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A STUDY OF AUTOMATICALLY DIAGNOSE FOR MEDICAL IMAGE PROCESSING

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ABSTRACT

In order to extract useful information from magnetic resonance imaging (MRI) images and identify specific brain regions, image processing methods like feature extraction and segmentation play a crucial role. There is evidence that supervised and unsupervised learning models, two types of machine learning algorithms, may learn complicated patterns and help in illness categorization. Furthermore, image-based diagnostics have shown outstanding performance with the use of AI, especially deep learning architectures such as convolutional neural networks (CNNs). In the third part, we take a close look at the difficulties and moral questions surrounding the creation and use of automated Alzheimer's disease detection tools. To guarantee the fair and ethical use of these technologies in healthcare settings, concerns including data privacy, model interpretability, and possible biases in training data need to be addressed. Successfully navigating these problems requires multidisciplinary cooperation among medical practitioners, computer scientists, and ethicists, according to the research. The topic of automated Alzheimer's disease diagnosis utilizing MRI scans has made significant contributions, as highlighted in the case studies and major research initiatives of the fourth section. The research deduces information on the approaches used, the accuracy attained, and the scalability of these systems by examining these endeavors. In order to guide the creation of future diagnostic tools, it is essential to understand the benefits and drawbacks of current methods.

KEYWORDS: Automatically Diagnose, Medical Image Processing, magnetic resonance imaging, Alzheimer's disease detection tools, MRI scans

INTRODUCTION

A diversified collection of MRI scans from persons with and without Alzheimer's disease is used to train machine learning models. This dataset will form the basis of an automated method for Alzheimer's diagnosis using MRI pictures. This dataset is used to train the algorithm to recognize the complex disease-related patterns and characteristics. In order to teach the algorithm to differentiate between normal and Alzheimer's-related brain regions, it iteratively adjusts its settings. It is possible to test the model's performance and generalizability on fresh, unseen MRI pictures when it has achieved an adequate degree of accuracy during training. Using AI to diagnose Alzheimer's disease has many benefits, one of which is the possibility of early detection. Early illness detection enables prompt action and the development of tactics to impede the disease's progression. A key component of efficient care of Alzheimer's disease is the capacity to detect tiny changes in brain structure prior to the emergence of apparent symptoms, since the illness frequently progresses over a prolonged time. Artificial intelligence (AI) automated systems may help in early detection by seeing patterns in magnetic resonance imaging (MRI) scans that humans would miss.

In addition, healthcare systems may be made more efficient by the automated diagnosis of Alzheimer's utilizing MRI scans. The skill and time needed for manual image processing is a major obstacle in the medical imaging industry, which is seeing a surge in demand. Artificial intelligence systems can handle massive volumes of data far more quickly than a person can, which means diagnostic procedures can be completed more quickly. Both the efficiency of the healthcare system as a whole and the diagnosis procedure for individual individuals are aided by this.

The use of artificial intelligence (AI) in medical diagnostics, however, is not devoid of concerns and difficulties. Important considerations include the need for thorough validation studies, the ethical considerations of using algorithms to make life-or-death healthcare choices, and the safeguarding of patient data. To further guarantee the appropriate and ethical use of AI in healthcare, it is vital that regulatory agencies, data scientists, and medical practitioners work together continuously to develop and enhance standards.

There is great potential for healthcare to be transformed by the merging of AI with medical imaging, especially when it comes to the diagnosis of Alzheimer's disease using MRI scans. The field of neurodegenerative disease management stands to benefit greatly from the creation of an automated system that can reliably and quickly diagnose Alzheimer's disease.

MEDICAL IMAGE PROCESSING

Almost all people of our population depend on the medicine sector to fulfil their health care needs. Most of the health problems of people are related to organs or tissues that are inside of the body. Medical image processing is the process of producing visual representation of inside of a body using different imaging technique, which is analyzed using image processing techniques for diagnosis and treat abnormality [1]. Medical image processing is the area of research of image processing that works for public health that encompasses with many challenges.

The imaging techniques that are commonly used in medical image processing are as follows

- **X-ray:** X-ray is a non-invasive medical imaging technique that uses high energy electromagnetic waves to produce image of interior body. Soft tissues of body like skin do not absorb these waves but hard tissues like bone absorb these waves. Finally the x-ray machine transfers the results onto a film showing hard tissues with white colour and soft tissues with black. X-ray technique is commonly used to look for any breakage of bone. There is a risk factor of using x-ray technique as it uses high energy radiation that is harmful for human body.

