MULTIPLE SCLEROSIS DETECTION USING IMAGE PROCESSING TECHNIQUES

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE

AWARD OF THE DEGREE

OF

MASTERS OF TECHNOLOGY IN

[SIGNAL PROCESSING AND DIGITAL DESIGN]

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CANDIDATE'S DECLARATION

I SRISHTY SINGH, Roll No. 2K20/SPD/13 student of M. Tech Signal Processing and Digital Design, hereby declare that the project Dissertation "**MULTIPLE SCLEROSIS DETECTION USING IMAGE PROCESSING TECHNIQUES.**" which is submitted by me to the department of electronics and communications, Delhi Technological University, in partial fulfilment of the requirement for the award of the degree of Masters of Technology.

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Date: 31-05-2022

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CERTIFICATE

I hereby declare that the project Dissertation titled "**MULTIPLE SCLEROSIS DETECTION USING IMAGE PROCESSING TECHNIQUES**" which is submitted by SRISHTY SINGH, Roll No. 2K20/SPD/13 Electronics and Communications, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Masters of Technology, is the record of the project work carried out by the students under my supervision.

S. Majumdar

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Date: 31-05-2022 SUPERVISOR

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ABSTRACT

Cancer is the main and the most crucial reason behind the huge number of deaths across the world, and in the developing countries like India the inception of sickness equivalent to cancer will disgrace the economy of the country. The disease like cancer ,ore importantly the disease Multiple Sclerosis is the only and the crucial reason behind the huge number of death rates and it is autoimmune disease which cause the most mortality rates due to being non curable disease. Computer tomography scan like MRI (Magnetic Resonance Imaging) is employed by radiologist to discover lesions present in the gray or the white matter of the brain which causes neurological disorders and is used to artifact the growth of the symptoms. Seeable version of the information that is obtained which enable the one to detection of Multiple Sclerosis at subsequent phases, therefor resulting in the prolonged treatment of the disease that ultimately increases the number of deaths caused by the different types of cancers. Because of this reason the Image Processing Toolbox which has many different tools is employed in order to detect the Multiple Sclerosis in advance. In the presented work, multiple Sclerosis is detected in the brain MRI image and the detection algorithm for the same is accomplished using the brain MRI image which is segmented with the help of Fuzzy C- means Segmentation algorithm in addition with some of the morphological operations that are employed for the accurate segmentation of Brain Region of Interest, from which Gray-Level Co-occurrence Matrix Algorithm (GLCM) features are extracted using discrete wavelet transform (DWT) algorithm and then finally used for classification of Lesions by traditional machine learning Classifier which is support vector machine (SVM) along with the Deep learning classifier which Convolutional neural Network (CNN).

CHAPTER 1
INTRODUCTION

1.1 Overview

Multiple Sclerosis is a remarkable generic health issues across world with highest death rates day byy day. The grandness of determining the accurate and streamlined implementation for identification of diseases like Multiple Sclerosis have been increased all over time and to find an optimal and accurate technique has become an important for the proper designation of the diseases. Multiple sclerosis, which is also better-known as MS, which is a very chronic and prolonged disease which directly attacks the Central Nervous System (CNS) and which basically exert influence on the brain's white matter automatically with the one's personal immune systems because of this Multiple Sclerosis is also best-known by an autoimmune disease. In the spinal cord and the brain the nerve fibre present is all surrounded by the liquid which is called as Myelin, that is basically used for protecting the nerves present and additionally helps the nerve bindings for proper functioning and conducting the Electric signals that is also called as Impulse among one another.

Myelin is the liquid which plays a vital role in the proper and the accurate functioning of the nervous System. During the electric impulse or electric signal transmission from one end to the other end in the body the only liquid that helps in proper transmission is myelin as it prevents the impulse or an electric signal from leaving it's parent axon by increasing the electrical resistances which subsequently enhances the transmission. The state is de-myelination occurs in the nervous system when the production or the existence of the conducting liquid that is myelin starts disappearing or is exhausted, due to which the various deficits takes place like the motor, cognitive and sensory in the body which can result in the neurological diseases. One among other the most renowned disease due to the lack of myelin or de-myeliniation is known to be as MS or specifically Multiple Sclerosis. MS is basically mostly an unheard-of disease these days, for which the diagnosis of this disease is accurately not known and the early detection of this disease plays a significant outcome on disease advancement [1].

The demyelination in the nervous system is responsible for the onset of the lesions in the brain. Therefore, the Brain lesions that are created are used for the proper detection of MS, and is the only way which is utilized to detect the patient's disease.

Presently, lesions are noticed semi-automatic or manually segmentation techniques, which are highly time-taking and depicts a full inter and variability [2].

Magnetic Resonance Imaging (MRI) was formally enclosed in the identification of the patients existing with a medically sporadic disease indicative of multiple sclerosis in the year of 2002 by an International panel of Experts [3]. Identification of multiple sclerosis basically relies on the mark of disease transmission in location and the time and omission of another symptoms that can simulate the multiple sclerosis with the specifications such as the laboratory and the clinical. MRI basically the most useful tool and substitute medical information for the diagnosis of the serious and chronic disease like multiple sclerosis, resulting in the early detection and early treatment of the disease. [4] MRI images is a important practical application and the almost communal technique for finding the MS patients. The medical demonstration of MS patient's regards a varied range of cognitive symptoms and physical disorders. Cognitive Disablement decreases the degree of life and the following treatment among the MS patients [5-8].

Multiple Sclerosis is a noteworthy general heath issue worldwide with mortality rates increasing day by day. Multiple Sclerosis, among all other cancer types is the most common and deadly that occur both in men and women, Multiple Sclerosis additionally Eating tobacco and smoking are the leading risk factors for causing malignant nodules. The survival rate of MS patients combining all stages is very less roughly 14% with a time span of about 5-6 years. The main problem with MS is that most of these MS cases are diagnosed in later stages of cancer making treatments more problematic and significantly reducing the survival chances. Hence detection of Multiple Sclerosis in its earlier stages can increase the survival chances up to 50-60% by providing the patients necessary fast treatment and thus it curbs the mortality rate. Small lesions in the brain and non-small lesions are two main types of MS classifications based on cell characteristics.

The most commonly occurring is non-small lesion that makes up about 80-85% of all cases, whereas 15-20% of multiple Sclerosis cases are represented by small lesions. Multiple Sclerosis staging depends on the lack of the liquid Myelin which results in the lesions formation in the spinal cord or the brain. Multiple Sclerosis diagnosis can be done by using various imaging modalities such Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and skull X-rays. CT scan images are mostly preferred over other modalities because they are

more reliable, have better clarity and less distortion. Visual interpretation of database is a tedious procedure that is time consuming and highly dependent on given individual. This introduces high possibility of human errors and can lead to misclassification of Multiple Sclerosis. Hence an automated system is of utmost importance to guide the radiologist in proper diagnosis of Multiple Sclerosis. The methodology developed for this system includes dataset collection, pre-processing of the MRI image and then followed by segmentation and morphological operations , feature extraction and finally classification.

Medical imaging methods are vitally employed for medical diagnosis, medical imaging techniques are utilized to examine the inner parts of the human body. The most challenging and the important sector in the field of the image processing is the method called as the medical image classification. Medical image classification algorithm is basically used for the detection of tumor or cancer detection and this is the most prominent application of the medical classification techniques. The death rate that is taking place from the cause of Multiple Sclerosis is very alarming and the statistics revealed that this kind of cancer is the most critical type of cancer in the human body which basically affects the brain and the spinal cord. According to the Interrnational Agency for Research on Cancer (IARC), with over 1,000,000 individuals are diagnosed with a Multiple Sclerosis each year around the world, with a death rate that is steadily growing. It is the second highest common cause of death in infants and individuals under the age of 34 years [1]. In recent years, clinicians have used sophisticated technologies to identify malignancies that are more uncomfortable for patients. CT (computed tomography) scans and MRI (medical reasoning imaging) are two useful technologies for analyzing abnormalities in various sections of the body. Due to a growing requirement for efficient and impartial evaluation of vast amounts of medical data, MRI-based medical image analysis for brain tumour investigations has gotten a lot of interest recently. This wide range of image forms necessitates the use of sophisticated computational quantification and visualization techniques. Since a result, automatic Multiple Sclerosis detection from MRI scans will be critical in this scenario, as it will eliminate the need for manual data processing.

1.2 Multiple Sclerosis

Multiple sclerosis, which is also better-known as MS, which is a very chronic and prolonged disease which directly attacks the Central Nervous System (CNS) and which basically exert influence on the brain's white matter automatically with the one's personal immune systems because of this Multiple Sclerosis is also best-known by an autoimmune disease. In the spinal cord and the brain the nerve fibre present is all surrounded by the liquid which is called as Myelin, that is basically used for protecting the nerves present and additionally helps the nerve bindings for proper functioning and conducting the Electric signals that is also called as Impulse among one another.

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The de-myelination in the nervous system is responsible for the onset of the lesions in the brain. Therefore, the Brain lesions that are created are used for the proper detection of MS, and is the only way which is utilized to detect the patient's disease. Presently, lesions are noticed semi-automatic or manually segmentation techniques, which are highly time-taking and depicts a full inter and variability [2].

1.3 Classification of Multiple Sclerosis

Since we can say that there is no fixed way or measure to predict whether how the disease of the person will progress. There are basically four different types of the Multiple Sclerosis which are also known as the phenotypes those are studied and published by the Internnational Adviisory Commiittee on Clininical Tririals of MS in 2013 which are defined as follows : relapsing remitting, clinically isolated syndrome, primary progressive and secondary progressive.

1.3.1 Clinically Isolated Syndrome (CIS)

CIS which is defined as the clinically isolated syndrome which is the most important and the first episode of neurological symptoms that takes place due to the presence of inflammation and de-myelination that occurs in the central nervous system. The basic characteristics of the disease is that when the first episode takes place in the central nervous system of the chronic disease which is Multiple Sclerosis should vitally exist or last only for at least 24 hours and this is not the only criteria that should be meant for the disease prediction as there are many patients who are suffering from the serious disease multiple sclerosis but they might or might not develop the symptoms of the disease.

When the lesions present in the brain MRI images are combined with the CIS they somewhat resembles to these lesions that are present in the disease multiple sclerosis when the second episodes of the neurological symptoms in the multiple sclerosis occurs, then in that case the patient is likely to suffer from the relapsing-remitting MS and the person is diagnosed with the RRMS.

1.3.2 Relapsing-remitting multiple sclerosis (RMMS)

RRMS that is abbreviation of the Relapsing Remitting multiple sclerosis which is the nearly common and basic disease type or course, this course is identified as the clearly outlined attacks of increasing or new neurological symptoms. These attacks are also named as the exacerbations or the relapses. Which are defined by the intervals of the complete or the partial recovery also called as remissions. During the state of remissions the symptoms that have occurred maybe either truly diss-appear or some of the symptoms may be consistent and become permanent to the patient. Although at this remission stage there is no significant progression of the disease. Relapsing-remitting multiple sclerosis can be classified in four different groups one is

active, the second is non active and followed by worsening and non worsening. In active is characterized as in which the relapses occur or there is a evidence of new MRI activity over a significant time period. Then is the not active which is characterized by the confirmation of increase in the disease followed by relapse. The various ratio of the individual's suffering from the chronic disease like multiple sclerosis in their initial state are basically effected by the first stage of the multiple sclerosis which is relapsing-remitting course.which is defined by the acute exacerbation, at this stage patient's suffering will be either completely or will incompletely never recover, and in between these periods there is a period in which the patient is clinically and medically stable. the International Panel on the Diagnosis of multiple sclerosis (IPDMS) defined the exacerbation as an attack or the relapse after observing the symptoms and highly objectively observing the early symptoms of the patients. Approximately over 85% of people are suffering from this disease.

