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# Medical Image Classification Using Neuro & Image Contrast Enhancement using Fuzzy Technique

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## Abstract

It is a challenging task to analyze medical images because there are very minute variations & larger data set for analysis. It is a quite difficult to develop an automated recognition system which could process on a large information of patient and provide a correct estimation. The conventional method in medicine for brain MR images classification and tumor detection is by human inspection. Fuzzy logic technique is more accurate but it fully depends on expert knowledge, which may not always available. Here we extract the feature using PCA. Here the result confirmed that the proposed ANFIS classifier with accuracy greater than 90 percentage has potential in detecting the tumors. This paper surveys image contrast enhancement using a literature review of articles from 1999- 2013 with the keywords fuzzy set theory and fuzzy rule-based and explore an idea how fuzzy set theory and fuzzy rule-based improve the contrast enhancement technique in different areas during this period. Image enhancement improves the visual representation of an image and enhances its interpretability . Low contrast images generally occur in poor or nonuniform lighting environment and sometimes due to the non-linearity or small dynamic range of the imaging system. Vagueness in an image appears in the form of uncertain boundaries and color values.Fuzzy sets (Zadeh, 1973) present a problem solving tool between the accuracy of classical mathematics and the inherent imprecision of the real world. In this review paper we survey different types of enhancement technique applied for enhancing the contrast of an image based on applied different fuzzy techniques, i.e., fuzzy Intensification operator (INT), fuzzy inference system, “index of fuzziness”, etc.

Keywords **ANFIS, Brain tumor, MRI images, Brain MRI, Neuro fuzzy logic, PCA. Adaptive Contrast Enhancement Fuzzy Intensification operator (INT), Fuzzy Inference System, fuzzy entropy, involutive fuzzy complements, “index of fuzziness”.**

## Introduction

Biomedical image processing has experienced dramatic expansion, and has been an interdisciplinary research field attracting expertise from applied mathematics, computer sciences, engineering, statistics, physics, biology and medicine. Computer-aided diagnostic processing has already become an important part of clinical routine. Accompanied by a rush of new development of high technology and use of variousimaging modalities, more challenges arise; for example, how to process and analyze a significant volume of images so that high quality information can be produced for disease diagnoses and treatment. The principal objectives of this course are to provide an introduction to basic concepts and techniques for medical image processing and to promote interests for further study and research in medical imaging processing.

