Novel Intelligent Traffic Light System Using PSO and ANN

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Abstract--- Today, traffic congestions at streets became a serious problem specifically in the area with the high population density. In this paper a novel intelligent controller system was proposed and designed to reduce the congestions on the streets. The system consists of two intelligent controllers that are designed to be similar to the human brain in solving problems and finding the best solutions; two main methods are used in the training of the controllers: the first one is the super vised feed-forward neural networks and the second one is the Particle Swarm Optimization (PSO).The results of the two methods are compared with each other and the best one was chosen for the designing. The first intelligent controller was used to check all the streets according to its traffic while the second one is used to determine the necessary time for each street based on the results which are obtained previously from the first controller in order to control the traffic light that allows the vehicles on each street to be moving or waiting its turn.

Keywords--- Traffic Light, Intelligent Traffic System, Control System, PSO Method, Neural Network, Monitoring Street.

I. Introduction

At 20th century, the vehicles became available for the global use of transportation; the year of 1908 was considered as the birth year that the first vehicles became accessible for the masses and used by them for the transportation purposes instead of using the traditional methods that are basically based on the animals. In previous time there was no need to organize the movement of vehicles because of its few number; however, the tremendous development of technology and the competition of companies in the vehicles industry leads to increase the number of vehicles and make them as an essential part of human life.

Therefore, the terminology of “traffic” was appeared to facilitate the movement of vehicles as well as to save the human life [1] [2]. All over the world, people spend an approximately 8.1 million of hours that equivalent to 40% of working hours because of traffic congestion which became as a serious problem specifically in area with high population density [3].

Today, most of country depends basically on two types of methods to organize the traffic either the using of traffic light that periodically sets a fixed times for each street, however, it can’t be considered as a good solution due to increase the congestion at a specific roads that contains a high number of vehicles. Or using the second method that depends on human intervention that is known as a traffic cop which is also not a good solution, therefore, the researchers were started to find a good solutions through using the modern technologies such as the using of cameras and putting a someone to monitor the traffic and maybe set a period of time depends on his considerations, also, this method is not a good solution because it leads to human energy consumption and lack of idealization of technology [4][5]. These problems encourage the researchers to increase the competition to find the best solution.

[4] Presents an intelligent traffic light control system. Image processing algorithms with the help of Infrared sensors and Cameras signals used to detect traffic density.

The MATLAB use image with empty road and compare it with new captured image to find the density of cars.[1]Presents digital-logic based system and compared it with currently used traffic control systems. By using Digital Signal Processing and the sensors placed at every entry and exit of a junction and monitoring the number of cars present at the junction.[6] Presents traffic light control system using (LabVIEW). The study of the street at different times used to detect the number of cars and then give the time for the traffic light depend on that.[7] Presents system to control traffic at road, the microcontroller used as hardware part and the control of timers of each road depend on image processing algorithms such as Background Subtraction and Haar Cascade.

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Data of real-time traffic image, traffic density and other statistics sent to server, at any time the data can be broadcasted from server through digital solutions.[3] Presents system detecting the number of cars by using cameras and image processing and depend on that the system adjust the timer with time in order to reduce the crowded of cars at the street. FPGA and intelligent systems used in many application with great efficiency [8] [9].

This paper tries to decrease the congestion of traffic through determining the number of vehicles at each street and setting a variable period of time for these streets according to its congestion at a specific time; which is differing from the other solutions that mentioned above. An intelligent controller which designed by using electronic devices that uses simple circuits with low cost and high efficiency is trained to control the traffic.

II. Proposed System

The proposed system was designed to resolve the problem of congestion and decrease the crowded as well as facilitate the process of traffic at the streets; it depends on the modern technologies according to the human nature to resolve the problems through using an intelligent controller that trained to work as a human brain. Figure (1) shows the block diagram of the proposed system.

It consists of three main parts; each one of them is responsible for a specific task and they will be discussed in more details in the next subsections.

2.1 Number of Vehicles

The first part as shown in figure (2) is responsible for the training of the neural networks to determine the exact number of vehicles at each street and at each lane of that street according to the readings of the sensors which are distributed along the street. The intelligent neural networks are placed on each street which needs to be controlled to decrease the congestion as well as facilitate the process of traffic.