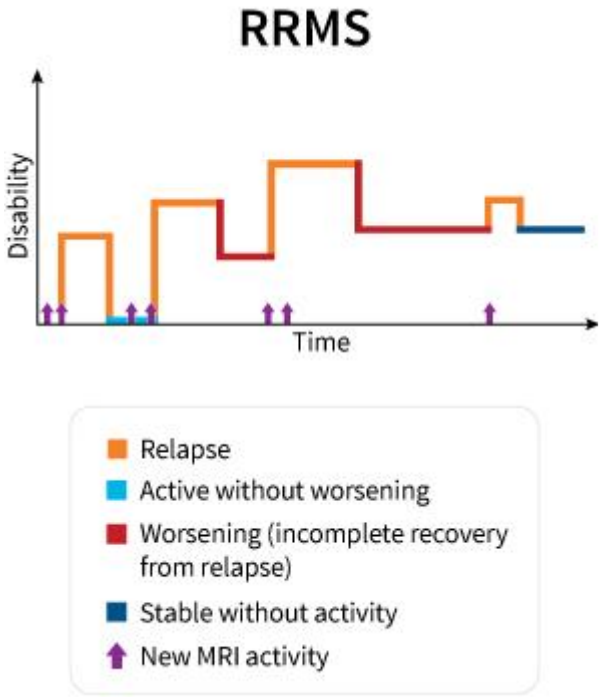

Figure1. Graphical view of Relapsing-remitting multiple sclerosis (RMMS)

This picture above depicts the various kind of activity of the disease that can take place in the form of RMMS over certain time period. Although each patient suffering from the disease will suffer in the unique way. There could be cases in which the person is having a relapse and the new symptoms that are aroused from the disease might get disappear without increasing the level of disease, or this might also happen

the the new symptoms may partially disappear and resulting in the increase of the disease. The new lesions present in the MRI image are represented by the arrows and they are often represented as the relapse. Sometimes the person suffering from the symptoms may have no knowledge that they are suffering from the multiple sclerosis and they can develop new lesions.

1.3.3 Secondary progressive MS (SPMS)

SPMS is basically a follow up step of the RMMS course. Patients who are at presently suffering from the RMMS they will eventually will transit to the new kind of course that is SPMS which results in the progressive worsening if the symptoms that are the neurological functions of the body resulting in the accumulation of the disability with the time. SPMS can be broadly classified into again four different categories the first two are active and not active and the last two are as follows as progression and without progression.

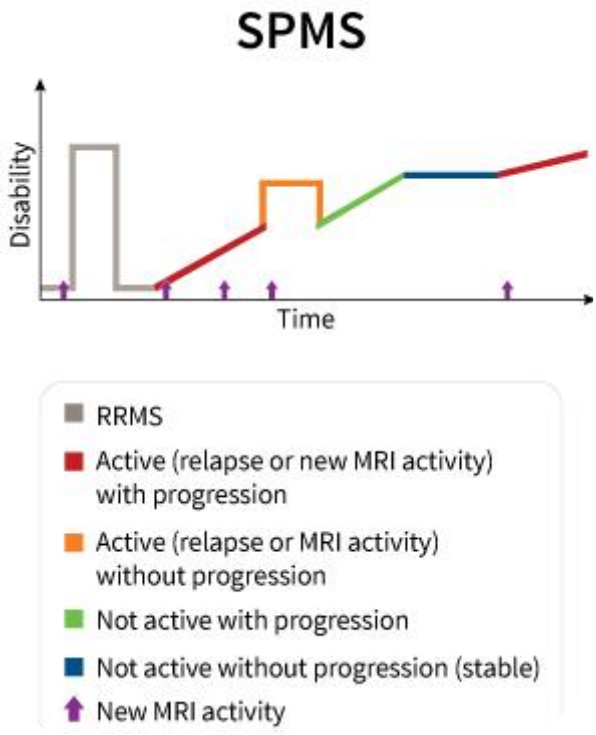

Figure2. Graphical view of Secondary progressive MS (SPMS)

This picture above depicts the various kind of activity of the disease that can take place in the SPMS over certain time period. SPMS basically is a follow up step of RMMS person suffering from RMMS will definitely be transitioning in the SPMS stage. Although each patient suffering from the disease will suffer in the unique way. There could be cases in which the person is having a relapse and the new symptoms that are aroused from the disease might increase resulting in the overall increase in the disability over time. The new lesions present in the MRI image are represented by the arrows and they are often represented as the relapse. Sometimes the person suffering from the symptoms may have no knowledge that they are suffering from the multiple sclerosis and they can develop new lesions.

1.3.4 Primary progressive MS (PPMS)

PMMS is a kind of disease or the type of multiple sclerosis in which the patient's neurological functions get worse and the accumulation of disability takes place as soon as the symptoms arrives without any occurrences of the relapses or remissions. PPMS can be broadly classified into again four different categories the first two are active and not active and the last two are as follows as progression and without progression.

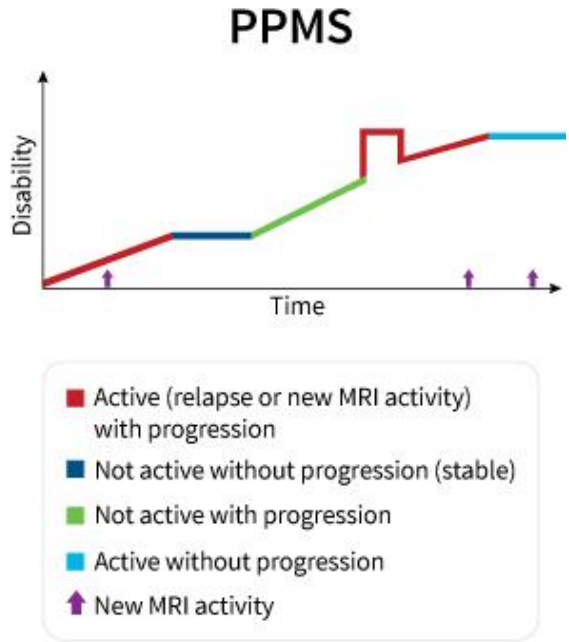

Figure3. Graphical view of Primary progressive MS (PPMS)

This picture above depicts the various kind of activity of the disease that can take place in the PPMS over certain time period. PPMS basically is a follow up step of RMMS person suffering from RMMS will definitely be transitioning in the PPMS stage. Although each patient suffering from the disease will suffer in the unique way. There could be cases in which the person is having a relapse and the new symptoms that are aroused from the disease might increase resulting in the overall increase in the disability over time. The new lesions present in the MRI image are represented by the arrows and they are often represented as the relapse. Sometimes the person suffering from the symptoms may have no knowledge that they are suffering from the multiple sclerosis and they can develop new lesions.

1.4 Motivation

Studying the recent fatality rates statistics that are resulted from the brain tumors or the multiple sclerosis is very high and on based of that we have selected the the multiple sclerosis detection with the help of image processing techniques. Lesions detection n the fled of image processing is very tough and time consuming as it is directly proportional to the human's judgement. The people who are expert in this related works like doctors , radiologists they study the MRI, PET scan and CT scan images of the brain and then suggest the required treatment depending upon the disease detected, and doing this all things the process is very much time consuming which can result in the progression of the disease resulting in the death of the patient that is why the automated methods are being used like image processing where the image is being fed into the classifier designed for the purpose of detecting the disease and then finally the time gets reduced and the treatment can be stared at earlier and the fatality rates decreases.

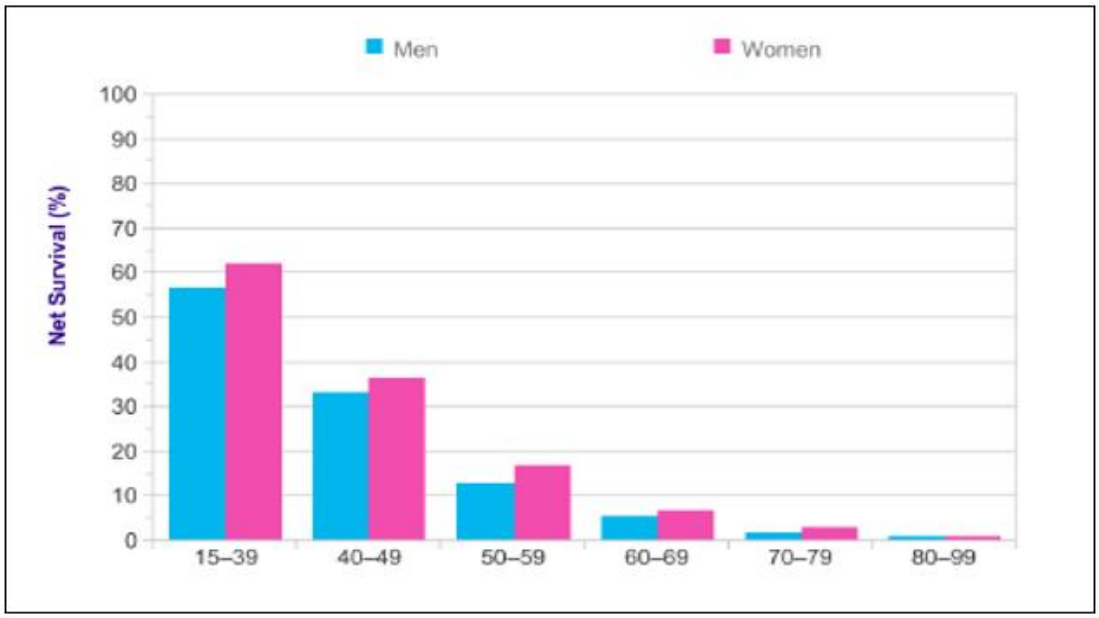

Figure 4. Survival and Cases rate of Multiple Sclresosis.

Figure above depicts the fatality rate or the deaths that are caused by the multiple sclerosis is comparatively very much higher than the rest other types of cancers. Multiple Sclerosis when detected at the early stage can significantly help in the reduction of the death rates in the filed of the cancers. With the advancement in the recent technologies used like image analysis and processing this will be beneficial for the people suffering from the disease like multiple sclerosis and resulting in the early treatment of the people and thereby reducing the death rates to a significant amount.

1.5 Objective

The vital aim and the objective of the projected thesis is to create and innovate a model or the classifier which will be efficient enough to detect any sort of tumor in the medical images that will be fed to the classifier as an input and simultaneously find some properties related to that tumor. The first and the foremost step of the multiple sclerosis detection is to acquire the data as this is the main and one of the hardest task as the data set for the brain images is rarely available and very much complicated for acquiring this data and then feeding in the classifier. Many researchers studied and focused on the defined work and methods like filtering, segmentation and feature selection. In our present work we focused on building or innovating a method or the system which can fulfill all the basic and the vital tasks to detect the tumor or the lesions and its features. We in the presented work formulated a

model which is very effective and accurate and the model helps in the process of segmentation and the finding of the multiple sclerosis lesions without the indulgence of the human and the manpower is also saved. Depending upon the traditional classifiers and the most effective classifier CNN classifier we came out with the result which will give the best results and the performance of the model is also the best in terms of accuracy and the sensitivity.

1.6 Thesis Formulation

This thesis work that is being proposed is formulated in the form of seven different section. In an upcoming section we will be briefly describing the chapters of the thesis in detail.

- **Chapter 1:- Introduction**

This id the first and the foremost important chapter of the thesis which includes the objective or the aim , the goal and the contribution related to our thesis. Herein we will describe the multiple sclerosis detection and classification .

- **Chapter 2:- Literature Review**

In this section we have described about the past and the related work that has been already studied and researched and depending upon the past work how we have modeled a new present method and explained about the disadvantages and advantages of the previous works

- **Chapter 3:- Background Study**

This chapter of our presented work describes about all the prerequisites that are needed for this thesis work in this chapter I have described the basics of the image processing methods and techniques and the various traditional and new machine learning algorithms and classifiers in detail.

- **Chapter 4:- Proposed Methodology**

The chapter 4 of our thesis describes the methodology that is being employed in innovating the model to segment the rain MRI image containing tumor with the help of the image processing techniques and methods along with the traditional machine learning classifiers to detect the tumor in brain MRI image and subsequently describing the CNN approach used in detail.

• **Chapter 5:- Experimental Results**

In this chapter five, we have explained the performance of the model that is being designed and along with the results that are obtained based on the proposed methodology are discussed in detail in this chapter.

• **Chapter 6:- Conclusion**

In this chapter six the main aim of this chapter is to discuss the conclusion that is being taken from the proposed algorithm. IN this proposed work we will list the limitations that are resulted from our proposed work and future scope and further innovations that we can add onto our proposed work.

CHAPTER 2
LITERATURE SURVEY

The approach of image processing is using the new and advanced approach which is given by Masive Training Artificial Neural Network (MTANN) is invented and prosed in the research paper which is done by the author Keniji Suzuki ete al [1]. The technique is very much useful for the radiologists to identify these lesions in the brain and if the lesions overlaps with the skull in MRI radiographs. In order to train the new proposed model that is MTANN the new and advanced algorithm is used which is named as the linear output Back- Propogation (BP) which is derived or traced for the multi layer ANN approach. The technique that is used efficiently for seperating the bones present in the soft tissues in the chest radiographs with the help of energy dependent function of X - Rays is the dual energy substraction technique. Kazunori Okada et al[2] proposed a statistical estimation and verification for illustrating the non-circular mathemtical structure of pulmonary lesions existing in multi-slice X-Ray CT scans. In this paper[3] two different approaches are proposed one is multiscale joint segmentation and model fitting solution.