## PRINCIPLES OF MAGNETIC RESONANCE IMAGING

During the past few decades, with the increasing availability of relatively inexpensive computational resources, computed tomography (CT), magnetic resonance imaging (MRI), doppler ultrasound, and various imaging techniques based on nuclear emission (PET (positron emission tomography), SPECT (single photon emission computed tomography), etc) have all been valuable additions to the radiologist’s arsenal of imaging tools toward ever more reliable detection and diagnosis of disease. Tomographic imaging principles are rooted in physics, mathematics, computer science, and engineering Here, we mainly focus on the conceptual overview of the principles of MRI, one of the major imaging modalities currently in use. Excellent detailed discussions can be found in Nishimura [1] and Liang and Lauterbur [2]. What is MRI? Briefly, it is a tomographic imaging technique that produces images of internal physical and chemical characteristics of an object from externally measured nuclear magnetic resonance (NMR) signals. MR imaging is based on the wellknown NMR phenomenon independently discovered by Bloch and his coworkers at Stanford [3] and Purcell and his colleagues at Harvard [4] in 1946. Bloch and Purcell shared the Nobel prize in physics for this discovery in 1952. An MR scanner shown in Fig. 1 consists of three main hardware components: a main magnet, a magnetic field gradient system, and a radio-frequency (RF) system. The main magnet is a permanent magnet. It generates a strong uniform static field, referred to as the B0 field, for polarization of nuclear spins in an object. Most imaging systems operate at fixed field strength in units of Tesla (1 Tesla (T) = 104 Gauss (G)). The magnetic field gradient system normally consists of three orthogonal gradient coils, Gx , Gy and Gz, essential for signal localization. The gradient field strength is usually less than 1 G/cm. The RF system consists of a transmitter coil that is capable of generating a rotating magnetic field, referred to as the B1 field, for exciting a spin system, and a receiver coil that converts a precessing magnetization into an electrical signal. On human imaging systems, the strength of B1 is typically a small fraction of a Gauss. Imaging technology in Medicine made the doctors to see the interior portions of the body for easy diagnosis. It also helped doctors to make key hole surgeries for reaching the interior parts without really opening too much of the body. CT Scanner, Ultrasound and Magnetic Resonance Imaging took over x-ray imaging by making the doctors to look at the body's elusive third dimension. With the CT Scanner, body's interior can be bared with ease and the diseased areas can be identified without causing either discomfort or pain to the patient. MRI picks up signals from the body's magnetic particles spinning to its magnetic tune and with the help of its powerful computer, converts scanner data into revealing pictures of internal organs. Image Processing techniques developed for analyzing remote sensing data may be modified to analyze the outputs of medical imaging systems to get best advantage to analyze symptoms of the patients with ease. An Automated classification and detection of tumors in different medical images demands high accuracy since it deals with human life. Different approaches that can produce medical images must be studied. Also, the technique that produces those images is very important in order to know what to apply to a certain medical image in order to get better results. A lot of methods have been proposed in the literature for CT (Computed Tomography), such as scans, different types of X-rays, MRI images and other radiological techniques. The problem is that it is not very easy to obtain such results. The idea is to reduce human error as much as possible by assisting physicians and radiologists with some software that could lead to better results. This is important since it involve saving human lives. Figure 2 shows the schematic of an MRI machine. utilized yet. These include the clustering and classification techniques especially for MR images problems with huge scale of data which consumes time and energy if done manually. Thus, classification or clustering techniques is essential to the developments of neuro fuzzy systems.

Fuzzy set theory plays an important role in deal with uncertainty when making decisions in medical applications[1]. Neuro fuzzy systems are fuzzy systems which use ANNs theory in order to determine their properties (fuzzy sets and fuzzy rules) by processing data samples. A specific approach in neuro fuzzy development is the adaptive neuro fuzzy inference system (ANFIS) , which has shown significant results in modelling nonlinear functions.

