of pulse Loss of consciousness Altered level of consciousness Limb weakness Coordination irregularities	
level of consciousness lowering of pulse dilatation of pupil	
Red eye battle sign CSF rinorrhoea Racoon's eye CSF autorrhoea haemotympanum	
Severe headache and vomiting following trauma deteriorating GCS Fundscopy findings	
Panda eye sign Battle sign Dilated pupil	
Depending on 3 points 1.general signs such as unconsciousness 2.focal signs visual hearing defects 3.false focal signs such as nerve palsies - ptosis etc Panda ayes, bleeding from ear,nose, or more episodes of vomiting	
Low GCS, Blood Pressure, size of Pupils	
papilledema bradicardia hypertension loss of consciousness fatigue head ace disorientation or imbalance	
Headache 2. Nausea/vomiting 3.dilated pupils 4.seizures 5.Loss of consciousness	
Unconscious altered speech headache	
Hypotension Tachycardia Dyspnoea A reduced GCS score	
It depends on the damaged area..anyway it can be 1.Inability in speech 2.sensation loss 3.paralyse	
Drowsiness ,drop blood pressure, low pulse	
Loss of consciousness Nausea Vommiting Dizziness Headache Short term memory loss Blurry vision Slurred speeching	
Conscious level of the patient Blood pressure Bleeding	
Hypertension 2.Bradycardia 3.Dialated pupils- if acute, constricted pupils 4.Absent light reflexes	

Loss of consciousness Absent pupil reflex Bradycardia Hypertension
bilateral pupillary reaction to light is lost or unequal high blood pressure with low pulse rate GCS low
Conscious level deteorate Motor functions (limb movements etc)deteorate Pupilary reactions to light affected
Bleeding from ears Pupilary construction Altered level of consciousness
Well You can improve this question..If it is intracranial injuries you would want to know, 1. Pin point pupils 2. High BP with Bradycardia initially and later dropping BP 3. Deteriorating GCS
unconsciousness headache postural imbalance vomiting disorientation tremors

According to the survey results, a higher number of respondents' stated, Papilledema, Bradicardia, Hypertension, Unconscious, Vomiting, Headache, Unequal pupils and Nausea as the major clinical signs that can be identified in a head injured patient. Therefore when considering the average clinical signs, most of the head injured patients willhave headache, unconsiousness, Hypertension, Vomiting and Papilledema.

4. What could be the immediate actions taken when the cerebral auto-regulation fails in a head injured patient?



Continously measure arterial blood pressure	8	25%
Continously measure pulse rate	9	28.1%
Maintaining Glasgow Coma Scale (GCS)	21	65.5%
Other	9	28.1%

5. Do you think is it appropriate to detect cerebral auto-regulation and predict secondary brain damages using clinical signs of a head injured person?

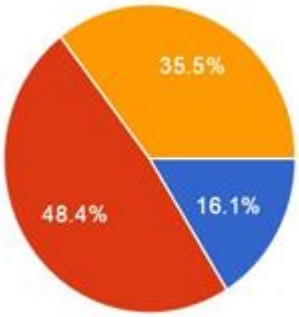
		Response count
Yes	75%	24
No	25%	8
Number of respondents answered this question :		32

6. Would you like to have an intelligent system to detect cerebral auto-regulation without using individual's clinical signs?

		Response count
Yes	72%	23
No	28%	9
Number of respondents answered this question :		32

72% of respondents agreed to have an intelligent system to detect cerebral-auto regulation while 28% of them disagree to have an intelligent system.