The technique that is used here in the paper has an extended version in the context to the robust Shift - Based analysis till the linear scale space theory is achieved. A quasi-real time three dimensional lesion instance method is invented with the help of the above mentioned approach and is verified using the two varied clinical data-sets of the chest CT scan which is of thin quality. The projected work approach consists of three varied but sequential levels that are basically defined as the model verification, model estimation, and volumetric calculations. The author Ingirid Sluimier et al [4] invented a byregestration - Segmentation method in which the brain MRI image scan is elasticized certified with the scan that consists of the pathology scans. The other regestriation_segmentation approach incorporates the usage of the elastic certification of the important scans that are used with the help of the mutual information as the feature measure of similarity. In this proposed work the three different methods are being comapred for acquiring better results which are as follows Segmentation by Interactive Region growing, Segmentation by Rule-Based Region growing, and Segmentation by Voxel Classification. The results that are obtained from the comaparative study of the three approaches are better and accurate and we acquired refined registrations and along with the added benefits of the self-directed

pathalogical training data. The author Payel Ghosh et al [5]. in this paper proposed a new genetic segmentation algorithm for segmenting the medical images that are taken as an input. In this paper a novel approach for segmenting the prostate of the two dimensional pieces of the computed tomography (CT) scans which is automated in nature. In this technique the sectioning curve is depicted with the help of the level set function that is innovated from the novel algorithm which is called as the Genetic Algorithm (GA). Shape and textural priors obtained from manually segmented images are used to limit the development of the segmenting curve over successive generations. Some of the existing medical image segmentation approaches were reviewed by the author. Also they compared the performance of the approach with a simplex quality extraction technique (Laws texture measures) along with the GA-based segmentation means defined as the GENIE[6]. The primary tests were conduited on a very tiny grouping of sectioning contours. It is observed that, a significant result by converging on the prostate region was obtained. The future advancements are achieved using the spatial relations among the automated land-spots and with the extended three dimensional approach toward accomplishing it. A novel approach for lung nodule detection was described by Antonelli et al [7]. A Computer aided device (CAD) method actually is discussed over here for the accurate and efficient perception of the pulmonary approach was described for automated detection of pulmonary nodules in computed-tomography (CT) images.

Union of image processing approaches were employed I order to percept the disease like pulmonary parenchyma. A region growing approach based on 3D geometric features was applied to detect nodules after the extraction of pulmonary parenchyma. From the experimental observation, it was notified and concluded after the deep research that all of the present nodules those are malignant in nature are detected using the nodule perception technique resulting in the decreased false positives perception rates. Xujiong Ye et al [8] proposed a new CT lung nodule CAD approach. The technique can be applied for identifying both ground-glass opacity (GGO) nodules and solid nodules efficiently. Firstly the lung cancer nodule is segmented from the lung region of the MRI image with the help of the Fuzzy thresholding technique followed by computing the dots or the indexes present in the background of the image. The map taht is formally discussed actually is dependent on the local Gaussians along with the mean curvatures and the map that is discussed in the later section is dependent on the hessian matrix’s eigen values. Actually the voxels present

insdie the lungs are accurately measured in order to overall improve the objects with the following shapes and with the proper sphere elements. The aggregation of the “dot” features and shape index actually permits the accurate description of the structure in relation to the initial nodules of the candidate generation. In ancient period, the accurate segmentation of the brain mri image with the multiple sclerosis lesions is done by the method of deep neural networks. In the paper [9], a original techniques of deep 3D conolutional network method for encoder with some connection of short-path in the ways is represented for segmenting the Multiple Sclerosis detection of lesions in the brain MRI image.

This technique was assessed on he basis of the dataset that is publicly accessible onMICCAI-2008 [11] and ISBI-2015 [10] objection. In this paper the writer compared this method with the different other five paper techniques which are employed in the segmentation of the lesions present in the MRI images. The results that are obtained by using this techniques is better than the other techniques used in the previous works of the author for segmenting the MS lesions in brain mri image.In the paper [12], the new technique of automated multi-view CNN method for the segmenting the MS lesion in the mri data-set is used and carried out on the ISBI-2015 data-set available. Different Deep learning methods and acquisition techniques for the medical examination image investigation are conferred in [13]. Author has innovated a novel approach fr the segmenting of the (WM) white matter lesions present in the Multiple Sclerosis. (MS) with the help of the minute number of the processing imaging data-set [14]. In this paper the author employed a method which is named as cascaded CNN method for the working on 3-Dimentional MRI spots from the T1w modalities and FLAIR data-set.

In this technique the output form the first mesh network is being fed to the other second or subsequent mesh network in order to diminish the mis-classification from the earlier network used. The proposed approach is used or applied on the following data-set which is available on the MICCAI-2008 and this approach evaluated to give the better results used in the other papers. In this paper the writer invented a novel approach or method to segment the white matter from the lesions in the brain is called to be as Fully Convolutional Neural network (FCNN) [15]. The first method of the Cnn includes the dual- convolutional filter that are used for the two different images models. In the second method the dual- convolutional filer is employed on the output that is obtained from the first network which are connected in the parallel

fashion. This technique is employed on the dataset that is available on the ISBI-2015 data-set. Here the new technique is executed which is employed using the full 2 Dimensional Cnn approach which is used basically to segment the lesions in the brain mri image. [17]. In the fresh studies, a new novel approach for segmenting the tissue using the multimodal data-set of MRI images. And for the fresh studies that are carried out for the segmentation of brain tumor , for this a deep neural multitask method that is executed on the dataset which is called as BraTS is shown in[18].

The author in this paper innovated a well proposed method instead of the conventional V-Net with the help of two cascaded decoder roots. The segmentation process is performed with the help of the novel decoder, and simultaneously the The original decoder performs segmentation, and the newly added decoder performs the auxiliary task of distance estimation to make more accurate segmentation boundary. A total loss function is introduced to combine the two tasks with a gamma factor to reduce the focus on the background area and set different weights for each type of label to alleviate the problem of category imbalance. Zhang et al. proposed the ME-Net model and obtained promising results using the BraTS 2020 dataset [19]. In this paper for the different volume of the brain Mri Image four varied modal encoder blocks are being employed along with the skip connections. In this the author actually gives the combined feature map to the decoder block. The new model by the author proposed in this paper which introduces a recent loss function which is named as the categorical Dice, and the set varied weights for the execution of varied tasks.[20].

CHAPTER 3

IMAGE PROCESSING TECHNIQUES AND CLASSIFIERS

3.1 Introduction about Medical Image

The observation of body parts, tissues, or organs for medical assessment, treatment, and disease surveillance is referred to as medical imaging. Nuclear medicine, Radiology, image-guided intervention and optical imaging are all examples of imaging techniques.

3.2 Importance of Medical Image Analysis

The technique in which the image or the videos are being processed is the most advanced and the modern technology which is known as the Digital Image Processing. At present time the X-Ray has came out to be the most important physical application of the digital image processing technique. In the earlier times when the X-Ray images were not available at that the time it was very difficult for the experts like doctors and the radiologists to detect the human body for the fracture of the bone, for detecting the fracture caused in the human body the doctor has to cut the flesh and then look into bone whether it is cracked or damaged which was a very tedious and time consuming and painful method to detect the fracture in the bone so with the advancement the detection of the fracture became easy with the help of the X-Ray images.

Digital Image processing techniques has become so much important in every field and every perspective and it can be applied and used for all types of securities and for personal application as well. As the advancement took place the X-Ray images by the Roentgen IN the year of 1895 till the present time the imaging models like Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) the technologies and the methods have been emerged and gotten advanced and for future they will be keep on progressing.

Although , in today’s scenario the focus of working is getting shifted from the medical imaging techniques for the formulation and acquisition of data in the form of images to the post processing of images and the data and further the management of the data images.this is incorporated in the present scenario because this will be helpful in the proper and the accurate and efficient usage of data that is provided. Recent advances in imaging studies have demonstrated the technology's ability to improve and transform a wide range of clinical practices.

3.3 Medical Image Analysis using Machine Learning

The advancements in the fields of computers and imaging have been exponentially increased and had led to the exponent increase in the expected usage of the techniques like artificial intelligence in the various sector of radio-logical imaging techniques like detection,risk management,prognosis, diagnosis, rapid disease discovery as well as the therapy response. For machine learning algorithms the the computer extracted features can be helped to serve as the input and then processing those input fed to the machine learning algorithms the suitable outputs can be produced.

Employing these new and varied kinds of machine learning algorithms, there can be many features which are merged into the unique and single value like tumor representation which is directly related to the state of the disease [14]. There are various and many machine learning algorithms which have been applied since decades such as the linear discriminant analysis (LDA) support vector machine(SVM), decision tress and neural networks along with some random forest algorithms. These various machine learning algorithms have made it obvious that with the usage of these algorithms the better results can be generated and the tumor can be detected easily and the disease can be diagnosed in efficient manner and can be treated in the early stages.

3.4 Image Processing for Multiple Sclerosis Segmentation

The most demanding and the most challenging work in the area of disease detection and perception using image processing is to segment the ROI which is known as the region of interest from the image or any object and then followed with the segmentation of the lesions from the Brain or spinal cord MRI images that are considered as an input is very much ambitious type. For accurate segmenting the Lesion or tumors present in the Brain or spinal cord MRI images, the considerable amount of data has to be taken otherwise it would be very tedious task to segment the lesions from the brain MRI images. Furthermore, soft tissue boundaries might make tumour s difficult to define. As a result, obtaining reliable tumour segmentation from the human brain is a huge undertaking.

Image processing assists to modify the degree of quality of the MRI images and afterwards to execute the classification following the features extraction. For lesion detection and segmentation the MS disease, Image Processing methods concerns versatile paths such as pre-processing step , segmentation step, morphological operations step , feature extraction step and finally followed by classification step.

3.4.1 Pre-processing

For proper and accurate detection of the suspected region or region of interest (ROI) in the MRI Magnetic Resonance Image these two different techniques are used that are pre-processing and enhancement. In this following section the image enhancement method is used which is named as the gradient -based enhancement technique which is dependent on the local statistic and the first derivative of the image .The enhancement and the pre-processing techniques that have been deployed consists of two various steps out of which the first step is to remove the basic artifacts and the noises such as the X-rays marks or spots and the labels existing in the brain MRI image. The intermediate step involved in the enhancement and the pre-processing step is to move out the high frequency elements with the help of the different filters such as weighted median filters are used [12].

The medical images that are of the utmost interest used in the filed of medical image processing are vitiated by various types of noises. It is of utmost importance that the images should be accurate free form noises and should obtain the precise images for the responsible application of image processing[18]. Pre-processing process includes various steps such as filtering, morphological operations etc.

3.4.1.1 Filtering: Image filtering is the most and the foremost important step in the tract of Image Processing and it is very much useful for carrying out many various applications such as sharpening, smoothing, removing noises from the images.and followed by edge detection in which basically all the edges presented in the images are detected.

A filter is small array which is applicable to each pixel and the following neighbour present in the image is also defined as the kernel. Convolution is the method or the process in which the filter is applied the image, this process can be carried out in both the spatial as well the frequency domain. In filtering the spatial-domain filtering can be categorized into two main categories first is smoothing and the second is sharpening depending upon the outputs obtained.

1. Smoothening Filter: Smoothing filters are the filters which comes under the category of spatial filtering in this kind of filtering all sorts of the noises that are present in the images are being reduced with the help of smoothing and the blurriness present in the images are also being reduced. This smoothing spatial filtering includes

different kinds of filters such as box filter, median filter, Gaussian blur filter and bilateral filter etc.

1.1 Box Filtering: Box Filtering is a kind of spatial smoothing filtering technique which is fundamentally an average- of -surrounding- pixel. This box filtering is also called as the convolution filtering which is fundamentally used for the computation of mathematical operations in the filed of image processing. The process of multiplying two arrays in the manner to produce the third array is given by the convolution filters. The principle behind the box filtering is that two arrays or two images that are the sample images and the kernel filter are multiplied together to produce the third array which is called as the filtering result. The filter kernel present or used basically gives the description of how the filtering will happen and basically it defines the kind of filtering. The minimal standardized size of the filter kernel is 3x3, as shown in below diagram.

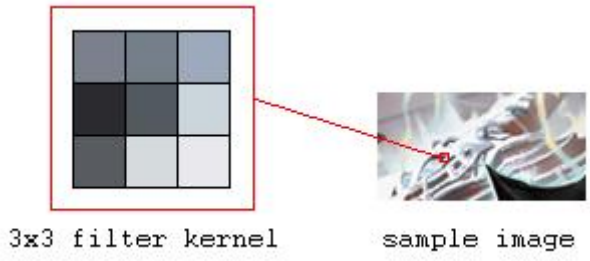

Figure 5. Diagrammatic view of 3x3 Kernel

1.2 Gaussian blur filtering: Mathematically Gaussian blurr filtering is also called as the Gaussian smoothing filtering in which the Gaussian blurr is applied onto the sample image is exactly same as the convuling the sample image with the Gaussian function. This filtering technique is also called as the Two Dimensional 2D Weierstrass transform. It is the technique which is used basically blurr the image and are employed in order to remove the noises and the details existing in the images. In this the Gaussian shaped kernel is used rest it is exactly same as the mean filter with the only difference is that in this the bell shaped kernel which represents the Gaussian function. The standard deviation of the Gaussian function is used to determine the degree of the smoothing.

