**Particle Swarm Intelligence algorithm implementation and performance analysis on training of an artificial neural network**.

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**Statement of Purpose:**

Artificial neural network is an advance algorithm inspired by biological neural network in human brain. For decades, engineers tried to build artificial intelligence smart enough to serve humankind aside human. But its never that much robust to serve like the way it aimed to be served. But artificial neural network algorithm is able to do something which is something like a human can do. Learning from the nature. The term training is used to describe the fact. Training of an artificial intelligence was not easy. It is not like training a human but, it is do like raise a baby. There are several approaches were discovered to train artificial neural network. One of them is Swarm intelligence. Swarm intelligence is a new algorithm also came from biological background. Bees, Ants and insects or animals like them who live in packs has a unique nature of sharing knowledge among each other to reach the goal. This behavior is labeled as swarm intelligence in biology. But this is now implemented in computer science, robotics. Neural network is also a discrete network of neurons. Its also need to be combined and which is very important step to build an accurate neural network. Swarm intelligence is also deal with discrete intelligence and combinations of those discrete intelligent. So, it seems like a perfect combination of these two powerful algorithms. The application will be neural network based algorithms. It can benefit us in many areas. The major area is medical science followed by autopilot and many others. Because of considering a huge number of input domain so efficiently. This algorithm is able to deal with major serious problems like autopilot and finding tumor, cancer.[1] Finding wood defect and many more.[2] Now a days, almost every system has a large number of users because of availability of internet. So, almost every system is having a large number of users from around the world. It is creating a large number of input domain which is not pre planned. But we have to deal with it and this algorithm is perfect choice for that. So, in future it will be needed for all type of application.

That’s why I choose to work with this algorithm to develop it. A lot of people were interested to combined this algorithm. It was implemented before using different techniques and this paper is focusing on the performance of the implementation. Analyzation, and optimization result will be discussed in this paper.

**Introduction:**

Now a days, Medical science is more advanced. It is not look like what it was back in 19th century. All this is happened because of advanced machines and tolls. This tolls and machine are run by different algorithms. In early days of technology, hardware implementation was a barrier. But now, things are different. Now a days, advanced algorithms are needed which will be robust. Which will run efficiently and which will deal with a large input domain because as many criteria is considered, the output of a system will be more accurate. In case of medical science, autopilot and many more application the system had to be error free. It will risk many of life if these things will not work properly.[3] So new algorithms are introduced which are capable of handling large input domain as well as robust, efficient and more accurate. Neural network is one of the modern networks which has the ability mentioned earlier. There are many implementations techniques for neural network. Using Particle Swarm Optimization is been introduced recently. It was a revolutionary combination. Though It is not proven to apply in many areas but there are some visions to that and that is why it an area where significant improvement can be made. The efficiency of this combined algorithm is incredible. So, it is important to make this combination more accurate. Many works have been done based on this combination of two algorithm. Everyone is considering this because the application of this algorithm will work on much wider areas. In near future, the application which has larger input domain will need this algorithm to gain more efficiency and robustness. So, improving this algorithm will be beneficial for future works. It seems to be limited now but in near future, it will be needed by a wide range of application. Improving this combination is not an easy task as both of the algorithms are advanced but there are some issues where it lacks. Many lacking is also reveled in some papers. It is necessary to work with this lacking to make it more relevant combination. If it will improve in a stage which will give an efficiency of a percentage close to 100 then it can be implemented in more sensitive applications like laser surgery.[4]

This paper will put a bit of knowledge in this vision of making this combination of two powerful and modern algorithms. The approach followed in this paper is critical literature review. The previously done projects are taken in consider and the results they have generated. The analysis of the results will come to a conclusion that is this combination gives more efficiency and accuracy that we are searching for.