- **Computed Tomography:** Computed tomography (CT), a medical imaging technique that is also known as computerized x-ray imaging technique. In this technique a narrow x-ray beam is allowed to rotate around the body part to be examined. As a result of this procedure some signals are generated and are used by computer to create cross-sectional images or slices of the body part. The procedure is repeated until a number of successive slices are generated and then they are stacked together by the computer to create detailed image. The image obtained by this method gives more detailed information about the structure or any abnormalities compared to conventional x-ray method. It also has the risk factor of high energy radiation. CT scans are commonly performed to determine brain stroke, head injuries, tumours etc.

- **Ultrasound:** Ultrasound is another one medical imaging technique where high frequency sound waves are used to produce image of the inside of body. Ultrasound technique is normally used when high resolution is not required like to look at foetuses in the womb.
- **Magnetic Resonance Imaging:** Magnetic resonance imaging (MRI) is a noninvasive medical imaging technique that uses radio waves and strong magnetic fields to produce images of organs, bones or tissues of body. The MRI scanner contains a large circular magnet that generates a powerful magnetic field to align the protons of hydrogen atoms in the body. Then radio waves are applied causing the protons to rotate. When the radio waves are turned off, the protons realign themselves by emitting the radio waves. These emitted radio waves are detected by the machine and recreated into an image. MRI technique is most commonly used where high resolution images are needed like brain abnormality detection. This technique also overcomes the risk of using high energy radiation.
- **Positron Emission Tomography:** Positron emission tomography (PET) is a medical imaging technique where radioactive tracers are used to generate image of internal body parts. Radioactive tracers are introduced into the body and then the radiation emitted by the material is detected to create an image of inside of the body. PET technique is normally performed to detect brain disorders, digestive or circulatory disorders, tumour and cancer.

The brain images that are used in this research work are MRI images. Literature review reveals that MRI images are most effective for analysis of AD. It gives far more detailed information about the internal anatomy of brain compared to other techniques. Soft tissue differentiation is very high in MRI images, which is very beneficial for brain analysis. Also, this technique is not harmful for patient body as it does not use any high energy radiation.

Till now, there have no known side effects of MRI technique.

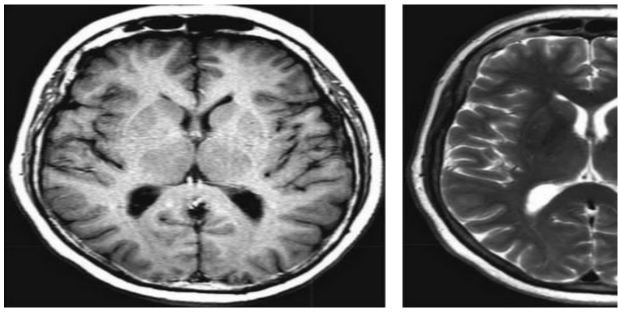
Working of MRI Technique

MRI technique works on water molecule (H2O) of human body. Inside of human body is mostly covered with water. MRI technique uses the magnetization property of hydrogen nuclei (proton) of water molecule. During the MRI procedure, a person is asked to lie on the movable scanning table and the table slides into the tunnel of the machine.

The machine itself produced powerful magnetic field normally of strength 0.2 to 3.0 tesla around the person's body. This makes the protons to align or magnetize. This magnetization is then interrupted by applying radio frequency waves.

When radio waves are turned off the protons return to their stable alignment by emitting the radio waves. These emitted radio waves are converted to an image by the machine. Figure 1.1 depicted an MRI machine.

Figure 1 MRI machine



(a) (b)

Figure 2 (a) T1weighted MRI and (b) T2 weighted MRI

By applying different sequence of radio waves different types of images can be created. Repetition time (TR) is the time between successive radio wave sequences applied to the same slice. Time to echo (TE) is the time between the transmission of the radio wave and the receipt of echo signal. Tissues can be distinguished by two different relaxation times. One is T1 or

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longitudinal relaxation time or spin-lattice relaxation time and the other is T2 or transverse relaxation time or spin-spin relaxation time. T1 determines how quickly the excited protons return to equilibrium. T2 determines the rate of exciting protons reaching equilibrium or go out of phase with each other. MRI image sequences can also be commonly classified as T1 weighted and T2 weighted. T1 weighted images are generated by using short TE and TR times and T2 weighted images are generated using longer TE and TR times.T1 weighted and T2 weighted images can be easily differentiate by examining the cerebrospinal fluid (CSF) of brain. CSF appears dark in T1 weighted and bright in T2 weighted image. Figure 2 shows a T1 weighted and a T2 weighted image.

