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Intelligent traffic light controller based on MCA associative memory

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Abstract: Traffic in urban areas is mainly regularized by traffic lights, which may lead to the unnecessary long waiting times for vehicles if not efficiently configured. This inefficient configuration is unfortunately still the case in a lot of urban areas where most of the traffic lights are based on a 'fixed cycle' protocol. This paper aims to design an intelligent controller of an intersection in a specific city using associative memory with multi-connect architecture via using this structure of neural network the intelligent controller can adapt to all street cases, which may be faced during its work. Not like other controllers, this work uses small associative memory. It will learn all street traffic conditions. The controller uses virtual data about the traffic condition of each street in the intersection. Thus, in an image processing module this video camera will provide visual information. This information will be processed to extract data about the traffic jam. This data will be represented in a look- up table, then smart decisions are taken when the intersection management determines the street case of each street at the intersection based on this look- up table.

Keywords: Transportation System, Traffic Light Controller System, Associative Memory, MCA Associative Memory

1. Introduction

Transportation's researches goal are to optimize transportation flow of people and goods. As the number of road users constantly increases, which resources provided by current infrastructures are limited, intelligent controller of traffic will become a very important issue soon.

Traffic in urban areas is mainly regularized by traffic lights, which may contribute to the unnecessary long waiting times for cars if not efficiently configured. This inefficient configuration is unfortunately still the case in a lot of urban areas where most of the traffic lights are based on a 'fixed cycle' protocol, which basically means that the lights will be turned on green for a fixed amount of time and consecutively on red for a fixed amount of time [1].

In recent years, computer vision systems have been applied in traffic systems. Gradually, computer vision systems were broadly considered and impelled in two aspects. First, computer vision systems were widely placed in more positions, such as tunnels and other places related to the automotive world such as streets, highways; etc. Second, computer vision system was evolving, and more complex techniques start to help human supervision, such as license plate recognition, counting cars, detection and tracking of cars, etc. In the references it is possible to find these applications [2].

This work aims to design intelligent system using neural network with multi-connect architecture can control an intersection in a specific city depending on virtual data (see figure 1), where this system dealing with all possible street traffic conditions, which will face during the management of these intersections.

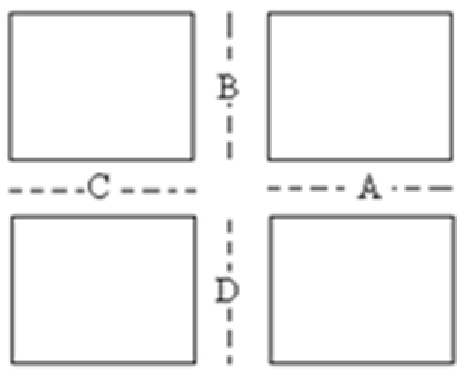

Figure 1. *An intersection in city.*

2. Previous Works

The representation of a traffic light as an example of an object has been presented by [3]. That exhibit a rich behavior set and serves as a case study for a number of interesting design issues. It focuses on the implementation of the internal state and corresponding control information on the traffic light. It discusses how various important kinds of behavior can be added to this extensible design.

The detecting vehicles approach in urban traffic scenes by rule-based reasoning about visual data has been presented by [4]. This approach is the separation between the low-level image processing modules (used for extracting visual data under various illumination conditions) and the high-level module, which provides a general-purpose knowledge-based framework for tracking vehicles in the scene. The image-processing modules extract visual data from the scene by spatio-temporal analysis during daytime and by morphological analysis of headlights at night. The high-level module is designed as a forward chaining production rule system, working on symbolic data, i.e., Vehicles and their attributes (area, pattern, direction, and others) and exploiting a set of heuristic rules tuned to urban traffic conditions.

At traffic light Intelligent Controller has been designed and implement by [5] for a single intersection. The Intelligent Controller is constructed from a finite state machine used to control the actual operation of the traffic lights. The remainder of the system consists of supporting subsystems, including RAM, a Timer, Divider, and various synchronizers. Time values used by the finite state machine are written to and read from the RAM.

A Fuzzy Traffic Light Method is developed by [6]. This method retains the clarity of the standard Traffic Light Method while resolving difficulties that have been encountered with it. An adaptive traffic light system Presented by [7] based on wireless communication between vehicles and fixed Intelligent Controller nodes deployed in intersections. [1], Study the simulation and optimization of traffic light controllers in a city and present an adaptive optimization algorithm based on reinforcement learning. This controller has implemented a traffic light simulator, Green Light District that allows experimenting with different infrastructures and to compare various traffic light controllers.

A system to perform an intelligent real-time control of a crossing point regulated by traffic lights has been presented by [8]. The problem is particularly adequate for a multi-agent solution, as an individual agent is a satisfactory tool to control each traffic light as well as a cooperating behavior is also required. Each agent makes decisions according to local variables, and in a synchronized way with the information received from other agents. Position [9] has been described an existing approach of reinforcement learning applied to the optimization of traffic light configurations, and introduce an approach. It used implicit cooperation between traffic lights, letting cars take into account the traffic situation on the road ahead.

At traffic lights logic algorithm has been proposed by [10], which uses the length of a jam in front of a traffic light as input. The idea is that each traffic light is trying to solve the jams in its front by itself. To achieve this, it looks into the incoming lanes and measures the jam lengths on these lanes. If at one of these lanes the jam gets longer, this lane gets green for a longer time.