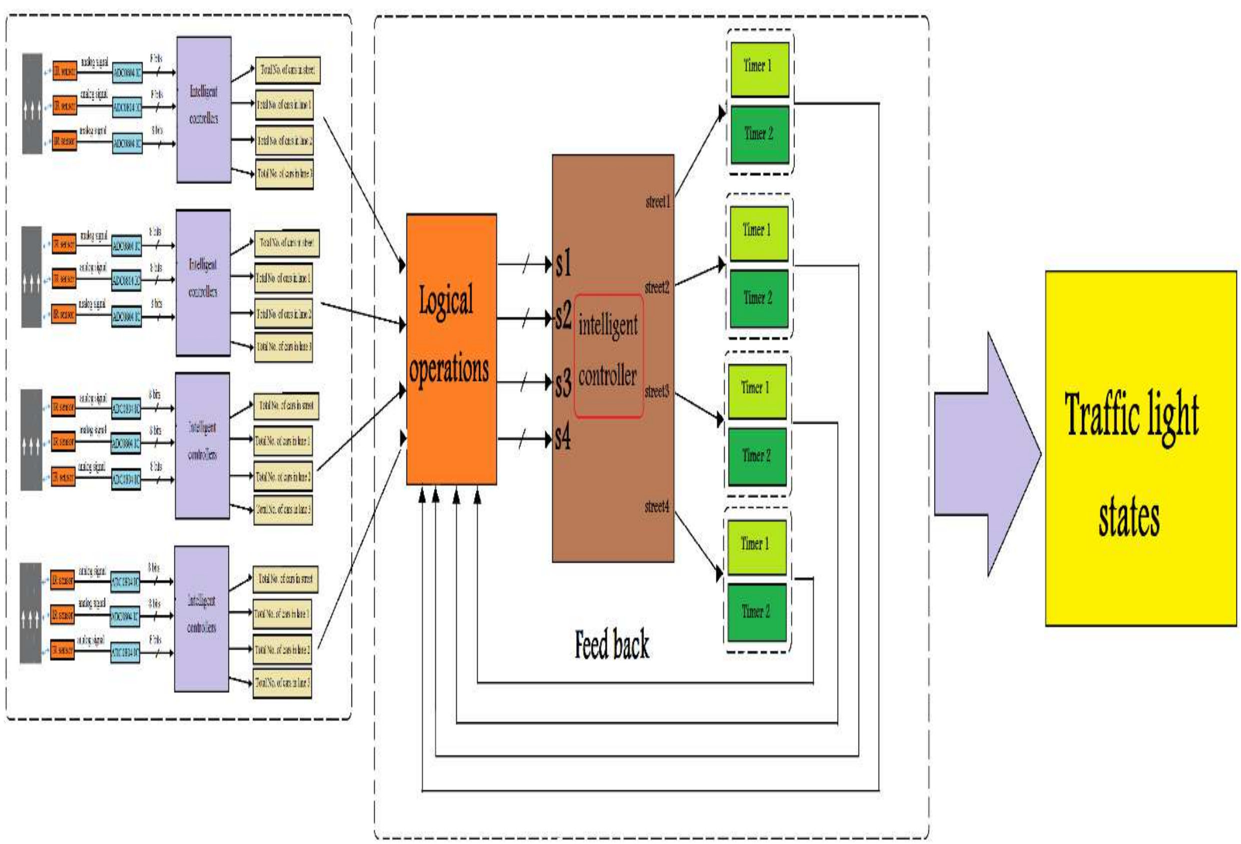

Figure 1: Block Diagram of the Proposed System

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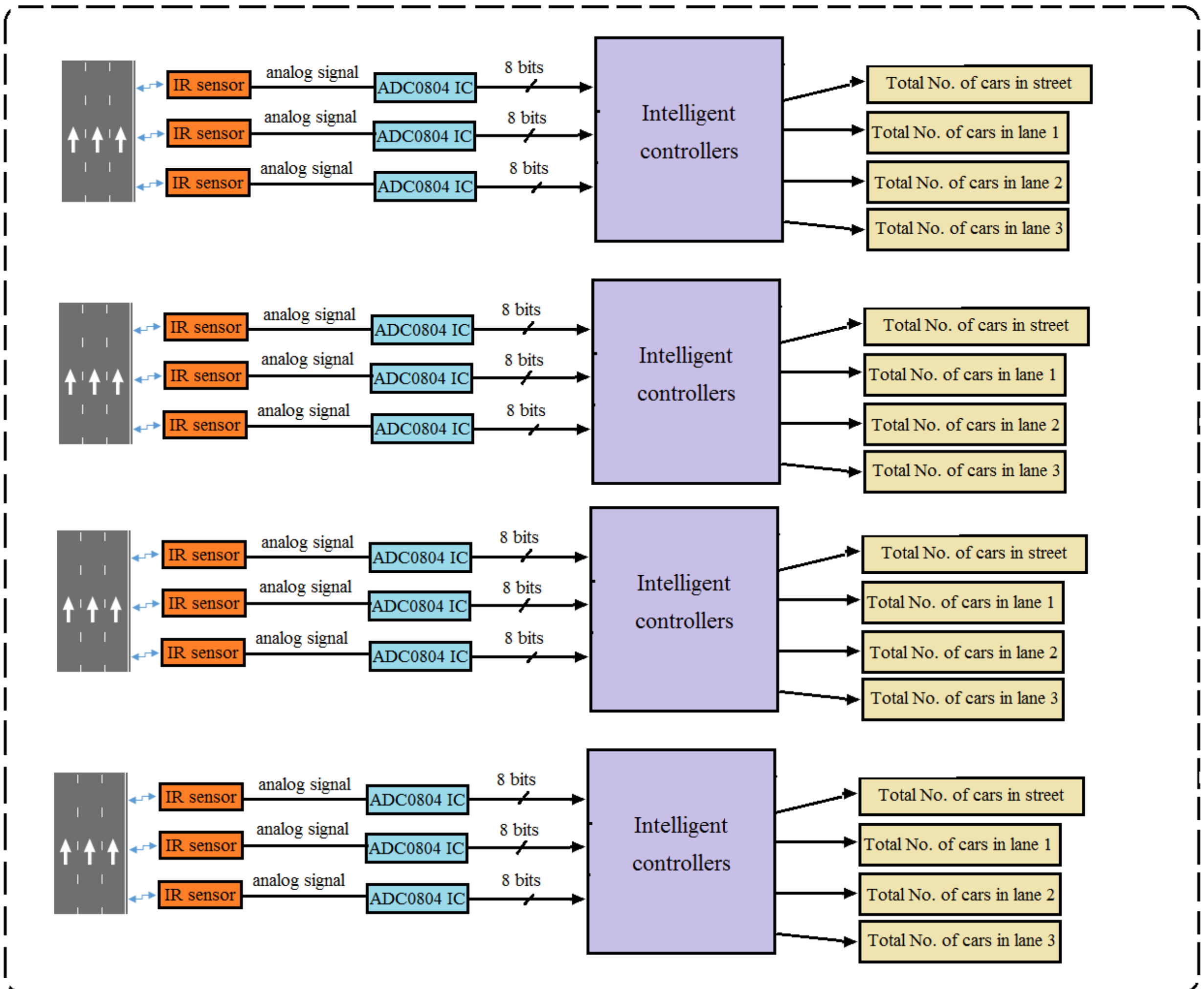

Figure 2: The First Part (Number of Vehicles)

In this part, a street with a maximum of three lanes has been used as shown in figure (3). IR sensors are distributed along the street with a fixed distance between them. In more details, the IR sensors continuously send an analog signals to exactly determine the necessary distance to calculate the exact number of vehicles; and these signals are converted to digital signals to be used as an input parameters to the neural networks which in turns are trained to read and compute the number of vehicles at each lane as well as at each street. According to figure (3) four streets are used with three lanes for each one; therefore, this part repeated four times regarding to the number of streets.