In the present study, T1 weighted MRI has been used due to clear visibility of AD affected structures, compared to T2 weighted images. In MRI machine images can be taken in multiple planes without changing the position of the person inside the machine. These multiple views of an image in MRI become helpful in the analysis process of disease. The three views of MRI technique are axial, coronal and sagittal.

The three views of MRI image have been depicted in Figure 3.

Figure 3 (a) Axial T1weighted MRI, (b) Coronal T1weighted MRI, (c)Sagittal T1weighted MRI , (d) Axial T2weighted MRI , (e) Coronal T2weighted MRI, (f) Sagittal T2weighted MRI.

Axial MRI are obtained by slicing the brain as a series of images starting from chin and moving to the top of head. Coronal MRI looks at the brain by slicing it as a series of images starting from the back of the head and moving to the face. Sagittal MRI are obtained by slicing the brain to a series of images starting from one ear and ends at another.

Phases of Medical Image Processing

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After obtaining or acquisition of the medical images, they are subjected to the developed techniques of digital image processing to analyse and diagnose disease. The MRI images have gone through different phases of digital image processing.

Figure 4 has depicted the overview of the phases of medical image processing.

Figure 4 Phases of Medical Image Processing

- **Pre-processing**

Pre-processing or enhancement is the first step and is very essential for medical image processing [1]. Image enhancement or pre-processing is performed to make the image more acceptable for further processing than the original image. It is performed to improve the quality of an image because poor quality image may leads to a wrong decision in the diagnosis process. So it is very necessary for medical images to be enhanced before subjected to the process of diagnosis. MRI image enhancement commonly includes noise reduction, contrast enhancement and skull stripping.

- **Noise reduction:** There are always some amount of noise present in an image may be due to the acquisition process or machine used for acquisition. The process of removal of noise from an image is known as noise reduction. There are various filtering techniques available in digital image processing that are commonly used for noise reduction. Figure 1.5 shows a noisy MRI and an MRI after noise reduction.
- **Contrast enhancement:** Contrast enhancement is another image enhancement technique that refines the contrast of an image by expanding the dynamic range of intensity value of the image. Contrast enhancement makes the features of interest more clearly visible than the original image. Figure 1.6 shows a low contrast MRI and a contrast enhanced MRI.

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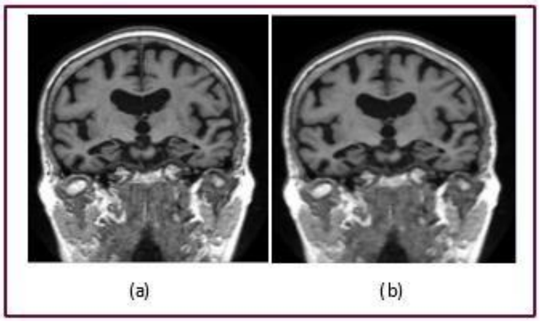

Figure 5 (a) Noisy MRI, (b) Noise reduced MRI

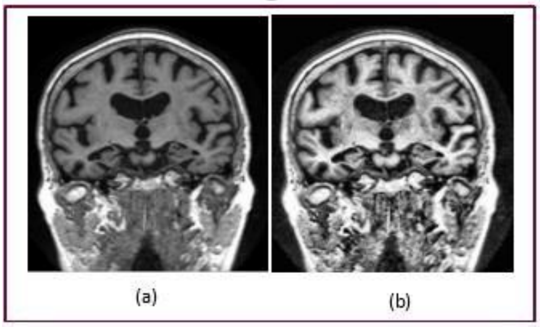

Figure 6 (a) Low contrast MRI, (b) Contrast enhanced MRI

Skull stripping: MRI brain image contains some non-brain tissues like skull, skin, fat, muscle, neck etc. These non-brain tissues are considered as a cause of difficulty in further analysis. So it is essential to remove these non-brain tissues before detail analysis and this process is referred to as skull stripping [3]. In the present study skull stripping has been performed using entropy based thresholding and morphological operations. Figure 7 shows an MRI without skull stripping and a skull stripped MRI.

