Recognition, Analysis and classification of Alzheimer ailment using Hybrid Genetic and Particle Swarm with Deep Learning Technique

[1]Manpreet Kaur, [2]Rachhpal Singh

[1]Department of Computer Engineering, Thapar University Patiala, India.

[2] P.G. Deptt. Of Computer Sc. and Applications, Khalsa College Amritsar

ABSTRACT

Nature-inspired methods play significant role in different applications in arena of computer science, industrialized designs, business and medical field. Generally, these techniques are nature inspired that is helpful in segmentation of brain's internal parts and related disease. Dementia is brain related Alzheimer's disease (AD) that is very difficult for clinical identification, classification and supervision. Presently, AD has no remedy, but at initial stage there is an effective treatment. It is very important and challenging job to diagnosis of AD. Only it can be treated efficiently at early stages with the early prediction through various biomarkers. Deep Learning (DL) is the only best approach in the medical field for prediction. Depending upon the different hyper-parameters, the performance and convergence of Convolutional adopted Neural Networks (CNN) affect the prediction liable upon the input data. Number of nature inspired optimization approaches is developed for optimization and segmentation of the data. Particle Swarm Optimization process (PSO) and Genetic Algorithm (GA) are the best optimization algorithms for the diagnosis of AD. GA optimizes the hyper-parameters and configuration related with network architecture of this system. The proposed hybrid approach using GA and PSO with deep neural network classify and diagnose the disease efficiently after inspecting the brain's magnetic resonance imaging (MRI). As classification error decreases with the increase of features that mend the accuracy of classification. Experimental outputs and comparisons show the accuracy of proposed approaches is comparatively better than other classification techniques.

Keywords

Alzheimer disease, Deep learning, Optimization technique, Genetic Algorithm, Particle Swarm Optimization, Convolutional Neural Networks, Magnetic Resonance Imaging.

1. INTRODUCTION

Today in this advance going age, many individuals are exaggerated by decline in memory that leads the misplacing of things, have a language problem and regular activities break down etc. occurs. Examining the functional activities and structure of the brain in old age human beings specifies that something is wrong with the brain memory. These changes or problems related with the brain in neurobiological and cognitive parts are linked with age that roots of Alzheimer [1].

Number of old person is affected today by dementia which is due to AD. Alzheimer's disease progress in slow form from a mild to moderate and then reaches up to a severe stage. Mainly it occurs due to some abnormality in the proteins that build-up slowly in the brain. At preclinical stage, fluctuations occur in the brain's regions before any diagnosis regarding the AD. In the next stage, there is some mild cognitive impairment (MCI) in the brain occurs that slightly affects the memory and is noticeable. It also shows some change in cognitive functionalities. The final stage is very dangerous as dementia clearly occurs and shows the full loss of memory. It also reduced the daily activities. No treatment is available today to cure completely about this disease. At early stage, strong requirement is for identification of this disease so that some preventive measures can be implemented effectively. Significant studies with various forms of data were carried out for understanding the brain's pathological conditions. Some of the image scanning related techniques are discussed. These imaging modalities are functional and structural Magnetic oriented Resonance Imaging (MRI) [2]. Mild cognitive prediction progression to AD has effect with MRI [3]. With MRI diagnosis of AD at early stage based on brain

networks system [4], Cerebro-Spinal Fluids (CSF) and Positron Emission Tomography (PET) [5]. These scanning techniques are some biomarkers for classification of various aspects of disease's stages either in a combined format or separately [6]. Such techniques have some best learning features for AD diagnosis [7].