Figure 3: Street Prototype

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2.2 Timer

The second part of the proposed system as shown in figure (4) is responsible for the process of determining the period of time that is needed for each street according to the results of the first part which calculates the number of vehicles for each street. It will set a period of time for each street according to its crowded and congestion. Three main states are taken into consideration at this part:

1. The first state is used when the street is empty; there is no need to set the timer for a specific time for that street.
2. The second state is used when there are a few numbers of vehicles at the street, where a specific period of time will be set according to the congestion of that street in order to save the rest of time to the other streets which are more crowded.
3. The third state is used when the street is fully crowded with the vehicles; the timer is set with an extend period of time for that street to resolve the problem of congestion and decrease the crowded as compared with the other street.

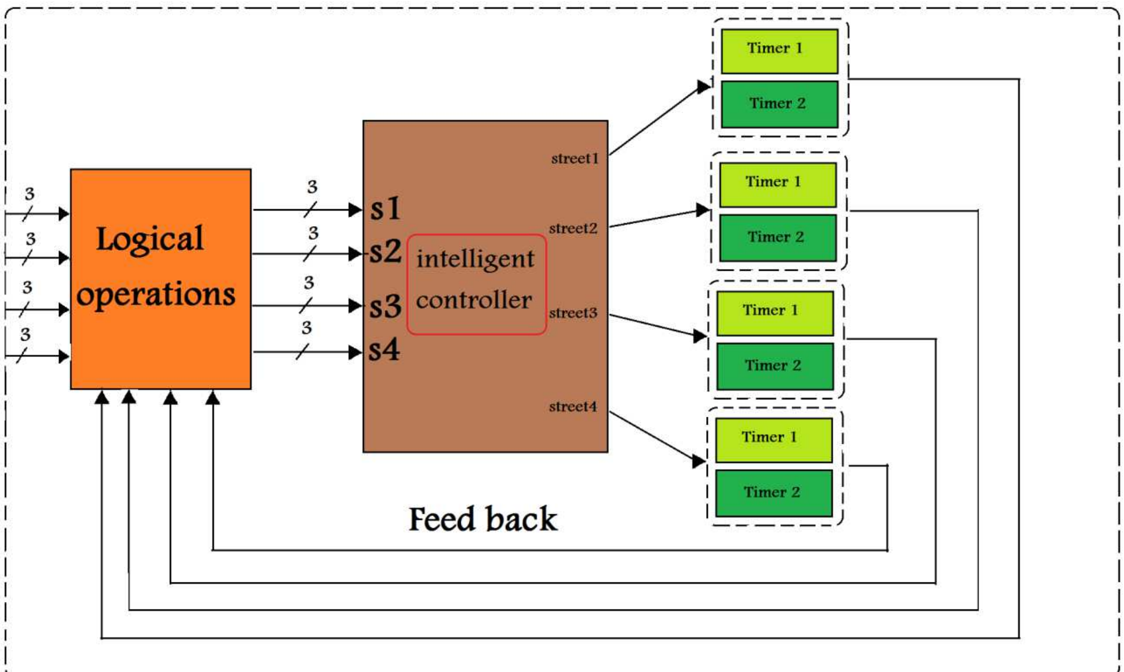

Figure 4: The Second Part (Timer)

Furthermore, when the time which is specified for a specific street elapsed, the controller will repeat the process of determine the number of vehicles for each street to reset the timer with a new period of time according to the new calculations.

In more details, the neural networks are trained for each street where three bits are used to represent the current case of that street and as followings:

a. The first bit represents the empty case of the street.
b. The second bit represents the case of the street when is medium crowded.
c. The third bit represents the case of the street when is fully crowded.

Because of the proposal system takes a prototype consists of four street and three lanes for each one as shown previously in figure (3); there are 2^{12} states are trained and taken into consideration in determining the priority for each street and computing the necessary period of time in order to control the traffic as well as decrease the congestion at the street. Clock will be used to control the timer with the required period.

Controlling traffic light

The third part of the proposed system as shown in figure (5) is responsible on the process of controlling the traffic light; it will control the light of the traffic according to the period of time which is set previously at the second part.