7. How do you detect brain damages of a head injured patient?



Clinical signs	5	16.1%
CT Scanning	15	48.4%
MRI Scanning	11	35.5%
ECG Scanning	0	0%
MEG Scanning	0	0%

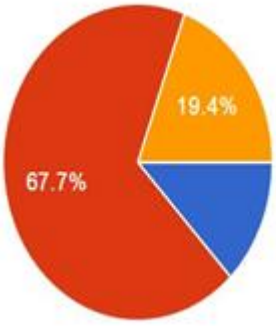
There are many ways to identify a brain damage of a head injured patient. It is evident from the survey results that CT scanning is the mostly used method to detect brain damages. 48% of the respondents agreed on CT scanning. 35% of them agreed to MRI scanning.

8. How do you read CT images normally?

		Response count
Naked Eye	82%	26
Automated System	18%	6
Other	0%	0
Number of respondents answered this question :		32

It is evident from the survey results that the reading and analysing of a CT image is done manually through naked eye. 82% responded as naked eye while 18% responded using an automatic system.

9. Based on the above opinion, how would you rate the method of reading/ analysing CT images?



Very Effective	4	12.9%
Moderately Effective	21	67.7%
Somewhat Effective	6	19.4%
Not Effective	0	0%
Other	0	0%

67% of the respondents stated that the reading and analysing a CT image is moderately effective based on the opinion they agreed in the question 8. Only 12% of the respondents stated that this is very effective. And 19% of the respondents responded as somewhat effective.

10. Is it possible to predict the severity of the brain damage by analysing a CT image?

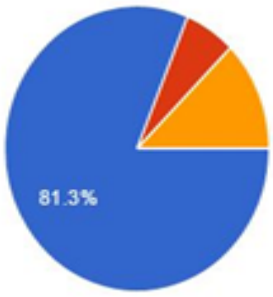
		Response count
Yes	69%	22
No	31%	10
Number of respondents answered this question :		32

Predicting the severity using a CT image is somewhat challenging. But 69% of the respondents said that the prediction of the damage severity using a CT image is possible. 31% disagreed with the idea.

11. If it is over 50 to 100 CT images are done per day, how would be the accuracy and the effectiveness of the outcome of the results?

		Response count
Highly Accurate	9%	3
Moderately Accurate	72%	23
Somewhat Accurate	13%	4
Not Accurate	0%	
Other	6%	2
Number of respondents answered this question :		32

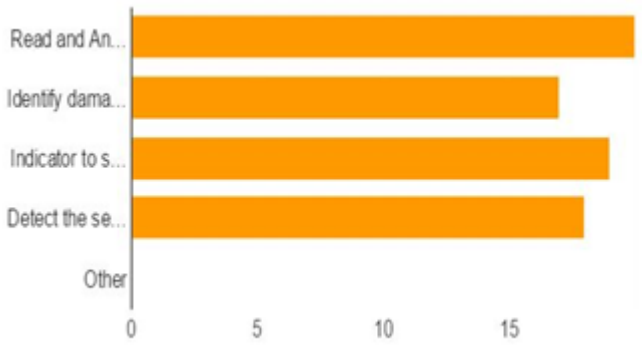
12. Would you prefer to have an automated intelligent system to detect brain damages and predict the severity of the damage?



Yes	26	81.3%
No	2	6.3%
Other	4	12.5%

81% of the respondents agreed to have an automated intelligent system to detect brain damages and predict the severity of the damage. 6% of the dislike t have an automated system and some said that severity cannot identify using an automated system.

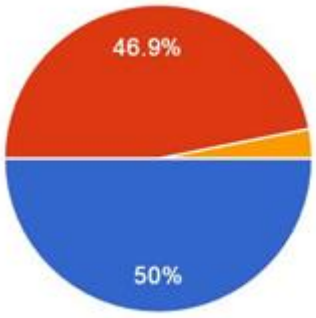
13. If yes what kind of features would you like to have on this automated system?



Read and Analyse CT images	20	64.5%
Identify the damage areas of the brain	17	54.8%
Indicator to show the damage areas of the brain	19	61.3%
Detect the severity of the brain damage (Light, Medium, and Heavy)	18	58.1%
Other	0	0%

According to the survey results a higher number of respondents would like have read and analyse CT image using the system as a main feature of the system. 61% of the respondents would like to have an indicator to show the damage areas of the brain. 58% of them like to have a feature to state the severity of the damage. Whether identify its severity status.

