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Prognosis of Neurological Disorder

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Abstract -Neurological disorders of the brain are generally difficult to diagnose at the early stages. Since common symptoms like headaches, fatigue or difficulty in speaking and understanding can be related to any neurological disorder. It can be noted that most of the neurological disorders are curable if detected at an early stage. Thus, the life expectancy of the patient will be increased through an early detection and an early start of the curative procedure. An accurate identification of the disorder can be done by processing the MRI images of the patient. While brain disorders like tumor, stroke can be classified with an abnormal growth of the brain tissue., disorders like Alzheimer's occur due to degeneration of brain cells. Since all the neurological disorders have common symptoms differentiating them at the beginning stages is considered a challenge. A rule based expert system with a set of rules is used for processing the symptom experienced by the patient. Each symptom is associated with a weighting factor that determines the risk to a particular disorder. Once the risk factor is evaluated the MRI images of the patient is scanned to obtain the severity of the disorder. By utilizing an expert system for analysis of symptom and image processing to detect the region of abnormality we may derive accurate results. Thus an effective prognosis can help patients get into the treatment at the earliest.

Keywords- Neurological Disorders, MRI (Magnetic Resonance Imaging), Pre-Processing, Feature Extraction, Classification

I. INTRODUCTION

Brain is a vital organ of every human being as it controls our perception, motor control, motivation, homeostasis, learning and memory. This organ is responsible for both voluntary and in voluntary actions. The brain is made up of a network of neurons that carry messages back and forth between bran and other parts of the body. The brain is made up of two kinds of cells namely the neurons which send signals in the form of electrochemical signals and Glial cells that are responsible for maintaining homeostasis. The brain have three region prosencephalon, mesencephalon and rhombencephalon.

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forebrain consists of the cerebral hemisphere, thalamus and hypothalamus which are responsible for the complex cognitive activity and other sensory and motor actions. The midbrain is responsible for eye movement and image processing. It forms a bridge between the brain and the spinal cord. The hind brain consists of three parts cerebellum, medulla and pons which are responsible for the involuntary movements like breathing and is also responsible for maintaining posture and balance of the body.

Neurological disorders can be classified into tumours that revolve around the abnormal cell growth, stroke that can be characterised by a rupture causing hemorrhage or a lack of blood flow, Alzheimer's disorder and Parkinson's disease which are both neuro-degenerative disorders. Brain Tumours are generally an abnormal cell growth which can be cancerous or non-cancerous. The primary brain tumours may originate from brain cells, membrane of the brain, the nerve cells or even from the glands that are present in the brain. Gliomas are tumours that develop on glial cells of the brain. Strokes occur due to the rupture of any blood vessel present in the brain. Since the blockage or rupture can stop the oxygen flow from reaching the brain tissue thus damaging the tissue. Stroke can be classified into three types based on their cause. The Alzheimer's disease can be described as a progressive degenerative disorder that causes the brain cell to degenerate over a period of time. Thus it affects the person's memory and can reduce the life expectancy of the patient. Parkinson's disease can also be described as a progressive neuro degenerative disease characterised by the constant tremor. This is caused by degeneration of neurons which are associated with movement of the body.

Since all these disorders affect brain they have common factors like headaches, blurred vision, difficulty in speaking or understanding, loss of balance, memory-loss, tremor, fall often while walking, loss of appetite, and seizure inability to combine muscle movement or show stiffness or slow movement. Hence it is difficult to identify the neurological condition the patient is suffering from. Thus a proper analysis of the symptoms is required for the identification of the neurological disorder. Medical diagnosis based on expert system [12] can derive at a highly accurate result. The analysis of the patient's symptoms can be used to predict the neurological disorder in spite of the common symptoms the disorders have. The symptom analysis using the expert system can be used for the early detection of the disorder. An intelligent system is proposed for the detection of neurological disorders by the symptoms. To improve the accuracy of the result form the symptom analysis the MRI image of the patient's brain is analysed to identify the disorder. Since, MRI utilises the resonating hydrogen atoms present in the water content of the body to capture the cellular structure of the part of the body.