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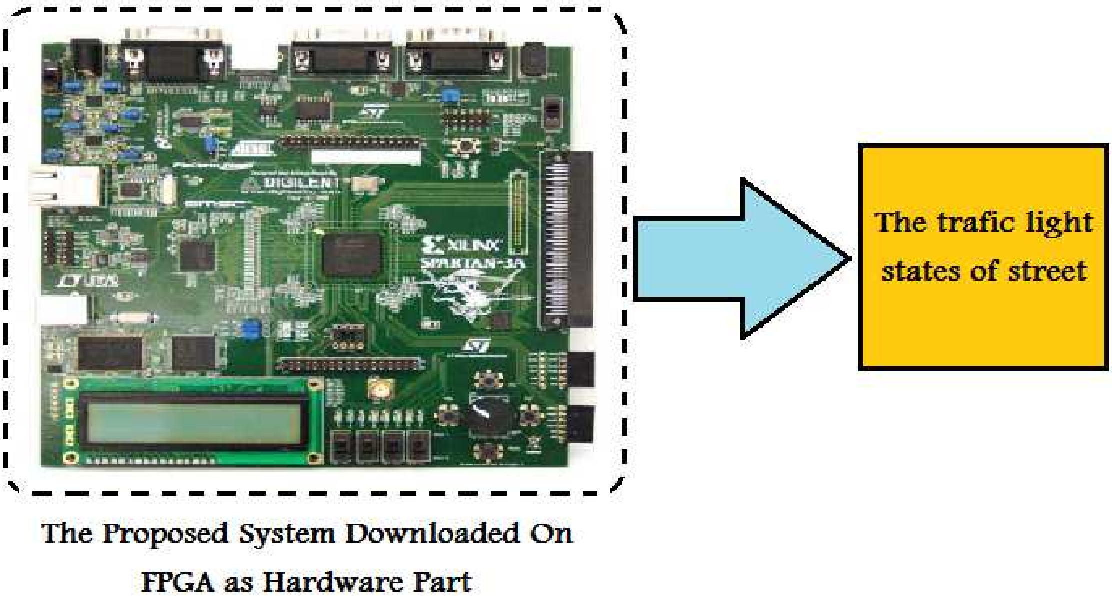

Figure 5: The Third Part

III. Implementation and Simulation Results

Today, the using of intelligent systems became widespread in the most field of life because of its high efficiency and ability to control the different parameters as a human brain. In this paper, the novel intelligent proposed system was trained using two methods that the first one is the super vised feed-forward neural networks and the second one is the Particle Swarm Optimization (PSO); these two methods are compared together and the one with the best result was chosen in this work which was the first method (super vise feed-forward neural algorithm). Trial and error method was usedto specify the number of layers, number of neuron for each layer and the type of activation function for each neuron.

Simulink is used for the process of implementation where each part of the proposed system was trained individually; then these parts are collected together in one intelligent system to perform the main task that controlling and organizing traffic. The implementation and training of each part will be discussed in more details in the next subsection.

3.1 Designing and Implementation of the First Part

The neural networks of this part are trained to detect the number of vehicles at the street; it consists of ten neurons in the hidden layer and three neurons in the output layeras shown in figure (6). The simulation results of the training of the intelligent network controller are shown in figure (7).

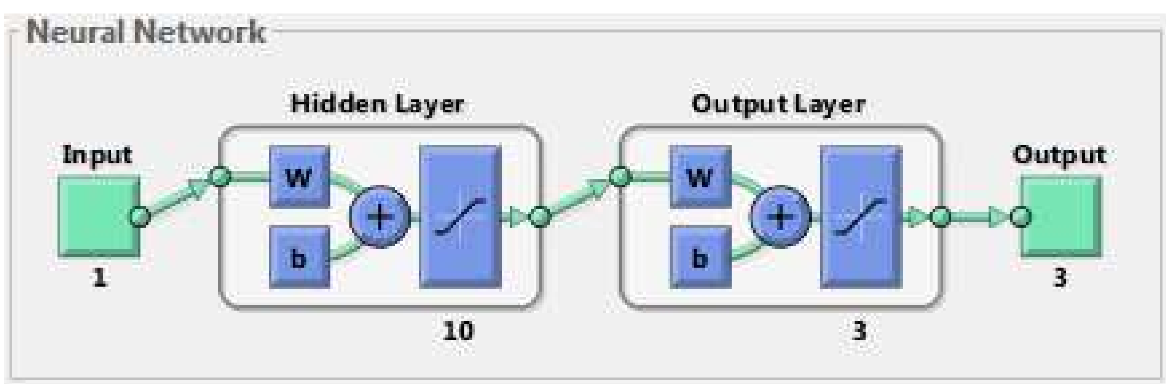

Figure 6: number of neurons of the first part

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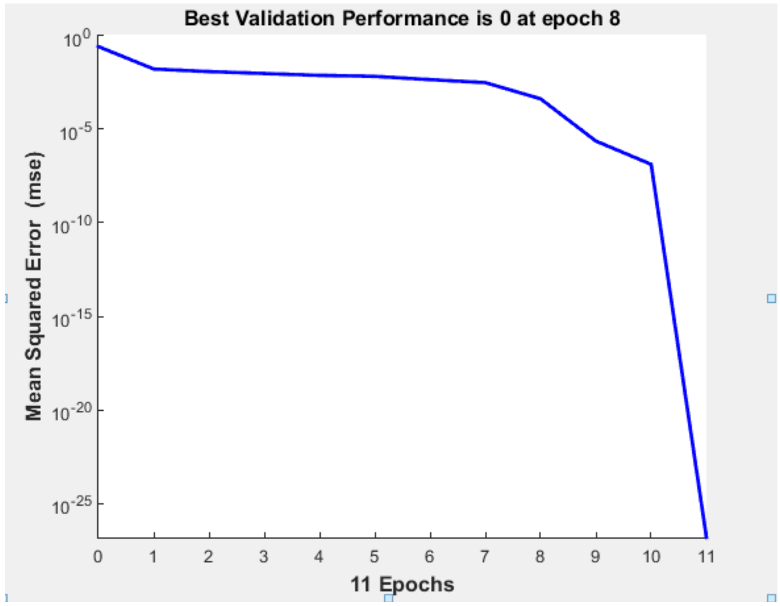

Figure 7: Simulation results of training of the first part

As mentioned previously in the beginning of (section 3), two method are used in the training of the proposed system where the above results that shown in figure (6) and figure (7) represent the training of the first part using first method “super vised feed-forward neural networks” while figure (8) represents the training and the performance of this part using the second method “Particle Swarm Optimization (PSO)”,and figure (9) represents the accuracy of performance.