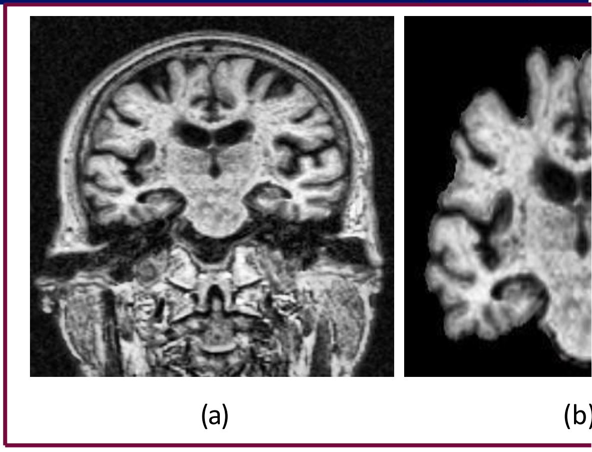

Figure 7 (a)MRI before Skull Stripping, (b) MRI after Skull Stripping

- **Segmentation**

Segmentation is performed in medical image processing to extract out the region of interest from the rest of the part for perfect analysis of disease. It partitions the image into homogeneous regions based on having similar characteristics such as intensity or texture [1]. Meaningful features that can be useful for disease detection can be extracted smoothly from the segmented region of interest. Some common methods of segmentation in medical image processing are threshold based segmentation, region based segmentation, edge based segmentation and clustering techniques.

- **Threshold based segmentation:** Threshold based segmentation is the simplest method of image segmentation. It converts the image into a binary image. In this method each pixel of the image is converted to either black or white. If the intensity of a image pixel is greater than some fixed constant 'T' or threshold then it is replaced to white pixel and if it is less than 'T' then it is replaced to black pixel.

- **Region based segmentation:** Region based segmentation technique identifies regions that have some similar properties. It partitions the image into some distinct sub regions where no two sub regions can have similar properties. It can be further subdivided into region growing technique and regions split and merge technique. In region growing technique, it starts with a seed point and from the seed region grows by adjoining neighbouring pixels of the seed that have similar properties with the seed. The number of starting seed points can be one or more. In split and merge technique, the image is initially subdivided into some random regions and then merging and/or splitting of regions are performed in an aim to partition the image into distinct regions of uniform nature.

- **Edge based segmentation:** Edge based segmentation technique segments an image by detecting the edges or boundaries of the objects of interest in the image. There are different edge detection techniques available in image processing. Edge detection techniques works on intensity dissimilarity or discontinuity. Intensity values of an image object abruptly changes at the edges.

- **Clustering techniques:** The most common clustering technique that is used in segmentation of medical image is k-means clustering technique. In clustering method the image is divided into non-overlapping groups or clusters. Each pixel of the image is assigned to some cluster and each cluster has a reference point. In k-means clustering there has k reference point and image is divided into k clusters. The steps of k-means clustering are as follows.

- Initialize k cluster centres or reference points.

- Assign each pixel of the image to the closest cluster centre using Euclidean distance.
- Update the cluster centre as average of all the pixels in a cluster.
- Repeat assign and update step until convergence occurs.

➢ **Feature extraction**

Feature extraction is performed to extract out meaningful and useful information from the segmented region of interest that can help in disease diagnosis. The accuracy of disease diagnosis directly depends on the extracted features. Proper extracted features can lead to accurate classification results that in turn help in proper decision making. The features that are useful for medical image processing mainly includes shape and size based features. Shape and size based features have very much affects on the classification results of brain MRI for Alzheimer's detection as the size and shape of brain changes due to Alzheimer's disease. Shape and size based features includes perimeter, area, rectangularity, aspect ratio, centre of mass, solidity [1] etc.