Once the image is captured using image processing the image is analysed to provide an effective diagnosis of the neurological disorder like tumor, stroke and dementia. There are various ways in which the image can be analysed. While some utilize feed forward neural network [13] as an unsupervised approach for analysing the MRI images, there are a works [3] where in a supervised approach finding the region of abnormality.

The image processing has a sequence of steps that are performed in order to attain a result. First the obtained images go through the pre-processing phase where in the noise is removed from the raw image. Then the boundary of the image is detected. The MRI images are then going through feature extraction to detect the abnormality finally SVM is used to classify the neurological into different stages of their severity. Thus an accurate prognosis of the neurological disorder can be attained through the expert system.

The report, Neurological disorders: Public health challenges, released by the world health organisation reveals that of the one billion people affected worldwide irrespective of age, or sex. The detection and diagnosis of any neurological disorders has been done manually based on the medical reports. Considering the fact that almost a billion people across the globe suffer from one of these neurological conditions it is suffice to say that a faster detection and identification of brain disorders is required to start the curative procedures at the early stage.

II. RELATED WORKS

Abdu Gumaei, and Mohammad Mehedi Hassan proposed a work based on automated classification of brain tumor using a regularized extreme learning technique. This approach uses a feed forward neural network that is trained to extract the tumor image since classification of tumor is purely as on the physician's knowledge. Here the authors have proposed a hybrid feature extraction technique for classification of the tumor. The hybrid feature extraction technique called RELM Regularized Extreme learning machine is a combination of regression and classification technique that overcomes the disadvantages of back propagation [1].

Adel Kermi, and Khaled Andjouh, Ferhat Zidane proposed a tumor segmentation method that automatically detects and extracts the tumor image from 3D MRI. This process utilizes the symmetry analysis of the brain to perform region and boundary based segmentation using the Fat bounding box method. This method is efficient for detecting tumours that are of 7 cubic centimeters. It has a total of three stages that are performed in a sequence. The system delivered promising results in regard to tumor detection in different MRI images with tumor of different shapes and sizes [2].

Amruta Hebli and Dr. Sudha Gupta have proposed a system for Brain Tumor Prediction and Classification using Support Vector Machine. This system uses a step by step procedure for image pre-processing, segmenting brain tumor using morphological operations, extracting tumor feature using DWT and classification of the tumor using SVM. The authors propose a work based on quick and accurate segmentation of tumor images by integrating image processing with machine learning [3].

Anne Humeau-Heurtier proposed a paper on the analysis of different texture feature extraction methods used in image processing to find an efficient way of extracting useful information from a raw image with high efficiency and performance. The paper is analyses the performance of different feature extraction technique that are available. The paper also provides a detailed analysis of the advantages and drawbacks of all the seven categories of the feature extraction including statistical approaches, structural approaches, transform-based approaches, model-based approaches, graph-based approaches, learning-based approaches, and entropy-based approaches [4].

Aymen Bougacha, et.al proposed a work for obtaining diagnostic information from high grade gliomas using artificial neural networks on the BRATS 2015 brain MRI dataset. This paper provides a comparative study on supervised and unsupervised classification methods. Since it is highly challenging to perform segmentation on high grade gliomas due to their complex heterogeneous structure. The proposed work utilises ANN which provides an efficient result for segmentation of these complex structures [5].

Bhavana Ghotekar, and Mrs. K. J. Mahajan, proposed a work on brain tumor classification using SVM. The tumor image obtained is segmented and trained using an artificial neural network to identify the type of brain tumor. The authors have proposed a work to compare the accuracy of different classifiers used in classification of the tumor. The proposed work provides an accurate result in terms of classification and segmentation [6].