Machine Learning (ML) methodology works in phases and these are organization of data, data modeling, learning process and estimation [8]. So number of machine learning technique needs some strong domain specialists for transformation of raw facts [9]. Using ML, many learning techniques invented for clustering and classification of available data. At initial stages, these ML methods were worked on a standalone machine [10]. As there is the requirement for fast computing and to get the reliability in the process, frameworks and distributed computing was carried out [11]. These contexts deal in a large volume of data or information. Deep Learning (DL) is another powerful technique and is a one of the strong category of ML [12]. It is a mathematical model that creates a representation of learned information from the raw data. The deep learning and a network technique known as CNN vary in the forms of hidden stratums. These have ability in connections to acquire some applicable observations or formats from computed or inputted values or data [13]. Also accuracy of any classifier depends on the input's dimensions and size of the data. Note that dimensions have many features used for classification and to find the accuracy. A study was focused on the reduction of dimensions for optimal outcomes. Large data was depends upon homogeneous data and it was proved that it was expensive for huge amount of inputted data [14]. By taking the clinical datasets, it was observed that large data or scanned images are of multimodal in nature or in high dimensional form as AD's databank having neuroimaging initiative and some genome data. So using such data, it was observed that the amount of features here are more than the available sampling amount. As previously old techniques are based on machine learning that was further depends upon samples of a singular inputted mode. It works only on single dimensional format. It creates a prediction of discrete outcomes in regression based classification. Aspects having single outline have been assigned to machine learning methods at a time. As current ML techniques depend upon either single only or on the bimodal data sets, hence, there is the requirement for ML that fully depend upon high dimensional biomedical multimodal data [15]. Here study emphases on comparing different DL methods for handling and controlling the multimodal data. Data inputs in two forms used for experiment work. First one is scanned images by MRI, second is feature extracted data [16].

Many authors tried for various approaches like bi-level as well as multilevel thresholding to segment all regions depending on classification and so measure accuracy [17]. Note that multilevel thresholding is very powerful and advanced method as compared to bi-level for solving complexity [18]. So, multilevel approach was powerfully adopted as having simple processing, local minima avoidance and flexibility [19]. Nowadays, different techniques have been studied by using various optimization algorithms like GA, ABC, PSO, BA, grey wolf optimization (GWO) and firefly algorithm (FA). All these approaches are inspired by animal and birds's natural behavior. These gave some better global optimum outcomes [20]. There are many approaches like K-Nearest based Neighbors (KNN), Support based Vector Machine (SVM), Self Organizing oriented Map (SOM) and last Neural Network (NN) available for classification [21]. Before applying these classification techniques, there is a need for extraction of features by using the feature extraction techniques. Then best feature can be adopted by using the feature reduction methods. Deep Learning is a best technique to follow the steps used for classification [22]. Basically work initially starts by acquiring MR images of the brain and then passes through the pre-processing technique. Further segmentation was done on the available damaged scanned images using many optimization algorithms such as GA, PSO, ABC etc. Note that here some quantitative and qualitative measures were taken for these algorithms. Then, some validation procedures were adopted to correlate the given clinical values. This assessment approach is beneficial for clinically diagnosing the AD.

GA [23] is a computational optimized tactic derived from the Darwin's model, like genetic mechanisms as well as natural selection [24]. Basically GA finds optimal results using some created simulation procedure of nature based evolution and is more positive for all those problems that have complicated computations and evaluations to get their results. Further Genetic oriented CNN [25] is another prevalent case established from the GA. It optimizes CNN structure having goal oriented objects. Network oriented such structure organized from method revealed some like performances that were matched with some state-of-the-art classifications.

Another optimization mechanism is PSO that finds behavior of birds so that optimal solutions obtained with fast speed. Appropriate selection of various parameters from the GA and PSO will gives the fast convergence for global minimum point having some errors. It leads having an excellent job performance that avoids the problems like overfitting etc. Here, GA with PSO is capable for searching the best-performing CNN architecture. It includes the optimization methods and algorithm activation function that was explicit for a known inputs or some of available sets of data. Inputted set of data values used here is set of MRI or CT Scan or PET scanned pictures having amyloid. Note that scanned images mostly used for AD diagnosis at early stages and so the dataset taken is appropriate for extracting and classification of the AD's features.