1.3 Median blur filter: Median filtering is smoothing technique which is defined as the non linear technique that is employed to eliminate the noises those are existing in the images. This technique is used widely since this technique is very effective and accurate at removing noises present in the images along while preserving then use full edges of the images. The main and the basic noise that is salt and pepper noise can be easily removed with the help of this technique or using the median filtering. Mathematically if we see how the median filtering actually works is it moves through the image in the manner of pixel by pixel, and simultaneously replacing that pixel value by the median value of the neighbouring pixels in the images. There exists a term window which is represented by the pattern in which the neighbors of pixels occur. And the window actually slides in the pixel by pixel manner through the entire image and converts the images into the pixel.

The median is usually calculated by initially sorting all the pixels present in the window of the images I the numerical way or the order then followed by replacement of the pixel values by the middle or the median in short pixel value of the image.

1.4 Bilateral filter: bilateral filtering is filtering method which is a non-linear method which is also an edge preserving and also used for noise reducing smoothing filter for images. This is the only filtering mechanism which preserves the sharp edge. In this technique the intensity of each pixel is replaced with the weighted averages of the intensity values of the neighbors pixels in the images.

2 Sharpening Filter: sharpening filtering which is carried out in the spatial domain, this filtering technique is used to highlight the fine details present in the images and simultaneously removes the blurring present in the images and also used to highlight the edges present in the image. Sharpening filters are the different kind of spatial filtering technique which depend upon the spatial differentiation , and the various kinds of the sharpening filters are as follows sobel filter, Laplacian filters, and the difference filter etc.

2.1 Laplacian filters:

A Laplacian filter is spatial filter which is used for detecting the edges present in the images and it is used for the computation of the second derivative of the images , simultaneously measuring the rate at which the first derivative changes the values. The rate determines that the change caused is because of the change in the adjacent pixel values of the image or the continuous progression has caused the change. In

Laplacian filters the kernels basically contains the negative values that are present in the cross patterns which are centered inside the array. The values present in the corner of the array can be either a zero or the positive value followed with the centre value being the positive number or the zero. The following array represents the 3X3 kernel for a Laplacian filter

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

2.2 Sobel fifilters:

Sobel filters are the spatial filters which are used for the detection of edges present in the images. The principle behind this sobel filter is that it calculates the gradient of the image intensity present at the respective pixel within the images. This sobel filter is helpful for finding the direction of the highest increment from the light region to dark region and simultaneously finding the rate of change of the values in that particular direction respectively.

2.3 Difference filters: Difference filters are the filters that are used for enhancing the details and detailed information in the specific direction in which the mask is selected.

3.4.1.2 Morphological Operations:

The basic idea behind morphology is pixel dependent analysis. The most important ideology behind the morphological operation is basically to remove any sorts of imperfections present in the images[19]. Dilation and erosion are two most basic and important morphological operations present in the fields of image processing. The main ideology of the two morphological operations are the first dilation is that it adds the pixels to the surrounding boundaries of objects present in the images, and the second operation erosion is basically a process where the pixels of image are removed on the objects boundaries.Morphological operations also concludes the other functions such as the hit, Closing, opening, and miss transform etc. Morphological operation that is erosion is useful for removing the islands and small objects because only the substantive objects remains.

$$I \oplus H = \{(p + q) \mid for\ every\ p \in I, q \in H\}$$

The above equation represents the morphological operation being carried on the image, where the original or the sample image is represented as I the and the structured element in the image is represented by H. Erosion is basically the compliment of the process dilation. The outputs that are obtained on the application of morphological operation is the maximum value among all the pixels values present in the neighborhood of the images. If the neighbourhood pixel is assigned with the value 1 then the pixel value is also assigned with the value of 1in binary image. Morphological operation that is dilation creates the objects that are more visible and automatically fills up the minute holes present in the objects which are called as images of interest.

$$I\,H = \{p \in Z2\,|(p+q) \in I, for\ every\ q \in H\}$$

The above equation represents the morphological operation which depicts the I as the original image and the other H parameter represents the structured element. In the process of segmentation of lesions or tumors in the brain MRI image the morphological operations plays the major and the important roles for removing the soft tissues and boundaries and for proper and accurate segmenting the tumor sector in the MRI image.

3.4.2 Segmentation:

The basic and the primary step that is required in the image processing and analysis is the image segmentation. The basic ideology behind the segmentation procedure is to excerpt the Region of Interest of an image. The advanced technology of segmenting the medical images like MRI , Retinal image and X-Ray images has made an advancement in the establishment of varied applications in the medical field like treatment of people , diagnosing the disease in patients, and proper treatment and planning automated Surgeries.

Segmentation process that is the most important step in the lesion detection woks in the manner in which the image is divided into different regions and isolating the objects from the background. There are versatile varieties of segmentation algorithms that are as follows as thresholding based, edge based, clustering based, region based, etc.

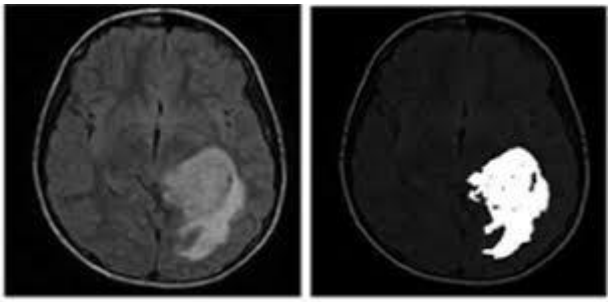

Figure 6. View of Segmented image.

For the advanced and accurate analysis and followed by segmentation of images, different new techniques have been developed during the last two decades and the images are being able to be segmented properly into its minute and basic components of interest. The different methods for detecting of the edges is also being deployed in the thesis which is again a very important and vital step in accurate and efficient image processing. Edges are basically are the boundaries that are present between the two varied regions of the images. By detecting the boundaries the image which is of interest can be detected and further the operations can be performed on that image to finally detect the disease and the region of interest. The main and principle image processing technique is the edge detection which is usually used for discovering the boundaries of an image with the help of detecting the discontinuities of brightness present in the images. The edge detection method in images have been studied in depth for almost last two decades rigorously and it plays the major and vital role in the detection and proper image processing and computer vision systems.
The following methods that have used for segmenting the image are as follows:

3.4.2.1 Canny Method:

This is the most important edge detection technique is widely used for the segmentation of the images depending upon the Precipitous changes in the intensity in the image.this canny edge detection technique basically works like a multi stage procedure. Canny edge detection algorithm is the only and mostly used algorithm which produces the best result in the form of the unbroken edges of the brain image [5].

3.4.2.1.2 Otsu Thresholding Method:

Otsu's - thresholding technique is the non -linear technique which basically works on the principle of converting the grayscale image into the binary image which consists of two levels which are assigned to the pixel values which are above or below the specified value which is called as the threshold value [4]. the two different levels that are present in the binary image are assigned to pixels above or below the specific value . it is basically dependent on the threshold value which is calculated using statistical calculations. Otsu- thresholding technique give the basic knowledge that the weighted sum of the class variance can be minimized present in the image or the object and the background pixels are used to establish the desired threshold values [5].

3.4.2.1.3 Particle Swarm Optimization:

The technique that is named as the particle swarm optimization had been invented by the adaption of the collaborative behavior which is exactly used for the searching of the food sources [6]. There is a terminology called as the particle which is represented by the bird which is in search of the space and this is all that is being represented in the Particle swarm algorithm. All of the particles that exactly has a value of fitness
Which is measure or computed using the fitness function with a velocity information of the particles that is responsible for the orientations of the flights. In this algorithms the particles are basically move in relation to particles those are the most fastly moving particles. PSO formula or technique initially executes with the combination of the particles those are randomly generated using the starts [7]. In every iteration , every particles that are present in the image are updated according to the two different values which are considered to be the best one. The initial of the present foremost values is that a particle found so far and is called "pbest". The other one is the best value found so far by any particles in the population. The value that is obtained is the globally the best value for the proper population which is defined as the terminology that is the "gbest".

3.4.2.1.4 Watershed Segmentation:

watershed segmentation technique is the method which is a gradient based segmentation algorithm which basically works on the principle where it studies the gradient maps of an image represented as the relief map[9]. This technique basically used for segmenting the image which is represented as the dam. The regions which

are segmented with the help of this method are termed as the catchment basins. Many problems that arises in the process of image segmentation are pretty easily solved by this watershed segmentation method. This technique is highly suited for the images which consists of the higher intensity values. Marker controlled watershed segmentation method is used for controlling the segmentation . The most used method for the edge detection is the Sobel operator [10]. The Sobel operator is used in the marker controlled watershed segmentation method for distinguishing the edges of the image or the object [11].

The watershed algorithms is the most classical algorithm used in the segmentation process that is basically used for segmenting of separating various objects from the image. This segmentation algorithm is applied on the gray scale image in the form of transformation. The main ideology behind the watershed segmentation technique is that the segmentation of the image, basically useful when the two different regions of interest (ROI) are very in proximity to each other by this means the edges or the boundaries of the objects touch each other[14]. this watershed segmentation technique of transformation considers the image like the topographic image, in which the height is represented by the intensity of each pixels present in the image. For example in this technique the darker areas are apprehended as the lower in height and they represents the troughs. On contrary the brighter regions present in the images are considered as the higher regions mimicking as the hills or can be also called as the mountain ridges[14]. watershed segmentation algorithm is fundamentally the most helpful algorithm for grouping all the pixels of the images depending upon the intensities of all the pixels in the images, pixels having the same properties or pixel having the same intensities levels are grouped together.

Figure 7. Segmented Image using Watershed Algorithm

3.4.2.1.5 Fuzzy C-Means (FCM) Clustering:

FCM that stands for the fuzzy C -Means algorithm which is an algorithm of clustering in which one piece of data is clustered into the two or more clusters. IN pattern recognition this is the only effective method is used. Fuzzy C-Means technique is the mostly used clustering techniques. Clustering, which is also defined as the cluster investigation, which is the accurate method of grouping the data information or data spots in the same category which are of similar nature or that shares same properties. while those in other clusters are as distinct as feasible. Similarity measures are used to identify different clusters. And the measures like connectivity, distance and intensity are the similarity measures depending upon which the clusters are formed [18]. Minimizing the objective function is the main objective of the clustering algorithm.

Figure 8. Segmented Image using Fuzzy C-Means (FCM) Clustering

3.4.2.1.6 K-Means Clustering:

Means algorithm is a type of an unsupervised learning algorithm in which if we have any sort of the un-labeled information that can be employed using the K-Means clustering algorithm for segmenting and clustering the data. This algorithm is incorporated to detect the groups those are not explicitly defined or labeled in the data. The main objective of the proposed algorithm is to define and detect the groups present in the data, where the variable K is used to express the number of the groups [12].

This algorithm is basically responsible for assigning each data point to the one of the groups present itertively. The centroids present in the form of the K Clusters, that can be employed to identify new information and classifications for the new training data that are present, the results of the K-Means Clustering algorithm. The collection or the group of data points which are aggregated altogether due to some similarities are called as clusters. The centre of the cluster is represented by

the real or the imaginary line or location which is called as the centroid. Each cluster's centroid is a set of characteristic feature values that defines the resulting groups that are formed using this algorithm . The feature weights of the centroid are basically used to subjectively evaluate the type of behaviour reflected by each cluster.

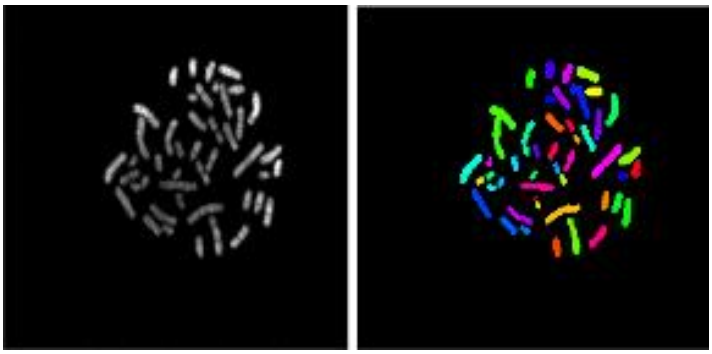

Figure 9. Segmented Image using K-Means Clustering

3.4.3 Extraction

Feature extraction is the method of extracting the useful and important information or the message from the images in the terms of the texture, colour features, contrast and shape of the images under test. In this feature extraction we have basically used two different techniques those are named as the GLCM which is defined as the gray level co occurrence matrix and the DWT which is defined as the discrete wavelet transform for extracting the statistical features.