Eman Abdel- Maksoud et al. have proposed a system for early detection of brain tumor with image segmentation technique. The system uses a K-means clustering technique integrated with Fuzzy C means algorithm for brain MRI segmentation. They use two further segmentations such as threshold and level set segmentation to make an accurate brain tumor detection. This technique promised an increased accuracy, performance and minimal computational time. Thus provides a solution to a large number of segmentation problems [7].

K. A. N. N. P Gunawardena, R. N Rajapakse, N. D Kodikara, I. U. K. Mudalige proposed a work on detection of Alzheimer from the MRI image. this approach utilizes support vector machine for early detection of the disorder. They also utilize a convolutional neural network for training the data for brain image classification. Since there are limitations in diagnosis of Alzheimer's disease through the current system which is highly inaccurate [8].

Hiroki Fuse and Kota Oishi have proposed a system for the Detection of Alzheimer's Disease with Shape Analysis of MRI Images. Here, Magnetic resonance imaging (MRI) is used for the diagnosis of Alzheimer's Disease. The classification is performed using a support vector machine. The authors utilize the combination several descriptors as features to perform the SVM classification which produced highly accurate results compared to other evaluation based on morphological changes [9].

Keerthana T K and Sobha Xavier have proposed an Intelligent System for Classification of Brain Tumor. Here, Data mining techniques is used to detect brain tumor. This paper proposes an intelligent system for the early assessment of brain tumor. The system identifies the type of tumor by Support Vector Machine using data mining techniques and it optimizes it with genetic algorithm. The system also provides healthy advice to people suffering from the long term impact of the tumor [10].

G. Kharmega Sundararaj and Dr. V. Balamurugan have proposed an Expert System Based on Texture Features and Decision Tree Classifier for Diagnosis of Tumor in Brain MRI images. Firstly, Gaussian filter is applied for extracting the noise for experimental image. Then Statistical texture features are extracted for the purpose of classification and a decision tree classifier is used to classify the type of tumor image [11].

Manish Rana and Dr.R.R.Sedamkar have proposed a system for the Design of Expert System for Medical Diagnosis using Fuzzy Logic. This paper work proposes a system for the detecting brain tumor, Hemorrhage in brain, cardiac disease and thyroid disease. System uses Fuzzy logic design. The work carried in this paper proposes to develop a control system to enhance the efficiency to diagnose a disease [12].

Swapnil R. Telrandhe, Amit Pimpalkar, and Ankita Kendhe proposed a work for adoptive brain tumor imaging using k-means segmentation to MRI images for which the tumor region cannot be identified. The system is made adaptive with the usage of SVM classification in unsupervised manner to detect a pattern for tumor detection. To detect the patterns texture and colour features are trained using SVM to maintain it future use [13].

H. M. Tarek Ullah, Zishan Ahmed Onik, Riashat Islam, and Dr. Dip Nandi proposed a work to detect Alzheimer using a convolutional neural network which acts as a multilayer perceptron to perform image processing. This system utilizes 3D MRI for the detection of Alzheimer's disease. The proposed system utilises a deep convolutional neural network inspired by combining deep learning of machine intelligence and CNN for image processing for the detection of Alzheimers's disease at the earliest [14].

Yi Ding, Fujuan Chen, et. al proposed a work image segmentation using stacked unet to achieve increased performance to extracted features from a complex image. Due to the increase in amount of parameter considered during image segmentation for complex images there is a possibility of excessive information which is countered by a framework called Stack Multi-Connection Simple Reducing Net in the proposed system [15].

III. PROPOSED SYSTEM

The proposed system can be used for early detection of neurological disorders. Neurological disorders have common factors hence an expert system is proposed to perform an analysis on the symptoms experienced by the patients. Once all the symptoms are analysed the possible neurological disorder is identified. To improve the accuracy of the prediction the MRI of the patient is analysed to find the severity of the disorder.