3. Multi-Connect Architecture (MCA) Associative Memory

It is described as associative memory, which is a simple single-layer neural network. It can learn a set of pattern pairs (or associations). An efficient associative memory can store a large set of patterns as memories. During the recall, the memory is excited with a key pattern (also called the search argument) containing a portion of information about a particular member of a stored pattern set. This particular stored prototype can be recalled through association of the key pattern, and the information memorized [11] [12].

Depending on our previous research [13], [14] and [15] this net can deal with any size of the pattern and with (pattern: It means a sequence of 1s and 0's). Thus, we will divide the pattern into a number of parts with size three, to be considered as a vector (V), which it needs to create its learning weight matrix (see figure 2).

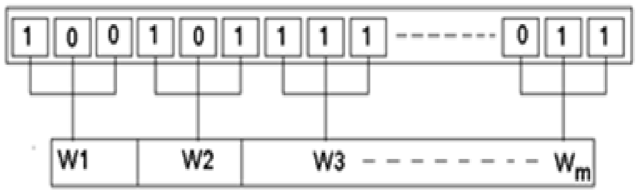

Figure 2. *The data (pattern) divided into a number of vectors with size three, which it needs to create its learning weight matrix.*

Since the size of the vector is three then there are no more than eight states for this vector as 000, 001, 010… 111. Thus, the process of learning for all patterns will create four learning weights matrices as a maximum. Each matrix of these will be of 3*3 size (as in figure 3).

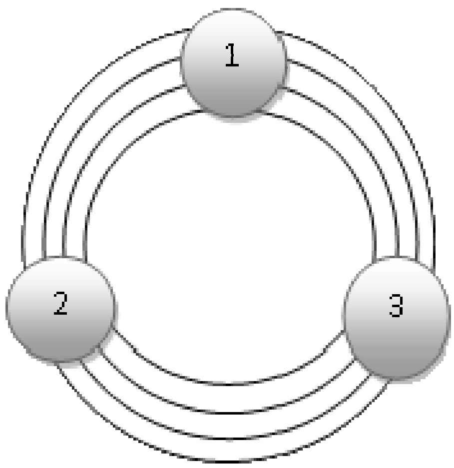

Figure 3. *NN with multi-connect architecture.*

$$E=-\frac{1}{2}\left(\sum_{i=1}^{n}\sum^{n}w_{ij}v_iv_j+\sum_{k=1}^{n}t_kv_k\right) \quad (1)$$

Where: n is the number of elements in the vector v.

Wij is the weight from the input of neuron i to the output of neuron j. t limiting (threshold) value, which equal to zero in this net.

One can calculate the energy function E for every input vector, which can be created on the network. If one calculates the function E for all the possible input vectors, an energy landscape with maximums and minimums can be obtained. The point is that the minimum is taken when the input is a pattern [2].

4. Intelligent Traffic Light Control System

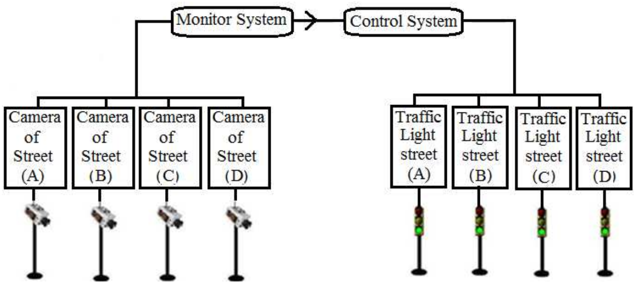

Figure 4. *The whole Intelligent Traffic Light system framework.*

The proposed control system will be integrated with our previous work [16] which it presented an intelligent a traffic light monitor system (see Figure 4). This monitor system supplies a virtual data about the condition of each street in the intersection. In this work street traffic condition was one of three conditions: 1) empty street (there are no vehicles in the street), 2) normal street (the number of vehicles in the street is within its capacity and 3) crowded street (the number of vehicles in the street is over its capability). The output of this monitor system in addition to other data will be represented in a truth table (see Table 1). This table includes the condition of each street in the intersection in addition to other two information which are the presence of pedestrians whether or not and the street's role of the green period time.

The smart decisions are taken when the propose control system determines the street traffic condition at the intersection based on Table 1. This table contains all the expected street traffic condition (just eight cases) with its priority score based on the following factors:

1. Is the role of this street in the green light Period?
2. Is this street crowded?
3. Are there any pedestrian?

Each one of them has its own priority, as follows:

1. Is the role of this street in the green light Period?
2. If yes the priority (PR) = 3, if not the priority (PR) = 0
3. Is this street crowded?
4. If yes the priority (PC) = 4, if not the priority (PC) = 0
5. Are there any pedestrian?

If yes the priority (PP) = 1, if not the priority (PP) = 0

The score was calculated in the table (1) by the following equation:

$$\text{Score} = \left| PR+PC-PP \right| \quad (2)$$

Table 1. *Tables may span across both columns.*

Case No.	Case code	Are there any pedestrian?	PP	This street is crowded?	PC	Is the green period time role to this street?	PR	*Priority Score*
0	000	No	0	No	0	No	0	*0*
1	001	No	0	No	0	Yes	3	*3*
2	010	No	0	Yes	4	No	0	*4*
3	011	No	0	Yes	4	No	3	*7*
4	100	Yes	1	No	0	No	0	*1*
5	101	Yes	1	No	0	Yes	3	*2*
6	110	Yes	1	Yes	4	No	0	*3*
7	111	Yes	1	Yes	4	Yes	3	6

Through using neural network with multi-connect, the proposed control system will learn all the street traffic conditions that could face during its work. Thus, it will adapt itself automatically. The work of the proposed control system has been described using the following algorithm:

Input: one-dimensional array contains the case of each street in the intersection 1... N, where N<=4.

