Traffic Signal Control Based On Fuzzy Artificial Neural Networks With Particle Swarm Optimization

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ABSTRACT: This paper develops a traffic signal control method using fuzzy artificial neural network at isolated intersection and bridges. A traffic light controller based on fuzzy artificial neural network is used for optimal control of irregular traffic densities during oversaturated or abnormal load condition. The main intention is to reduce delays and increase vehicular throughput. Here I have used a fuzzy artificial neural network for real time traffic signal control. The FANN has advantages of human reasoning as well as self-study. For adjusting the parameters and to calculate the performance of the Fuzzy artificial neural network here I used two optimisaton algorithms such as genetic and particle swarm optimisation for training process. By comparing with traditional control methods for controlling the traffic signal, the FANN algorithm with PSO shows better performances and adaptability than FNN with genetic algorithm and a normal fuzzy logic controller.

KEY-WORDS: Traffic signal Control, waiting time, Genetic Algorithm, Fuzzy Artificial Neural Network, Particle Swarm Optimisation, Performance.

I. INTRODUCTION

Excess of Traffic has become a common problem in large cities. We have two types of traffic control method .The first one is static control method. In this method the signal duration is fixed irrespective of the traffic. As the preset time is fixed , these systems doesn't consider which intersection has more load of traffic, to maintain green signal more or else to terminate it in advance to entire cycle time. The second one is dynamic control method.In dynamic case the duration of the signal varies depending on the load. Although we have many conventional methods for controlling the traffic signal most of them fail as they are not capable to deal efficiently with the complex and time-varying traffic conditions. In recent times, key research on urban traffic focusing on artificial intelligence techniques: neural networks, fuzzy logic control, particle swarm optimisation and genetic algorithm. The main idea is to teach or train a system how to perform a task instead of programming it. To train a system we have to develop an Artificial Intelligence System. Practical model which can quickly and accurately find the patterns covered in data that replicate useful knowledge. Neural networks are one of the most important cases in AI model. The most important feature that an AI model should have is the system should be able learn from data on continuous basis that is we can say that AI system should be adaptive. A traffic signal control model should consider three factors:(1) Computing model should be simple, the output has to be produced in a specified period of time; (2) Consider below control intersection as well as adjacent intersection, for realizing both linear and non-linear control ; (3) Ability to learn itself(self learning). By using fuzzy logic for classifying traffic flow under bridges control intersection, the model save control schemes of signal in different traffic flow into knowledge-database as rule set. In traffic signal controlling process, to update rule set we are using artificial neural network according to different control effect of control schemes in different traffic flow, thus we can say that the model has the ability of self-learning. The fuzzy logic controller rules are formulated by using the same methodology and rules that a human operator would use to control the traffic light time intervals effectively. The duration length of present green phase is incremented or terminated depending upon the number of vehicles "arriving" to the green phase and the number of vehicles in "queue" in both the green phase and red phases. For training and tuning the parameters of fuzzy artificial neural network particle swarm optimization is used. MATLAB tool is used for simulation process and hence it shows that model control effect is more superior to traditional control methods.

II.FUZZY ARTIFICIAL NEURAL NETWORK

As a main ingredient of soft computing, fuzzy artificial neural network (FANN) is a hybrid intelligent system that possesses the capabilities to adjust adaptively and intelligent processing of information. FANN's based on fuzzy operators are firstly studied by Lee and Lee in 1970s such FNN's have become one of the foci in neural network research since Kosko introduced the fuzzy operators 'V and 'Λ' in associative memory to define fuzzy associative memory (FAM) in 1987. A FAM is a feed forward FANN whose information flows from input layer to output layer. It possesses the capability of storing and recalling fuzzy information.