The image processing is performed through a series of steps. Pre-processing using a low pass filter to remove spatial and salt and pepper noise. It is followed by edge detection to determine the boundary of the image. Once the boundary is detected it is followed by Feature extraction. GLCM - Grey Level Co-occurrence Matrix is used to extract the morphological features of the brain. It is followed by the application of HOG – Histogram Oriented Gradient to select the features which will be useful for identifying the neurological disorder. The final stage of image processing is Classifying the image which is done using SVM – Support Vector Machine to identify the type of disease. In case of tumor it identifies the stage of tumor growth as normal, benign, and malignant. In case of Alzheimer it denoted it classifies the normal brain from a brain diagnosed with dementia. The architecture of the proposed system is given below,

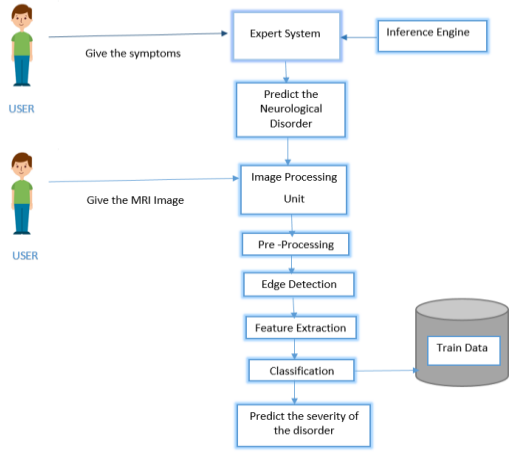


Fig 3.1 Architecture of the proposed system

3.1 System overview

3.1.1Expert system

A rule based expert system is used to predict the neurological disorder of the patient using the symptom experienced by the patient. Neurological disorders like tumor, stroke Alzheimer and Parkinson's disorder have a lot of common symptoms which must be analysed thoroughly in order to attain an accurate diagnosis of the neurological disorder

Table 3.1 Symptom Analysis

Symptom	Tumor	Alzheimer	Stroke	Parkinson's
Age>60	No	Yes	No	Yes
Headaches	Yes	No	Yes	No
Blurred vision	Yes	No	Yes	No
Difficulty in speaking and understanding	Yes	Yes	Yes	No
Loss of balance	Yes	No	No	Yes
Memory loss	No	Yes	No	No
Seizure	Yes	No	No	No

Tremor	No	No	No	Yes
Fall often while walking	No	No	No	Yes
Loss of appetite	No	Yes	No	Yes
Inability to combine muscle movement	No	Yes	Yes	Yes

Once the diagnosis of the common symptoms is done. the expert system analyses other symptoms associated with the disorder. Each disorder has a specific set of disorders that can be classified into categories of cognitive, muscular, visual, behavioral, psychological, and other symptoms that are not classified into these categories.

The rule based expert system gets the input from the user and analyze them to predict the neurological disorder. The system is implement using python programming language where in the class expert is imported to define the inference engine and the knowledge base. Using the symptoms obtained from the user the facts are derived to predict the neurological disorder the person is affected.

3.1.2 Image Processing Unit

The image processing unit is used to increase the predictive accuracy of the expert system. The MRI image of the patient is analysed to identify the disorder. The MRI images are analysed because it depicts the cellular structure of the brain. The image processing has a sequence of steps as follows, pre-processing, edge detection, feature extraction and classification.

A Pre-Processing

Pre-processing is the step performed to improve the quality of image. It can be said as he lowest level of abstraction which is used to increase the interpretability and precision of the image. Noise removal is done using Median filter. Median filter digital non-linear filtering technique is used since it is ideal for salt and pepper and spatial noise removal. It utilises a method where in it replaces the pixel value with median value combining the value of its neighboring pixels. Median filter is not affected by changes in intensities in terms of grey level intensity such as edges. Unlike other spatial filters it does not have any adverse effect on the image boundary.

Once the noise is removed the edge detection is used to find the image boundary using the canny method to detect both strong and weak edges in the image. It detects the discontinuities in brightness and enable data extraction from the MRI images.