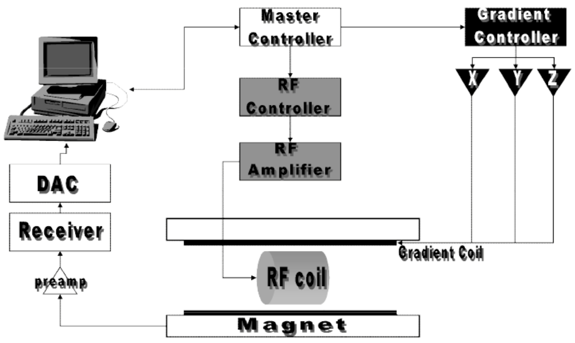


Figure. 1 Simplified drawing of the basic instrumentation

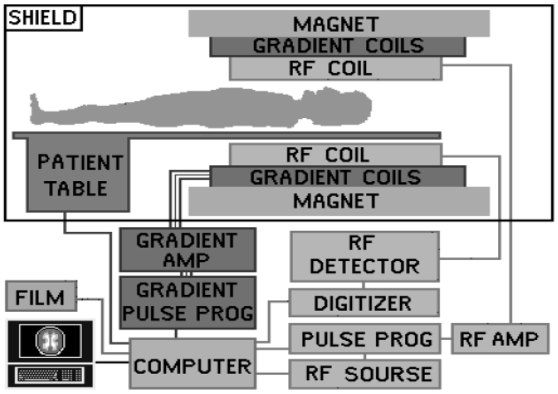


Figure 2 Schematic diagram of MRI machine

The ANFIS learns features in the data set and adjusts the system parameters according to a given error criterion [2]. Successful implementations of ANFIS in biomedical engineering have been reported, for classification [3] and data analysis [4]. The Self Organizing Feature Map (SOFM) ANN based algorithms [5] shows good results in the classification of brain tumor images. Learning vector quantization (LVQ) ANN show the potential of these architectures in the case of supervised classification. Hopfield neural networks (HNN) [6] prove to be efficient for unsupervised pattern classification of medical images Segmentation of images using neuro fuzzy model has been studied by Rami J. Oweis and Muna J. Sunna [7]. Image segmentation using neuro fuzzy tools are also implemented by Mausumi Acharyya [8].

## Image Processing Systems for Medical Applications

### A. Endoscopy

In each *endoscope*, there are two fiber bundles. One is used to illuminate the inner structure of object. Other is used to collect the reflected light from that area. The endoscope is a tubular optical instrument to inspect or view the body cavities, which are not visible to the naked eye normally. For a wider field of view and better image quality, a telescope system is added in the internal part of the endoscope. Astrointestinal fiberoscopes and laparoscopes are important endoscopes used in hospitals for examination, treatment of diseases and surgery. Technological advances in computers and semiconductor chips have brought about lot of changes in health care during the last decade. For digestive diseases, this advancement is represented by the incorporation of charge-coupled device (converts optical image to electronic image) into gastrointestinal endoscopy. These *video endoscopes* use xenon arc lamps as light source. Color Imaging is achieved by incorporating RGB filters between Xenon Lamp Supply and the proximal end of the endoscope. The other approach to the generation of color image is to divide the available cells on the CCD among the three primary colors by means of filters. Three images one for each color are then produced simultaneously by the CCD. Endoscopic pictures are converted to digital images by using CCD cameras and associated image digitizer circuits into a PC/AT. The recorded images can be image processed for better quality.

### A. Stereo Endoscope

Two cameras are mounted on a single laproscope. Images from the cameras are transmitted alternately to a video monitor. Few types of display techniques are used to realise *stereo images* from two dimensionalimages recorded from the above cameras. As the cameras transmits images at 60-120 cycles per

second a three-dimensional, real time image is perceived. As the images are transmitted at a high frequency, the effect is that of seeing different images simultaneously.

### A. Computer Tomography (Ct)

*Computerised Axial Tomography* or computer transmission tomography or computer tomography is a method of forming images from X-rays. Measurements are taken from X-rays transmitted through the body. These contain information on the constituents of the body in the path of the X-ray beam. By using multidirectional scanning of the object, multiple data is collected. An image of a cross-section of the body is produced by measuring the total attenuation along rows and columns of a matrix and then computing the attenuation of the matrix elements at the intersections of the rows and columns. The number of mathematical operations necessary to yield clinically applicable and accurate images is so large that a computer is essential to do them. The information obtained from these computations can be presented in a conventional raster form resulting in a two dimensional picture. The timing, anode voltage and beam current are controlled by a computer through a control bus. The high voltage d.c. power supply drives an X-ray tube that can be mechanically rotated along the circumference of a gantry. The patient lies in a tube through the center of the gantry. The X-rays pass through the patient and are partially absorbed. The remaining X-ray photons impinge upon several radiation detectors fixed around the circumference of the gantry. The detector response is directly related to the number of photons impinging on it and hence to the tissue density. When they strike the detector, the X-ray photons are converted to scintillations. The computer senses the position of the X-ray tube and samples the output of the detector along a diameter line opposite to the X-ray tube. A calculation based on data obtained from a complete scan is made by the computer. The output unit then produces a visual image of a transverse plane cross-section of the patient on the cathode ray tube. These images are also stored into computer for image processing.