14. Would you be interested in an automated system proposed?



Definitely	16	50%
May be	15	46.9%
Not at all	1	3.1%
Other	0	0%

Most of the experts and consultants would like to have an automated system to read and analyse medical images. It is evident from the survey results as well. The 47% respondents stating that they may be interested in an automated system and 50% stating that they definitely interested in an automated system.

15. Any other suggestions, comments or feedback on the proposed system?

Number of respondents answered this question :	8
Neurology is a growing field with still another to be discovered. Good luck with your research.	
Clinical signs and proper examination and history are always important. An automated system will improve the accuracy, reliability and speed. So it's good to go for such technology. At the same time, one should not disregard history, examination findings.	
This proposed automated system would be really helpful for doctors	
MRI scanning may be more effective in localizing head injuries than CT scan	
Affordability should be considered.	
It should be consistently accurate.	
A system like this would be really helpful for doctors for further management	
Good luck.	

Appendix 3: Feedback by Experts

One review feedbacks shown here were supplied by,

• Sergey M Plis

Doctorate Researcher

Albuquerque, United States

http://www.cs.unm.edu/~pliz/

Referred to: http://journal.frontiersin.org/article/10.3389/fnins.2014.00229/abstract

Reviewer	Comment
Sergey M Plis	Thank you for your interest! Unfortunately I neither work with CT nor lesion data. Judging by what you told me your project sounds very interesting and potentially impactful. However, I would first consider having a (preferably) large dataset that contains information of interest. In deep learning more than half of the success is the right data (and better lots of data). I think you need to speak with your advisers about building a neural network project around what data is available rather than trying to find very specialized data that would work with neural networks. I work at the Mind Research Network that collects the data for various research purposes. You can try to access the data from our organization through this portal: https://coins.mrn.org/ Otherwise, you can always look into the following sharing initiatives: https://openfmri.org/ https://www.nitrc.org/projects/fcon_1000/ http://www.humanconnectomeproject.org/ and similar I am wishing you best in your research project and good luck!

Appendix 4: Use Case Descriptions

Use case descriptions for the use cases discovered in the requirement analysis phase

A4.1 Use Case Description for Login Use Case

Priority:	High
Use Case Name:	Login
Summary:	The user logins to the system to read and analyse the damages of the brain image
Actors:	User (Doctor, Medical Student, Radiologist, Neurologist)
Pre-condition:	User must have open the application
Triggering events:	User selects 'Login' option on the Login screen

Main flow of events	
Actor	**System**
2.User enters username and password 3.User clicks 'Login' button	1.System displays Login window 4.System validates the user credentials 5.System will prompt for the main menu window

Alternative flow of events 1	
Actor	**System**
1. User clicks 'Login' button	At 4: Displays an error message "Invalid Username or Password" Go back to 2

Exceptional flow of events
At 4: System shows an error message , " System Unexpectedly Close, Please Try Again Later " After 4: at any point system shows an error message , "System Not Responding, Please Try Again Later"

Post condition:	User can Login to the system in order to detect bran damages.
Inclusions:	Validate Credentials
Extensions:	-

A4.2 Use Case Description for Process Image Use Case

Priority:	High
Use Case Name:	Process Image
Summary:	Remove noise and filter the brain image before detecting the damage areas.
Actors:	User (Doctor, Medical Student, Radiologist, Neurologist)
Pre-condition:	An image must have been uploaded to the system
Triggering events:	User selects 'Image Filter' option from the window

Main flow of events	
Actor	**System**
2.User clicks 'Image Filter' button 5. User click on "Detect Damage Areas" button	1.System displays the uploaded image 3.System will remove noise and pre-process the image 4. System applies thresholding and watershed methods on the image.