2. RELATED WORK

A progressive illness causes the dementia. It creates big number of pathologies related with the brain. Note that here AD is the one basic and mostly shared pathology. A main source of problem has neurons' loss that was due to very big deposition protein amyloids in brain nerve cells. AD's early detection symptoms have impaired storage, apathy and gradual depression onset [26]. Neurons killed by AD affect neurons communication in brain cells and such type of operation is called brain atrophy [27]. In all the regions significant genes identify by extracting AD's region in special format [28]. To access brain's atrophy is the linear and simple way out for early finding of AD in all the datasets and its related progressions [29]. So, it is a necessary for sub region analysis in the brain and brain's nerve cells at early stage to diagnose AD problems. Main sources in functioning of internal brain are HC, CC, MW and GM that create a complex structure of brain in solving the problem related with AD.

CNN is multilayer perceptron type that initiates from animal's nervous system's behavior in visual form. Further it is noticed that CNN layer's network system outperform naturally comparing with remaining layers or existing layers in the same network system having sets of nerve values. These are Visual Words Bags etc. for analyzing the visual feature based tasks [30].

GAs data are useful and suitable for complex, large or data having poor feature sets because GAs operations and set values have fast convergence for getting the optimal outcomes [31]. Further optimized processes gave a direction for any measure in finding the exact values so that either very low feature numbers or having high accuracy used for training the data sets in classification model that provide a better predictive and powerful models having fraction initial set values of all the feature given [32].

GA is helpful in ML search process that was inspired by a great evolutionary theory called Darwinian models [33]. The GA's pros over analytic factors and statistical techniques are to address, solve problems in those cases where no human proficiency is used. To challenge optimized functional problems GA is best formulated. Mixed integer numerical and discrete combinatorial problems for solving all the ideal applications GA is well defined [34]. So GA methodology is best for searching the outcomes that needs efficient subset searched values from a set of features for finding the high dimensional optimal classification problems [35]. It is processed in those cases when it has complex and large search space or poorly understood. It identifies all the measures by investigating all the tests of multiple neuropsychological optimally for AD classification to the concerned problem. So GA gives better outcomes represented by an objective sets or values known as fitness function [36]. Individual's identification becomes helpful disease diagnosis using all the clinical criteria after understanding all the cognitive impairment in case of AD. Purpose of research is the GA use for quantification and determination of all the predictive values having neuropsychological combination for measuring the prediction AD or MCI.

AD attacks brain directly and worsens more and more with time. At end it leads to death. PSO is only technique applied for classification by applying Decision Tree Classifier (DTC) and Feature Reduction (FR). AD detection at earlier stages passes through three stages. Eigen brain, eigen vectors, mean, skewness, variance, kurtosis, area measurements, standard deviation, perimeter computations and eccentricity etc. are the features and extract MRI Images in the first phase. PSO with FR applied in second phase. DTC applied in third phase for AD detection through brain images. At end a comparisons was done [37]. Identification of AD was done by automation process. Sub region of brain has heavy loss of neurons by giving maximum distinctive that increase the AD.

Number of optimization processes like Grey Wolf Optimization (GWO), PSO, Cuckoo Search (CS) and GA were developed for getting optimum results to detect AD by segmenting the data sets in the hectic regions. Validation of images of ground truth classified with classifier of Deep Learning (DL) in segmented regions. So 98% high accuracy outcomes occurs by using PSO with GA by segmenting brain's sub regions and images of GT. 95% high accuracy outcomes by using the classifier of DL in segmented regions by classifying these. Classification and segmentation outcomes prove that proposed approach provide best results as compared to other traditional methods. So observation was done from evaluation that proposed technique is correlated with high performance. Further can say that proposed pipeline is main factor on AD diagnosis [38]. Total execution time required for executing all the tasks for optimal outcomes is similar to problems like NP-complete [39][40]. So prediction of Disease becomes optimal in such cases [41].

The research works cited in the references [42][43][44][45] highlighted the usage of swarm intelligence and meta-heuristics in solving the issue related to the feature selection, disease diagnosis and remote monitoring.

3. METHODOLOGY AND EXPERIMENTAL RESULTS

Objective of methodology is to explain the process in such a way that optimized results can be obtained. The entire process passed through five stages. The various stages in a sequence are image acquisition at first, further pre-processing is next part, at third segmentation process occur, Ground Truth validation is at fourth level and at end classification is the final solution that require. Followings are the steps during work flow:

Step 1: MRI of the brain for image acquisition is the primary task. For this 200 MR images are collected from Dhillon Scan Centre at Amritsar.