Output: SA it is one-dimensional array 1... k.

Step 1: initial value found = false.

Step 2: {Determining the case of each street of the intersection using Table (1).}

Cnow =	Street 1	Street 2	…	Street N
	Case No.	Case No.	…	Case No.

Where: N: the number of streets in the intersection N<=4.

Cnow: the case of the intersection now.

Step 3: {Determine, whether this case has been learning it before or not?}

Step 3-1: for k = 1 to NLP do

Where NLP: no. Of learning patterns in the associative memory

Step 3-1-1: for each weight (WLP: which it two dimensional array) in LP [k] and each vector

VCnow in Cnow do

$$EF=\sum_{i=1}^{3}\sum_{j=1}^{3}WLP_{ij}*VCnow_{i}*VCnow$$

Step 3-1-2: Calculate EF (LP [k]) using this Equation :

$$EF\ (LP\ [k\ ])\ =\ \sum_{i=1}^{NLP} EF_i \big/ M$$

Where : M: number of WLP in LP

Step 3-1-3: if EF (LP [k]) = - 3 then Found : =true.

Return SA [k] of LP [k] and exit.

Where : SA is the sequence of actions which it have a sequence of streets to get the green light period { End of if statement step 3-1-3} { End of loop step 3-1}

Step4 :{ the Intersection Management mast implement the following steps:}

If found=false then

Step 4-1: {Priority is determined to every street at the intersection using Table (1). Taking into account the cases 2 and 6, where increases the value of priority by one if this street has a role in the green light period in the previous circle, else decrease the value of priority by one.}

If case no =2 or 3 then

If (PR)=true then PS=priority score +1

Else

PS= priority score – 1.

Where: PS is the priority score of the street

{ end of if statement}

Step 4-2: {Giving the green light Period to the street with the larger value of priority.}

	Street 1	Street 2	…	Street N
Cnow =	Case No.	Case No.	…	Case No.
	PS	PS	…	PS

GP= no. of street with the maximum value of PS in Cnow.

Step 4-3: {save GP in sequence street action (SA) }

SA=	First Street	Second Street	……	K'th Street

Step5: Repeat steps 1, 2, 3 and 4 until it is given all the streets in the intersection green light period.

5. Controller Implementation Using VHDL

VHDL code has been written to implement Table 1. The code was synthesized and simulated successfully using Xilinx 9.2i software. Figure 5 shows the timing diagram that demonstrates the operation of the circuit. The signal names appear at the left, starting with clock, followed by the reset n signal, the 3-bit case code input and score output. Notice how the reset n signal causes the score output to go to zero. Furthermore, note how every change to score happens on the rising clock edge.

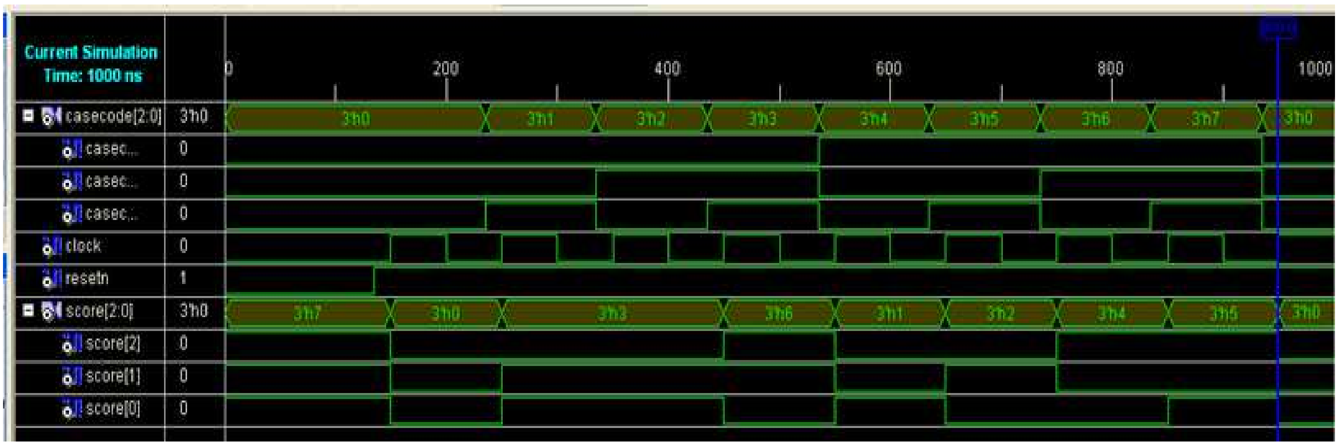

Figure 5. *The timing diagram.*

The internal structure of the top-level symbol shown in Figure 6, has been shown in Figure 7. It consists of nine (2-input NAND) gates, five (2-input OR) gates, nine inverters, three D- flip flop latches and eight IO buffers. For more clarity, a summary report and the chip layout with the description for each pi of this design has been shown in Figure 8 and Figure 9 respectively.