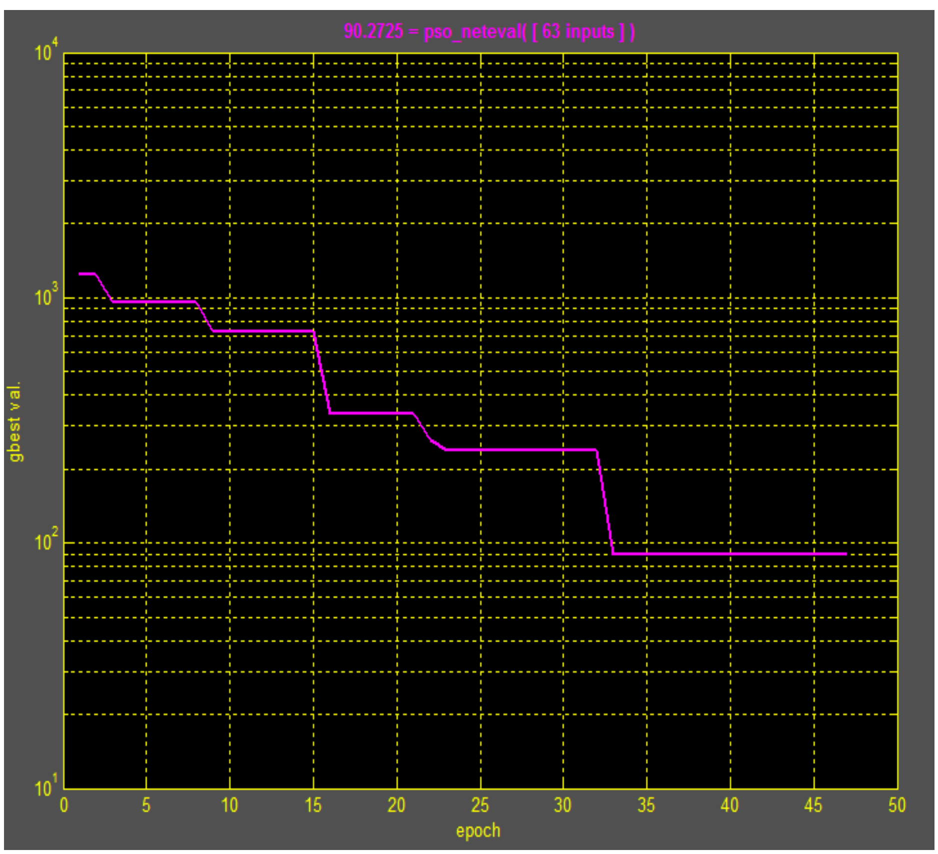

Figure 8: The performance of PSO network of the first part

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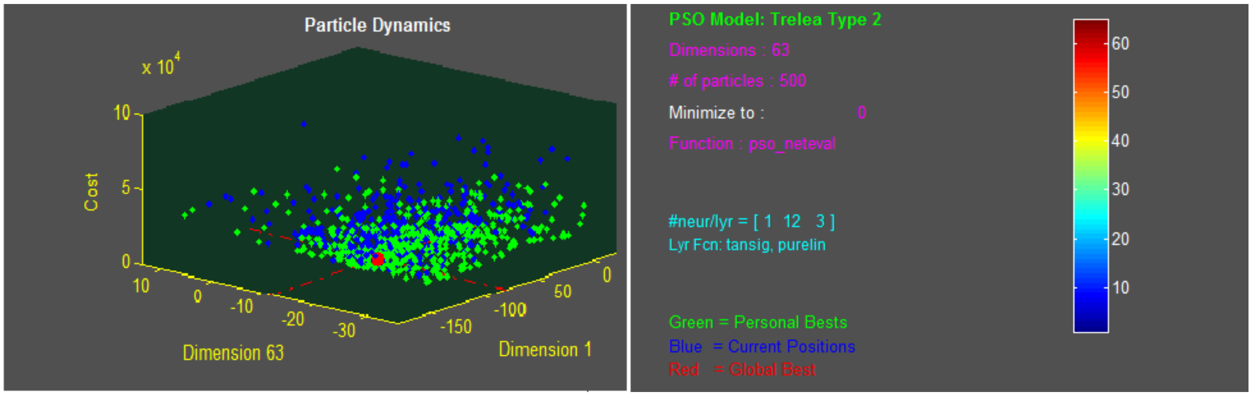

Figure 9: The accuracy of performance of the first part

The simulation results of the training of networks clears that, the networks which are trained using supervised feed forward neural network method have the best results as compared with the PSO method in this part as shown in table (1).

Table 1: the Result of Training of the first part using Two Methods

Parameters	PSO	BP
Learning Iterations	47	11
Error Convergence	90.2725	8.52e-26
No. of Initial Weights	500 set	1 set

According to table 1 that represents the simulation results of the training in terms of learning iterations, error convergence and number of initial weights; the PSO method needs to 47 learning iterations to obtain the parameter of error convergence that equal to 90.2725. While super vised feed-forward neural networks method needs only 11learning iterations to obtain the parameter of error convergence that equal to8.52e-26 that is much better than the PSO.

The Simulink form of the trained networks that shown in figure (10) is tested with different states.

