Application of Optimization Techniques on Brain MRI for Abnormal Intrusion Detection

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Abstract- Brain neoplasm/tumor is defined as any abnormal growth of cells in the brain. Basically brain tumors have variety of shapes and sizes. It can occur at any location and in different intensities. It can be Benign and Malignant. Benign tumor is not cancerous. So different techniques are used to solve the problem Clustering aims at representing large datasets by a fewer no. of prototypes or clusters. It brings simplicity in modeling the data and thus plays a central role in the process of knowledge discovery and data mining. In this method a hybrid approach for classification of brain tissue in MRI based on Particle Swarm Optimization (PSO) and Support Vector Machine (SVM) wavelet based texture feature are extracted from normal and tumor region by using HAAR wavelet. These features are given as input to the SVM classifier which classified them into normal & abnormal brain neoplasm. The algorithm incorporates steps for pre-processing, image segmentation and image classification using SVM classifier.

Keywords- AIS, ACO, PSO, SVM, SI, HAAR wavelet

I. INTRODUCTION

Swarm Intelligence (SI) it is the collective behavior of decentralized, self-organized systems, natural or artificial. It was basically introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems. The concept is employed in work on intelligence. It systems consist typically population of simple agents or boids interacting locally with one another and with their environment. The inspiration often comes from nature, especially biological systems. The agents follow very simple rules, and although there is no centralized control structure dictating how individual agents should behave, local, and to a certain degree random, interactions between such agents lead to the emergence of "intelligent" global behavior, unknown to the individual agents. Examples in natural systems of SI include ant colonies, bird flocking, animal herding, bacterial growth, and fish schooling. The definition of swarm intelligence is still not quite clear. In principle, it should be a multi-agent system that has self-organized behaviour that shows some intelligent behaviour. There are different types of swarm intelligence:

1. Particle Swarm Optimization (PSO)
2. Ant colony optimization (ACO)
3. Artificial bee colony algorithm
4. Artificial immune systems (AIS)

Particle swarm optimization (PSO) is a global optimization algorithm for dealing with problems in which a best solution can be represented as a point or surface in an n dimensional space. Hypotheses are plotted in this space and seeded with an initial velocity, as well as a communication channel between the particles.

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Particles then move through the solution space, and are evaluated according to some fitness criterion after each time step. Ant colony optimization (ACO), introduced by Dorigo. ACO is a probabilistic technique useful in problems that deal with finding better paths through graphs. Artificial 'ants'—simulation agents—locate optimal solutions by moving through a parameter space representing all possible solutions. Natural ants lay down pheromones directing each other to resources while exploring their environment. The simulated 'ants' similarly record their positions and the quality of their solutions, so that in later simulation iterations more ants locate better solutions. Artificial bee colony algorithm (ABC) is a meta-heuristic algorithm introduced by Karaboga in 2005, and simulates the foraging behavior of honey bees. The ABC algorithm has three phases: employed bee, onlooker bee and scout bee. In the employed bee and the onlooker bee phases, bees exploit the sources by local searches in the neighborhood of the solutions selected based on deterministic selection in the employed bee phase and the probabilistic selection in the onlooker bee phase. In the scout bee phase which is an analogy of abandoning exhausted food sources in the foraging process, solutions that are not beneficial anymore for search progress are abandoned, and new solutions are inserted instead of them to explore new regions in the search space. The algorithm has a well-balanced exploration and exploitation ability. The Bees Algorithm in its basic formulation was created by Pham and his co-workers in 2005. Modeled on the foraging behavior of honey bees, the algorithm combines global explorative search with local exploitative search. A small number of artificial bees (scouts) explores randomly the solution space (environment) for solutions of high fitness (highly profitable food sources), whilst the bulk of the population search (harvest) the neighborhood of the fittest solutions looking for the fitness optimum. A deterministic recruitment procedure which simulates the waggle dance of biological bees is used to communicate the scouts' findings to the foragers, and distribute the foragers depending on the fitness of the neighborhoods selected for local search. Once the search in the neighborhood of a solution stagnates, the local fitness optimum is considered to be found, and the site is abandoned. In summary, the Bees Algorithm searches concurrently the most promising regions of the solution space, whilst continuously sampling it in search of new favorable regions. Artificial immune systems (AIS) concerns the usage of abstract structure and function of the immune system to computational systems, and investigating the application of these systems towards solving computational problems from mathematics, engineering, and information technology. AIS are a sub-field of biologically inspired computing, and natural

computation, with interests in Machine Learning and belonging to the broader field of Artificial Intelligence.

