Intelligent Traffic Control system using cooperated Agents

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Abstract

Increasing in the number of cars over the roads cause the road congestion problem. In fact there is a bottleneck in time distribution for passing vehicles at intersection, and vehicles tend to be lined along the road in one direction but less in the other direction. In this case we can alleviate traffic congestion to improve the efficiency of handling the junction of the traffic by designing an intelligent traffic light system.

We introduced two types of agent, one central agent and other local agents. The local agent located at each intersection which is responsible for updating the light signals. The designed local agent receives the vehicles queue length through the sensors distributed at each side of intersection. Then perform sequence of control instruction to update the time of the green light at each side of the intersection. While the central agent is perceive the local agents status in different locations, then analyze the received data and sort the nodes in different location ; after that share the announcement at each node in the CITY road map that describe the CITY road map at the moment. The announcement changed at each central agent cycle. The system implemented in Babylon City and uses Babylon City road map as a case study.

Keywords: *Cooperated agent, local agent, central agent, road map.*

1. Problem Statement

The current system of traffic light have been provides a fixed traffic control plan, which settings are based on prior traffic counts but may be manually changed. It is the most common form of signal control for nowadays and result in inappropriate behavior in traffic which differs from that which the plan was based, such as the use of unnecessary phases when the traffic is light.

2. Introduction

The primary purpose of traffic signals is to separate conflicting traffic by the division of time, within the available road space, in a safe, efficient and equitable manner.

Nowadays, with the growing number of vehicles, the congestion of the traffic and the delay of transportation in urban roads are increasingly worldwide. So, it is important to develop a system that help balancing the road traffic and make the motorists on highways and urban cities roads more comfort.

The popular configuration is allocating right of way to the roads as distinct time intervals but this is not efficient way, so here we will describe the way that could solve this problem.

3. Looking for the problem previously

Here we will mention two different works, the first: Emad Abdul Kareem, who proposed monitoring system to introduce new additional component to the intelligent traffic light system. This component is able to determine three street cases (empty street case, normal street case and crowded street case) by using small associative memory. The work of that monitoring system consist of two phases: training phase and recognition phase. The experiment was applied by using a program to monitor one intersection in Penang Island in Malaysia. The program can determine different weather conditions for all street cases depending on the stream of images, which are extracted from the streets video cameras. In addition, the observations show a high flexibility to learn all cases of the street using a few training images, thus the adaptation to any intersection can be done quickly [1].

The second work : Yujie Dai, et al., they use a neural network (NN) based signal controller is designed to control the traffic lights in an urban traffic road network. Scenarios of simulation are conducted under microscopic traffic simulation software. Several criterions are collected. Results demonstrate that through online reinforcement training the controllers obtain better control effects than the widely used pre-time and actuated methods under various traffic conditions [3].

4. Basic concepts

Queuing Theory is mainly seen as a branch of applied probability theory. Its applications are in different fields, e.g. communication networks, computer systems, machine plants [2].

4.1 Traffic Control Methods

Influencing and steering a transportation network can be done through several technical means[4]:

- Traffic signals and dynamic signposts.: Adaptive control of the green- andred-phases of traffic lights may significantly reduce waiting times atintersections. This requires optimization of the model-equations. The timefor numerical solutions of these equations can be reduced using artificialintelligence techniques. Some cities (e.g. Dresden in Germany) routevehicle streams on some sections using dynamic signposts in order toachieve better load balancing. This results in hard optimization problems,which can be alleviated by artificial intelligence techniques.
- Navigation recommendations: Traffic information was provided by someradio station in their program to inform drivers of the current traffic situation, thus a driver can circumvent closed roads, delays by accidents ortraffic jams thereby caused. The goal of these efforts is providing a decision support for a driver.

Artificial intelligence techniques which are:

- Expert Systems: These can be classical rule-based systems, or employ more general forms of logic like fuzzy logic, resembling human reasoning more closely than crisp logic does.
- Self-Adapting systems: Neural Networks and Bayesian Networks have the ability to adapt themselves to a required behavior during a learning phase. This class of systems used algorithms likes Genetic Algorithms, resembling Darwin's theory of improvement by selection of those individuals with best survival skills.
- Autonomously acting systems: Combining decision making techniques and self-adaptation principles gives powerful autonomously acting systems, known as agents.

A traffic signal may be operated in one of two ways, when it is installed: pre-timed or actuated. In practice, the installation of isolated pre-timed intersections has become rare. Most signals in isolated circumstances control highly variable traffic, and therefore work better when actuated by traffic [5].
Agents represent the most important new paradigm for software development since object – orientation [6].An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators [4]. The environment that influences an agent's behavior can itself be influenced by the agent. We tend to think of the environment as what influences an agent butin this case the influence is bidirectional: the ant can alter its environment which in turn can alter the behavior of the ant [7].