3.4.4 Classification

3.4.4.1 Traditional Machine Learning Classifiers

The proposed method can only be evaluated when the classifier is used or when the appropriate classification algorithm is used. The task of building a model or the system which can detect and segment the tumor or the lesions present inside the MRI image is only the half of the work. The term model evaluation or the assessment or analyzing of the proposed model when done only justifies the proposed model and justification only gives the best result and the proper functioning of the innovated model. The various kind of machine learning algorithms or the classifiers that can be incorporated in the methodology for justifying or evaluating the proposed system or the model. The six various different machine learning algorithms or the six different

classifiers that can be employed for the effective evaluation of the proposed model are as follows: Logistic Regression, Multi-layer Perceptron, K-Nearest Neighbor, Random Forest, Support Vector Machine and Naive Bayes so that using these techniques the best accuracy for the process of lesion detection inside the Brain MRI images can be obtained so the proposed methodolgy that is used and evaluated is SVM.

3.4.4.1.1 K- Nearest Neighbor

KNN which stands for the term K -Nearest Neighbor is the one of the most efficient and the easiest of the classification algorithm or the technique that is accessible for the supervised learning. The ideology behind the K-Nearest Neighbour algorithm is that the search is done for the nearest match of the data that is under test in the features space. Fundamentally the classification of the objects is done depending upon the labels or tags of the K nearest neighbour present indicated by majority vote. The object is classified easily to the class of the object that is absolutely near to it when the value of K is exactly equal to 1. K should be an odd integer only when there are two classes present. While executing the multi-class classification sometimes by chance there are some times when the value of K is again a odd integer. After converting all images to a fixed-length vectors of the real values, we utilized the crucial and so common KNN distance function, that is known as the Euclidiean distance between the two points x and y, which can be expressed in the following way:

$$d(x,y) = |x-y| = \sqrt{(x-y).(x-y)} = (\sum_{i=1}^{m} (x_i - y_i)^2)^{\frac{1}{2}}$$

3.4.4.1.2 Logistic Regression

The deep learning algorithm which is logistic regression analysis is also known to be as the predictive analysis like all the regression analysis present in the field of machine learning. The principle of logistic regression analysis is basically describing the relationship that exists between one of the dependent variable which is of binary nature and the one or more among the ordinal, nominal ratio-level or interval independent variable. The equation which is used to represent the logistic regression basically resembles the basic linear equation. In the equation the output variable (y) is usually predicted depending upon the input variable (x) which are combined linearly using coefficients or weights. A major difference that exists between the linear

regression and the logistic regression is only that the output value or the output variable is being modeled as the binary value either 0 or 1 rather than a numerical value in linear regression is used to express the output variable. The equation written below depicts the that the predicted output is shown by the variable y and the b0 is the intercept or the bias term and for the single input value (x) b1 is the coefficient

$$y = \frac{(e^{b_0 + b_1 x})}{1 + e^{(b_0 + b_1 x)}}$$

3.4.4.1.3 Multi-layer Perceptron

A multi layer perceptron (MLP) is the deep learning algorithm which is also a feed forward neural network which is usually used to generate the group of output depending upon the a certain group of inputs. In this artificial algorithm there are three different layers that are present are as follows, first layer is the input layer , the second layer is the hidden layer and the last third layer is the output layer [14]. every node that uses a non linear activation function is represented as the neuron and this is only valid for the input nodes. Several layers of input nodes are connected in a manner which is represented as the directed graph between both the input and output layers of an MLP. Back-propagation is used by MLP to train the network. Except for deep learning, most neural networks are multi-layer. One or two concealed layers are used.

3.4.4.1.4 Naive Bayes

Naive Bayes is the artificial machine learning algorithms which is used for the classification purposes and to solve the classification problems. This algorithm is fundamentally dependent on the on the Bayes's probability theorem which is used to predict the group of unknown data - sets. This algorithm is used to predict the probabilities of each group like the probability that is being given and recorded and the data sets or the points that is belonged to a certain class of the data. The class is the main class only when the probability of that class is the highest. The machine learning algorithm such as the Naive Baye's artificial classification machine learning algorithm have multiple and many important features and particular classes,

3.4.4.1.5 Random Forest

Random forest is a kind of algorithm which is supervised in nature which is dependent upon the ensemble learning. The type of learning where varied types of algorithms or the similar kind of algorithms are joined or summed up so many times to produce the most potent prediction algorithm and the model produced depending upon tat powerful algorithm will be the best model that is created. In random forest algorithms the various algorithms of the similar types are just grouped together like the multiple decision trees are combined together to form the random multiple forest decision trees algorithm which is responsible for over-fitting to the corresponding training data-set[16]. It works by building a large number of decision trees during training and then outputting the group which represents the mode of the classification or the classes or represents the mean prediction (regression) of the individual trees [16].

3.4.4.1.6 Support Vector Machine (SVM)

Support vector machines are the machine learning supervise models that are linked with varied machine learning algorithms which analyses the data that is being used for the classification purposes along with the regression computation analysis. Depending upon the training set that is provided is marked as the group or the class that is belonging to the one or more categories . The SVM support vector machine algorithm is the algorithm which is used for the formation of model which is used to assign the new examples to a specific category and to the other , keeping it to be non - probabilistic binary linear classifier [17]. The SVM classifier is generally used to represent the instances represented as the points in space which are certainly lined in the manner that the instances of the other categories are separated in such a manner that the gap between the two categories is as wide as possible. The algorithm works in the manner that the instances are being mapped onto the similar space and then the prediction is done on the basis of the category they belong to and onto which of the side of gap they exactly fall. For performing the linear classification the SVM algorithm can be accurately used to execute a non linear classification as well which is given by the name of kernel trick which generally maps down the inputs present onto the high dimensional features space.

3.4.4.2 Convolutional Neural Network (CNN)

The author Kunihiko Fukushima in the year 1980 introduced the fundamental model that is convolution neural network [18]. (Conv-Nets or CNN) are the terms used for the Convolutional Neural Network represents the type of the neural networks which are very effective and accurate and actually have proved to be the best for the image classification as well as for image recognition. Convolutional neural networks CNNs have basicalyy dominated the computer vision algorithms as the accuracy that is obatined from the CNNs is very high in the field of image classification and image recognition. Convolutional neural networks usually are the sub parts or belongs to the category of the FNN which is termed as the feed forward artificial neural networks which are the algorithms that are in the filed of deep learning, which comprises of the nodes that are connected in such manner that they do not from a cycle. The CNNs uses different sorts of the perceptrons which are fundamentally designed in a manner to acquire the marginal pre-processing easily. The main principle behind the Conolutional neural networks is that it is pre-assumed that the input to the ConvNets architecture are images in nature , which certainly allows the users to encode specific properties and characteristics in the architecture or the model. The model then subsequently allows the forward function to take place easily and effectively and this certainly reduces the abstraction of the parameters used in the network. The Convolutional neural networks are basically build from the neurons which comprises of some weights and the biases. The main ideology behind this is that every neuron present exactly receives an input in the form of an image and simultaneously performs the dot product.

In this algorithms firstly all the layers are arranged in manner that they appear in three different dimensions that are height, width and depth. In this neurons that are present in single level they does not get connected to these neurons those are present in the succeeding level but only gets connected to the smaller area of it. To sum up this algorithm procedure the final output that is obtained will get reduced in the manner and will be represented to a individual vectors of probable scores which are arranged depending upon the depth dimension. In addition the Convolutional Neural Network the also performs the conolutional operations in the case of the matrix multiplication.

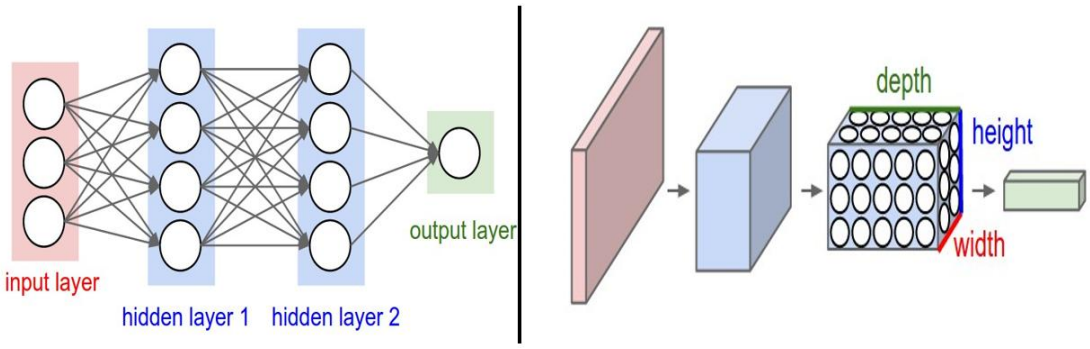

Figure 10. Simple view of Convolutional Neural Network.

The above figure depicts the convolutional network in which the left part of the diagram shows that the orderly three layers of the neural network. On contrary the right hand side of the diagram shows that the convolutional neural network which is significantly responsible for arranging the neurons present in the three dimensions (height, width, depth) [16]. Every layer present in the convolutional network the three dimensional input volume is being transformed and results in the generation of the three dimensional output volume that is of neuron's activation's. In this diagram the red colour layer is used to hold the image so the three dimensions that are width , height and depth are represented in the manner the height and the width of the images. And the depth is represented by the three channels that are red, green, and blue.

1 The Convolutional Operation: Convo-Nets executes a mathematical operation, which is called as the convolutional operation. The basic work of the convolution operation is that it convolves the two function that are g and f and after convolution it produces the third function that is called as the convolved output. The convolutional function of two functions can be represented as the (f * g). It is basically given as the integral product of the two various functions f and g where after one of them has been inverted and shifted. This is a specific type of integral transformation [19]: There are three different elements that are used to performing the convolution operation [19]:

• **Input Sample image:** This is the image which is fed to the input layer of the convolutional neural network in the form of input.

• **Feature detector:** A feature detector is sometimes known as a "filter" or "kernel", As a feature detector, a 5*5 or 7*7 matrix is sometimes employed.

• **Feature map:** An activation map is another name for a feature map. It's called as a features map due to this is a map indicating exactly which a specifies a specific type of feature can be spotted in the image. Figure 11 depicts the convolution operation.

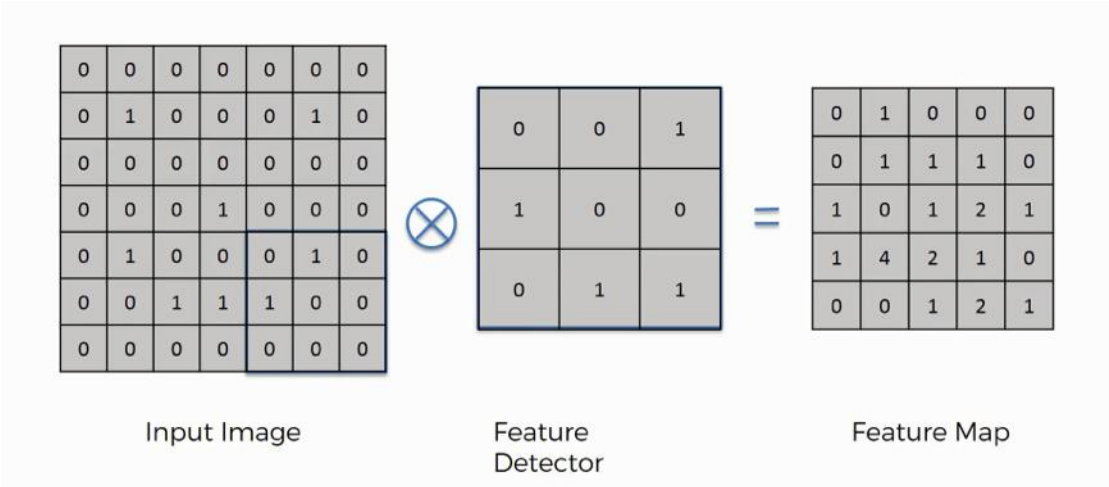

Figure 11. Process of Convolution Operation.