Alternative flow of events 1	
Actor	**System**
1. User clicks 'Image Filter" button	At 3: Displays an error message "Image is already pre-processed"

Exceptional flow of events
At 3: System shows an error message , " System Unexpectedly Close, Please Try Again Later " After 3: at any point system shows an error message , "System Not Responding, Please Try Again Later"

Post condition:	User can process the image in order to detect damages and predict the severity of the brain damage
Inclusions:	-
Extensions:	-

Appendix 5: Interview Questions

1. What is the best method (CT / MRI scan) that is used to identify a brain damage?

2. Do you always read and analyse CT scan to identify brain damages?

3. How many CT images do you analyse for a day?

4. How long do you take to read and analyse a CT image?

5. Is analysing results always accurate?

6. How easy would it be to have an automated system to read and detect brain damages?

7. How you identify the severity of the brain damage?

8. What are the factors that should consider when diagnosing the severity of the damage?

9. What are the features that you would like to have in such a system?

10. What are your feedbacks and comments about the project?

Below table contain the interview details.

Interviewee	Designation
Dr.S.H.Egodage	Consultant Radiologist, Military Hospital Narahenpita.
Dr.S. Wijekoon	Consultant Physician and Senior Lecturer in Medicine, Colombo South Teaching Hospital Kalubowila.

Appendix 6: Evaluation Questionnaire and Results

A6.1: The Evaluation Questionnaire

No	Question Text	Response Type
User Identification		
1	Name	Open ended
2	Designation	Open ended
Main Functional Requirements		
3	What is your opinion on using an intelligent system to detect brain damages?	Open ended
4	Out of the two segmentation methods what method will give a satisfactory output?	Open ended
5	How easy to identify the damage area using the system? Does it have any indication to the damage area?	Open ended
6	What are your comments on the general flow of the system?	Open ended
Non Functional Requirements		
7	What is your opinion on the performance and usability of the intelligent system?	Open ended
8	How accurate is the system in detecting brain damages?	Open ended
9	Do you think that the proposed system is flexible in detecting the severity of the brain damage?	Open ended
Benefits of the System		
10	In what kind of situations do you think that the detection of brain damages are most useful in?	Open ended
11	In your opinion what are the main benefits of the system regarding the detection of the brain damages?	Open ended
Future Work		
12	What do you suggest as future enhancements for this system?	Open ended

A6.2: The Evaluation Questionnaire Results

Dr.S.H. Egodage	Consultant Radiologist , Military Hospital Narahenpita
Dr.S. Wijekoon	Consultant Physician & Senior Lecturer in Medicine, Colombo South Teaching Hospital Kalubowila
Dr.Umesha Herath	Intern Trainee Doctor, gampola Base Hospital
Nimesha Dilanthi	Medical Student, Faculty of Medicine Ragama
Rashmi Haniska	Medical Student, Faculty of Medicine karapitiya

3. What is your opinion on using an intelligent system to detect brain damages?

Name	Answer
Dr.Egodage	It is a good approach to minimize the mistakes. On the other hand it will help to give better reading on the CT scan.
Dr.Wijekoon	I think it is an interesting idea as long as the system gives accurate result as the output.
Dr.Umesha	This is a good idea.
Nimesha	It is a very good idea.
Rashmi	Really great. Can be used as a learning material to identify damages.

4. Out of the two segmentation methods what method will give a satisfactory output?

Name	Answer
Dr.Egodage	I prefer both the methods.
Dr.Wijekoon	Segmentation using the second method gives a satisfactory output.
Dr.Umesha	Since both methods doing the same task. I don't see any difference.
Nimesha	Using method 2.
Rashmi	Both methods give expected results.