4.2 Software Agent kinds

The four basic kinds of agent program that embody the principles underlying almost all intelligent systems[4,8]:

1- Simple reflex agents
2- Model-based reflex agents
3- Goal-based agents; and
4- Utility-based agents.

In this work we used simple reflex agent as a local agents and the Model based one for the central agent.

5. The Designed system

The Intelligent traffic control system consists of seven local Agents derived from the number of intersection in the Babylon City and one Central Control Agent.

The local agents deals with the process of time distribution at each intersection and the central agent receive the information from the local agents and after sequence of operations derive the priority of for choosing the suitable routing road. These priorities listed as an advices for the driver at each intersection. Figure(1) represent the block diagram for intelligent traffic control system.

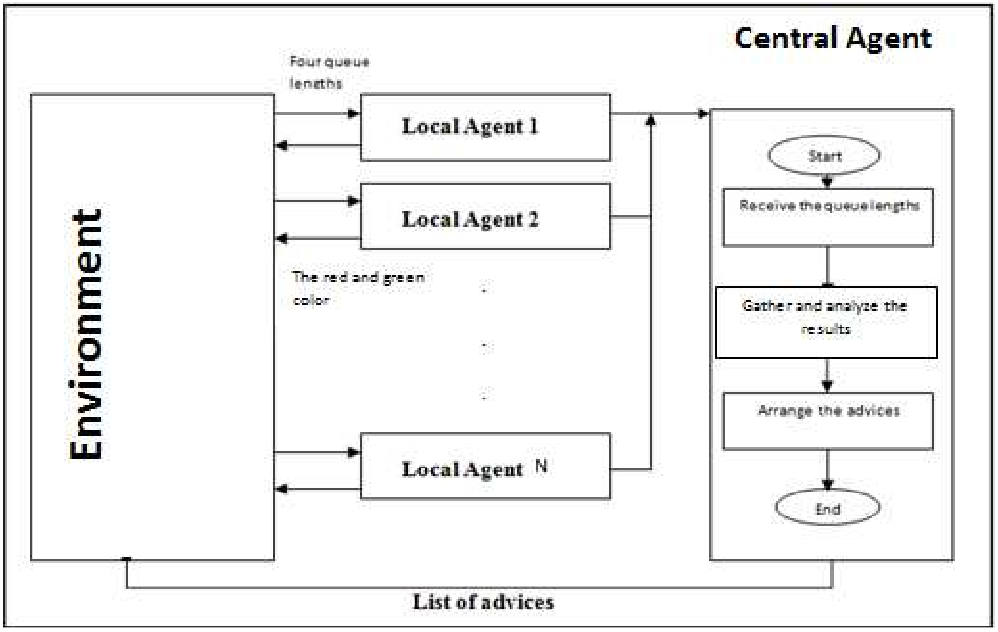

Figure 1. Intelligent Traffic Control System Structure

In this figure the local agents receive the queue lengths at each intersection in different sides and perform sequence of processes and then send the results to the Central Agent, the Central Agent will gather and analyze the results and arrange the priorities to be announced as a list of advices to the drivers at the intersections.

5.1. Local Agent perceptions

The local agent can perceive the vehicle queue using number of active sensors. These sensors could be planned in the ground of each side of intersection along distinct distance (50 meters). This distance represent maximum queue length. We suggest the maximum length of sensory distance from the intersection side which is 50 meters and no matter if the length of queue is longer. And this 50 meters have 10 sensors, 1 sensor per each 5 meters.

5.2 Agent performing steps

We can summarize the local/central agent performing steps as follows:

1- Perceive the vehicle queue in different side of the intersection. If there calculate the queue length accordingly.

2- Computing the time distribution
The green time distribution over each intersection can be computed automatically (this time is cycle time and we can reset it to any number of minutes).
The distributed time evaluated by the following equation:
Green time = queue length * cycle time / summation of queue lengths of the four intersection's sides.
This equation calculated m times at each intersection.

3- Compute the priority of the distribution
In this step, the agent can distribute the green time for each intersection side according to the result of the equation in step 2. In some cases like in the time 2 a.m., the roads become as empty, in such cases the agent distribute the green time equally in the intersection's sides. In other cases when the intersection have unbalanced flow in its sides, In this case the system give a priority to the right side to cross the intersection that have the highest calculated value of green time. Hence, we can get a better service rate.

4- Give a list of advices
The results of pervious two steps will be analyzed and arranged to be derived as a list of advices to select the path that have a shortest time if they need to save the time, or continue in their path if they don't. The benefit of this step as mentioned is to help in saving the time for the drivers.

