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PSOFUZZY Automated Detection Model for the Detection of Mild Traumatic Brain Injury

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***Abstract*—Traumatic brain injury (TBI) is the brain injury caused by trauma to the head. There are three types of traumatic brain injury based on the range of Glasgow Coma Scale (GCS) and the level of consciousness namely mild, moderate and severe. Detection of mild traumatic brain injury is difficult because of the Hydrocephalus condition. Hence an automated approach PSOFUZZY model has been proposed in this paper for the detection of mild traumatic brain injury. The proposed PSOFUZZY model performs Normalization, Segmentation, Feature Extraction based on intensity as well as texture and Classification. The Normalization and Segmentation process are performed using Particle Swarm Optimization whereas the Classification process is performed using Adaptive Neuro Fuzzy Inference System.**

***Index Terms*— ANFIS, Brain injury, Fuzzy, Optimization, PSO, Traumatic.**

I. INTRODUCTION

Awareness of traumatic brain injury has been increased traumatically in recent years. TRAUMATIC BRAIN INJURY (TBI) is one of the major cause of death and disability. Sports injuries, automobile casualty, smash injuries in the army, and falls in workplace are the major causes of traumatic brain injury [2].A traumatic brain injury basically affects young people in industrialized countries. Relatively 25% of these injuries results in a long term impairment, social and economic concern. When elementary injury cannot be prevented, secondary brain damage can be reduced [14].

From the information of Centers for Disease control, 85 cases per 100,000 populations are affected by traumatic brain injury, which means that in United States 1.4 million people are TBI patients per year. 235,000 people are hospitalized in each year with a diagnosis of TBI and 50,000 do not survive. If the Abbreviated Injury Score (AIS) for the head region was equal to or more than 4 then those patients were known as have traumatic brain injury [7]. If the patient had a 90 mm Hg or lesser systolic blood pressure then it was described as hypotensive. The American College of Surgeons defines a criterion which says when blood pressure was not recorded; presence of a pulse was used for the estimation of blood pressure.

The Glasgow Coma Scale (GCS) is a valuable first observation to measure the severity of traumatic brain injury immediately following brain trauma [6].The duration of loss of consciousness (LOC) is also plays a significant diviner of the severity and long-term prognosis of injury. The duration of posttraumatic amnesia (PTA) is also another clinical predictor of the severity of traumatic brain injury.

From the level of consciousness or Glasgow coma scale(GCS) score traumatic brain injury is classified as mild, moderate or severe [12]. When loss of consciousness is shorter than 30 minutes and GCS score ranges from 13-15 then it is known as mild Traumatic Brain Injury (mTBI). If loss of consciousness is 30 minutes to 6 hours and GCS score ranges from 9-13 then it is known as moderate traumatic brain injury. And when loss of consciousness is more than 24 hours and GCS score ranges 8 or less then it is established as severe traumatic brain injury.

Amid mild traumatic brain injury is a complex condition. Which is difficult to detect in automated detection approaches like magnetic resonance imaging (MRI) and Computed Tomography (CT) scans. Because of the hydrocephalus the lesion area appears as low contrast in MRI images. Hydrocephalus is a condition that occurs when fluid builds up in skull and causes the brain to swell [1].

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Among 1.5 million Traumatic Brain Injury (TBI) persons 75% of those are classified as mild Traumatic Brain Injury (mTBI) by the criteria of the Centers for Disease Control and Prevention (CDC). The cerebral concussion is another name of mild traumatic brain injury which results from a blow to the head. Mild traumatic brain injury results a transient loss of consciousness or a brief period of amnesia or per-injury confusion. In most of the cases mild traumatic brain injury is a concussion, many of these patients have short-term memory and concentration difficulties. Significant disability and unemployment exists from an effect of cognitive, physical, psychological, and social dysfunctions after mild TB [16].

Hence we propose a method PSOFUZZY model for the detection of mild traumatic brain injury. Which uses particle swarm optimization (PSO) and Adaptive Neuro Fuzzy Inference System for segmentation and classification.

This paper is organized as follows; Section II illustrates the related work, section III describes PSOFUZZY model, section IV presents the Experimental Result, section V represents the conclusion.

II. RELATED WORK

Traumatic Brain Injury can be detected by using six methods. The methods are Pressure Monitor, Diffusion tensor imaging, Biomarker, Neuropathology, Portable medical system, Electrophysiological.

Wakeland et al. [13] proposed a computer model of intracranial pressure (ICP) dynamics that measure clinical treatment options for high ICP during Traumatic Brain Injury (TBI). This model uses fluid volumes are primary state variables and explicitly models fluid flows associated with each intra- and extracranial compartment and it evaluates clinical events and therapies are intra and extra parenchymal hemorrhage and mild hyperventilation.