### D. Ultrasonic Imaging System

*Ultrasonography* is a technique by which ultrasonic energy is used to detect the state of the internal body organs. Bursts of ultrasonic energy are transmitted from a piezo-electric or magnetostrictive transducer through the skin and into the internal anatomy. When this energy strikes an interface between two tissues of different acoustical impedance, reflections (echoes) are returned to the transducer. The transducer converts these reflections to an electric signal proportional to the depth of the interface, which is amplified and displayed on an oscilloscope. An image of the interior structure is constructed based on the total wave travelling time, the average sound speed and the energy intensity of the reflected waves. The echoes from the patient body surface are collected by the receiver circuit. Proper Depth Gain Compensation (DGC) is given by DGC circuit. The received signals are converted into digital signals and stored in memory. The scan converter control receives signals of transducer position and TV synchronous pulses. It generates X & Y address information and feeds to the digital memory. The stored digital image signals are processed and given to digital-to-analog converter. Then they are fed to the TV monitor. These signals are converted to digital form using frame grabber and can be stored onto PC/AT disk. Wherever the images lack in contrast and brightness, Image Processing techniques may be used to get full details from Ultrasound images. Figure 3 shows Ultrasound Imaging System.

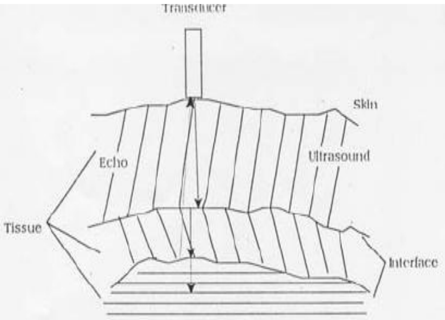


Figure 3. Ultrasound Imaging System

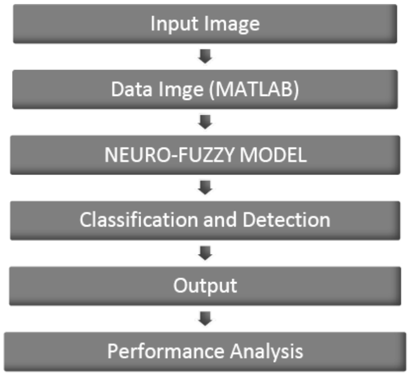


Figure 4. Stages in the Proposed Model

## E. METHODOLOGY

The methodology used for MR brain tumor image classification is shown in Figure 4. The first stage is the image processing system in which image acquisition and enhancement are necessary steps to be done. The proposed model requires converting the image into a format capable of being manipulated by the computer. The MR images are converted into matrices form by using MATLAB. Then, the neuro fuzzy model is developed. After the neuro fuzzy model is successfully developed, the classification of the MR images starts. Symptoms detection phase will follow once the output from the classification technique is done and lastly, performance based on the result will be analyzed at the end of the development phase.

For the classification of normal and abnormal brain images a data set is collected from different sources. Our source is the Harvard medical school website. [http://www.med.harvard.edu/aanlib/home.html]. The various types of brain images include Axial, T2-weighted, 256-256 pixels MR brain images. The images are classified as normal and abnormal brain images. The MR image will obtain and convert it to data form in MATLAB environment such as basic arithmetic operations and indexing, including logical indexing reshaping and reordering. MATLAB stores an intensity image as a single matrix, with each element of the matrix corresponding to one image pixel. The matrix can be of class double, uint 8, or uint l6. Normal brain image (prior image) and abnormal brain image (diagnostic image) are converted to matrix format automatically while the image being read in the MATLAB environment. Both images are converted to binary images. The region of interest [13][14] is determined by subtracting the normal brain image with abnormal image brain image as shown in Figure 5 ,6and 7.