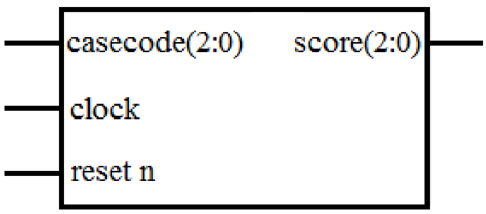

Figure 6. *Top level symbol.*

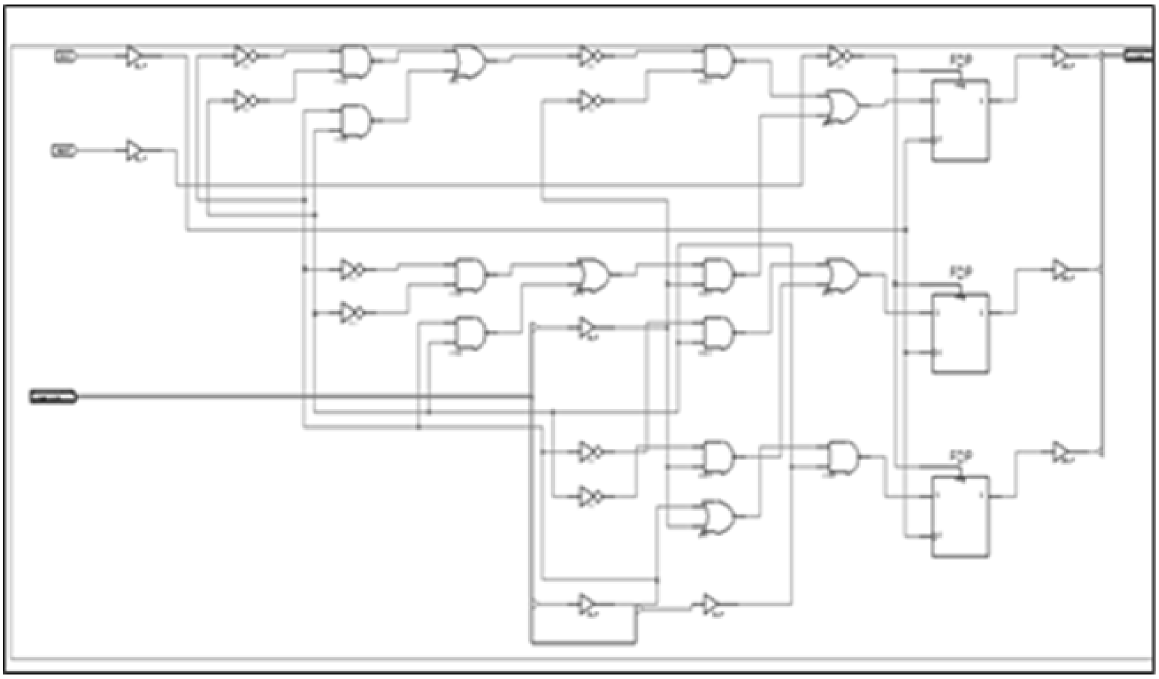

Figure 7. *Internal structure of the controller.*

Summary

Design Name	s1
Fitting Status	Successful
Software Version	J.36
Device Used	XA9536XL-15-VQ44
Date	3-22-2013, 7:08PM

RESOURCES SUMMARY

Macrocells Used	Pterms Used	Registers Used	Pins Used	Function Block Inputs Used
3/36 (9%)	7/180 (4%)	3/36 (9%)	8/34 (24%)	6/108 (6%)

PIN RESOURCES

Signal Type	Required	Mapped
Input	3	3
Output	3	3
Bidirectional	0	0
GCK	1	1
GTS	0	0
GSR	1	1

Pin Type	Used	Total
I/O	6	28
GCK/IO	1	3
GTS/IO	0	2
GSR/IO	1	1

GLOBAL RESOURCES

Signal mapped onto global clock net (GCK1)	clock
Signal mapped onto global output enable net (GSR)	resetn

POWER DATA

Macrocells in high performance mode (MCHP)	0
Macrocells in low power mode (MCLP)	3
Total macrocells used (MC)	3

Figure 8. *Summary report for intelligent traffic light controller design.*

```
□*****************************  Device Pin Out ***********************

Device : XA9536XL-15-VQ44


   -------------------------------
  /44 43 42 41 40 39 38 37 36 35 34 \
 | 1                             33 |
 | 2                             32 |
 | 3                             31 |
 | 4                             30 |
 | 5        XA9536XL-15-VQ44     29 |
 | 6                             28 |
 | 7                             27 |
 | 8                             26 |
 | 9                             25 |
 | 10                            24 |
 | 11                            23 |
 \ 12 13 14 15 16 17 18 19 20 21 22 /
   -------------------------------

              Pin Signal                        Pin Signal
              No. Name                          No. Name
                1 KPR                             23 KPR
                2 KPR                             24 TDO
                3 KPR                             25 GND
                4 GND                             26 VCC
                5 KPR                             27 KPR
                6 KPR                             28 casecode<2>
                7 score<2>                        29 KPR
                8 KPR                             30 casecode<0>
                9 TDI                             31 casecode<1>
               10 TMS                             32 KPR
               11 TCK                             33 resetn
               12 KPR                             34 KPR
               13 KPR                             35 VCC
               14 KPR                             36 KPR
               15 VCC                             37 KPR
               16 KPR                             38 score<0>
               17 GND                             39 KPR
               18 KPR                             40 KPR
               19 KPR                             41 score<1>
               20 KPR                             42 KPR
               21 KPR                             43 clock
               22 KPR                             44 KPR
```

Figure 9. *The chip layout with the description for each pi.*

6. Simulation

A simulation program has been used to evaluate the proposed intelligent traffic light controller. In this simulation, two actual intersections in Penang one of the Malaysian Islands have been used, taken into account the actual situations of each street in these intersections. First intersection was Batu Uban intersection (see Figure 10), where the second intersection is Sungai Nibong intersection (see Figure 11). Just like the most intersections in other places in Malaysia, this intersection used fixed time traffic light controller. Thus, the green period time for each street depends on months of a field survey to determine the ideal time for a green light, which furnishes the largest number of vehicle departure of the intersection.