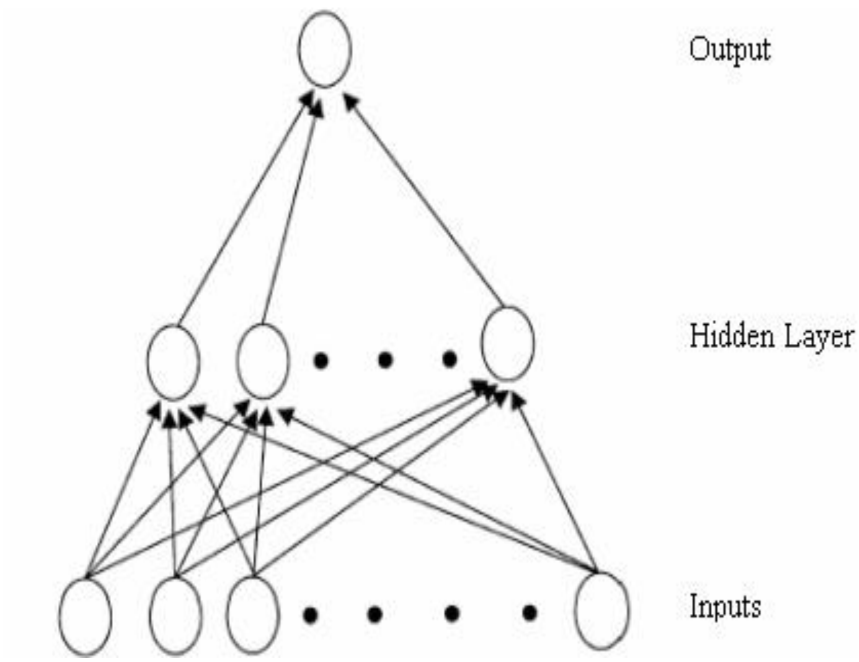


Figure .1 The architecture of a FANN system

A FANN system is represented as special three-layer feed forward neural network as it is shown in Figure1. The first layer corresponds to the input variables let us consider target traffic t_r and test traffic t_e, the second layer symbolizes the fuzzy rules here gauss function is used, the third layer represents the output variables where defuzzification takes place, the fuzzy sets are converted as (fuzzy) connection weights. We choose the correlation-product inference and the fuzzy centroid defuzzification scheme. Some approaches also use five layers where the fuzzy sets are encoded in the second and fourth layer units respectively. However, these models can be transformed into three-layer architecture. The performance of the fuzzy neural network is shown below. Here I calculate the performance with respect to RMSE value.