The principal component analysis (PCA) [13][16] is used as a feature extraction algorithm. MR image recognition systems find the identity of a given test image according to their memory. In this paper, the training database consists of a set of MR images. Thus, the task of the MR image recognizer is to find the most similar feature vector among the training set to the feature vector of a given test image. The training and testing phase are shown in the Schematic diagram of a MR image recognizer as shown in Figure 8.

The coordinated abnormal tissues which are in the matrix form are presented to ANFIS for training (estimating) membership function parameters. They fully represent the features of the data that the trained FIS intends to model in data modelling phase. Each row of the training data is a desired input/output pair of the target system to be modelled. Each row starts with an input vector and is followed by an output value. The data are provided from the transformationMR images into data form. The data is divided into 3 partition which are training, checking and application. In data mining there are 4 phases - input phase, classification and FIS phase, ANFIS phase, output phase (application and detection). There are some biomedical slides in Figure 9 which are used.

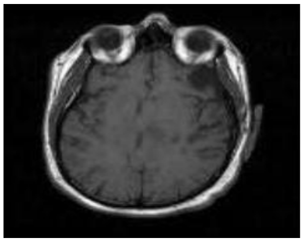


Figure 5. Normal Brain

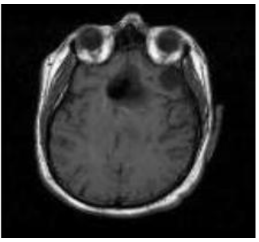


Figure 6. Abnormal Brain

Figure 7. Area of Interest (tumor)

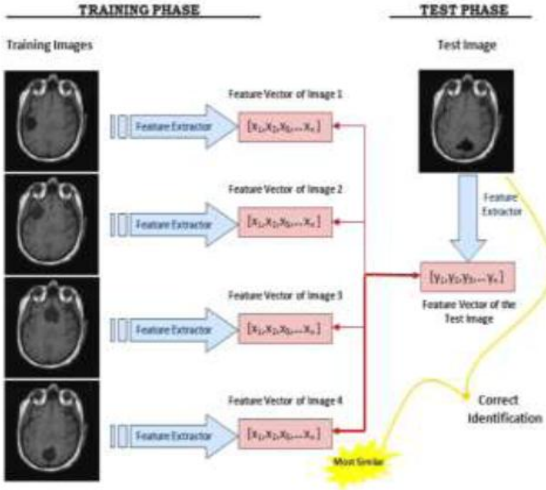


Figure 8. Schematic diagram of a MR image recognizer

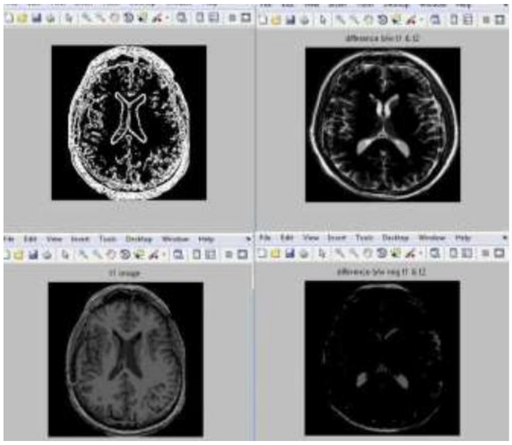


Figure 9. Different slides of brain medical images of various classes

## Multispectral tissue classification of Magnetic Resonance Imaging (MRI)

- MRI data consists of multiple channels of independent but geometrically registered medically significant data, it analogous to multispectral remote sensing data.
- Multispectral analysis of proton MR images may provide tissue characteristic information encoded therein.
- Using well-established methods for computer processing of multispectral images, tissue characterization signatures are sought; using supervised or unsupervised classification methods. The principal advantages of Multispectral analysis of MRI include: It is a quantitative means of analyzing multidimensional image data, such as MRI.

∗ In other applications, multispectral methods have been useful in identifying subtleties that would otherwise be overlooked.

∗ MR images are intrinsically multispectral. The data in a set of MR images is highly redundant, both geometrically and radiometrically.