II. RELATED WORK

Many techniques have been developed for the classification of brain MRI. A hybrid approach for classification of brain tissues in magnetic resonance images had been proposed in [1] using GA &SVM. A wavelet based texture feature set is derived. The optimal texture features extracted from normal and tumor regions by using Spatial Gray level Dependence Method (SGLDM). These features are given as input to the SVM classifier. The choice of feature, which constitutes a big problem in classification technique, is solved by using GA. In [2] computer based method for defining tumor region in the brain using MRI images using two different segmentation steps canny edge detection and adaptive threshold. The comparison between SVM with and without the implementation of principle component analysis has been proposed by in [3]. A genetic fuzzy system for modeling different tissue in brain MRI and proposed a statistical pixel classification based on maximum likelihood (ML) and Bayesian classifier has been defined in [4]. SVM is an effective tool in sonography for diagnosis of breast cancer. A SVM is a machine learning system developed using statistical learning theories to classify data points into two classes. It has been applied extensively for classification, image recognition and bioinformatics [5]. Classification of brain MRI using Back Propagation neural network (BPN) and Radial Basis Function (RBFN) has been demonstrated in [6].it is classified in the axial and coronal images. Both testing and training phase gives the percentage of accuracy on each parameter in neural network. Another method [7] is using Support Vector Machine with Recursive Feature Elimination (SVM RFE). A knowledge based technique [8] and neural based network [10] has also been developed.

III. PARTICLE SWARM OPTIMIZATION (PSO)

It is a population based stochastic optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish school [2]. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. Malignant tumor is cancerous and had heterogeneous structure. Glioblastoma Multiform (GBM) is the most common and most aggressive malignant primary brain tumor in humans, involving glial cells and accounting for 52% of all functional tissue brain tumor cases and 20% of all intracranial tumors. It presents two variant giant cells Glioblastoma and Gliosarcoma. Treatment can involve chemotherapy, radiation, radio surgery, corticosteroids, antangiogenic therapy, surgery and experimental an approaches such as gene transfer. MRI is efficient in supplying the location and size of the tumor but it is very difficult to classify the tumor type, so a process of biopsy is known for classifying the images. Biopsy is a very painful process. This inability requires development of new analysis techniques that aim at improving diagnostic ability of MR. In PSO, the potential solutions, called particles, fly through the problem Space by following the current optimum particles. Each particle keeps track of its coordinates in the problem space which are associated with the best solution (fitness) it has achieved so far. This is called the pbest. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the neighbors or the particle. This location is called lbest, when a particle takes all the population as its topological neighbors, the best value is a global best and is called gbest. PSO has been used for approaches that can be used across a wide range of application focused on a specific requirement. At each iteration, each particle adjusts its velocity vector, based on its momentum, influences of its best solution of its neighbors, and then computes a new point to be evaluated. The displacement of a particle is influenced by three components:

1. Physical component: The particle tends to keep its current direction of displacement.
2. Cognitive component: The particle tends to move towards the best site that it has explored until now
3. Social component: The particle tends to rely on the experience of its congeners, then moves towards the best site already explored by its neighbors.

The collective and the social behavior of living creatures is known as the swarm intelligence. The main properties of collective behavior are homogeneity, locality, collision avoidance , velocity matching and flock centering.