Wilde et al. [4] proposed the Diffusion tensor imaging of the corpus callosum. In which adolescents with mild traumatic brain injury (MTBI) result of Glasgow Coma Scale rate is 15 and unfavorable CT, diffusion tensor imaging (DTI) performed not beyond 6 days post injury showed enlarged fractional anisotropy and drop diffusivity suggestive of cytotoxic edema.

Vergara et al. [8] proposed a biomarker. From the functional magnetic resonance (fMRI) imaging to derived resting state functional network connectivity (rsFNC). The fMRI is emerging as a possible biomarker. The main concerns with this technique is the suitableness of methods and this method used to correct for subject movement.

Michael Falcone et al. [15] Proposed speech analysis method that detect mild Traumatic Brain Injury. Vowel sounds are isolated by the recordings and acoustic features. These features are extracted and used to one-class machine learning algorithms.

Sjaaheim et al. [5] proposed a portable system for emergency TBI analysis and observe personalized treatment based on quantitative electro encephalography (qEEG) and High interpretation transcranial Electrical Stimulation (HD-tES).

Gaetz et al. [11], Proposed visual event-related method of potentials and post-concussion syndrome (PCS) self-reports. The cumulative damages are indicated by event-related potentials that damages can occur successive lot of concussions. These measures correlate much with cognitive self-reports of PCS symptoms.

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III. THE PROPOSED PSOFUZZY MODEL

The proposed PSOFUZZY (Particle Swarm Optimization and Adaptive Neuro Fuzzy Inference system) is a model which is used for the detection of mild traumatic brain injury. The proposed model consists of 3 modules. The first module describes preprocessing, the second module describes contrast enhancement using PSO algorithm and the third module describes classification by Adaptive Neuro Fuzzy Inference System (ANFIS).

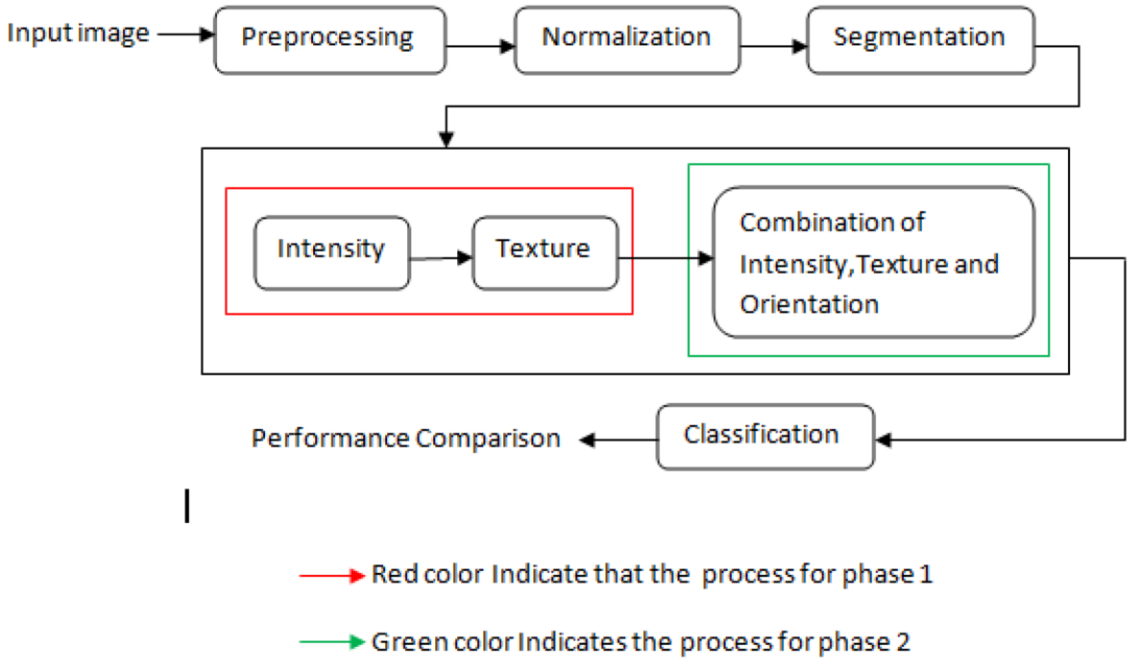

Fig 1.Blocck Diagram of PSOFUZZY model

A. Preprocessing

The MRI images are obtained from the hospital that contains injured brain images [3]. In the first step, implement the preprocessing techniques. The process is conversion from RGB to grayscale and remove the noise by using the median filter [2]. This means discard noise and developing or altering image quality. The most commonly used enhancement and noise reduction techniques are implemented. The image enhancement that the result of more prominent edges and a sharpened image, noise will be reduced thus reducing the salt paper effect from the image. After image enhancement, image segmentation will be provided. This step is vital as the improved and enhanced image will produce better results when detecting edges and developing the quality of the overall image. Edge detection will guidance to finding and understanding the outline shape of the injury. The following steps will be described in the preprocessing stage [5]:

(i) Noise can be described as unwanted pixels present in the image that reduce the quality of the image. It can be written as:

$$f(x, y) = g(x, y) + \eta(x, y)$$

Here $f(x, y)$ is defined the noisy image, $g(x, y)$ is considered original image and $\eta(x, y)$ is the noise occur in the image. There are varies types of noise present in the brain image, the

noise are Gaussian noise, Salt and pepper noise. Salt and pepper is one of the common types of noise present in x-ray images. The noise are removed by using mathematical transformation on the images. It protect the edges while removing noise. The median filter is used to remove noise such as salt and pepper noise.

(ii) Any type of filter able to remove the noise present in the original image. However, in injury detection, the sharpness of the edges, occur from the immediate change of intensity. Then improve the sharpness of the edges.

(iii) Sharpening is generally achieved by using high pass filters. It also used for implement the boundaries of the object. The low pass filters (noise removing step), are need to sharpen the image to ensure edges are kept. The preserve edges will detect and highlight the injury.

B. PSO method for the contrast enhancement

This method is performed based on the Particle Swarm Optimization (PSO) algorithm. It is a population-based stochastic optimization technique with self-adaptive mechanism based on the progress of swarms and influenced by primate performance of bird flocking or fish schooling. In the previous several years, PSO has been effectively applied in many far application areas, such as arrangement of antennas of transmission systems, system recognition on control engineering, etc., by reason of its robustness and simplicity. Instead of using historical operations, such as gloss over and deviation of genetic algorithms (GA), to manage the individuals, every particle in PSO documents in the inquiry space with acceleration which is dynamically adjusted to its own flying training and its flying associate involvement.

Appropriately, trajectory of each individual is influenced by its own prosperity experiences, as well as the successes of its neighbors. Toward the end of the optimization, maximum particles combine to the global optimum, which expectedly results into the best design [9]. In relation to GA, PSO has an uncomplicated configuration with less complicated operations during the evolution process. Because of these advantages, PSO algorithm is used for performing normalization segmentation and feature extraction process. Here the preprocessed output is forward to normalization module. In general noises in image provide low contrast images. Hence the Normalization performs reduction of noises in MRI image without disturbing edges. And after normalization the normalized image is send to segmentation module. Segmentation is that the method of separation a digital image into multiple regions.

The segmentation goal is change and/or modify the illustration of a picture into one thing that's higher purposeful and easy to research. Image segmentation is often accustomed place the objects and limits (lines, curves, etc.) in pictures. A lot of exactly, image segmentation is that the method of allocating a label to every constituent in a picture such pixels with an equivalent label share bound characteristics. The results of image segmentation may be a set of segments that together cowl the whole image, or a collection of contours extracted from the image .Each of the pixels in every region are similar with relation to some characteristic or computed property, like color, intensity, or texture. When segmentation process is completed the segmented output is send to 2 phases particularly phase1 and phase2. Phase 1 performs enhancement of intensity feature and implement texture Feature .Phase 2 performs implementation of orientation feature and combine it with intensity feature and texture Feature.

C. Performance of classification by ANFIS

A specific method in neuro fuzzy development is the adaptive neuro fuzzy inference system (ANFIS), which produce significant results in modelling nonlinear functions. ANFIS learns features in the data set and adjusts the system parameter present to a given error criterion. Strong performance of ANFIS in

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biomedical engineering has been reported, for classification and data analysis. An adaptive network is a multilayer feed forward network in which every node operates a specific function (node function) on incoming signals likewise asset of parameters related to this node. Fuzzy rule based system be contained of a rule base, database, decision making unit, fuzzification interface and a defuzzification interface.