5. How easy to identify the damage area using the system? Does it have any indication to the damage area?

Name	Answer
Dr.Egodage	Yes. Damage areas are taken out from the original image.
Dr.Wijekoon	Damage area is clearly indicating in the method 1. At once it is difficult to notice the damage area in the method 2.
Dr.Umesha	Yes damages are clearly indicated. Try to use a more visible indication.
Nimesha	It is easy to identify.
Rashmi	Damages clearly visible in the system.

6. What are your comments on the general flow of the system?

Name	Answer
Dr.Egodage	Flow is maintained well. Easy to navigate through the system.
Dr.Wijekoon	The system seems to be well maintained.
Dr.Umesha	Good.
Nimesha	The flow is good.
Rashmi	General flow is fine.

7. What is your opinion on the performance and usability of the intelligent system?

Name	Answer
Dr.Egodage	It is easy to handle the system without any difficulty.
Dr.Wijekoon	No complex windows. It is a user friendly system
Dr.Umesha	System performs well with easy usability.
Nimesha	Easy to use.
Rashmi	Simple and easy to handle.

8. How accurate is the system in detecting brain damages?

Name	Answer
Dr.Egodage	Not 100% accurate in detecting the damage areas.
Dr.Wijekoon	Somewhat accurate.
Dr.Umesha	System gives accurate results.
Nimesha	Moderately accurate.
Rashmi	Gives accurate results.

9. Do you think that the proposed system is flexible in detecting the severity of the brain damage?

Name	Answer
Dr.Egodage	Yes, it seems flexible. Need to consider more factors.
Dr.Wijekoon	Apparently detecting severity status is not working.
Dr.Umesha	Appears to be flexible.
Nimesha	Can detect the severity in a flexible manner.
Rashmi	No comments.

10. In what kind of situations do you think that the detection of brain damages are most useful in?

Name	Answer
Dr.Egodage	When the exact damage area cannot examine through naked eye. So that can go for a system like this and take help.
Dr.Wijekoon	When reading amount of CT images is high.
Dr.Umesha	If there is any doubt in the readings.
Nimesha	Emergency situations.
Rashmi	Lack of experts to read the scanning.