Step 2: As we know the images at any scanning are in poor and so need the pre-processing for clearing the images fine. Pre-processing was done by the tool histogram equalization and thresholding to enrich quality of images by eliminating skulls of images.

Step 3: At third step, Segmentation process occurred by using GA and PSO optimization algorithms.

Step 4: Further segmented images checked for validation with the Growth Truth by using correlation coefficient measures, comparing similarity and overlapping.

Step 5: At end, Implementation of CNN classifier for categorization, normalization and diagnose of AD patients and the disease.

The proposed approach for classification and detection of Alzheimer disease into from five stages is encompassed of important three stages. Firstly, it starts with MRI images preprocessing using CNN and median filter. Secondly based on region segmentation and voxel based next is to implement segmentation. At last using deep approach with convolution network carried out for final classification. Flow process of proposed approach is represented in figure 1 by block diagram.

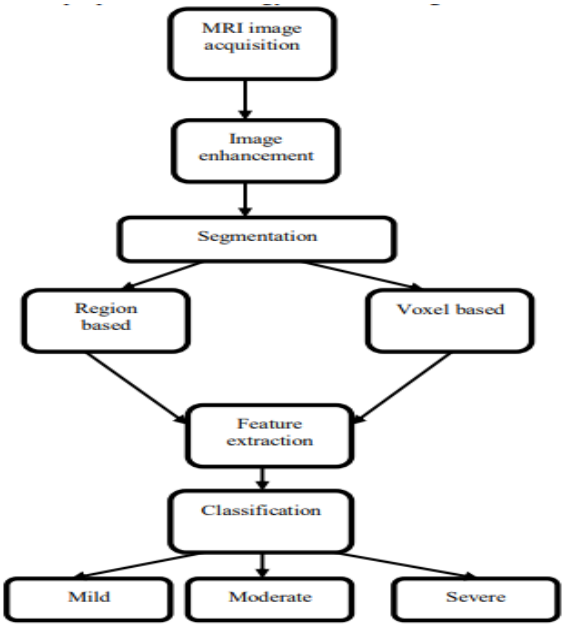

Fig 1: Proposed methodology with Block diagram

To overcome any confusion related with convolutional neural network and multilayer perceptron during experimentation to get minimum iterations, find local minima, variation in weight factors and sampling. So handling multimodal data is incorporated by hybrid deep learning. Here hybrid GA and PSO with deep learning (known as DBN (Deep learning based network)) using CNN utilized weight factor submission to two convolutional layers and sown in figure 2 (mixture format of coordinated process).

