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An Artificial Neural Network (ANN) is a group of neurons which act as nodes in an interconnected system serving a purpose similar to the neural network of the brain of a human being. Each node receives a signal and passes on to the next node only if its threshold value is crossed on the basis of a non-linear activation function. An activation function is used in neurons to process the inputs and return their computed outputs. They act as the thresholds for the nodes of the network. The weights of the layers of these neurons are learnt and changed to observe a corresponding modification in the output signal. They are adjusted only if the network produces an output containing lesser error. If the output is undesirable, no change in weights can be observed in that direction. The weights are adjusted using some optimizer like gradient descent. ANNs have diverse uses in today's world. It finds uses in many tasks like computer vision, pattern recognition, speech recognition, classification and other medical diagnosis and applications.

- **Particle Swarm Optimisation (PSO)**

  It is a stochastic optimisation technique. It is a population-based search method with position of particle is representing solution and Swarm of particles as searching agent. This technique helps in finding the minimum value for the function. A parallel can be drawn from real life: the main idea is similar to bird flocks searching for food. Here, a single bird acts as a *particle* and food is the *solution*. Hence, two methods can be realised; *pbest*: the best solution a particle has achieved so far and *gbest*: the global best solution of all particles within the swarm. The basic concept of PSO lies in accelerating each particle toward its *pbest* and the *gbest* locations, with a *random weighted acceleration* at each time.

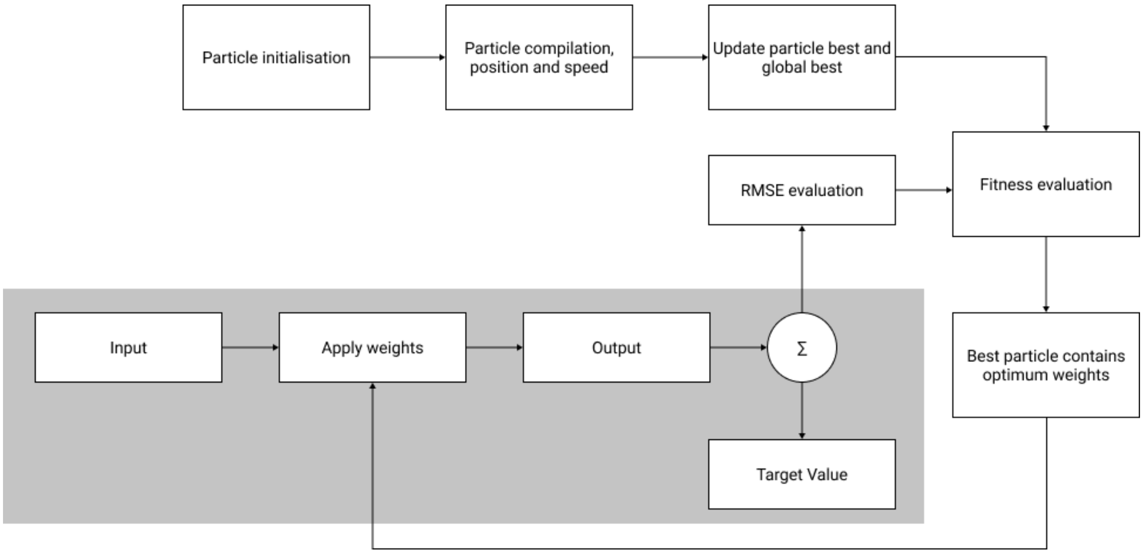
- **ANN with PSO**

  Each particle in the swarm is considered as a neural network and the forward propagation should be carried out for all particles. As backpropagation is not involved in the PSO algorithm, hyperparameters like learning rate do not exist. The fitness of each particle can be calculated by measuring the efficiency of the output by various methods like *Mean Square Error (MSE)* and *Mean Absolute Error (MAE)*.

  A swarm of particles can be created by keeping the number of dimensions equal to the total number of weights and biases of the neural network. These parameters can then be converted into an n-dimensional array and treated as the fitness function for further calculation. Each particle is uniformly and randomly placed in the entire problem space. Consequently, each particle from the swarm represents a distinct neural network and only the fittest networks will emerge. After training, these weights and biases can be constructed back to form the final neural network (*gbest*) to test the unseen data.

Every iteration of training the swarm, minimizes the cost of the function formed from the synaptic weights of the network and these weights and biases are changed to try and optimize the neural net as much as possible. This is done by comparing with the expected output and adjusting the parameters according to the pseudo code given above.

Given below is the flowchart of ANN with PSO hybridisation.



- **Genetic Algorithm (GA)**

  It is a stochastic search method that has been applied successfully for solving a variety of engineering optimization problems which are otherwise difficult to solve using classical, deterministic techniques. It is inspired by Darwin's survival of the fittest strategy, with sexual reproduction and Mendel's theory of genetics as the basis of biological inheritance.

  The GA search begins with a set of solutions, often labelled as a population. Each solution is represented as a chromosome in the population. In each generation, the reproduction operators such as mutation and crossover are used for the creation of the new chromosomes. The performance or suitability of a chromosome is then defined by some fitness. This fitness value of a chromosome serves as the basis for its survival into the next generation, i.e., fitter chromosome has higher chances of surviving. This fitness-based selection mechanism ensures the fitter chromosomes to survive across generations, whereas the least fit ones fail to replicate well. The process of evolution is repeated until some stopping condition is satisfied.

- **ANN with GA**

  Let's consider a conference paper published in IEEE which implements a hybrid GA BP-ANN model for medical image reconstruction in noise-added MRI data. The Genetic BP-ANN system undergoes a training process up to reasonable convergence is achieved. The optimal parameters are obtained on the basis of speed of convergence and quality of the reconstructed image.

Subsequent to training process, the random weight values are changed into updated weight values. After the training phase, updated weights are mapped for reconstruction of MRI phantom head images from any corresponding projection dataset. In Genetic BP-ANN testing phase also, normalized projection datasets are decomposed and then subsets of projections data are tested into system. The reason is that, only updated weights are mapped in the trained network. Also, there is no need for computational effort. The different dataset used in the Genetic BP-ANN training phase is used in testing phase also.

Given below is the flowchart of GA-based BP-ANN initial weight optimisation.