B Feature Extraction

Features are extracted in order to obtain the tumor and dementia affected region in the brain.

i. GLCM: Grey Level Co-occurrence Matrix is used to underlying texture in a unique form so that we can perform an accurate classification and segmentation of the image. There are four features considered here Contrast, homogeneity, entropy and Correlation for image processing. GLCM is based on the grey levels on the image.

1. Correlation: It is the linear dependency of grey levels of the image between one pixel i with its neighboring pixel j. Here σ denotes standard deviation and μ denotes mean value. p(i,j) denotes element i,j of the normalized symmetrical GLCM.

$$\sum_{i,j} \frac{(i-\mu i)(j-\mu j)p(i,j)}{\sigma_i \sigma_j} \quad (1)$$

2.Energy: It can be defined as orderliness. It makes use of the image texture to calculates orders in the image. Entropy is used to calculate sum of square elements in GLCM. Energy value is high when window is proficient. Here p(i,j) denotes element i,j of a symmetrical GLCM which is normalized.

$$\sum_{i,j} p(i,j)^2 \quad (2)$$

3. Homogeneity: It is used find the tightness of distribution of the pixels in the image. p(i,j) denotes element i,j of grey level co-occurrence matrix where i and j are neighboring pixels.

$$\sum_{i,j} \frac{p(i,j)}{1+|i-j|} \quad (3)$$

4. Contrast: It gives the contrast between a pixel and its neighbor pixel for the whole image. p(i,j) denotes element i,j of the GLCM.

$$\sum_{i,j} |i-j|^2 p(i,j) \quad (4)$$

ii. HOG: Histogram of Oriented Gradient feature descriptor is used to extract additional features for detecting the neurological disorder. Since HOG is suitable for detecting irregular shapes. It uses overlapping contrast normalization for improved accuracy of detecting anomaly in the image in case of tumor and Alzheimer detection. This is ideal for extracting useful information and removing unwanted information of the image.

C Classification

Classification is done using SVM a machine learning algorithm is used for classifying the tumor image into different stages such as benign, or malignant and it detects Alzheimer as level 1 2 or 3 from the MRI image.

A data set is trained to classify the MRI to distinguish a normal being and a person who has a neurological condition.

IV. EXPERIMENTAL RESULTS

The proposed system utilizes the symptoms experienced by the patients to detect the possible neurological disorder. Once the disorder is identified through the expert system. The MRI of the patient are analysed for more accurate results. For purpose of classification using SVM, BRATS 2012, OASIS, ATLAS are utilized as datasets to provide a highly accurate result.

The experimental results of the proposed system for an Alzheimer and Tumor affected patients are given below,

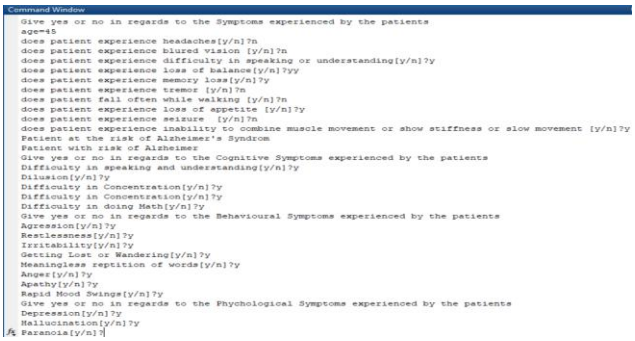
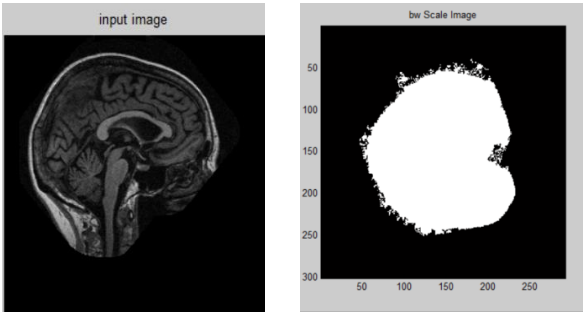