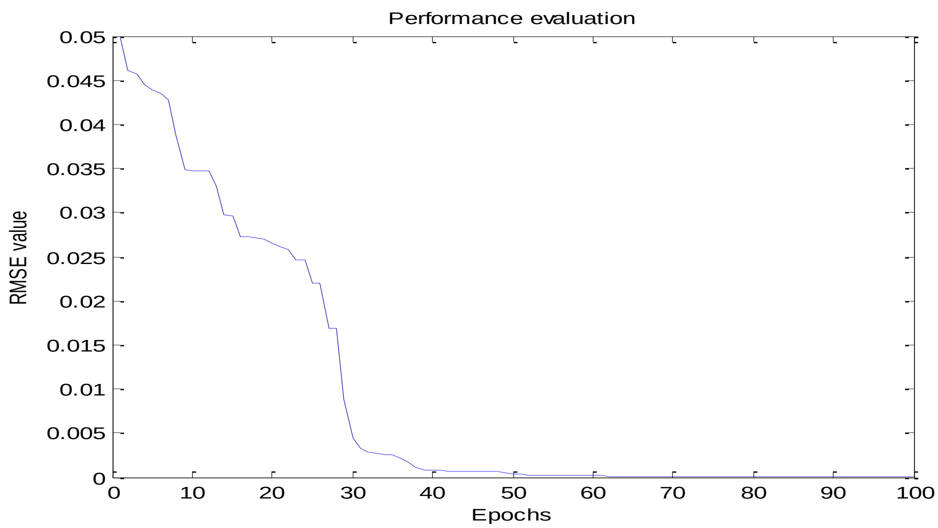


Fig.2 Epochs vs RMSE value

III. TRAINING FANN WITH GENETIC ALGORITHM

Genetic algorithms (GAs) are one among the classes of evolutionary algorithms. A GA generates solutions to an optimisation problem using operations such as selection (reproduction), crossover (recombination) and mutation, with each individual or a candidate solution in the population represented by a binary string of 0s and 1s or by other forms of encodings. We are implementing GA to optimize the current performance of FNN such that we can check that how much efficiency will be reached in how much average waiting time. A genetic algorithm (or GA) a search technique is used in computing to find approximate and best solutions to search and optimization problems.

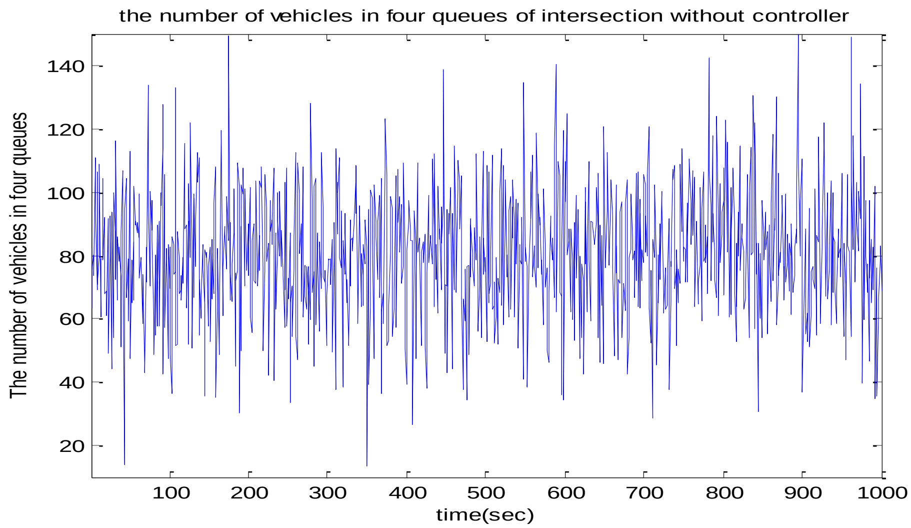
Step1: The control algorithm input parameters are the sample value of train. In this project I considered 150 samples.

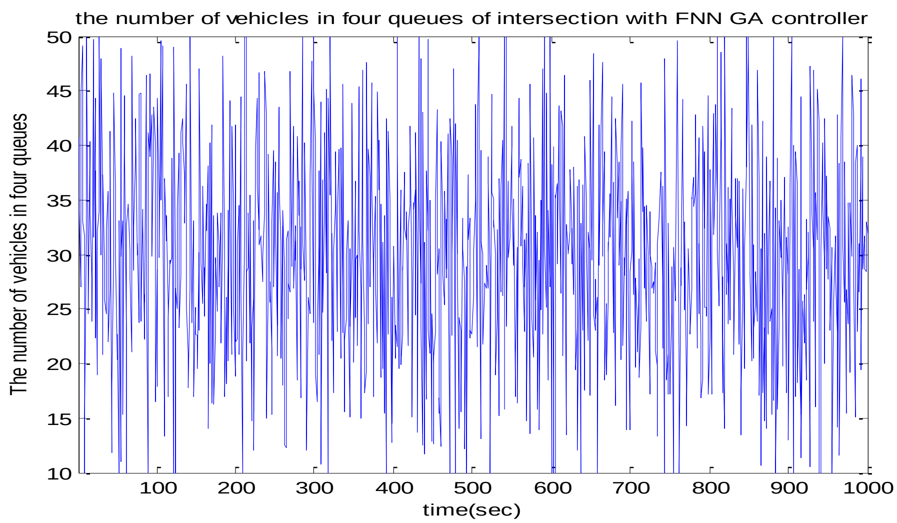
Step2: The fitness function of GA is mean square error function and its variables are FNN weights.