**Literature Review:**

There is some classification of neural network. Feed forward neural network is one of them which is the most advance and widely used. Previously, there are some methods to train neural network. Among them, back propagation was famous for its less complexity. PSO is better than backpropagation because PSO required lesser number of computations. PSO is better for those algorithms which support fast learning. So, PSO is suitable for those neural networking methods which are recurrent.[5] Another major disadvantage of backpropagation is to conjunction rate is relatively slow and always being stuck in local minimum. To overcome this problem, Genetic Algorithm (GA) is been introduced. It determined optimum value for Back Propagation parameter. GA is successfully improved backpropagation based neural network. But still it is proven time consuming because of the long and complex functions of GA. For neural network training It is still a step behind as compare to PSO.[6] There are some positive side of backpropagation that it is robust. But PSO seems to be valuable in case of high number local minima. PSO also work with general purpose where no specific knowledge is being used. But it successfully overcome the promising backpropagation algorithm.[7] There is a third contestant competing with PSO is GA. GA alone can be a learning algorithm rather than coupled with BP. It was an evolutionary algorithm for being simulated in neural evolution. It adopts pseudo biological operations like selection, crossover and mutation. It is very effective for discovering the search space but moderately poor in discovering the actual local optimal solution in the region in which the application congregates. That means it has a slow convergence rate which can be overcome by PSO. So, PSO arises as fast and simple for neural networks training phase.[8] Particle swarm intelligence optimization and hybrids were used to train feed forward neural network under GL5 stopping criteria. Generalized performance of the obtained MLP was increased. The process was guided by CPE on the validation data set to cease the execution of the algorithm before the overfitting can happened.[9] There is a place of improvement where the search space for PSO can be explored more widely by using an advance stopping criterion. Also, a simultaneous adjustment of weights and architectures of multi-layer perceptron (MLP) can get an accurate result of the implementing performance of PSO. As PSO need is implemented, there is need to classify the PSO. DOSI is a good method and extremely suitable for PSO because it has much lower complexity since it required a swarm for each neuron rather than swarm for every path. But DOSI had higher error than OSI in some lower memory operations.[10] The algorithm can be improved by adding methods for inter-swarm competition. As DOSI has a higher percentage of error so avoiding it could be a better approach though it seems perfect for PSO. OSI also can be developed in some manner that it could overcome the bindings it has. Splitting the neural network into multiple paths and training the network with localized swarm has been verified to improve accuracy. This time the OSI methodology performs better than DOSI and other method.[11] These methods are well implemented but missing one key concept that it is a discrete network so if it is assembled than it can propagate much faster. An improved model is developed not only for optimization of the swarms but also meliorated the ensemble mechanism. The NNE model is improved by adopting CPSO-GD. It is a coupling algorithm to train each component as an individual. Benchmark function which is previously used is now challenged by co-evolution algorithm based on multi heterogeneous swarm intelligence. It needed change because Benchmark function is not supportive to assembling swarms. The result is, it is superior to the simplex neural network.[12] Another algorithm can be cast-off which is CSONN-OBD. It is also CSO based algorithm used to create artificial neural network with low training fault and high cataloguing precision. But several additional task to be done before forming this algorithm like OBD pruning. The term is slightly changed with the change is action and it called cat swarm intelligence. It is able to produce neural network that showed a good performance on different datasets. By OBD pruning it used fewer connections to achieve the same performance which was achieved with lot of more connections with the neural networks which are not pruned. With a higher classification accuracy, it seems that the perfect organization of swarms to train neural network.[13] The swarm intelligence can be more developed by coupled with other algorithms like ACO for the same objective which is training the neural network. Reinforcement learning is method of learning for the neural network. Which can be developed by combining ACO and PSO.ACO for selecting the topology and PSO for adjusting the connection weights of the selection topology. This method has proven scalable, robust in some applied tasks.[14] In some applied task, PSO is been found doing better than other algorithms like handling permutation parameter sets. The approach is done to solve n-queen problem and it is been found effective. [15] Multi object optimization of hard turning by neural network and PSO is also an application. For the test case the algorithm yielded optimal parameter around 100 iteration. Which took a very little time.[16]

The main objective of this research is to examine that how PSO will performed in case of training feed forward neural network. It will increase the performance of neural network if the result came with a positive value. If the result will come with a small value or negative value then this approach will not be considered in future works. Sub objective for this research will be the performance analysis on different type of application. This combined algorithm is for very sensitive application related to medical science so that it will be taken in consider that it will generate more accurate result which will not cause any harm or ended up with a catastrophic situation. There is another one sub objective which is the comparison result of PSO based neural network with other algorithm based neural network.

The main research question is How PSO will perform in case of combination with neural network. And the sub question is how this combination will perform on different type of application. The application domain is a few now. Breast cancer detection.[17] Other type of cancer and tumor detection are some example. But in near future, application with large input domain will need this combination if it works properly and give a high percentage of accurate results.

**Proposed Research Methodology:**

The design for this research is to reviewing other research paper. The aim is to explain other papers followed the same procedure explained in the literature review section. The type of method followed by it is literature review. It is also a systematic review. There are some steps of this methodology which I determined and followed. In first step the comparison between PSO and back propagation will be done. To examine this comparison the time complexity for PSO and the time complexity for backpropagation will be taken in consider. Space complexity will not play a major role because these algorithms are for large number of input domain. In case of comparison with Genetic Algorithm (GA), time complexity is also taken in consider. GA is slower than PSO. In other case GA is also a strong and relevant algorithm. But the objective is important.[18] So, we will choose an algorithm which is properly suitable for the goal. So, there are some training algorithms exits.[19] But PSO is suitable for us and we find it out calculating complexities. Time complexity is the major criteria and space complexity is minor criteria. Data will be collected from other research papers. There is some performance analysis done in the previous papers and we will have the analysis they have generated. The modified code, Pie chart, Bar chart and other tabular form of data will be collected from different papers and those data will be examined. After that, the performance will be evaluated in some degree of metrics. Robustness, Accuracy, Dependency, complexity and flexibility. Every procedure will be evaluated with these metrics and the final performance will be analyze. The main objective will be meet if PSO shows better results than other algorithm in case of training a neural network. Then the best approach will be analyzed and the area of development will be discussed. Obviously, every system has an area of development and as this is a new algorithm it has many areas to develop. Here is our sub objective will be discussed. We wanted a better modified PSO algorithm which will not only show less time complexity but also show great accuracy which was never done before. The coding process will be done using python as it is a language develop especially for this type of application. There are some implementation techniques.[20] There are many areas to develop this implementation techniques. Some techniques can not adopt dynamic inputs. But some implementation techniques are innovative and adoptable. The FPGA implementation technique is something which is really adoptable for this process and it will be best suit.[21] When the implementation will be done the outputs will be evaluated again using the same metrics used before to evaluate data from other papers. If the process be able to give outputs with better results than the previous results than the approach will be consider otherwise it will be rejected. This step will be continued until a better performance against the metrics will be found. If it will able to give a better result than our objective and sub objective will be meet. The stop criteria is important as we find out by the literature reviews that the stopping criteria is important coz when the goal has been meet, the algorithm sometimes struggle to find out this. As we mentioned earlier the GL5 stopping criteria will be the best suit. And we also can modify that. This will be the primary methodology. During the process if change will required then some modification will be adopted.

Though the work seems to be done but there will be some area of development. New applications for this approach can be developed. The approach can be modified also the technique could be modified along with the conditions to reduce complexity.

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