∗ Multispectral methods are well developed, have been implemented on computers, for which software is readily available that can process MR image data efficiently, and can adapt to existing MR scanners.

## A. About Image Enhancement

Image Enhancement (IE) is a very well know technique in digital image processing. It provides a better solution for perception or interpretability of information of an image for human viewer. It has been applied some specific domain and also this process is suitable for one problem might be deficient for another. For example this method is quite useful for enhancing X-ray images where as it may be not necessary for best approach for enhancing satellite image taken in infrared band of an electromagnetic pectrum.Image enhancement approaches fall into two broad categories: spatial domain methods and frequency domain methods. The term *spatial domain* refers to the aggregate of pixels composing an image. Spatial domain methods are procedures that operate directly on these pixels. *Frequency domain* processing techniques are based on modifying the Fourier transform of an image. Contrast enhancement is one of the important image enhancement techniques in spatial domain.

## B. About Fuzzy Image Enhancement

L.A. ZADEH introduced fuzzy set theory [19] in 1965 which provides a suitable way in analyzing patternrecognition problems when the system complexity anduncertainty are due to ambiguity and fuzziness rather than randomness. A fuzzy set A in a space of points X={x} is a class of objects with a continuum of grades of membership in the interval [0, 1] and is defined as a collection of ordered pairs

$$A = \{(x, \mu_A(x)) | x \in X\} \quad (1)$$

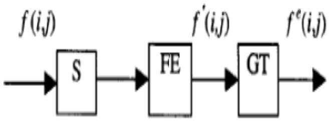
where $\mu_A(x)$ is the membership value of *x* in the fuzzy set *A*. A new image definition should enable us to process images as fuzzy sets. An image *I* of size M x N and L gray levels can beconsidered as an array of fuzzy singletons, each having a value of membership denoting its degree of brightness relative to some brightness level *l* with *l* =0, 1,.., *L*-1. A*fuzzy singleton* is a fuzzy set with only one supporting point. For an image *I*, we can write in the notation of fuzzy sets:

$$I = \bigcup_m \bigcup_n \frac{\mu(g_{mn})}{g_{mn}}$$

$g_{mn}$ is the intensity of (m, n)th pixel and $\mu(g_{mn})$ its membership value. The membership function characterizes a suitable property of image (e.g. edginess, darkness, textural property) and can be defined globally for the whole image or locally for its segments. The paper is organized as follows: Sections IIdescribes the contrast enhancement based on different fuzzy techniques between the periods of 1999 to 2013. Section IIIpresents some discussion. Section IVcontains a brief conclusion.

# Brief Description of different Fuzzy Techniques

In the year of *1999 H.D. Cheng and HuijuanXu* have proposed a novel adaptive direct fuzzy contrast enhancement method based on the fuzzy entropy principleand fuzzy set theory. In this paper, they have used maximum fuzzy entropy principle [20] for mapping an image from space domain to fuzzy domain by a membership function, and then apply the novel, adaptive, direct, fuzzy contrast enhancement algorithm for contrast enhancement [23]. *Later in 2001, M. Hanmandlu, DevendraJha, and Rochak Sharma* [19] have enhanced the approach of Hanmandlu et al., (1997) for the enhancement of color images.Hanmandlu et al. (1997) introduced a Gaussian type of fuzzification function that contains a single fuzzifier and a new intensification operator called NINT [21] that contains an intensification parameter. Fuzzifier is obtained by maximizing the fuzzy contrast and the parameter is obtained by minimizing the entropy. But this works have been bounded to the enhancement of gray images only. They used histogram as the basis for fuzzy modeling of color images. The main accent has been laid on the fuzzy entropy measure. For this work they choose HSV color model. Because RGB color model is notsuitable for enhancement as the color componentsare not decoupled. The color content hue (H) is separate from saturation (S), and can be used to dilute the color content and V , the intensity of the color content. By preserving H, and changing only S and V, it is possible to enhance color image. So, they first converted RGB into HSV for the purpose. A Gaussian type membership function used to model S and V property of the image. This membership function uses only one fuzzifier and is evaluated by maximizing fuzzy contrast, which is cumulative fuzzy variance about the crossover point. The contrast of Sand V is stretched globally using NINT operator. The entropy is minimized to find the intensification parameter involved in NINT operator. The intensification operation leads to enhancement by improving the fuzzy homogeneity of the pixel about the crossover point. Pal S.K. et al established the fuzzy enhancement in the early 1980s [6, 7].The gray level range of the output image using the fuzzy enhancement is almost unchanged, and therefore this enhancement method is not beneficial for less gray level and lower contrast images. To overcome this disadvantage, *Dong-Liang Peng and Tie-Jun WuI* [8] designedthe generalized fuzzy enhancement method in2002.