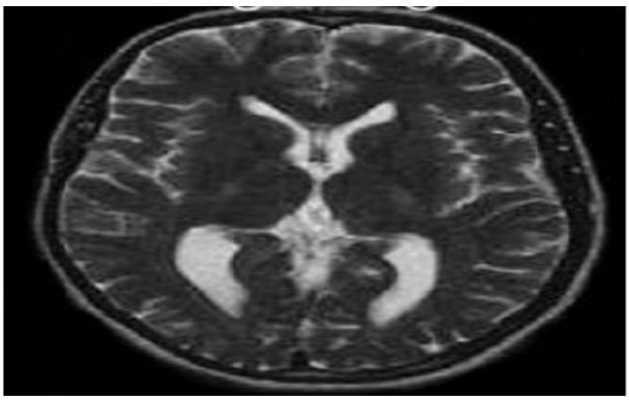

Fig. 1 Normal Brain

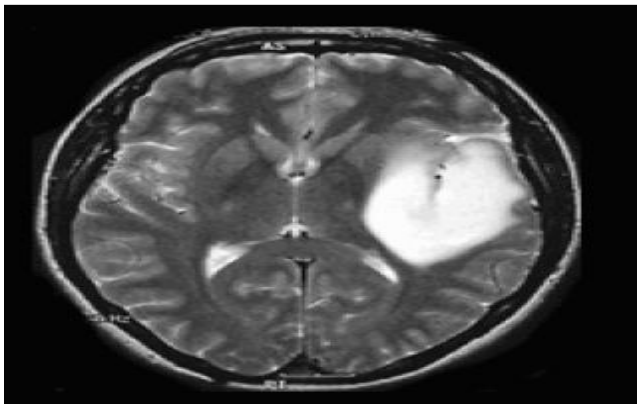

Fig. 2 Benign Tumor

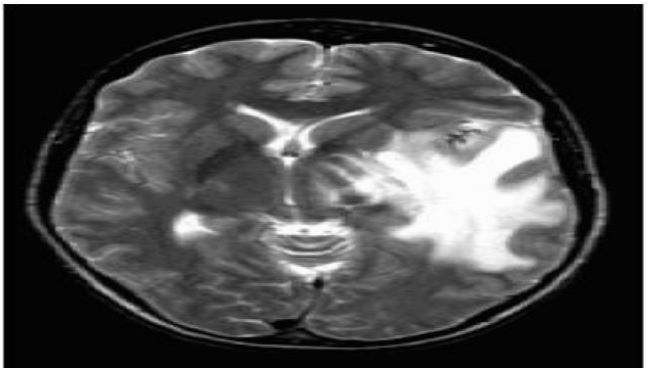

Fig. 3 Malignant Tumor

IV. SUPPORT VECTOR MACHINE

Support vector machine (SVM) was first heard in 1992, introduced by Boser, Guyon and Vapnik in COLT-92. It is a set of related supervised learning methods used for classification and regression.[13]. They belong to a family of generalized linear classifier. It is also defined as a classification and regression prediction tool that uses machine learning theory to maximize predictive accuracy while automatically avoiding over fit to the data. It can be defined as the system which uses hypothesis space of linear functions in a high dimensional feature space, trained with a learning algorithm from optimization theory that implements a learning bias derived from statistical learning theory. It gained popularity due to better empirical performance. The formulation uses the structural risk minimization (SRM) principle, used by conventional neural network. SRM minimizes an upper bound on the expected risk, where as ERM minimizes the error on the training data. It is difference which equips SVM with a greater ability to generalize, which is the main goal in the statistical learning. There are many common kernels such: Linear, Polynomial of degree and Radial Basis Function (RBF) .Here the linear kernel is used. SVM classifier is used to distinguish between the normal and the abnormal brain using the confusion matrix. The feature extraction is done using the wavelet based using the HAAR function. In statistical modeling, choose a model from the hypothesis space, which is closest (with respect to some error measure) to the underlying function in the target space Early machine learning algorithms aimed to learn representations of simple functions. Hence, the goal of learning was to output a hypothesis that performed the correct classification of the training data and learning algorithms were designed such that it accurately fit in to the data. The ability of a hypothesis to correctly classify data not in the training set is known as its generalization. SVM performs better in term of not over generalization, when the neural networks might end up over generalizing easily. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithm (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation.

V. PSO METHOD

Particle swarm optimization (PSO) is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. PSO optimizes a problem by having a population of candidate solutions, here dubbed particles, and moving these particles around in the search-space according to simple mathematic formula particle's position and velocity. Each particle's movement is influenced by its local best known position but, is also guided toward the best known positions in the search-space, which are updated as better positions are found by other particles. This is expected to move the swarm toward the best solutions. In this method the PSO technique has been applying to the brain MRI images. It involves the different steps like:

1. Repositioning using PSO
2. Initialization of population
3. Loop of multiple generations
4. Velocity of particle to be finding
5. Computing fitness of child
6. Nutant function
7. Local best is to be compute.

The different stages of proposed technique are shown in Fig 4.firstle the acquisition of image take place in which images are acquired from different equipments like MRI, PET,CT. Next step is the wavelet based feature extraction. In this technique, Haar is used. At last feature selection and the classification.

VI. EXPERIMENTAL RESULT

Our proposed hybrid technique is implemented on a real data set consisting of transaxial images of brain MRI. It consists of 246 images: 82 are normal, 82 are benign and 82 images are taken as malignant tumor suffering from a low grade glioma, meningioma. These normal and pathological images are axial, T2-weighted of 256*256 sizes and acquired at several positions of transaxial plane, images are taken from [11] . In this section, performance is evaluated by three factors that is sensitivity, specificity and accuracy.

Sensitivity= TP/ (TP+FN)*100% (1)

Specificity= TN/ (TN+FN)*100% (2)

Accuracy=TP+TN/ (TP+TN+FP+FN)*100% (3)

Where

TP (true positive) = correctly classified positive cases

TN (true negative) = correctly classified negative cases

FP (false positive) = incorrectly classified positive cases

FN (false negative) = incorrectly classified negative cases

Accuracy is defined as the degree of closeness of measurement of quantity actual value. Sensitivity is called true positive cases. It means proportion of actual true cases, which are correctly classified as true cases. Specificity is known as true negative cases. It defined as proportion of negative cases which are correctly classified as true cases. In this case total no images 247 are used for training purpose. Overall 35 images are normal, 30 are benign and 30 are malignant are given for testing. Table 1 shows the classification rates for performing the proposed hybrid approach and comparison with different methods.

The hybrid Technique	Sensitivity (%)	Specificity (%)	Accuracy (%)
SGLDM+GA+SVM	91.87	100	94.44
WT+SGLDM+GA+SVM	94.6	100	96.29
SVM+PSO(PROPOSED METHOD)	95	100	95

Table 1 Classification Rates (in %) for the Proposed Technique

VII. CONCLUSION

The paper developed a hybrid technique with normal and benign or malignant neoplasm. This method proposed a system consisting of wavelet transform using HAAR, PSO (Particle Swarm Optimization) and SVM (Support Vector Machine) using MATLAB Programming. All the simulation is done on the MATLAB editor by writing m-codes of the proposed system. Analysis of the system is done with the help of confusion matrix and the different performance measurement of the system. This proposed technique gives the Overall accuracy to be 95%, specificity is 95% and sensitivity as 100%. Overall model accuracy of this model is 97%.

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