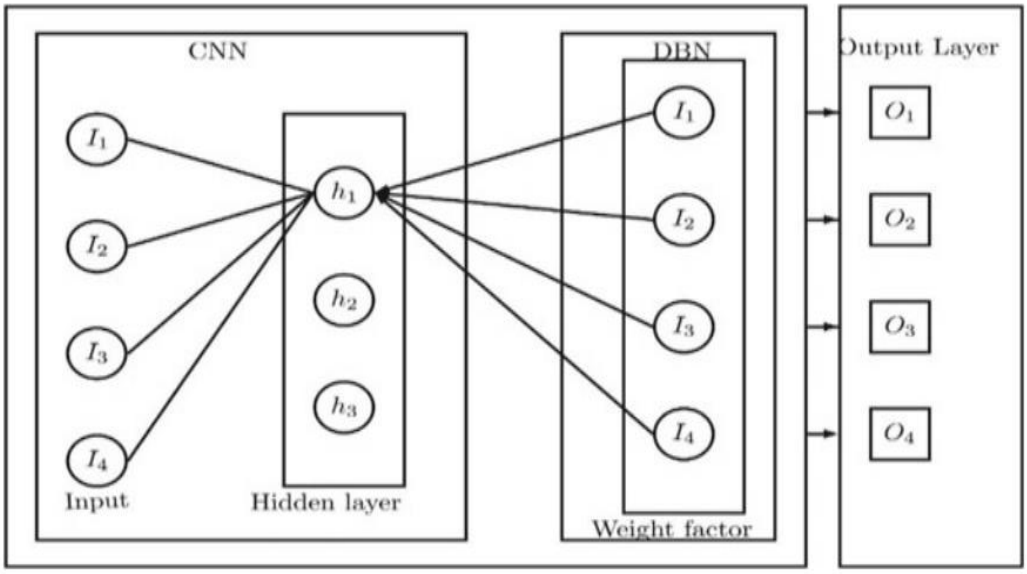

Fig 2: Hybrid Based Layers

Due to computational burden, poor generalization capability and unsatisfactory results, it is very important to do medical image segmentation. So these shortcomings and complexities can be overcome by better segmentation methods. This will give the best optimal outcomes. The massive segmentation techniques quantity was defined by clustering base, compression base, edge base, region base and thresholding base. Now these days the emergent approaches for the researchers are nature inspired multi-thresholding methods that is beneficial for analyzing the behaviors of various natural mimicking. These multi-thresholding methods also known as optimization algorithms that is best for getting the global optimum results. So here a hybrid approach is applied with GA and PSO using deep learning for best classification and segmentation.

For global optimization, GA is a primary nature-inspired approach. It is recognized from genetic inheritance and the natural selections. It passes through first by selection, the crossover process applied if not optimized, at third phase mutation process applied and at end a recombination process adopted. Coordinates are selected from the initial population and from that a new population produced. A fitness function is computed and directed for getting the optimized population. Till an optimized solution obtained, iteration process continues.

PSO is another nature inspired swarm intelligence optimization approach that mimics the organized social behavior of birds and animals. Here particles were taken as swarm and so fitness value based on fitness function was computed. By improving problems, it was optimized by using the movement of particles in the population. On the basis of number of iterations and threshold energy, stopping criteria set. The best optimized outcome has been obtained depending upon the movement of the particles in every iteration. This process will continue till an optimal results obtained. Also here local and global search applied. Also fitness function or fitness value was inspected by updating the best particle with local and global best search. Then, position and velocity updating of every movement of particles provide a new outcome or fitness function or value. This will improve in existing fitness value.

The performance of proposed approach was greatly exaggerated by applying hyper parameters and network architecture. Search space recommended by GA-PSO-CNN (GPC) has insufficient output. So, here, to search the effective optimized network design for a given set of inputs, selection of both hyper parameters and network configurations as evaluation of search space. Figure 3 illustrated usability of GA+PSO to search optimal ideal structure in CNN.