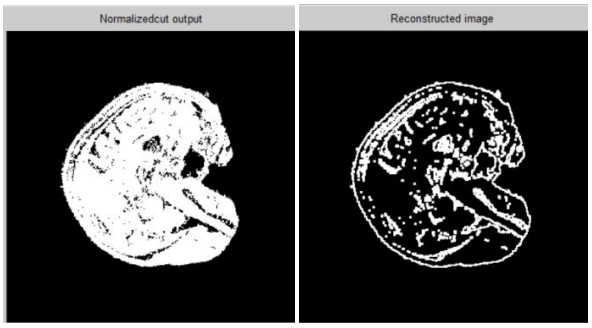
Figure 4.1. Expert system for symptom analysis

The expert system performs analysis on the symptom it gets the input from the user in regards to different categories of symptoms such as cognitive, muscular or behavioral as experienced by the user then provides a proper identification of the disorder the patient may suffer from.

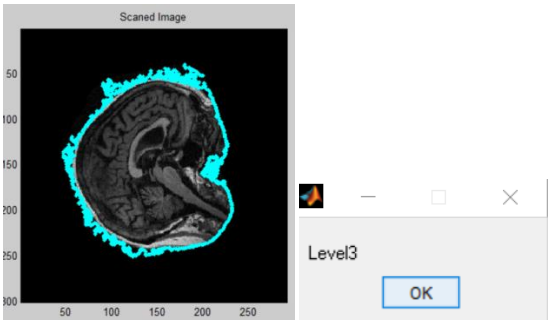
Once the disease is identified further analysis is performed and the accuracy is increased y performing an analysis on the patient's MRI image through image processing. This in turn provides the severity of the disorder.



(a) Input image **(b) BW Scale image**

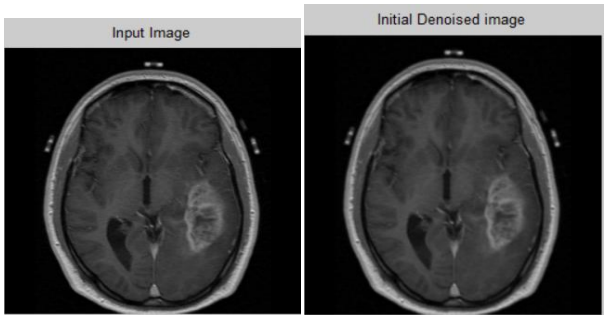


(c)Normalized output **(d) Reconstructed image**

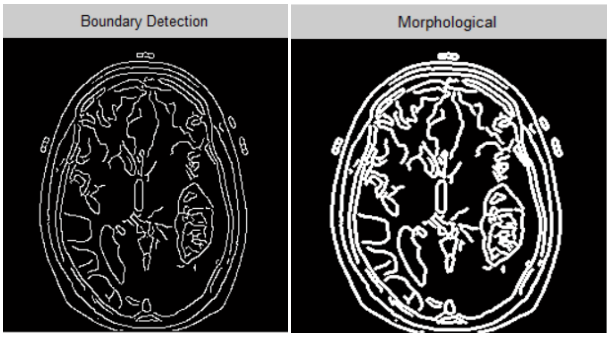


(e) Scanned image **(f) SVM classification**

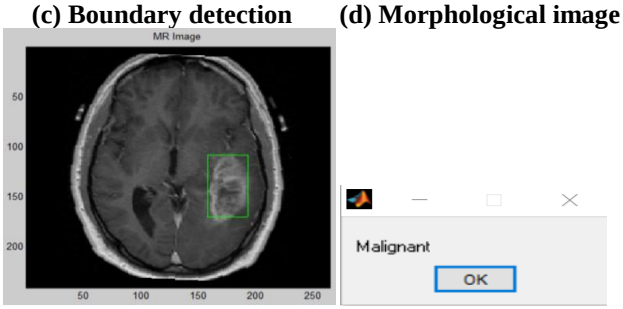
Fig 4.2 Image processing of Alzheimer affected patient