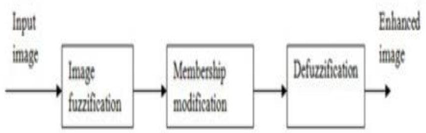
The main aim of Smoothing operation S is to suppress noise or other small fluctuations in images; it is equivalent to suppressing high frequencies in the Fourier transform domain. Median filtering is a non-linear smoothing method. It reduces the blurring of the edges by altering the current point in image by the median of the brightness in its neighborhood. The fuzzy enhancement (FE) method is then adopted to enhance the filtered image. The final processed result is achieved by a gray transformation, GT, of the enhanced image that can be represented as

$$f^e_{ij} = t(f'_{ij}) = \frac{f^e_{max} - f^e_{min}}{f'_{max} - f'_{min}}(f'_{ij} - f'_{min}) + f^e_{min} \quad (3)$$

where the gray level of the *(i, j)th*pixel, the gray maximum and the gray minimum of the final image are denoted by $f^e_{ij}$, $f^e_{max}$, and $f^e_{min}$, respectively. Similarly, $f'_{min}$ and $f'_{max}$ indicate the gray maximum and minimum of the image enhanced by FE, respectively. Moreover, the following relationships hold:

$$f'_{min} > f^{e}_{min},\ f'_{max} < f^{e}_{max} \tag{4}$$

Due to low contrast and noisiness of mammograms, diagnosing cancer tissues using the digital mammograms are very time taking task even for highly skilled radiologists. *Aboul Ella Hassanien and AmrBadr (2003)*[9]have given a comparative study on fuzzy image enhancement techniques applied on digital mammogram images. Basically,fuzzy image enhancement technique has three main parts: image fuzzification, membership modification and defuzzification.



After the image data are transferred from gray level plane to fuzzy membership plane (fuzzification), appropriate fuzzy techniques modify the membership values. It may be a fuzzy clustering, fuzzy rule-based approach, and fuzzy integration approach and so on.

# CONCLUSION

This paper presents an automated recognition system for the MRI image using the neuro fuzzy logic. Experimental result indicates that the technique is workable with accuracy greater than 90%. This technique is fast in execution, efficient in classification and easy in implementation. As an overall conclusion, this paper is successful as it met the objectives of the paper and successfully developed, run and optimized the performance of the classification technique. Image contrast enhancement using a literature review of articles from 1999 to 2013 with the keywords fuzzy set theory and fuzzy rule-based and explore an idea how fuzzy set theory and fuzzy rule-based improve the contrast enhancement technique in different areas during this period. In this paper, we have studied different fuzzy techniques to increase the contrast of the digital image. We conclude that, fuzzy Image processing is a very powerful tool for enhancement technique, not only that fuzzy logic tools empower a machine to answerthe human reasoning like good contrast" or "sharp boundaries", "light red", "dark green" etc. used in image enhancement by fuzzy logic are termed as linguistic hedges using IF-THEN rules.

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# Biographies

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