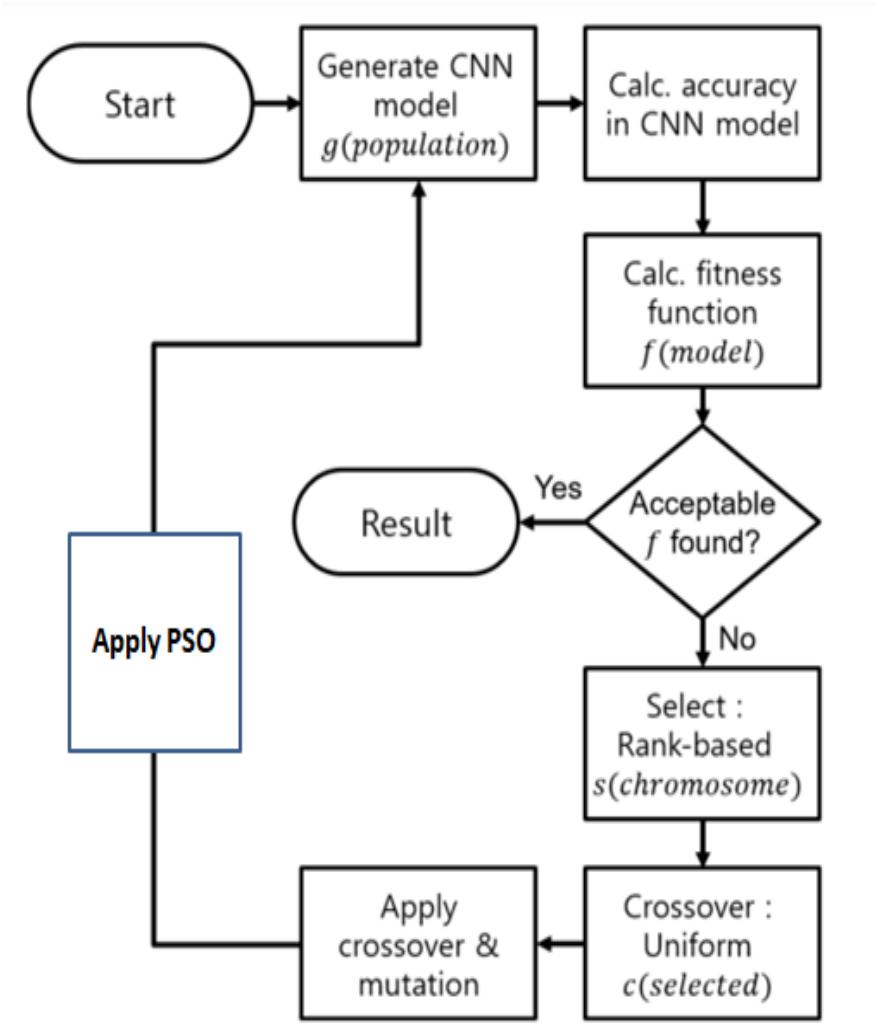

Fig 3: Flow chart of GA and PSO hybrid approach

Quantitative and qualitative validation applied on these optimization algorithms that is helpful for analysis of abnormal and normal patients. Using GA's operations and by selecting the optimized threshold standards for the segmentation process by population updating using crossover and mutation processes. The threshold standard for segmentation was affected by final generations of Gas. Updating iteration processes continue till an optimized outcome occurred. The main disadvantage of GA is to select the optimal value used for high standard region of segmenting due to its dynamic variables or parameter and that continuous change affect the outcomes during the iterations. Further, PSO technique applied on for segmenting the standard region and to get more optimized threshold value. As PSO working follows the Darwinian theory of natural selection to identify the particle position in a fine form that further affect the threshold values or standards for segmentation. Particle's position during updating is identified by the optimum threshold values or standards for PSO. It will give the optimized outcome. Here, the final particle's position was found depending upon the updating particles positions till a refined optimized and better than previous solution obtained. Weather PSO has a major limitation in searching the optimized values or outcomes. In other words it passes through number of iterations to get global optimum results. As after comparing GA and PSO with the previous methods both are having weaknesses in segmentation due to dynamic parameter

occurrences that require number of iterations in large quantity. The proposed GPC process compared with existing optimization approaches as ABC, ACO, VNS, BAT etc. The GPC results are much superior to get strong convergence and provide optimized outcomes globally. Various parameters or variables used for GA and PSO are in table1 and table2.

Table 1: Variables or Parameters of GA

Variables	Values
Size of given population	25
Generation's value or its maximum number	110
Threshold number or value	15

Table 2: Variables or Parameters of PSO:

Variables	Values
Particles Number	30
Iterations number (maximum)	98
Threshold number or value	15

In this experiment and result evaluation, performance of proposed hybrid approach of deep learning with GA+PSO classifier was computed and a comparison was done with existing approaches like CNN, DBN or DNN, MLP and SVM. Experiments were conceded by MATLABR2017a platform. So, performance evaluations of measuring values/metric parameters are as:

- true negative (αn),
- true positive (αp),
- false negative (βn)
- false positive (βp).