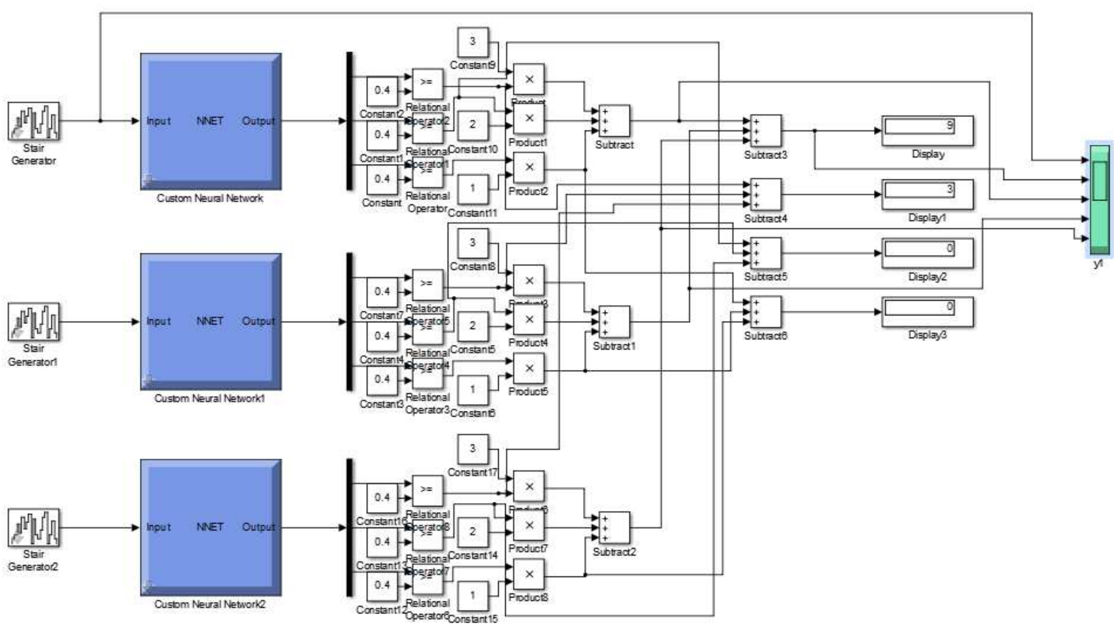

Figure 10: Simulink form of the first part

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The trained neural networks are repeated three times in order to detect the number of vehicles atone street with three different lanes. IR sensors are distributed at the street with different distance. In more details, the detecting process depends on the responses which are generated from the IR sensors. They send signals that collide and return with a specific time to determine the necessary distance.

The results of simulation of detecting vehicles with different times and states are shown in figure (11). Where the first one represents the responses of the IR sensors when detecting a target with a different time and the others represent the vehicles at the lanes three, two and one respectively.

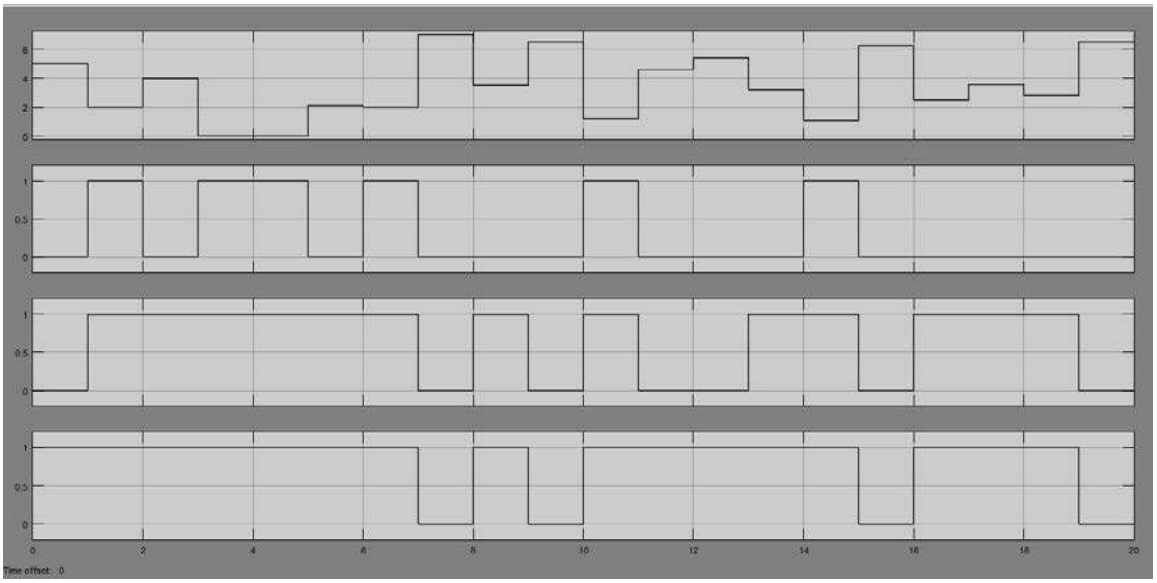

Figure 11: Simulation results of detecting of vehicles

However, figure (11) shows only whether there is a target or not at the street which means that it presents only the simulation results of detection process while figure (12) shows the simulation results of determining the exact number of vehicles for each street after the process of organizing streets according to the number of vehicles. Regarding to figure (12) the first line represents the IR sensor responses, the others represent the total number of vehicles at third, two, first lane respectively.