These intersections are quadrant intersections (see Figure 12 and 13). Table 2 and 3 illustrates the important information of each street in this intersection. This information has been taken through privet field visits to this intersection.

Table 2 and Table 3 showed the green period time to each street at these intersections. In addition, these tables show the vehicle departure rate per second. This rate has been found by a privet survey. The number of the departure cars calculated when the vehicle exceeds the white line of the street and entering the intersection. The last column of these tables calculated the rate of the departure cars during the green period time based on Equation 3.

VDR during the green period time= green period time × VDR per second (3)

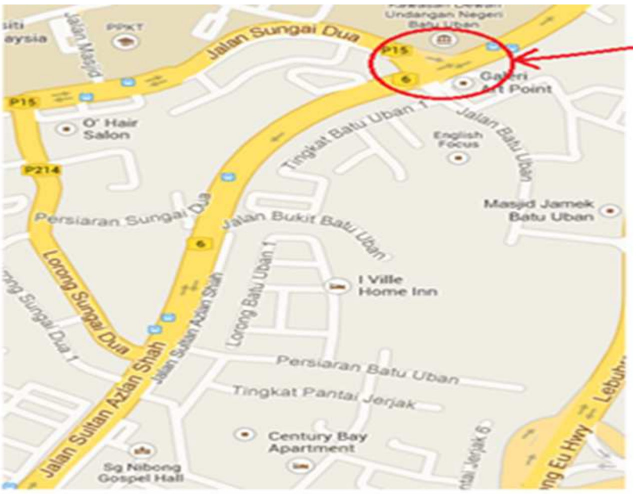

Figure 10. Batu Uban intersection on Penang Island, Malaysia.

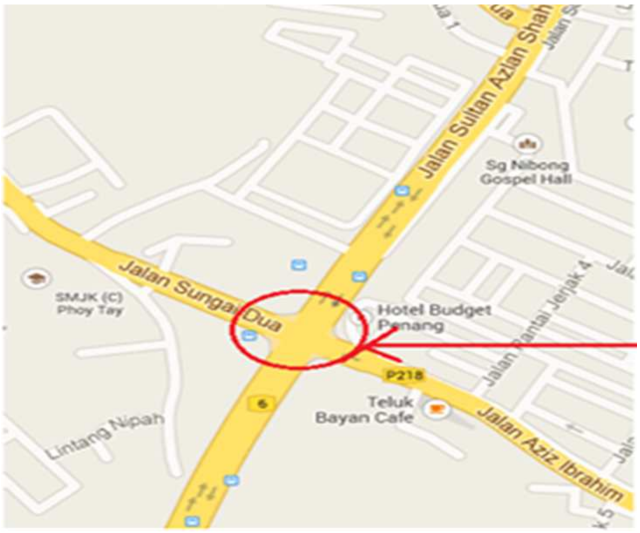

Figure 11. Sungai Nibong intersection on Penang Island, Malaysia

Table 2. Privet field visit information about Batu Uban intersection.

Street No.	Green period time	Car's departure rate VDR per second	Cars Departure rate VDR during the green period time
St1	60 Sc.	3	180
St2	60 Sc.	2	120
St3	150 Sc.	5	750
St4	150 Sc.	5	750

Table 3. Privet field visit information about Sungai Nibong intersection.

Street No.	Green period time	Car's departure rate VDR per second	Cars Departure rate VDR during the green period time
St1	90 Sc.	5	450
St2	120 Sc.	4	480
St3	120 Sc.	4	480
St4	90 Sc.	5	450

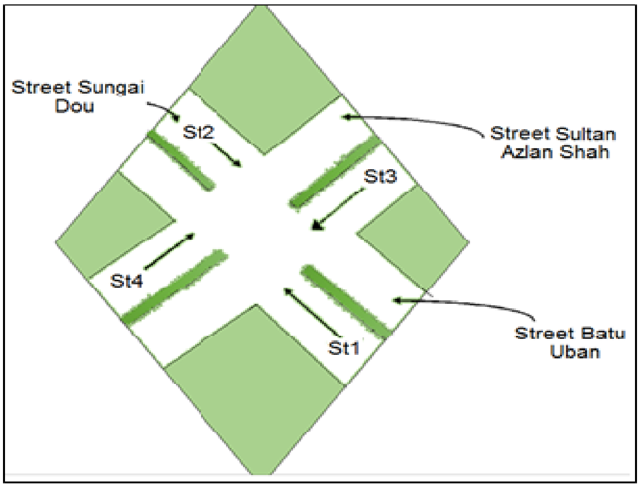

Figure 12. Batu Uban intersection on Penang Island, Malaysia.

This intersection is used to simulate the proposed intelligent traffic light controller based on the data shown in Table 2. In this simulation, a random street case was generated to calculate the priority of each street using Table 1 and 2. These priorities will be used to determine which street will be taking the green period time and determine if the street needs an extra time to be added (see Table 4 and Table 5).

In Table 4 and 5, the streets sequence was not a significant impact on the choice of the street, which would capture the green period time. Consequently, most of the streets that have been selected were the highest priority relative to Table 2. Extra time has been added to the crowded streets (which are shaded in the tables 4 and 5) of 10 percent of the original green period time avoiding any exaggerated increasing at the traffic light cycle time.