Sensitivity test (SEN), Specificity (SPE), Matthews correlation coefficient (MCC) are the standard formulas for evaluation and comparison of proposed approach with existing approaches. This will also compared with the accuracy (ACC) of the outcomes. SEN defines probability of disease in patients and is known as true positive rate and computed as:

$SEN = \alpha p / \alpha p + \beta n$

$SPE = \alpha n/(\alpha n + \beta p)$

$ACC = \alpha n + \alpha p \ / \ \alpha p + \alpha n + \beta p + \beta n$

$MCC = (\alpha p * \alpha n) - (\beta p * \beta n) \ / \sqrt{\alpha p + \beta p * \alpha p + \beta n * (\alpha n + \beta p) * (\alpha n + \beta n)}$

Table 3: Performance metrics of AD detection of different techniques (measured in %age)

Methods	Accuracy	Sensitivity	Specificity	MCC
SVM	50.45	58.36	87.2	76.8
MLP	53.79	52.14	82.66	81.2
CNN	84.6	84.11	86.98	86.88
DBN	84.5	82.86	83.75	82.05
Hybrid	92.5	90.89	90.67	93.5

The performance comparisons are as shown in the figure 4 as:

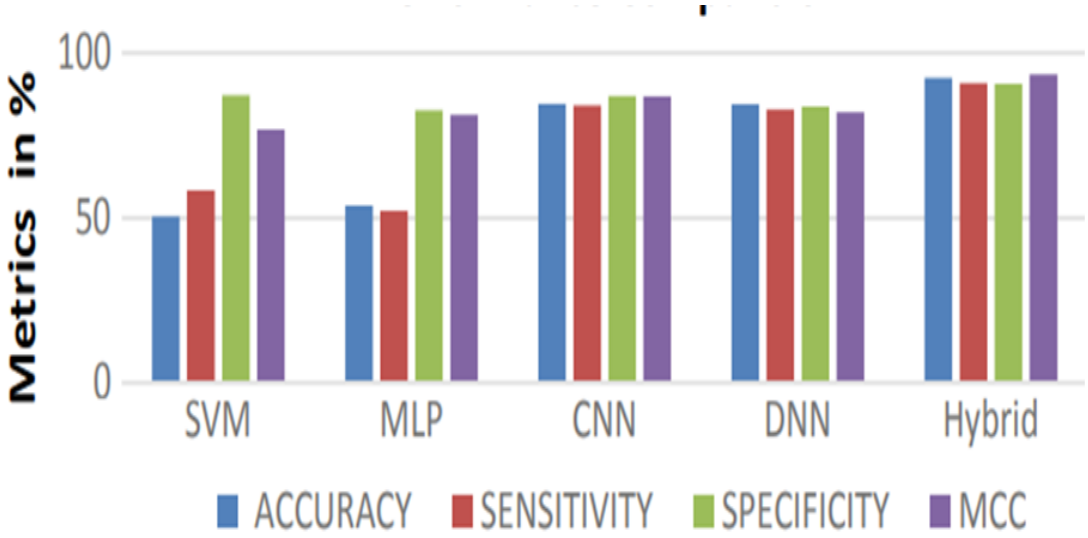

Fig 4: Performance comparisons with Hybrid method

4. CONCLUSION

In this paper, a robust classification and simple hybrid deep learning with GA and PSO was proposed to identify AD. This technique deals with multimodal data using MRI scans. The images attained from the scan center are of poor quality and further quality can be improved by skull stripping process and adopting contrast enhancement. The implementation of a coordinated model is improved on the basis of feature extraction and its weight factors in CNN. The experimental outcomes exhibit about the suggested approach and compare the accuracy to traditional algorithms like SVM, CNN etc. and proposed hybrid. The changes in brain's regions are used for diagnosis of AD. Proposed process observed all images structural changes by applying optimization algorithms like GA, CNN, PSO with DL for diagnosing AD and normal brain images. The enhanced scanned images found best to develop optimization processes for segmentation of internal regions of brain. By evaluating performance of segmentation for finding the validated data set values and afterwards verified by comparing segmented images. Outcomes showed data correlation is 97% with segmented images. It was observed that accuracy in case of proposed hybrid algorithm is more as compared to traditional approaches. The result exposes about the proposed approach that was highly correlated with the scanned images and clinical targets and was well to diagnose the AD. Experimental outputs and comparisons showed accuracy of proposed approach is much better by comparing with existing old traditional techniques.

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