- **Perimeter:** The perimeter of an image object is calculated as the number of pixels along the boundary of the object. The calculation starts at an arbitrary initial pixel on the boundary and returns to the initial pixel at the end. It can also be calculated as the sum of distances between each adjoining pair of pixels on the object boundary.
- **Area:** Area is calculated as the total number of pixels in the object of an image.
- **Rectangularity:** Rectangularity is the ratio of the area of an object to the area of its minimum bounding rectangle.
- **Aspect ratio:** Aspect ratio is the ratio of the height to the width of an image object. It helps to determine whether the object is circular or square.
- **Centre of mass:** Centre of mass is the central point or mean point of an object in an image.
- **Solidity:** Solidity is the ratio of the area of the object to the convex area of the same object. Solidity of convex shaped object is 1 and is lower for object that has rough perimeter or has holes in it.

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There are some statistical texture features also, like mean, variance, skewness, kurtosis, energy and entropy, which are helpful in disease recognition. Fusion of different features also shows good classification results.

- **Classification**

Classification is the process that is often performed after feature extraction in image processing. Classification result is directly controlled by the extracted features from an image and the classifier used for classification. The classifier gives a class label to an image whose class is not known. Here the class label may be normal (without disease) or abnormal (with disease). The most common classifiers that are often used in medical image processing include k-nearest neighbor, support vector machine, artificial neural network, random forest, decision tree etc.

- **K-nearest neighbor:** The k-nearest neighbor algorithm (k-NN) is a supervised non-parametric method used for classification. In k-NN classification, an image is classified as normal or abnormal by a plurality vote of its neighbours. The image is assigned to the class that is most common among its k nearest neighbours. K is a positive integer and commonly kept small.

- **Support vector machine:** Support vector machine (SVM) is a supervised learning algorithm that is commonly used as binary classifier. It takes feature vector as input and predicts the class of each feature vector. It creates an optimal hyperplane that separates the two classes (normal and abnormal) with the largest margin. The equation of hyperplane for linear SVM is given in (1.1). The SVM classifier shows good results when used with appropriate kernel, based on data.

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(1.1)

Where, b=real number, w=normal vector to the hyperplane, l=feature vector.

- **Artificial neural network:** Artificial neural network (ANN) is often used in classification of medical image for disease diagnosis. ANN works like human brain. It learns to predict the class of target image automatically by analysing example images. An ANN has a collection of connected units

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called artificial neurons like the neurons of human brain. Neurons are interconnected by edges. Neurons and edges possess weights that are adjusted during the learning .ANN normally consists of three layers; input layer, hidden layer and output layer. The number of hidden layers may be one or more and some may not have a hidden layer. The calculations or processing on input are being performed in hidden layer and weights are adjusted until desired output is obtained. Figure 1.8 shows a simple architecture of artificial neural network.

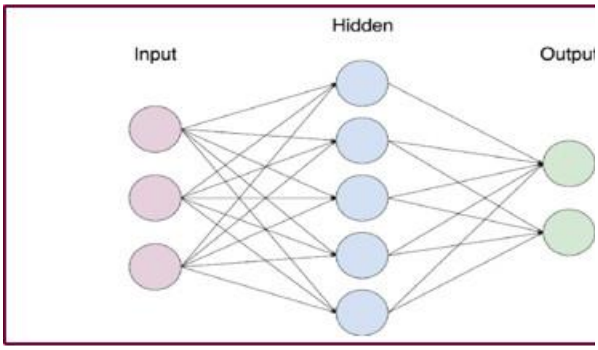

Figure 8 A Simple Architecture of ANN

CONCLUSION

The aim of this study is to the present research work of analysis and detection of Alzheimer's disease from MRI images has been included in this study. Analysis of different techniques for AD detection from MRI and find a good predictive marker from the images for AD is the main objective of the study. In the study, a discussion about the medical image processing, different medical imaging techniques and AD has been carried out. A detail discussion about MRI technique has been given. Challenges, objectives and motivation of the present research work have been included in the study. A review of related works in different phase of the MRI processing for AD detection has been provided. A detail description of the dataset i.e. ADNI that has been used in the present research work has been given in the study. Pre-processing is an important and necessary step for medical image processing. In the present work, skull-stripping, a necessary pre-processing step for neuroimaging has been carried out using entropy based thresholding technique and morphological operations along with noise reduction and contrast enhancement. There are some structures of brain that are most commonly affected by AD such as hippocampus of brain. In the present research work, some measurement with respect to hippocampus, cerebral cortex and the whole brain has been carried out for experiment. These structures have been segmented automatically from brain MRI using different techniques, details of which have been provided in the study.

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