CHAPTER 4

PROPOSED METHODOLOGY

4.1 Overview

In this thesis the first section represents the data acquisition and followed be the pre-processing techniques on the MRI Images that are obtained in the data acquisition step. In the second section of the thesis the different types of segmentation algorithms and followed by different morphological operations techniques are covered and discussed in the detail. In this thesis the following section includes the discussion about the different features extraction techniques that are used in the thesis and concluding the thesis with the explaining the different types of classification algorithms that have been employed in the presented work

The two methods that are proposed in the presented work for detecting the abnormal lesions present in the brain MRI images are done with the help of traditional machine learning algorithm calssifier and the deep learning algorithm Convolutitional Neural Network (CNN). In traditional machine learning classification step, the proposed model in the presented work can be trained using six different kinds of traditional machine learning algorithms those area s follows: Logistic Regression, KNN, Multi-layer perceptron,Random Forest,Naive Bayes and SVM, but since SVM gives the best accuracy so we have employed the SVM algorithm.. In the beginning the proper segmentation algorithm that have been used for segmenting the brain MRI images for detecting the lesions present in the brain MRI images are being studied in detail. Secondly the all the six different traditional machine learning algorithms those are used for the accurate detection of lesions in the brain MRI image are being discussed in detail, and in the end we will discuss the proposed system in detail and will explain the CNN algorithm for detecting the lesions in brain MRI image.

We have also proposed the segmentation of Brain MRI images with the help of clustering algorithms. The cluster is basically defined by the pixels which are grouped in the manner where the pixels share the similar properties[11]. The algorithm Clustering is also one of the kind of unsupervised learning algorithm. The system automatically classifies things based on user-defined criteria, hence the name unsupervised classification is given to the Clustering algorithm. For tumour detection from brain MRI scans, the K-means clustering technique is employed for picture segmentation, followed by morphological filtering.

The primary stages of our projected model will be depicted in the following sections with the help of following figure.

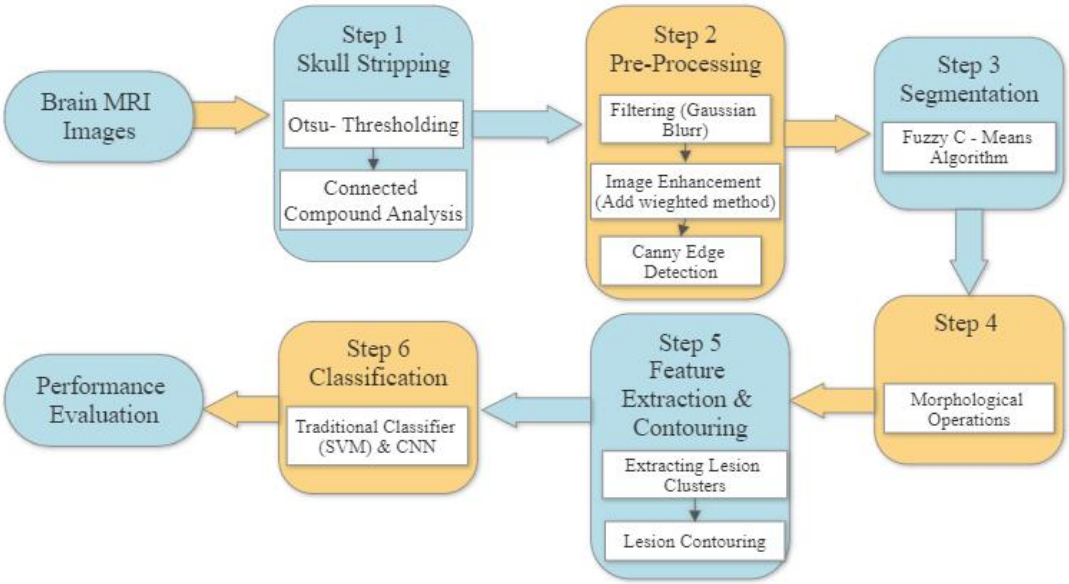

Figure 12. Block Diagram of Proposed Methodology.

4.2 Working Strategy for Lesion Detection

The work that has been proposed in the context for Multiple sclerosis detection, which requires the proper segmentation of brain MRI image have been broadly classified into two main stages and the stages are as follows :

• **Stage-1**: Multiple Sclerosis lesion Detection employing Traditional machine learning Classifiers like SVM

• **Stage-2**: Multiple Sclerosis lesion Detection employing Deep learning classifiers.

4.3 Stage-1:

Multiple Sclerosis lesion Detection employing Traditional machine leaning Classifiefiers

In the first invented model, the method that is proposed in the presented work for detecting the abnormal lesions present in the brain MRI images is done with the help of traditional machine learning algorithm calssifier SVM. In traditional machine learning classification step, the proposed model in the presented work can be be trained using six different kinds of traditional machine learning algorithms those area s follows: Logistic Regression, KNN, Multi-layer perceptron,Random Forest,Naive Bayes and SVM. The proposed model used for the detection and segmentation of

Multiple Sclerosis with the help of the traditional machine learning algorithms include seven steps that are as follows:

The projected system of multiple sclerosis detection employing the traditional machine learning algorithms comprising of six different stages:

• Step-1: Skull Stripping.

• Step-2: Filttering and Enhancement of the brain MRI Image.

• Step-3: Segmentation carried out with the Fuzzy C-means Algorithm.

• Step-4: Morphological operations.

• Step-5: Lesions extraction & contouring.

• Step-6: Classiification using traditional machine learning classifiers.

The outcome of our proposed work is established with the adequate and accurate and efficient results. We will extensively detail the suggested lesion segmentation model, and we will evaluate the performance of six conventional Machine learning classifiers utilised for classification of the projected model. The sections of the suggested technique will be extensively explained in the following section.

4.3.1 Skull Stripping

The most important and significant stage of Brain MRI image segmentation is the process called as the skull stripping. Skull stripping is the most vital stage and step that is used in the field of medical image processing because the background of the medical brain MRI image does not contain any useful information and so because of that reason it has to be removed for accurate and proper processing of the brain MRI image as it will help in reducing the processing time and the results obtained will be more efficient. In the literature survey many researchers have proposed different methods used for the process of skull stripping those are as follows in the paper [19]. usually the techniques used for the operation skull stripping should produce efficient, effective, reliable results and should be a fully automated technique. The various techniques that are proposed in the presented work have both some advantages as well disadvantages. In the projected work the new adaptive method is invented which is used for extraction for the brain tissues and simultaneously removing the skull bone from the brain MRI images. The proposed skull stripping technique that is used can be performed using three different steps which are as follows:

- First and the foremost step used in the field of the image processing is the image segmentation. Segmentation is the process that is the most important step in the

lesions detection works in the manner in which the image is divided into different regions and isolating the objects from the background. The one of the most easiest method used for carrying the segmentation operation successfully is the Otsu's Thresholding method that is used for the skull removal from the background of the Brain MRI Image. The basic ideology behind this is that in this process the image is converted in the binary format where the gray levels of the images are either 0 or 1 in which 0 is represented by the black and 1 is represented by white.

- After the binarization process of brain MRI images is completed, the erosion operation is carried preceding to the operation of connected component analysis.
- At the last when the erosion operation has been done then the at the last step of the skull stripping, the technique of connected component analysis is used which is applied in order to extract brain or the skull image, and as the result the skull is removed form the background of the MRI image.
- Using all these operation performed over the Brain MRI image we accurately discovered the biggest component of the brain MRI image which is the skull and is of the most important use, along with the mask which represents 1 for the inside of the brain region and 0 for the outside of the brain region.
- At the end when the mask is found and evaluated then the skull can be finally removed by executing the multiplication operation between the mask and the dateset images acquired.

4.3.2 Filtering and Enhancement

As we know, in medical image processing field, the medical images are more prone to the noises especially the brain MRI images than the other medical images, so we need to quantify the brain MRI image quality by reducing the noises present in the images for efficient segmentation. The Gaussian blur filter is used for the removal of Gaussian noises that are existing iin the brain MRI images which degraded the performance of the segmentation process. The brain images consist of many tissues and many abnormal regions and subtle details but since the most useful things required for the efficient segmentation of the brain MRI image is only the abnormal tissues present inside the brain MRI images. There might be the presence of the small abnormal region and the lesions tissues but among them we require to detect the tissue or the abnormal regions which is the maximal in nature.

The Brain MRI images are mainly comprised of the Gaussian nose in higher ratio than the other noises , since this is the scenario the Gaussian filter is used to remove the noise which is of Gaussian nature. After the removal of the noises present in the brain MRI image the edges are detected using the canny algorithm which is given by the most important edge detection technique widely is used for the segmentation of the images depending upon the precipitous changes in the intensity in the image. This canny edge detection technique basically works like a multi stage procedure. Canny edge detection algorithm is the only and mostly used algorithm which produces the best result in the form of the unbroken edges of the brain image [5], followed by enhancing the image with the help of the add weighted methods which basically provides the blending effects to the images. The enhancing of the brain MRI images includes the steps starting with the first step : the image is blurred using the smoothing filters, the high frequency components of the images are suppressed. Then after that the second step as follows: firstly the smoothed images are subtracted form original sample image and the result obtained is named as the mask, and the output would be comprising of all the high frequency components which gets obstructed by the smoothing filters used in the first step.

4.3.3 Segmentation using Fuzzy C-means (FCM) Algorithm

Fuzzy C-Means clustering algorithm is used for segmentation, FCM that stands for the fuzzy C -Means algorithm which is an algorithm of clustering in which one piece of data is clustered into the two or more clusters. IN pattern recognition this is the only effective method is used. Fuzzy C-Means algorithm is the mostly used clustering algorithms. Clustering, also known as cluster analysis, is the process of grouping data points into clusters so that things in the same cluster are as similar as possible, while those in other clusters are as distinct as feasible. Similarity measures are used to identify different clusters. And the measures like connectivity, distance and intensity are the similarity measures depending upon which the clusters are formed [18]. Minimizing the objective function is the main objective of the clustering algorithm.

4.3.4 Morphological Operations

The basic idea behind morphology is pixel dependent analysis. The most important ideology behind the morphological operation is basically to remove any sorts of imperfections present in the images[19]. Dilation and erosion are two most basic and important morphological operations present in the fields of image processing. The

main ideology of the two morphological operations are the first dilation is that it adds the pixels to the surrounding boundaries of objects present in the images, and the second operation erosion is basically a process where the pixels of image are removed on the objects boundaries.Morphological operations also concludes the other functions such as the hit, Closing, opening, and miss transform etc. Morphological operation that is erosion is useful for removing the islands and small objects because only the substantive objects remains.

For proper segmenting of the lesions from the brain MRI images, the only required and of the utmost use is the brain portion instead of the full skull part. For the purpose the the morphologigical operations are carried out in the brain MRI images. The first step carried out in the morphological operation is to execute the erosion operation for separating the weakly connected portions of the MRI images. Then after the erosion process is completed the output obtained are the multiple disconnected portions of the brain MRI images[20]. Dilation is the process which is executed afterwards. For the proper removal of noises present in the images of the brain MRI images the process of dilation following the erosion is used.

4.3.5 Lesion extraction & contouring

In the step of lesion extraction, the lesions are being extracted in the form of abnormal tissues that are present in the brain MRI images and by extracting the tissues we can outline the perimeter of the lesion[20]. The perimeter of the lesion tissues is defined by the maximum distance that is measured between the edges present in the brain tissues in brain MRI images. The thresholding method which is also called as the intensity based approach is used for extracting the lesion tissues present in the brain MRI images, following this approach the output that is obtained will be the extracted lesion area from the brain MRI image with the dark background. After the extraction process is carried out the next step or the operation that is done on the brain MRI image is the contouring where we contour the lesion present in the MRI image and the segmentation of the brain MRI image is done to get the lesion accurately from the MRI image. At the end after extraction and contouring , once the lesion is being detected then the mage is fed forward for classification using different sorts of classifiers and using them we will also detect some features from the images which are related to the brain MRI images.

A. Feature Extraction using Discrete Wavelet Transform (DWT) with Gray-Level Co-occurrence Matrix Algorithm (GLCM)

1. Feature Extraction

Feature extraction is the method of extracting the useful and important information or the message from the images in the terms of the texture, colour features, contrast and shape of the images under test. In this feature extraction we have basically used two different techniques those are named as the GLCM which is defined as the gray level co occurrence matrix and the DWT which is defined as the discrete wavelet transform for extracting the statistical features.

2. Discrete Wavelet Transform:

Discrete wavelet transform is a kind of the wavelet which is used for analyzing various frequencies that are present in an image with the help of the different scales that are present. In this proposed wok we are employing the technique the discrete wavelet transform (DWT) which is a very powerful method or tool used for extracting the features. This technique is used for extracting the coefficients of wavelets from the brain MRI image. The wavelet used here is used to localize the information in the form of frequency of the signal function that played a crucial rule in classification. The main principal on which this discrete wavelet transform actually works is that in this the images that are of interest are taken and are decomposed into different spatial frequency components those are extracted from the low level (LL) sub-bands although the high- low (HL) sub-bands have higher accuracy in comparison with (LL) lo-level, for better results both the techniques HL and LL are been employed which accurately defines the text features [21].