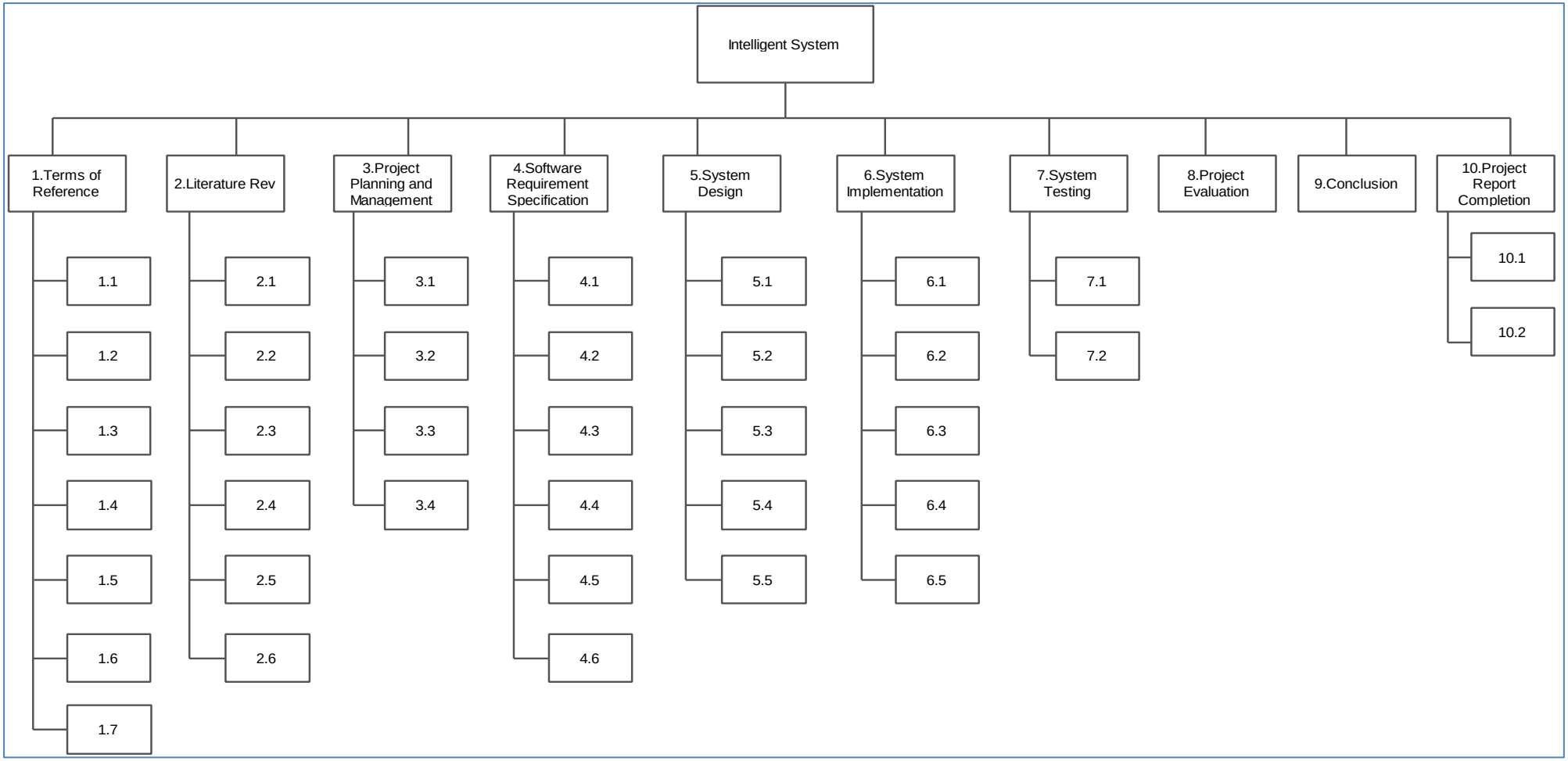
11. In your opinion what are the main benefits of the system regarding the detection of the brain damages?

Name	Answer
Dr.Egodage	Can reduce severe mistakes while reading.
Dr.Wijekoon	Save time.
Dr.Umesha	It minimizes human error due to the automation involve.
Nimesha	It's useful to anyone who is learning on the area.
Rashmi	Get practice to read any of the scanning's.

12. What do you suggest as future enhancements for this system?

Name	Answer
Dr.Egodage	Try to determine the presence or absence of a brain damage and give the severity status of the damage.
Dr.Wijekoon	Improve the system for both CT and MRI images.
Dr.Umesha	Improve identifying the severity status of the damage.
Nimesha	Try to Identify the affected brain area with the damage.
Rashmi	No comments.