6. Case Study

The system uses Babylon city as a case study. Babylon city have a seven main intersections named:

1- Hilla -Najaf -Dewaneya intersection.
2- Al_Umm intersection.
3- Bab Al_Mashhad intersection.
4- Al_Tahmazeya intersection.
5- 40 street intersection Al_Jameya intersection..
6- 40 street Bab Al_Husain intersection.
7- The Hilla -Karbala -Baghdad intersection.

This system consider one local agent at each intersection, for the whole city , The central control agent which dedicated in helping the drivers to make a choice for selecting of the optimal routing along to destination; path they intended is done by analyzing and sorting the results of local agents as a list of status of the intersection to inform the drivers about the city's intersections status at the time. So we can consider the system working on the fly. So, the central agent can support on the fly information for the city's intersection.

The interface of the single intersection in the case which represent the intersection with medium flow of vehicles, where the consuming arrival rate is 15 vehicles /cycle. The results in table (1) explain the use of local agent, while the table (2) represents the results of using traditional traffic light configuration. The difference between the two tables shows the efficiency of using the local agent compared with the traditional configuration.

Table 1. arrival rate= 15 vehicle/cycle and the simulation using local agent

No	No. of cycles	Service rate	Avg. W. T (in second)
1	10	73.5%	38
2	20	85.6%	37.8
3	30	90.16%	37.7
4	40	94.26%	37.4
5	50	95.54%	36.99

Table 2. arrival rate=15 vehicle/cycle and the simulation using traditional traffic light

No	No. of cycles	Service rate	Avg. W. T (in second)
1	10	56.38%	47.36
2	20	75.75%	46.45
3	30	80%	45.56
4	40	82.2%	41.47
5	50	84.26%	38

Figure (4) represents the service and delay rates when we use the traditional configuration. And figure (5) represent the service and delay rates using the agent system.

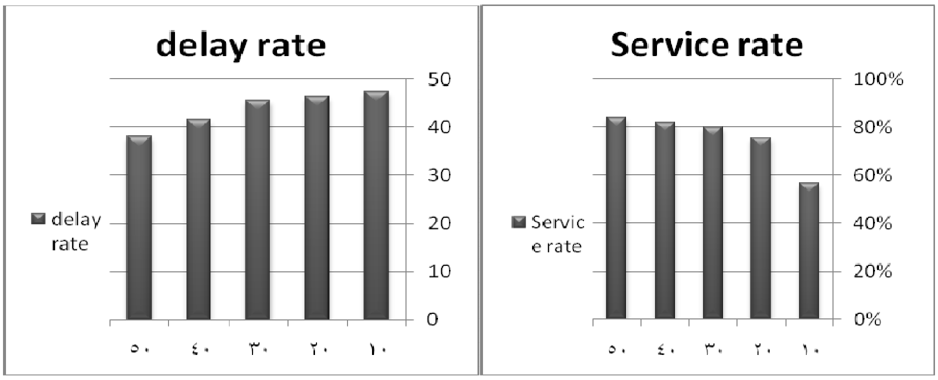

Figure (4) : the results when the AR=15 vehicle/cycle in traditional traffic light

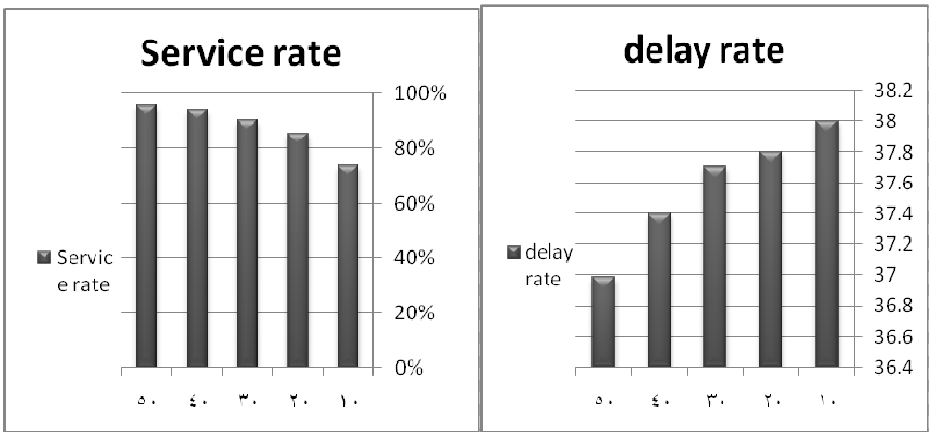

Figure (5) : the results when the AR=15 vehicle/cycle using Agent Subsystem.

When the intelligent traffic control system applied for the seventh intersections in Babylon city in cycles(5, 10, and 15) intersections in we get a perfect service rate and average weights compared with the traditional configuration as seen in table(3) and table(4). Also figures (6, 7) represent the difference between service and delay rates in traditional configuration and using the intelligent traffic agent.