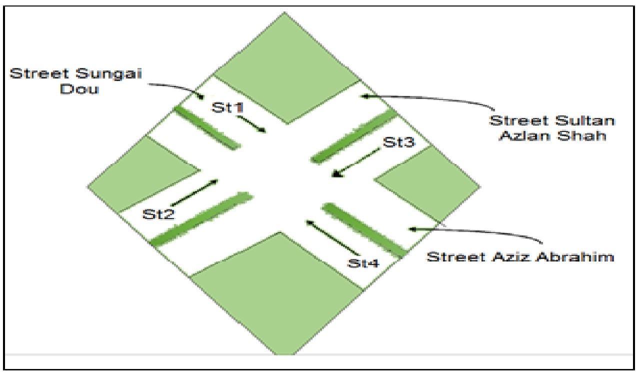

Figure 13. Sungai Nibong intersection on Penang Island, Malaysia.

Table 4. *the proposed intelligent traffic light controller response for Batu Uban Intersection.*

Traffic light cycle	St1				St2			
	Case No.	**priority**	**Green period time**	**Extra time 10%**	**Case No.**	**priority**	**Green period time**	**Extra time 10%**
Cycle 1	7	6	60 Sc.	6 Sc.	0	0	150 Sc.	0 Sc.
					5	2	150 Sc.	0 Sc.
					6	3	150 Sc.	15 Sc.
					2	4	150 Sc.	15 Sc.
Cycle 2	7	6	60 Sc.	6 Sc.	2	4	150 Sc.	15 Sc.
					7	6	150 Sc.	15 Sc.
Cycle 3	7	6	60 Sc.	6 Sc.	0	0	150 Sc.	0 Sc.
					3	7	150 Sc.	15 Sc.
Cycle 4	3	7	60 Sc.	6 Sc.	6	3	150 Sc.	15 Sc.
					3	7	150 Sc.	15 Sc.

Table 4. *Continued*

Traffic light cycle	St3				St4				Assigned to
	Case No.	**priority**	**Green period time**	**Extra time 10%**	**Case No.**	**priority**	**Green period time**	**Extra time 10%**	
Cycle 1	2	4	150 Sc.	15 Sc.	2	4	60 Sc.	6 Sc.	St 1
	2	4	150 Sc.	60 Sc.	4	1	60 Sc.	0 Sc.	St 3
					2	4	60 Sc.	6 Sc.	St 4
									St 2
Cycle 2	2	4	150 Sc.	15 Sc.	0	0	60 Sc.	0 Sc.	St 1
	4	1	150 Sc.	0 Sc.	0	0	60 Sc.	0 Sc.	St2
	5	2	150 Sc.	0 Sc.	6	3	60 Sc.	6 Sc.	St4
	4	1	150 Sc.	0 Sc.					St 3
Cycle 3	6	3	150 Sc.	15 Sc.	4	1	60 Sc.	0 Sc.	St1
	6	3	150 Sc.	15 Sc.	0	0	60 Sc.	0 Sc.	St2
	7	6	150 Sc.	15 Sc.	6	3	60 Sc.	6 SC.	St 3
					1	3	60 Sc.	0 Sc.	St 4
Cycle 4	6	3	150 Sc.	15 Sc.	6	3	60 Sc.	6 Sc.	St 1
	0	0	150 Sc.	0 Sc.	4	1	60 Sc.	0 Sc.	St 2
	3	7	150 Sc.	15 Sc.	6	3	60 Sc.	6 Sc.	St 3
					3	7	60 Sc.	6 Sc.	St 4

Table 5. *the proposed intelligent traffic light control ler response Sungai Nibong Intersection.*

Traffic light cycle	St1				St2			
	Case No.	**priority**	**Green period time**	**Extra time 10%**	**Case No.**	**priority**	**Green period time**	**Extra time 10%**
Cycle 1	1	3	90 Sc.	0 Sc.	6	3	120 Sc.	12 Sc.
	2	4	90 Sc.	9 Sc.	3	7	120 Sc.	12 Sc.
	2	4	90 Sc.	9 Sc.				
Cycle 2	1	3	90 Sc.	0 Sc.	2	4	120 Sc.	12 SC.
	0	0	90 Sc.	0 Sc.				
	6	3	90 Sc.	9 Sc.				
Cycle 3	1	3	90 Sc.	0 Sc.	4	1	120 Sc.	0 Sc.
	2	4	90 Sc.	9 Sc.	1	3	120 Sc.	0 Sc.
					4	1	120 Sc.	12 Sc.
					2	4	120 Sc.	12 Sc.
Cycle 4	5	2	90 Sc.	0 Sc.	6	3	120 Sc.	12 Sc.
	2	4	90 Sc.	9 Sc.	3	7	120 Sc.	12 Sc.
	4	1	90 Sc.	0 Sc.				
	0	0	90 Sc.	0 Sc.				