Appendix 7: Work Breakdown Structure



Appendix 8: Gantt Chart

ID	Task Name	Duration	Start	Finish
1	**01. Preparing the Terms of Reference**	**10 days**	Mon 9/28/15	**Fri 10/9/15**
2	1.1 Identifying problem background	4 days	Mon 9/28/15	Thu 10/1/15
3	1.2 Identifying project solution	3 days	Thu 10/1/15	Sat 10/3/15
4	1.3 Defining the project scope	1 day	Sat 10/3/15	Sat 10/3/15
5	1.4 Defining the project aim	1 day	Sun 10/4/15	Sun 10/4/15
6	1.5 Defining the project objectives	3 days	Sun 10/4/15	Tue 10/6/15
7	1.6 Submitting the draft terms of reference	0 days	Wed 10/7/15	Wed 10/7/15
8	1.7 Submitting the final terms of reference	0 days	Fri 10/9/15	Fri 10/9/15
9	**02. Literature Review**	**16 days**	**Sat 10/10/15**	**Fri 10/30/15**
10	2.1 Research on the problem domain	2 days	Sat 10/10/15	Mon 10/12/15
11	2.2 Evaluating the problem definition	1 day	Mon 10/12/15	Mon 10/12/15
12	2.3 Identifying various research approaches	5 days	Tue 10/13/15	Sat 10/17/15
13	2.4 Identifying techniques and technologies	4 days	Sun 10/18/15	Wed 10/21/15
14	2.5 Analyse existing systems	5 days	Thu 10/22/15	Wed 10/28/15
15	2.6 Submitting the literature review	0 days	Fri 10/30/15	Fri 10/30/15
16	**03. Project Planning and Management**	**6 days**	**Fri 10/30/15**	**Fri 11/6/15**
17	3.1 Identifying suitable development process model	2 days	Fri 10/30/15	Sat 10/31/15
18	3.2 Monitoring plan	2 days	Sun 11/1/15	Mon 11/2/15
19	3.3 Risk identification	2 days	Tue 11/3/15	Wed 11/4/15
20	3.4 Risk mitigation plan	2 days	Thu 11/5/15	Fri 11/6/15
21	**04. Software Requirement Specification**	**15 days**	**Thu 11/5/15**	**Wed 11/25/15**
22	4.1 Analyse of data gathering techniques	2 days	Thu 11/5/15	Fri 11/6/15
23	4.2 Execution of online survey	5 days	Sat 11/7/15	Thu 11/12/15
24	4.3 Analyse of survey results	2 days	Fri 11/13/15	Sat 11/14/15
25	4.4 Conduct interview with knowledge experts	3 days	Sun 11/15/15	Tue 11/17/15
26	4.5 Determine Functional and non-functional requirements in the system	4 days	Wed 11/18/15	Sun 11/22/15
27	4.6 Submission of the SRS	0 days	Wed 11/25/15	Wed 11/25/15
28	**05. System Design**	**10 days**	**Fri 11/27/15**	**Thu 12/10/15**
29	5.1 Determining the design methodology and design tools	2 days	Fri 11/27/15	Sun 11/29/15
30	5.2 Identifying design goals	2 days	Mon 11/30/15	Tue 12/1/15
31	5.3 Designing the high level design architecture	3 days	Wed 12/2/15	Fri 12/4/15
32	5.4 Designing the low level design diagrams	2 days	Sat 12/5/15	Sun 12/6/15
33	5.5 Completing the software design specification	0 days	Thu 12/10/15	Thu 12/10/15
34	**06. System Implementation**	**59 days**	**Tue 12/1/15**	**Fri 2/19/16**
35	6.1 Identifying implementation technologies and tools	5 days	Tue 12/1/15	Sat 12/5/15
36	6.2 Implementation of core functionalities	29 days	Fri 12/11/15	Wed 1/20/16
37	6.3 Implementation of sub functionalities	3 days	Thu 1/21/16	Mon 1/25/16
38	6.4 Submitting the interim report	0 days	Mon 1/25/16	Mon 1/25/16
39	6.5 Demonstration of the prototype	0 days	Fri 2/19/16	Fri 2/19/16
40	**07. System Testing**	**13 days**	**Thu 3/3/16**	**Sat 3/19/16**
41	7.1 Executing testing criteria	13 days	Thu 3/3/16	Sat 3/19/16
42	7.2 Completion of testing	1 day	Tue 3/15/16	Tue 3/15/16
43	08. Project Evaluation	4 days	Wed 3/16/16	Sat 3/19/16
44	09. Conclusion	1 day	Wed 3/30/16	Wed 3/30/16
45	**10. Project Report Completion**	**16 days**	**Fri 4/1/16**	**Fri 4/22/16**
46	10.1 Submission of draft project report	0 days	Fri 4/1/16	Fri 4/1/16
47	10.2 Submission of final project report	0 days	Fri 4/22/16	Fri 4/22/16