3. **Gray-Level Co-occurrence Matrix Algorithm (GLCM)**

GLMC is the method which is broadly used for the purpose of medical image processing, analysis and classification. The method used in the proposed work allows us to find the information regarding the relative positions of the two or more pixels with respect to one another. The GLMC matrix is then formed with the help of counting or calculating the number of the times the pixels pairs occurred at some specific distance[22].

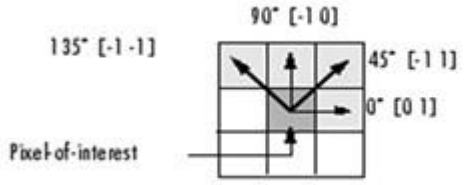

Figure 13. Eigen Vector of GLMCC.

The features that are extracted from the above algorithms are as follows:

1. **Correlation:**

Correlation is the term which is used for measuring the linear dependencies of the gray levels of the neighbouring pixels present in the images. Correlation can be defined with help of the equation 1 which is as follows:

$$Correlation = \sum_{i,j=0}^{N-1} P_{i,j} \frac{(i - \mu)(j - \mu)}{\sigma^2}$$

2. **Contrast:** Contrast is the most important feature which is calculated in the field of image processing which is also defined as the sum of square variances. The term contrast is used for postponing the calculation of the intensity contrast between a pixel and its neighbour throughout the entire image. Contrast can be defined with help of the equation 2 which is as follows:

$$Contast = \sum_{i,j=0}^{N-1} P_{i,j}(i - j)^2$$

3. **Energy:** Energy is the concept where it takes the use of a texture which is responsible for calculating the image ordering. In GLCM, Energy returns the sum of square of elements. Energy can be defined with help of the equation 3 which is as follows:

$$\mathbf{Energy} = \sum_{i,j=0}^{N-1} (P_{i,j})^2$$

4. Homogeneity: Homogeneity is the term which is defined in the manner is that it calculates the value of the tightness of distribution present in the elements in context to the GLMC-to-GLMC diagonal present in the GLMC matrix. Homogeneity can be defined with help of the equation 4 which is as follows:

$$Homogeneity = \sum_{i,j=0}^{N-1} \frac{P_{ij}}{1 + (i-j)^2}$$

5. Mean: The term mean is defined as the average of all the pixel values that are present in the input image. Mean can be defined with help of the equation 5 which is as follows:

$$Mean = \sum_{i,j=0}^{N-1} i(P_{i,j})$$

6. Standard Deviation: The term standard deviation is defined as the scattering of the pixels in relation to the pixel's mean value of the brain MRI image. Standard deviation can be defined with help of the equation 6 which is as follows:

$$Standard\ Deviation = \sqrt{\sigma_i^2}$$

7. Entropy : It displays the quantity of image data that is required for image compression. The loss of useful data or useful information in a message signal is measured by entropy, which also includes image information. Entropy can be defined with help of the equation 7 which is as follows:

$$Entropy = \sum_{i,j=0}^{N-1} -\ln(P_{ij}) P_{ij}$$

8. Root Mean Square (RMS) : The term Root Mean Square is basically used for giving an accurate quantity of the noise present in the images. To calculate the RMS of the set of pixels of an image, first the square of each pixels is calculated followed by the executing the sum of all those pixel squares and finally taking the square root of the result. At last the output obtained is scaled with the number of the pixels present in the image. RMS can be defined with help of the equation 8 which is as follows:

$$RMS\ noise = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \frac{\sum_{i=1}^{n} X_i}{n})^2}{n}}$$

9. Variance : Variance is the term which is defined by the expected squared deviation of the pixel from its mean value is called as the Variance. Variance can be defined with help of the equation 9 which is as follows:

$$Variance = \sum_{i,j=0}^{N-1} P_{i,j}(i - \mu_i)^2$$

10. Inverse Difference Movement (IDM): Inverse Difference Moment (IDM) is defined as the local homogeneity present in the input image. It is considered t be high when the local gray level in the image is uniform in nature along with the inverse GLCM being high. IDM can be defined with help of the equation 10 which is as follows:

$$IDM = \frac{\sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} P_{ij}}{1+(i-j)^2}$$

4.3.6 Classifification by traditional classififier

In classification step we have employed six different traditional machine learning algorithms for accurate classification of the brain MRI image , the proposed model in the presented work is being trained using six different kinds of traditional machine learning algorithms those area s follows: KNN, Logistic Regression, Multi-layer perceptron,Random Forest, SVM and Naive Bayes. out of all the algorithms that have been used the SVM showed the best results. In this following section, we will inform that why the SVM machine learning algorithm gave the most improved result.

1. Support Vector Machine (SVM)

Support Vector Machines are the machine learning supervise models that are linked with varied machine learning algorithms which analyses the data that is being used for the classification purposes along with the regression computation analysis. Depending upon the training set that is provided is marked as the group or the class that is belonging to the one or more categories . The SVM support vector machine algorithm is the algorithm which is used for the formation of model which is used to assign the new examples to a specific category and to the other , keeping it to be non - probabilistic binary linear classifier [17]. The SVM classifier is generally used to represent the instances represented as the points in space which are certainly lined in the manner that the instances of the other categories are separated in such a manner that the gap between the two categories is as wide as possible. The algorithm works in the manner that the instances are being mapped onto the similar space and then the

prediction is done on the basis of the category they belong to and onto which side of the gap they exactly fall. For performing the linear classification the SVM algorithm can be accurately used to execute a non linear classification as well which is given by the name of kernel trick which generally maps down the inputs present onto the high dimensional features space.

Support Vector Machine (SVM) produces the most improved results in context to the classification of the images. SVM is highly efficient in classifying the semi-structured or the unstructured data which can be in the form of images, text and trees. The lesion or the tumor can be easily and appropriately detected with the help of the accurate kernel. Unlike in the deep neural networks, In SVM all the pixels present in the image are considered as the features and SVM algorithm is no computed for the local optima only but also scales the high dimensional data pretty well. ON basis of the results obtained we can say that the SVM classifier is the most and the best suited classifier for classifying the lesion in the brain MRI images. This is the main reason behind using the SVM that is Support Vector Machine learning algorithm for lesion and Multiple Sclerosis detection in pour projected model[21].

4.4 Stage-2:

Multiple Sclerosis lesion Detection using Deep Learning classifiers.

A. Convolutional Neural Networks (CNN)

(Conv-Nets or CNN) are the terms used for the Convolutional Neural Network represents the type of the neural networks which are very effective and accurate and actually have proved to be the best for the image classification as well as for image recognition. Convolutional neural networks CNNs have basicalyy dominated the computer vision algorithms as the accuracy that is obatined from the CNNs is very high in the field of image classification and image recognition. Convolutional neural networks usually are the sub parts or belongs to the category of the FNN which is termed as the feed forward artificial neural networks which are the algorithms that are in the filed of deep learning, which comprises of the nodes that are connected in such manner that they do not from a cycle. The CNNs uses different sorts of the perceptrons which are fundamentally designed in a manner to acquire the marginal pre-processing easily. The main principle behind the Conolutional neural networks is that it is pre-assumed that the input to the ConvNets architecture are images in nature , which certainly allows the users to encode specific properties and characteristics in

the architecture or the model. The model then subsequently allows the forward function to take place easily and effectively and this certainly reduces the abstraction of the parameters used in the network[21]. The Convolutional neural networks are basically build from the neurons which comprises of some weights and the biases. The main ideology behind this is that every neuron present exactly receives an input in the form of an image and simultaneously performs the dot product. The figure shown below exemplifies the procedure applied during CNN [22].

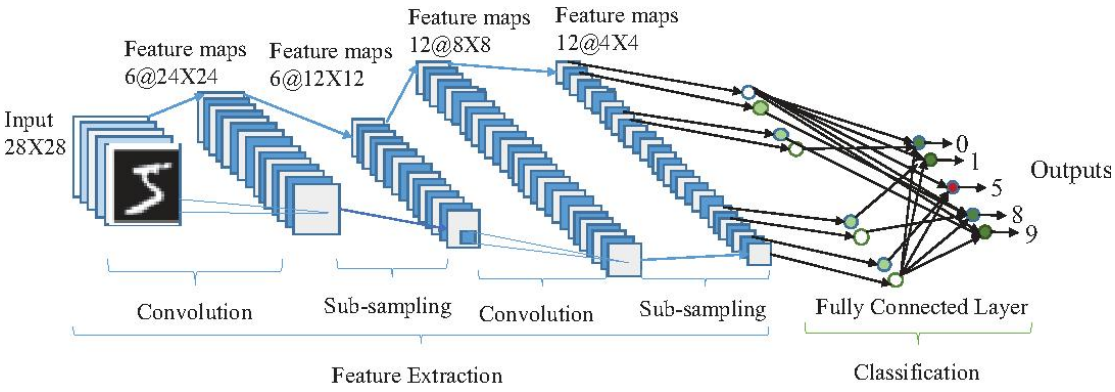

Figure 14. Procedure of CNN.

The CNN deep learning algorithm basically has two main procedures which are as follows: convolution and sampling.

- **Convolution:**

For the process of the convolution the trainable filter fx is used for carrying out the de-convolutional of the input images that are fed to the CNN classifier, the classifier has three layers out of which the first layer is the input layer in which the input is fed and after the convolution process is carried then the second layer has the input image which is called as the feature image also called as the feature map. Finally the bias bx is added to the feature map which finally results in the convolution layer cx.

- **Sampling:**

The sampling process is the second most important step that has to be carried out in order to implement the Convolution in which the n pixels of the neighbourhood are taken which are put through the pooling steps so that the output can be generated as pixel, simultaneously applying weighting wx+1 followed with the addition of the bias bx+1 then on carrying out all these steps then the result generated after this is the sampled signal which is represented by the Sx+1.

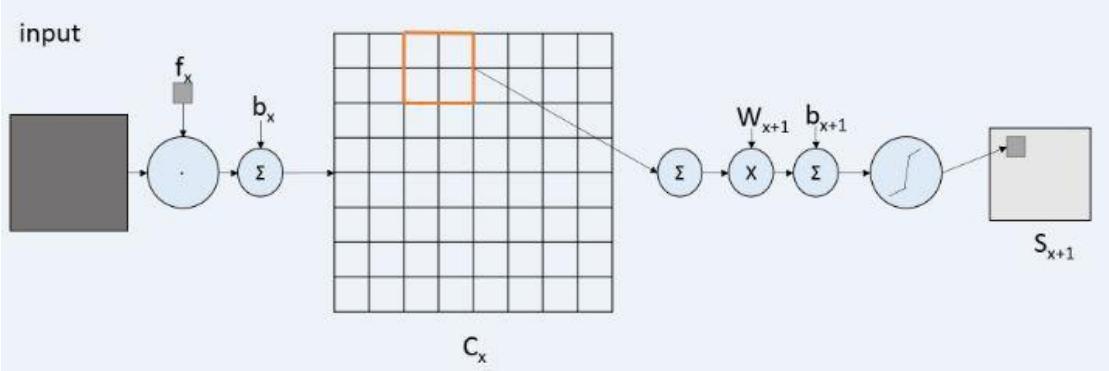

Figure 15. Diagrammatic View of CNN Working.

The main aim of the Convolutional Neural Network deep learning algorithm is to use the weight sharing, the local receptive field, and the sub sampling with respect to time or the space for the reduction of the size of the training parameters and the feature extraction. The main and useful advantage of the CNN algorithm is that it expressly avoid the usage of the feature extraction process and it tries to learn implicitly from the training data. The weights of the neurons present in the CNN are exactly same everywhere of the feature map's surfaces, thus making the network to understand the things in parallel and simultaneously making the network less complex in nature and more efficient.

CHAPTER 5
EXPERIMENTAL RESULTS & EVALUATION

5.1 Summary

In the following segment, we have extensively described the results that are obtained from the proposed methodology in the presented work. In the presented work, the lesions are being detected and segmented in the white or the gray matter of the brain using the Fuzzy C Means algorithm, along with classifying the proposed model to classify the Multiple Sclerosis disease with the help of the two different techniques which are as follows: Traditional machine learning algorithms and detection using the Convo-Nets that is Convolutional Neural Network.