Table 5. *Continued*

Traffic light cycle	St3				St4				Assigned to
	Case No.	priority	Green period time	Extra time 10%	Case No.	priority	Green period time	Extra time 10%	
Cycle 1	6	3	120 Sc.	12 Sc.	2	4	90 Sc.	9 Sc.	St 4
	6	3	120 Sc.	12 Sc.					St 2
	1	3	120 Sc.	0 Sc.					St 1
	5	2	120 Sc.	0 Sc.					St 3
Cycle 2	6	3	120 Sc.	12 Sc.	4	1	90 Sc.	0 Sc.	St 2
	6	3	120 Sc.	12 Sc.	6	3	90 Sc.	9 Sc.	St 3
					6	3	90 Sc.	9 Sc.	St 1
					5	2	90 Sc.	0 Sc.	St 4
Cycle 3	2	4	120 Sc.	12 Sc.	4	1	90 Sc.	0 Sc.	St 3
					6	3	90 Sc.	9 Sc.	St 1
					6	3	90 Sc.	9 Sc.	St 4
Cycle 4	0	0	120 Sc.	0 Sc.	2	4	90 Sc.	9 Sc.	St 4
	4	1	120 Sc.	0 Sc.					St 2
	1	3	120 Sc.	0 Sc.					St 3
									St 1

7. Comparisons with the Current Traffic Light Controller

According to the results shown in section 6, this section presents a comparison. This comparison is between the proposed intelligent controller and the current controller, which is currently used. The VDR during the green period time for the current controller has been calculated using equation 3. On the other hand, the VDR during the green period time for the proposed intelligent controller has been calculated using Equation 4.

$$\text{VDR During the Green Period Time} = (\text{Green Period Time} + \text{Extra time}) \times \text{VDR per second} \quad (4)$$

For the proposed intelligent controller, Equation 4 has been used instead of Equation 3 because the proposed intelligent controller gives an extra time for the crowded street to give the opportunity for the largest number of traffic condition to departure the street. Figure 14 and 15 illustrate that VDR of the proposed intelligent controller is larger than the VDR of the current controller. In other words the rate of the cars which are depart the street are larger than the current controller, which in turn decreasing the length of vehicles queue.

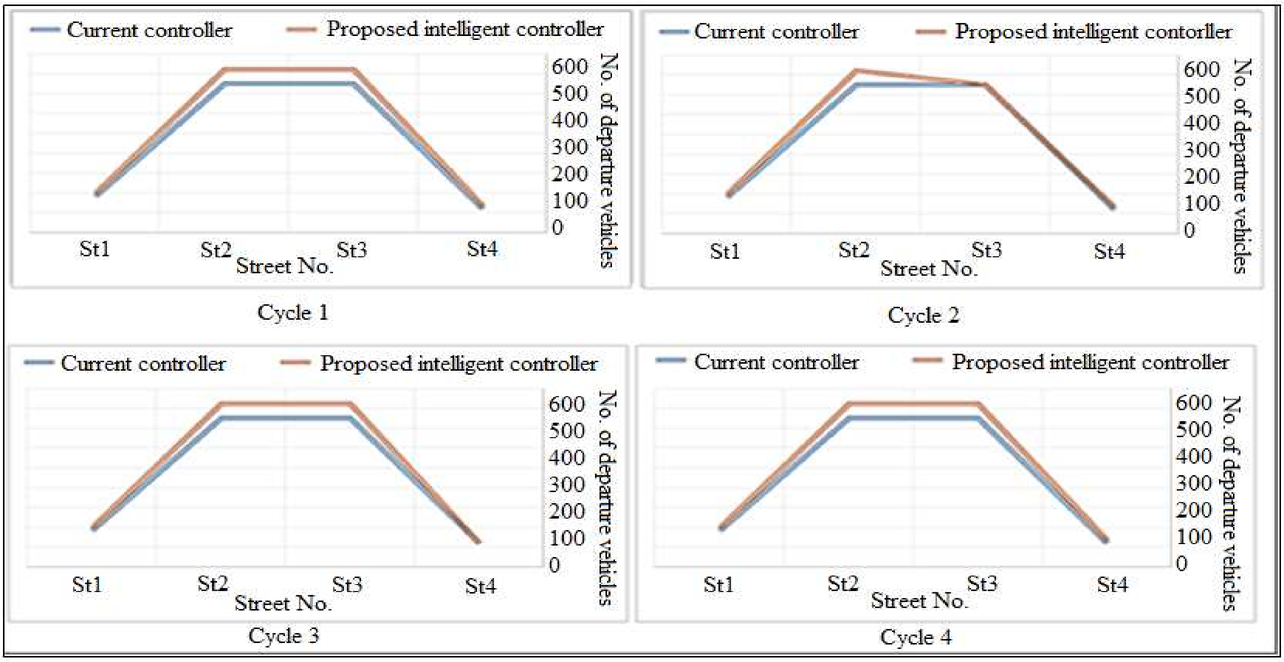

Figure 14. *VDR comparison between the current controller and the proposed intelligent controller for Batu Uban Intersection.*