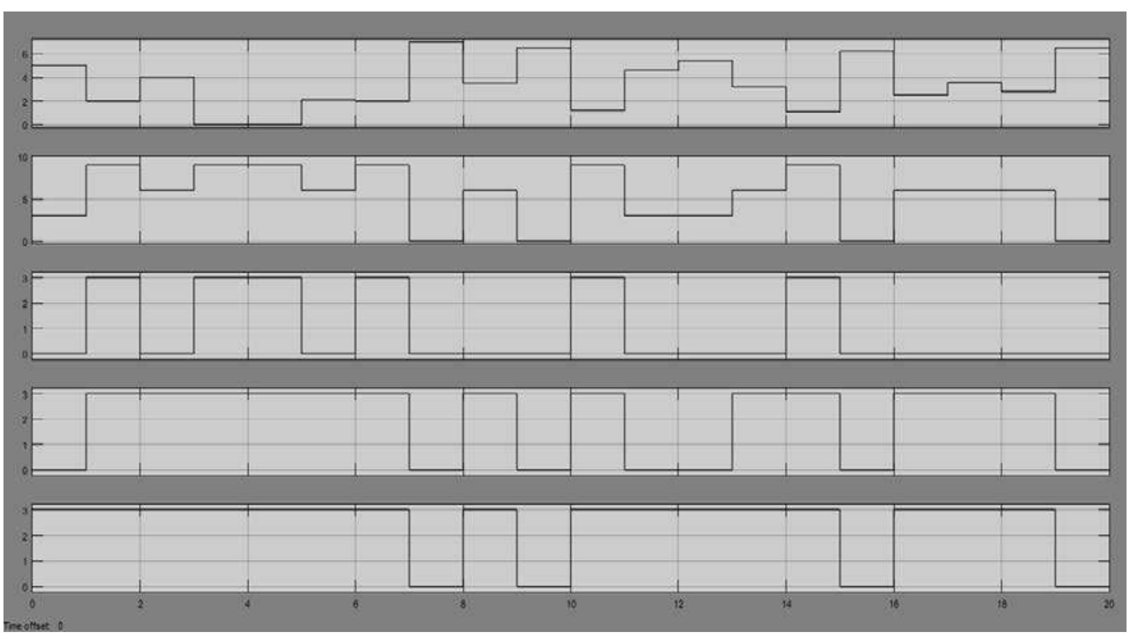

Figure 12: Simulation results for determining number of vehicles

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3.2 Designing and Implementation of the Second Part

The neuron networks of this part is shown in figure (13), which consists of twenty four neurons in the hidden layer and four neurons in the output layer.

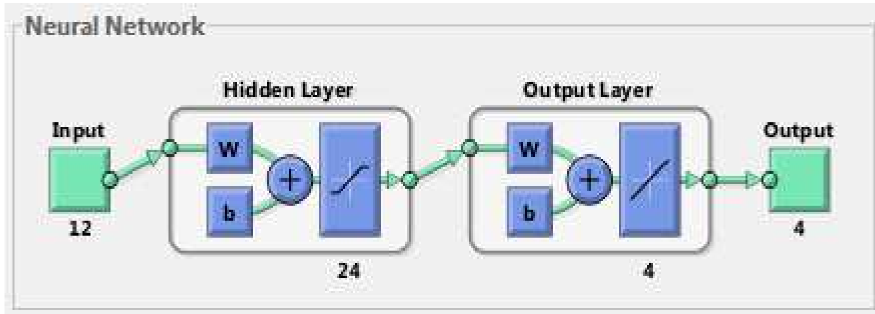

Figure 13: The neuron networks of the second part

The simulation results of the training process of the intelligent network controller are shown in figure (14).

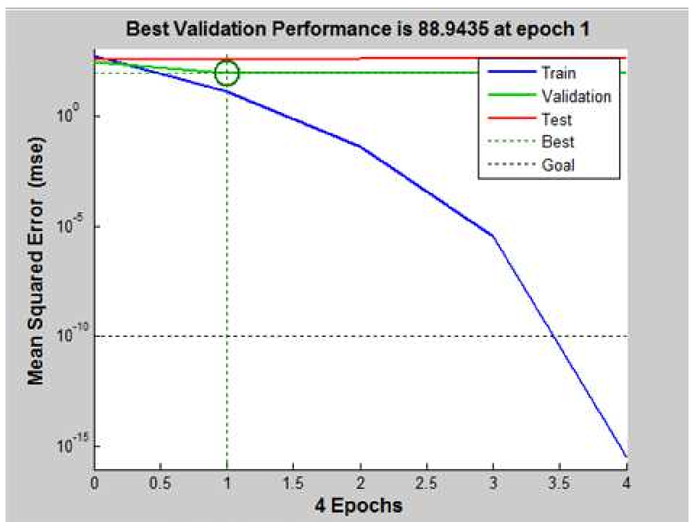

Figure 14: Simulation Results of the Training of the Second Part

This part was also trained using the two methods where figure (13) and (14) represents the training of using first method. While figure (15) represents the training and the performance of networks using the second method, furthermore figure (16)represents the accuracy of the performance of this part.