Table 3. using intelligent traffic system

No	No. of cycles	Service rate	Avg. W. T (in second)
1	5	50%	2
2	10	81.5%	8
3	15	86%	19

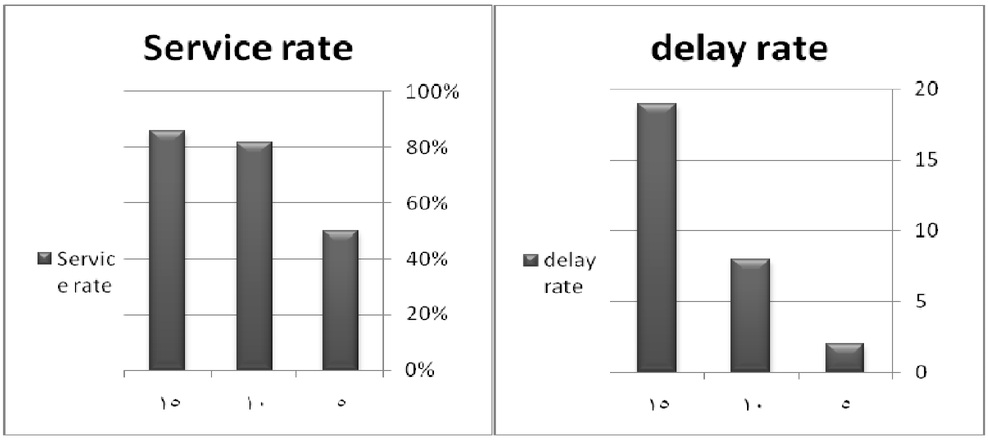

Figure 6. the results of using Agent System

Table 4. using traditional traffic light

No	No. of cycles	Service rate	Avg. W. T (in second)
1	5	45%	6.5
2	10	60%	25
3	15	66%	51

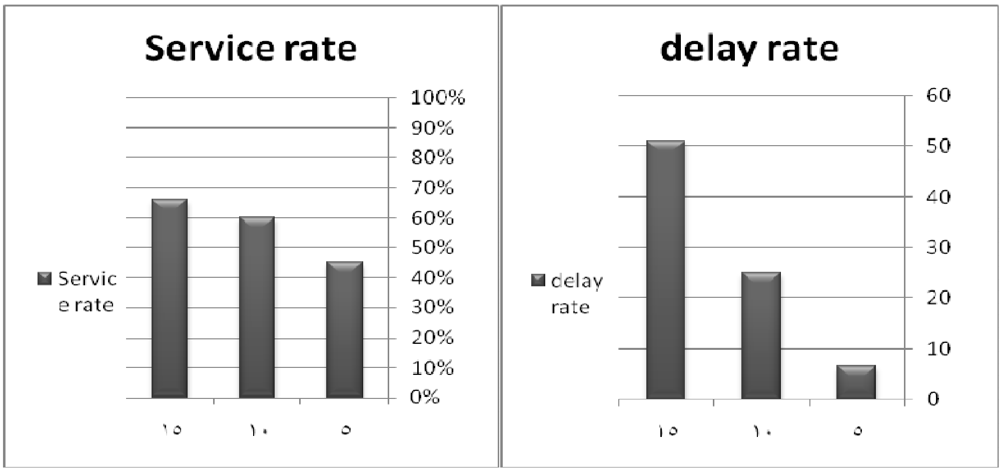

Figure 7. the results of using traditional traffic light

6.Conclusions

The goal of the intelligent traffic control system is to solve a real problem related with the traffic light congestion, which is become a waste time in our life. For this we decide to design software agents to compute the suitable time for green and red period firstly, manage and control the process of distribution the computed time and give the advices of the drivers.

The main advantage of intelligent traffic system is the ability of minimize the delay time in the first morning times or in late night times by rearranging the time value per cycle, which is offer to the driver a chance to access him/his destination in a appropriate time.

This intelligent traffic system performed in the Babylon city's road map and give perfect results. The designed system consists of two software agent types, the first located at each intersection, which can be evaluate the traffic at each intersection and suggest the new traffic light counter. The sensors which are percept the information shared from all local agents and classify the information according to the intersection status after that arrange the information increasingly and share the result to the advisor monitor and we can expand our system to include more than one city.

When we perform our system on the single intersection with arrival rate is 15 vehicles/ cycle and after 40 simulation cycle. The service rate become 82.2% on the traditional single traffic light system. While the service rate become 94.26% on the same single traffic light using the local software agent. Also the average waiting time is 41.47 second on the traditional traffic light system. While it was become 37.4 second using the local software agent. These results show better service rate and short waiting time in our agent.

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