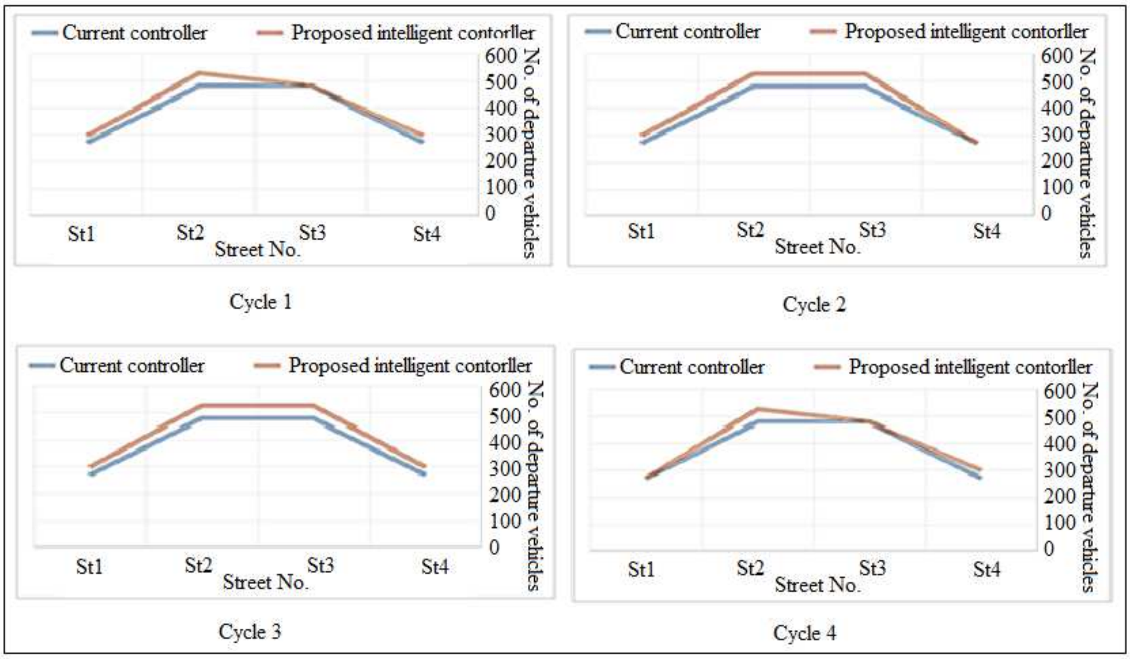

Figure 15. *VDR comparison between the current controller and the proposed intelligent controller for Sungi Nibong Intersection.*

8. Conclusions

Through using of neural networks with multi-connects architecture the controller acquired the susceptibility learning each case faced by the system during working at the intersection. It will be able to learn all the street cases after a few iterations, based on the fact that each intersection has its own causes, which are repeated every day, so the controller will be adapted to its environment quickly. The proposed technique has been applied and tested in two real intersections. The proposed intelligent controller proved its efficiency. Finally, the proposed intelligent controller has been compared with the current controller, which it used in these two intersections. These comparisons indicate that the rate of the vehicles which are departing the intersection's streets are larger than the current controller, which in turn decreasing the length of cars queue.

References

[1] Wiering M. and Veenen J. V. and Vreeken J. and Koopman A.,Intelligent Traffic Light Control, Ercim News, European Research Consortium For Informatics And Mathematics, 2004.

[2] Pérez J., P. G., Silva J. , Cabello E. , Monclús J. and Cristina T. S., A Conflict-Avoiding, Artificial Vision Based, Intelligent Traffic Light Controller. Universidad Rey Juan Carlos,ESCET,C/ Tulipán S/N,28933 Móstoles (Spain),(2) RACE,C/ Isaac Newton 4,28760 Tres Cantos (Madrid), 2004.

[3] Proulx, Viera K., Jeff Raab, and Richard Rasala, Traffic light: A pedagogical exploration through a design space., Journal of Computing Sciences in Colleges. Vol. 15. No. 5. Consortium for Computing Sciences in Colleges, 2000.

[4] Cucchiara R., Image Analysis and Rule-Based Reasoning for a Traffic Monitoring System, IEEE transactions on intelligent transportation systems, vol. 1, no. 2, 2000.

[5] El-Medany, W. M., and M. R. Hussain, FPGA-based advanced real traffic light controller system design. Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, 2007. IDAACS 2007. 4th IEEE Workshop on. IEEE, 2007.

[6] Silvert W., Fuzzy Logic Modelling of Traffic Light, Indicators: DFO Report, 2001.

[7] Gradinescu V., Gorgorin C., Diaconescu R., Cristea V. , Iftode L., Adaptive Traffic Lights Using Car-to-Car Communication , IEEE, 2004.

[8] Conde C. , Serrano A., Licesio J. Rodr´ıguez-Arag´on R., P´erez J., and Cabello E., An Experimental Approach to a Real-Time Controlled Traffic Light multi-Agent Application, In Procs. 3, 2004.

[9] Nijhuis E., Peelen S., Schouten R. , SteingrÄover M., Project Design and Organization of Autonomous Systems: Intelligent Traffic Light Control, 2005.

[10] Brockfeld D. K. E., Ringel J. M. J., Rössel C., Tuchscheerer W, Wagner P., Wösler R. Simulation of modern Traffic Lights Control Systems using the open source Traffic Simulation SUMO, Proceedings of the 3rd Industrial Simulation Conference, 2005.

[11] Zurada J. M. Ed., Introduction to Artificial Neural Systems, West Publishing Company, 1996.

[12] Fausett L.Ed., Fundamental of Neural Networks, Architectures, Algorithms and Applications. Prentice-Hall, 1994.

[13] Abdul Kareem E I, Alsalihy W. A. H and Jantan A., Multi-Connect Architecture (MCA) Associative Memory: A Modified Hopfield Neural Network, Intelligent Automation and Soft Computing, Vol. 18, No. 3, pp. 291-308, 2012 Copyright ©, TSI® Press Printed in the USA, 2012.

[14] Abdul Kaream E. I., Mutar k. N., Moussa H. A ,Gray Image Recognition Using Hopfield Neural Network With Multi-Bitplane and Multi-Connect Architecture. Proceedings of the international Conference on Computer Graphics, Imaging and Visualization (CGIV'06) IEEE, 2006.

[15] Abdul Kaream E. I., Hopfield Neural Network Using Genetic Algorithm. M.Sc. Thesis, High studies institute for computer and information, Baghdad, Iraq, 2001.

[16] Emad I Abdul Kareem, Aman Jantan (2011), "An Intelligent Traffic Light Monitor System using an Adaptive Associative Memory", IJIPM: International Journal of Information Processing and Management, Vol. 2, No. 2, pp. 23 ~ 39.