The embedding from the fuzzy inference system into the framework of adaptive networks, a new architecture specifically adaptive neuro fuzzy inference system (ANFIS) which is formed by combining neural networks and fuzzy theoretic approaches. This ANFIS classifier performs the classification of brain images to get an output of contrast enhanced lesion area from the segmented image. The performance of PSOFUZZY method is evaluated by sensitivity, specificity and accuracy.

$$\text{Sensitivity} = \text{TP}(\text{TP} + \text{FN}) \quad (1)$$

$$\text{Specificity} = \text{TN}(\text{TN} + \text{FP}) \quad (2)$$

$$\text{Accuracy} = {(TN + TP)}\Big/{(TN + TP + FN)} \quad (3)$$

IV. EXPERIMENTAL RESULT

To perform mild traumatic brain injury detection first considers the input image of brain as in Fig 2a.The output of magnetic resonance imaging is given to the preprocessing module in PSOFUZZY model. Preprocessing is done to remove noises by enhancing blurred image and sharpening edges in an image. After that the PSO algorithm performs segmentation of regions as in Fig 2b. This segmentation of region works from the inside out, instead of the outside in. And these segmented regions are used to locate objects and boundaries (lines, curves).

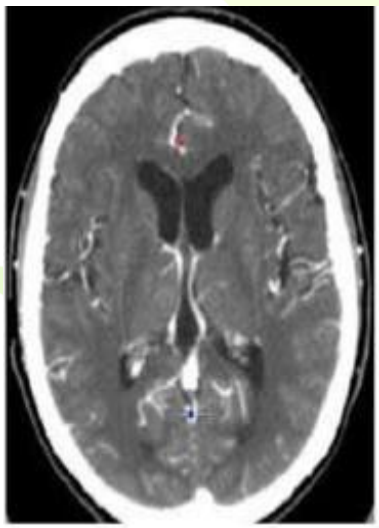

Fig 2a. Input image

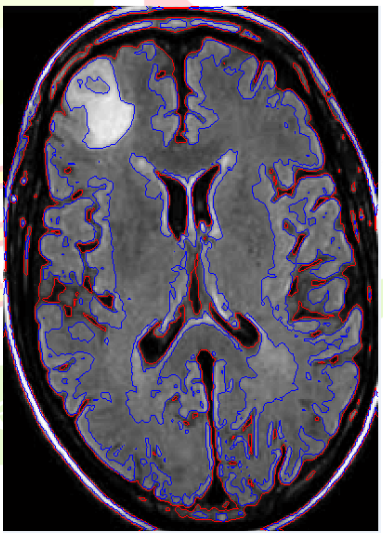

Fig 2b.Segmented regions

In general segmentation is the first stage in any attempt to analyze or interpret an image automatically. After the segmented region the segmented corrected region is produced by assigning label to each region as in Fig 3a.From this segmented image the PSO algorithm performs optimization to provide minimum of function which means this h can yield some of the largest byte savings and performance improvements in an image as in Fig 3b.

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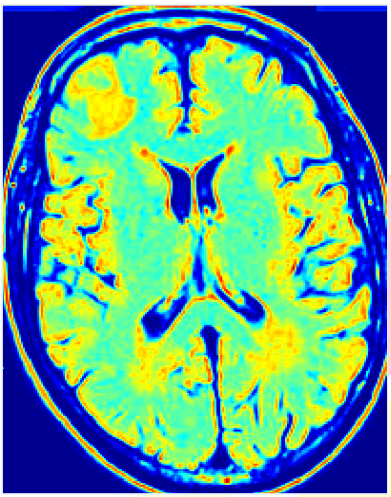

Fig 3a.Segmented corrected region

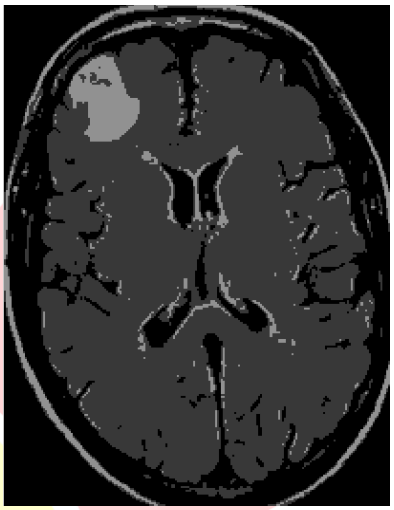

Fig 3b.PSO optimized segmented region

Finally the PSOFUZZY model provide output as segmented lesion region with greater accuracy and performance as in Fig 4.From this we can detect lesion area in brain and therefore we able to give treatment.

Fig 4.Output image

V. CONCLUSION

This paper presents a PSOFUZZY automated detection system model for the detection of mild traumatic brain injury (mTBI) using the particle swarm optimization method and adaptive neuro fuzzy inference logic. Experimental result indicates that the technique is workable with greater accuracy. This technique is fast in execution, efficient in classification and easy in implementation. This method is successful as it accurately identifies the detection of mild traumatic brain injury and optimized the performance of the classification technique.

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