(a)Input image **(b)de-noised image**



(c) Boundary detection **(d) Morphological image**



(e) Tumor detection image **(f) SVM classification**

Fig 4.3 Image processing of Tumor affected patient

V. RESULT ANALYSIS

The proposed system is highly effective in prognosis of the neurological disorder. The system has a high accuracy in identifying and detecting the disorder. The rule base expert system has a series of rules which performs symptom analysis of the patient. More than 500 rules are used for identifying the neurological disorder with high accuracy.

To increase the accuracy of the expert system the image processing unit is used to process the MRI image of the patient to identify the severity of the disorder. On performing an analysis on the accuracy of the algorithms used the proposed system has a high accuracy. The median filter used in image processing is efficient for boundary detection. GLCM utilized for feature extraction has greater accuracy when used with HOG. The performance of GLCM is shown below,

Table 5.1 Comparison of GLCM with Quad tree

Property	GLCM	Quad tree
Entropy	6.6	0.8
Contrast	0.01	0.8
Energy	0.3	0.4
Homogeneity	0.9	0.8

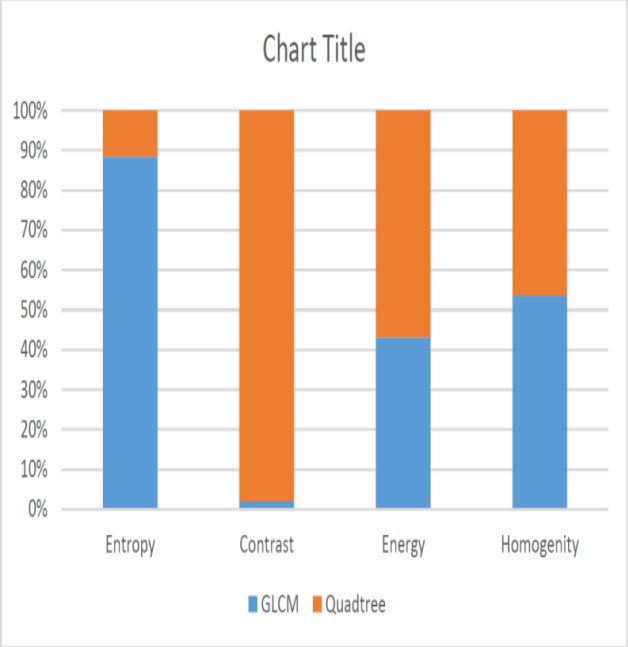


Fig 5.1 comparison of GLCM with Quad tree

The algorithm utilizes supervised learning hence require no optimization in regards to classification. SVM utilized for classification is better in capturing the feature points unlike naïve Bayes hence it is widely preferred. Since both BRATS and OASIS are large data sets SVM can perform the classification with higher accuracy than other algorithms.

VI. CONCLUSION

Using the proposed method neurological disorders can be classified and diagnosed from the symptoms and brain MRI image with accuracy. The system enables a quick and efficient detection of neurological disorders which is caused due to both abnormal growth of cells and degradation of cells in the brain. As all neurological disorders affect the brain it is noted that they share common symptoms that cannot be easily distinguished. Hence using an expert system for the prognosis of the expert system is highly accurate in terms of predicting the neurological disorder. The detection is enhanced through the means of analysing the Bain MRI of the patient. Thus this system provides a solution for performing predictive diagnosis of neurological disorders in spite of them sharing common symptoms. The present system is developed for the tumor and Alzheimer's disorder. The system is not only limited to tumor and Alzheimer prediction, but it can be further extended in the future for other disorders and diseases like stroke and Parkinson's which are also neurological disorders that occur in the brain.

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