5.2 Dataset Acquisition

The data-set used in the field of Multiple Sclerosis detection is BRATS 2020 Data-set [16]. BRATS in every-way focused on the evaluation of the sate of the art techniques for the appropriate segmentation of the brain tumors or the lesions present in the white or the gray part of the brain's multi modal magnetic resonance imaging (MRI) images. BRATs 2020 commutes the multi-institutional pre-operavtive MRI images so that it can chiefly focus on the segmentation of the lesions which are instrinsiclally hetrogeneous in nature in context with (shape, appearance and histology) commonly named as the Multiple Sclerosis. In addition, the main focus of the BRAT's clinical relevance segmentation task is made on the accurate prognostication of the patient's survival rates , as well as the differentiation made among the pseudoprogression and the true lesions recurrences with the help the combinatory analysis of machine learning algorithms and the radiomic features. Conclusively the BRAT's dataset is efficiently capable of evaluating the uncertainty if algorithms in the relation to lesion segmentation. BRATS is basically the multi-modal Brain lesion segmentation Data-set which is named after the The medical image Commputing and computer Assistted intervention society (MIC-CAI). The data-set which is labeled as the data-set detecting the Multiple Sclerosis. The data -set that is used is broken down into two different sectors one is training data and the other is testing data. There are Four different channels or modes of information that are represented by the four different volumes of same region of brain Those are as follows: Native (T1), T2-weighted (T2),

T1-weighted (T1CE), and Fluid Attenuated Inversion Recovery (FLAIR) volumes. Every volume of data set contains two different sets. One set is defined for lesions class-1 MRI and the second one is defined for the Non lesion class-0 MRI. the training data -set is consisted of the 187 MRI images which have lesions present in it and there are 30 MRI images which have no lesions present along with the 24 MRI images which are considered as the testing-data and employed for evaluating the performance of the model.

5.3 Multiple Measures of Performance

In order to evaluate our proposed model and to know up-to what extent the accuracy of the model is obtained, the performance matrices has to be discussed[21]. In the following section the performance measures or methods have been discussed in detail that we have taken into consideration for evaluating the model. So to evaluate the performance of the model some terms are there which have to be discussed those are as follows:

1 ACCURACY: Accuracy means the grade up to which the outcome of the brain MRI segmented images imitates to the accurate standards by equating with the truth or input images taken. The accuracy of the projected work is calculated using the formula shown below:

$$\boldsymbol{Accuracy} = \frac{Correct\ Predictions}{Total\ number\ of\ images} = \frac{TP + TN}{TP + TN + FP + FN}$$

2. SENSITIVITY: Sensitivity is the degree which appropriately categorizes the percentage of positives existing in the projected work. The sensitivity of the projected work is calculated using the formula shown below:

$$\boldsymbol{Sensitivity} = \frac{TP}{TP + FN}$$

3 SPECIFICITY:

Specificity is the quantity that suitably finds the percentage of all the negatives present in the projected work. The specificity is also named as the True Negative Test

(TNR) of the proposed model and it is also called as the statistical property of the binary classification model. In specificity we deal with the binary classification (lesions and non lesions) and this is the parameter is used for evaluating the performance. It is defined as the ratio of the number of non lesions images which are represented by the (TN) to the images which are classified or miss-classified as the lesion present images (TN+ FP). The specificity of the proposed work is calculated using the formula shown below:

$$\boldsymbol{Specificity} = TNR = \frac{TN}{TN + FP}$$

4. Precision:

Precision is the term which is again used for the evaluation of the model and it is characterized by the ratio of the number of the images which have lesions and that are rightly categorized as the (TP) to the number of the images which are classified or miss-classified as lesions (TP + FP). The Precision of the proposed work is calculated using the formula shown below:

$$\boldsymbol{Precision} = \frac{\boldsymbol{TP}}{\boldsymbol{TP + FP}}$$

5.4 Experimental Results

In the following segment, we will elaborate about the results of the projected methodology. The thesis of the work can be divided into three main sections and will be described in detail

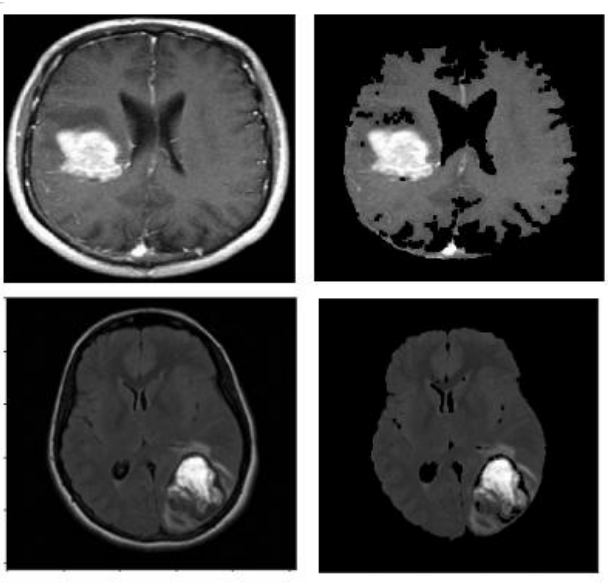

Figure 16. Skull Removed Images

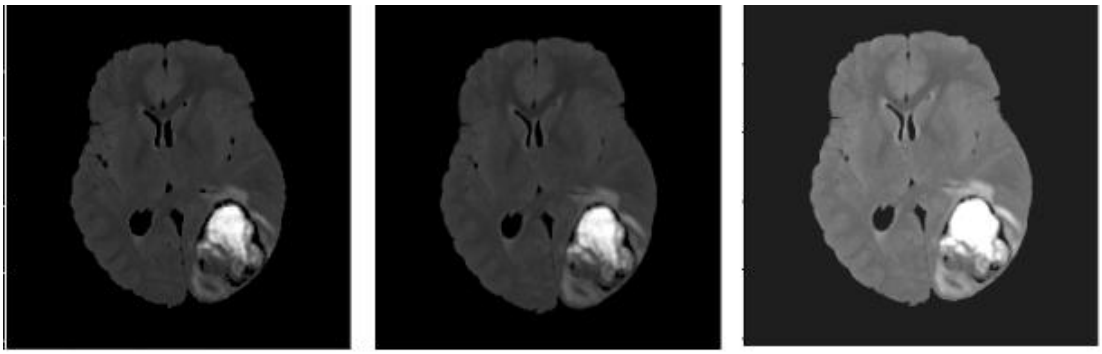

Figure 17. A) Skull Removed Image. B) Filtered Image. C) Enhanced Image

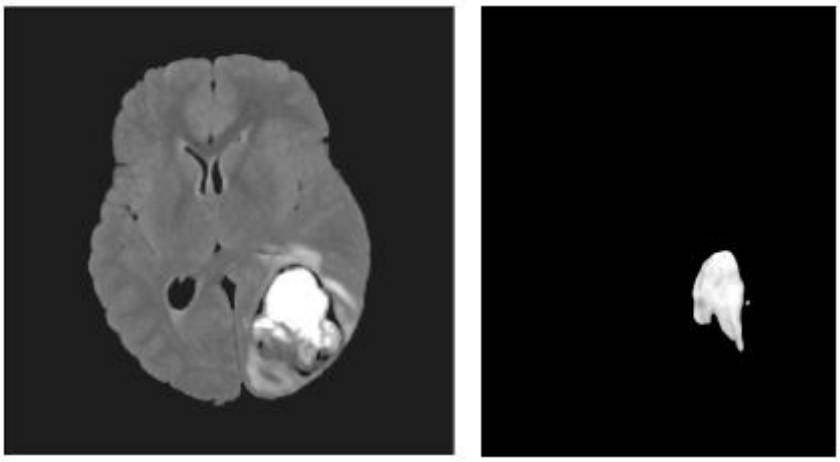

Figure 18. A) Enhanced Image. B) Segmented Image.

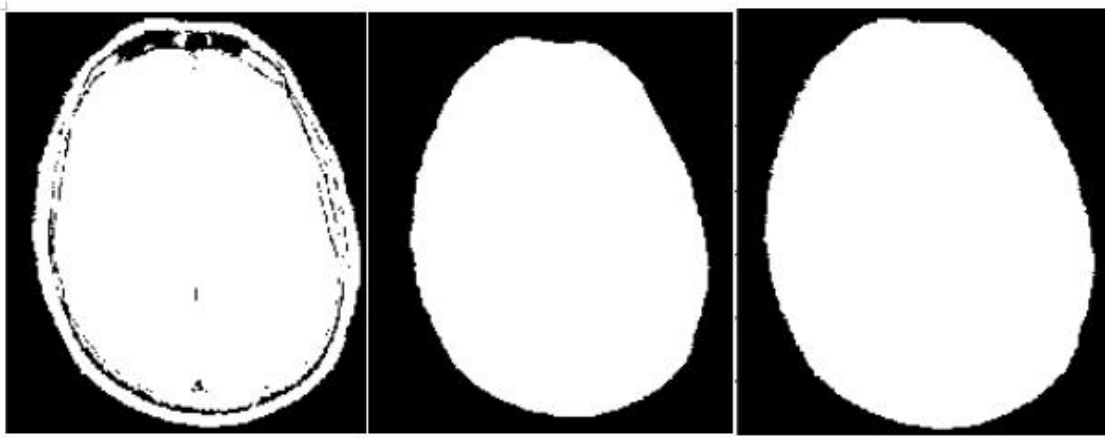

Figure 19. A) Binarized Image B) Eroded Image C) Dilated Image

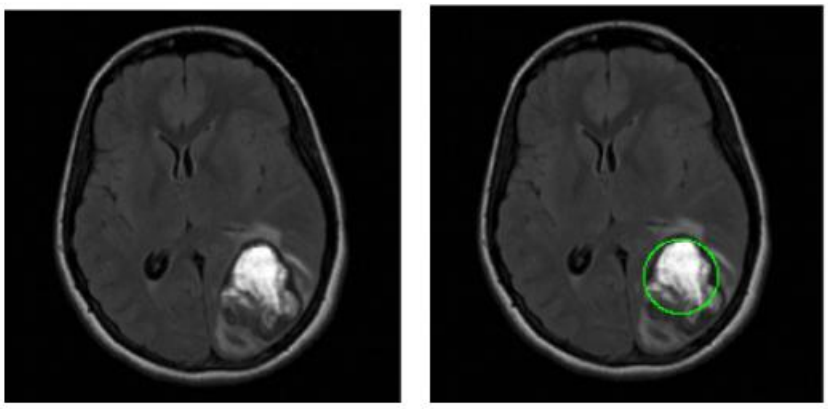

Figure19. A) Input Image. B) Contoured Image

Table 1. Features Extracted Using DWT with GLMCC.

FEATURES:	VALUE:
Correlation	0.199005437650890
Contrast	0.208843159065629
Energy	0.762099558154469
Homogeneity	0.935159436410827
Mean	0.003110700417272
Standard Deviation	0.089760824047292

FEATURES:	VALUE:
Entropy	3.173457393217405
Root Mean Square (RMS)	0.089802651013387
Variance	0.008047871307201
Inverse Difference Movement (IDM)	-0.057689795951983

Table 2. Performance Measures Using SVM.

Classifier	Accuracy	Sensitivity	Specificity	Precision
Support Vector Machine (SVM)	0.9242123	0.16745	0.429872	0.93537

Table 3. Performance Measures Using CNN.

Classifier	Accuracy
Convolutional Neural Network (CNN)	**97.87**

CHAPTER 6
CONCLUSIONS

We have employed the traditional machine learning algorithms that is SVM Support Vector Machine and classifiers for the detection of the lesions in the white and the gray portion of the images.Support Vector Machine (SVM) produces the most improved results in context to the classification of the images. SVM is highly efficient in classifying the semi-structured or the unstructured data which can be in the form of images. The lesion or the tumor can be easily and appropriately detected with the help of the accurate kernel. On basis of the results obtained we can say that the SVM classifier is the most and the best suited classifier for classifying the lesion in the brain MRI images. This is the main reason behind using the SVM that is Support Vector Machine learning algorithm over other traditional machine learning algorithms for lesion and Multiple Sclerosis detection. The accuracy of 92.42% which is very high and better than the other machine learning algorithms. We have applied the CNN that is Convolutional Neural Network for the lesion detection in our proposed work with the accuracy of 97.87% which is better as it accurately classifies the model that is proposed for the lesion detection.

6.1 Limitations

IN the projected work we have come across with some certain limitations which have degraded the accuracy of the proposed model to some extents and these limitations are as follows:

• The BRATS dataset consists of only 241 images which are little bit less for training and testing.

• The BRATS data-set Works solitary on 2-Dimensional images.

• We can have employed various other different traditional machine learning algorithms so that the accuracy can be increased.

• Types of the lesions that is the type of Multiple Sclerosis in the brain MRI could not be classifified

6.2 Future Scope

There are some more possibilities for the betterment or more deep investigation can be done on the proposed work in the future.

• Firstly, the dat-set that has been worked upon should contain more number of images in order to get the model trained easily and efficiently.

• Secondly, we should work on the 3D images as well in the future.

• Thirdly, some many traditional classiffiers should be applied in order to get the enhanced accuracy.

• Fourthly, the work on the classification of the multiple Sclerosis and the types of Multiple Sclerosis that is caused and carried out.

• To conclude the last work that can be done is to employ more deep learning approaches so that the model can be more automated and efficient.

CHAPTER 7

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