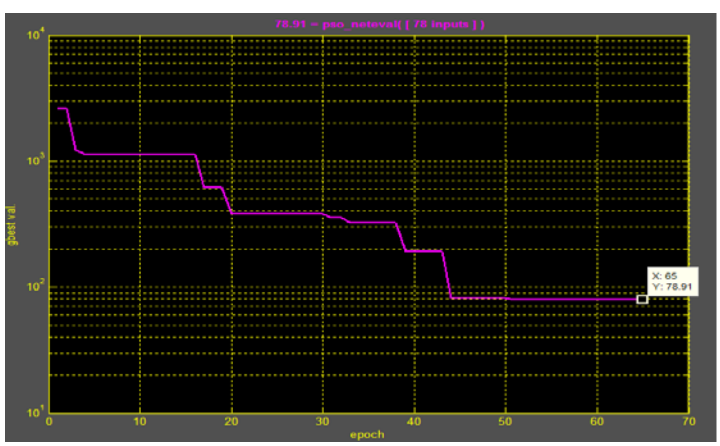

Figure 15: The performance of PSO network of the second part

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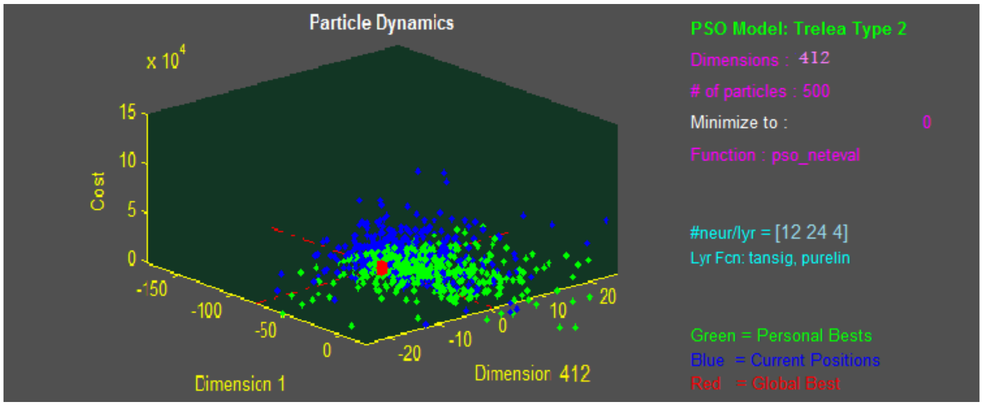

Figure 16: The accuracy of performance of the second part

According to the simulation results of training the networks, the network which are trained using supervised feed forward neural network method have the best results as compared with the PSO method in this part as shown in table (2).

Table 2: The Result of Training of Second Part using Two Method

Parameters	PSO	BP
Learning Iterations	65	4
Error Convergence	78.91	4.02e-015
No. of Initial Weights	500 set	1 set

According to table 2 that represents the simulation results of the training in terms of learning iterations, error convergence and number of initial weights; the PSO method needs to 65 learning iterations to obtain the parameter of error convergence that equal to 78.91. While super vised feed-forward neural networks method needs only 4 learning iterations to obtain the parameter of error convergence that equal to4.02e-015 that is much better than the PSO.

The second part of the proposed system implemented using Simulink as shown in figure (17), it is tested with different status and times.

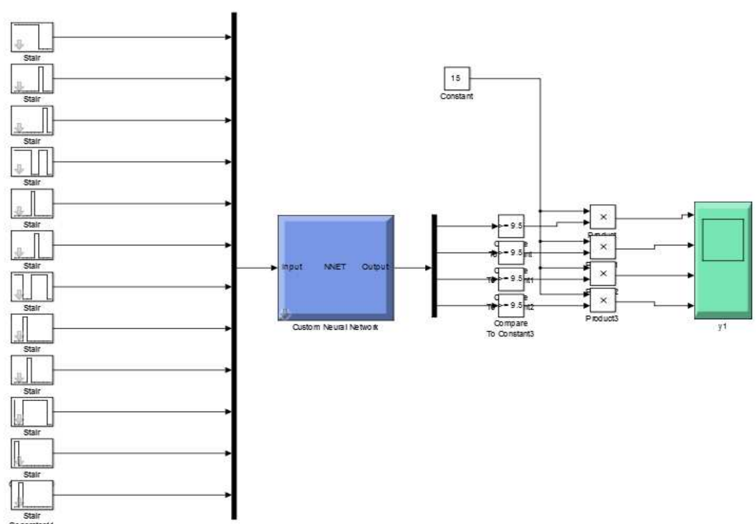

Figure 17: Simulink Form of the Second Part

As mentioned previously, the proposed system used a prototype consists of four streets with three lanes for each one; therefore, according to figure (17) there are four inputs, each one of them presented with three states. And four outputs each one of them represent the state of the timer to the specified street. The simulation results of the prototype of the proposed system are shown in figure (18) which takes different statutes at different times.

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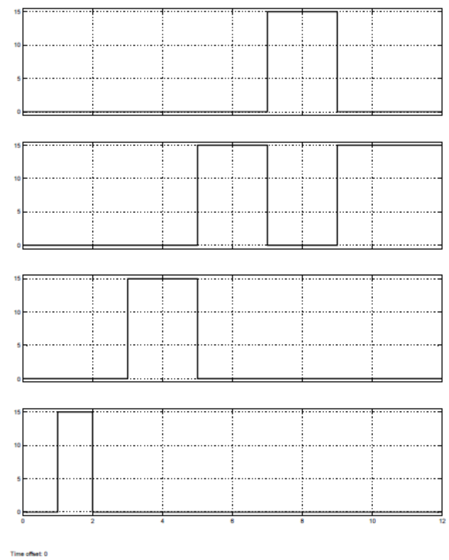

Figure 18: Simulation Results of the Prototype

The first line represents the states of the first street, while the second one represents the states of the second street, the third one represents the states of the third street and the last one represents the states of the fourth street. Each state of each street presented with deferent statues at different times.

IV. Conclusion

This paper proposed an intelligent system that consists of two main controllers, they are designed smartly to control the traffic on the street where all the networks of the system are trained individually and then collected to gathers to produce one intelligent system that has the ability to reduce the congestion of the traffic at the street. The networks are trained with two methods that the first one is the super vised feed-forward neural networks and the second one is the Particle Swarm Optimization (PSO), then the results of the two methods are compared with each other's where the first one was the best as compared with second as shown in table (1) where the error convergence for PSO method was 90.2725 while BP was approximately 8.52e-26; and for the second controller according to table (2) the error convergence for PSO method was78.91 while the BP was 4.02-015;therefore, super vised feed-forward neural networks was used for the training in this work. The proposed system can be used at any street which is considered a practical, low cost and high efficiency intelligent system.

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