Step3: Initialize the population of individuals.

Step4: Then evaluate all individuals' fitness, select fitter individuals for reproduction, recombine those individuals, mutate them, calculate the fitness of the individuals that are modified; now a population with new individuals will be generated.

Step5: If the trained error is less than the demanded trained error then the termination criteria is reached, then the network training stops and the weights are outputted, otherwise return to step4 and continue to train the network.





IV. TRAINING FANN WITH PARTICLE SWARM OPTIMISATION

PSO algorithm is an important member of swarm intelligence algorithms originally developed by Kennedy and Eberhart in 1995. It was motivated by social behavior of bird flock or fish schooling and the technique shares many similarities with genetic algorithms (GA). As in other population-based intelligence systems, PSO requires an initial population of random solutions. The search for optima is obtained by updating generations without evolution operators such as crossover and mutation. The potential solutions are usually called particles in PSO. These particles fly through the solution space by following their own experiences and the current optimum particles. Let us consider the search space is d-dimensional, and the i-ith particle of the swarm can be represented by a d-dimensional position vector $X_i = (x_{i1},x_{i2},\ldots..x_{id})$.

The particle velocity in d-dimensional space is denoted as $V_i = (v_{i1},v_{i2},v_{i3}\ldots.,v_{id})$

Also consider best visited position for the particle is $P_{i,Best} = (p_{i1},p_{i2},\ldots.,p_{id})$ and also the best position explored so far is $P_{g,Best}=(p_{g1},p_{g2},\ldots.,p_{gd})$ .Particle position and velocity is updated using following equations:

$$V_i\,(t+1) = w.V_i\,(t) + k_1\Psi_1\,(P_{ibest}-x_i) + k_2\Psi_2\,(P_{ibest}-x_i) \qquad (1)$$

$$X_i\,(t+1) = x_i\,(t) + v_i\,(t+1) \qquad (2)$$

Where k_1 and k_2 are positive constants, and $X_i\,(t+1) = x_i\,(t) + v_i\,(t+1)$ are two random variables with uniform distribution between (0 1).Inertia weight which shows the effect of previous velocity vector on the new vector is W. An upper Bound is placed on the velocity in all dimensions Vmax. This limitation prevents the particle from moving too rapidly from one region in search space to another. The feature that drives PSO is social interaction. Individuals (particles) within the swarm learn from each other, and based on the obtained knowledge then they move to become similar to their "better" previous positions they have obtained and also to their neighbors "better" position. Within a neighborhood all individuals communicate with one other.

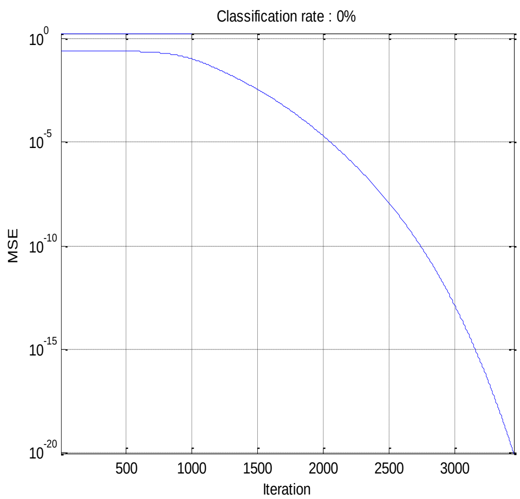
Therefore PSO algorithm can be summarized as follows:

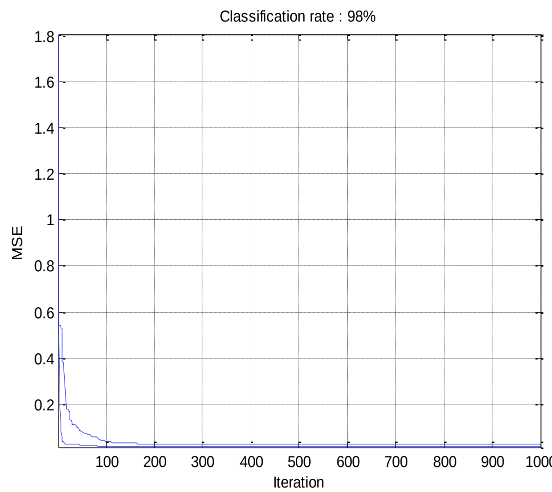
1. Initialize the swarm X i , the position of particles are randomly initialized within the feasible space.
2. Calculate the performance F of each particle, using its current position Xi (t).
3. The performance of each individual has to be compared with its best performance so far: F (X_i) < F (P_{ibest})

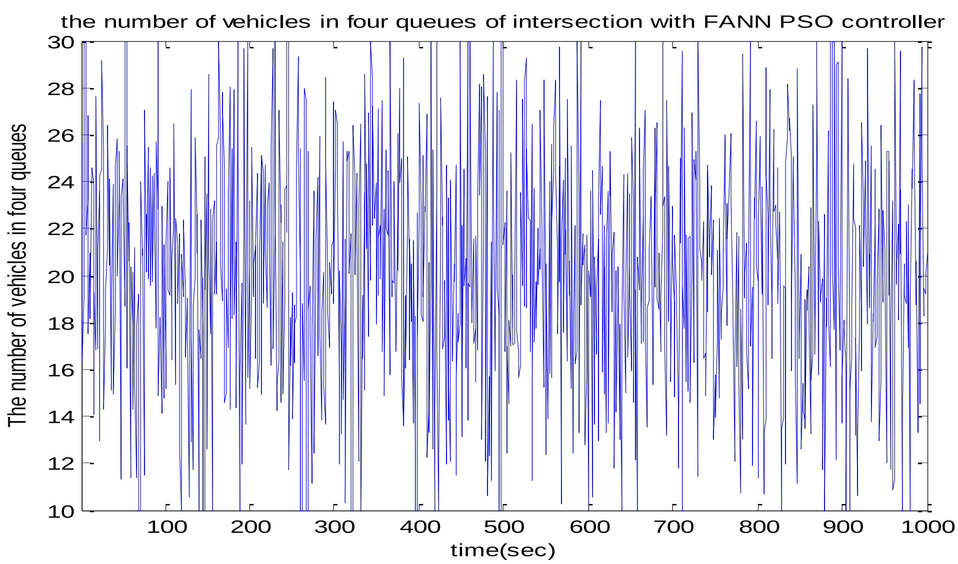
F (P_{gbest}) = F (X_i), P_{gbest}=X_i

5. Using equation (1) change the particle velocity.
6. Using equation (2) Move each particle to a new position
7. Repeat until convergence by going back to step 2.

Classification rate of PSO at zero and 98 percent is shown below







V. SIMULATION AND RESULTS

The simulation is carried out using MATLAB 2010a, PSO and the Genetic Algorithm Toolbox. The PSO Genetic Algorithm Toolbox is useful to train the network quickly and if any changes are required they are easily made. By this the development time of the simulation model has been significantly reduced. The fuzzy artificial neural network traffic controller developed here can optimally control traffic flows under both normal and abnormal traffic conditions. Table shows the waiting time for FNN GA and FANN PSO for thousand iterations.

Control Method	Average Waiting Time(sec)
FNN GA Control	.190.25
FANN PSO Control	145.81

VI. CONCLUSION

In this paper I attempted to apply the Fuzzy Neural Network model to traffic signal controller with expert knowledge. The tuning of fuzzy artificial neural network is done using the proposed learning method. Learning process is done with genetic algorithm and PSO. We can tune the fuzzy model and optimize system's parameters by making neural network to learn. The research results of proposed FANN algorithm were feasible and valid. By adopting the FANN based PSO for traffic signal controller it is showing the less average waiting time and queue in the vehicles also decreased comparatively in the FANN GA algorithm.

VII. REFERENCES

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