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An Integrated Traffic light Control System Using RFID Technology and Fuzzy logic

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ABSTRACT: In entire world especially in large urban areas traffic congestion and tidal flow management is a growing problem because of the increase in number of vehicles in all countries. Some of the traffic concerns are congestion and accidents which have caused noise pollution, travel time, property damage, fuel usages and environmental pollution. In urban areas, traffic signal controller plays an important role to improve the efficiency of vehicles, traffic congestion and hence reduce noise pollution, travel time, property damage, fuel usages and environmental pollution. Traditional traffic control systems lack the ability to manage with dynamic environments where several factors can affect the decision-making process. We have proposed an integrated traffic light control system using radio frequency identification (RFID) technology and fuzzy logic. The system provides both practically important for traffic light data collection and control information and can trace ambulance, Fire Brigades, VIP/police vehicles, criminal or illegal vehicles such as stolen vehicles that evade tickets, tolls or vehicle taxes. RFID reader has been used in order to identify vehicles and hence we evaluate the average speed of the vehicles, queue length and waiting time. This study improves on the authors' previous work in the field of traffic light control system using fuzzy logic. Software has been developed in MATLAB. Simulation results verify the performance of our proposed integrated traffic light control system using radio RFID technology and fuzzy logic.

Keywords: Radio Frequency Identification, Extension Time, Fuzzy Logic, ITLCS

I. INTRODUCTION

Traffic congestion of streets and roads constitutes a critical problem which is aggravated by the rise in the number of vehicles and by greater urbanization. The slow pace in the development of new highways and roads and public opposition to the widening of existing streets in some locations has forced the city managers to optimally use the existing infrastructures in order to effectively manage the flow of traffic. Moreover the loss of valuable time during traffic congestion can directly affect the production, productivity, performance and the utilization of fuel. The control of traffic light signal is one of the subjects of intelligent or advance systems being investigated by researchers because this kind of control has a direct impact on the effectiveness of urban transportation systems (Shahraki et al. 2013).

Radio Frequency Identification (RFID) is widely used in many applications like inventory tracking, personal identification, e-money and e-shipment transactions and gaming.

RFID is a contactless wireless device consists of tag and reader. The complexity of RFID systems differ from one application to another. RFID is very common in access control applications where access control information is usually stored in backend database.

Traffic signals operate in pre-timed, actuated or adaptive mode. Pre-timed control consists of a series of intervals that are fixed in duration. They repeat a preset constant cycle. In contrast to pre-timed signals actuated signals have the capability to respond to the presence of vehicles or pedestrians at the intersection. Vehicle actuated signals require actuation by a vehicle on one or more approaches in order for certain phases or traffic movements to be serviced. They are equipped with detectors and the necessary control logic to respond to the demands placed on them. Vehicle-actuated control uses information on current demands and operations obtained from detectors within the intersection to alter one or more aspects of the signal timing on a cycle-by-cycle basis.

Timing of the signals is controlled by traffic demand. Adaptive or area traffic control system (ATCS) is the latest generation of traffic control system. ATCS continuously compute optimal signal timings based on this detected volume and simultaneously implement them. Over the course of performing a literature review, adaptive traffic signal systems have been operating successfully in many countries since the early 1970. Adaptive traffic signal control systems are normally complicated and include prediction and estimation modules. More than twenty Adaptive traffic signal controls are available on the market. They are significant due to their relative acceptance in the field as well as the relative extent of their real world implementation. The most widely deployed control systems are discussed here. In the early 1980, Nathan Gartner at the University of Massachusetts at Lowell proposed a traffic control system called as Optimized Policies for Adaptive Control for the Federal Highway Administration. Optimized Policies for Adaptive Control sometime called as OPAC. The Split Cycle Offset Optimization Technique (SCOOT) was also developed in the early 1980 by the Transport Research Laboratory in the United Kingdom. The Sydney Coordinated Adaptive Traffic System (SCATS) is slightly newer, having been created in the early 1990 by the Roads and Traffic Authority of New South Wales, Australia. The Real-time Hierarchical Optimized Distributed Effective System (RHODES) is the newest of these four systems, having been produced in the mid-1990 at the University of Arizona at Tucson.

A decentralized adaptive traffic signal control method known as ALLONS-D (Adaptive Limited Look-ahead Optimization of Network Signals – Decentralized) presented by Porche (1997) in his dissertation based on a depth-first branch and bound algorithm. More recently, Yu and Recker (2006) developed a stochastic adaptive traffic signal control model. The authors formulated traffic signal control as a Markov Decision Process (MDP) and solved it by dynamic programming. Although dynamic programming algorithm can be used to solve this MDP problem and is guaranteed to find the optimal policy (Gosavi, 2003), it needs a well-defined state-transition probability function. An intersection traffic signal control application in addition to the number of states is usually very large. The dynamic programming algorithm to calculate the time could make a serious problem.

The first RFID application was the "Identification Friend or Foe" system (IFF) and it was used by the British in the Second World War (Jechlitschek C. 2006). Initially RFID tags were developed to eventually replace barcodes in supply chains. Their advantages are that they can be read wirelessly and without line of sight, contain more information than barcodes and are more robust. RFID transponders (tags) consist of Microchip, Antenna, Case and Battery (for active tags only). We distinguish 3 types of RFID tags in relation to power or energy i.e. Passive, Semi-passive and Active. RFID tags fall into three categories in respect to frequency i.e. Low frequency (LF, 30 - 500 kHz), High frequency (HF, 10 - 15MHz) and Ultra high frequency (UHF, 850 - 950MHz, 2.4 - 2.5GHz, 5.8GHz).

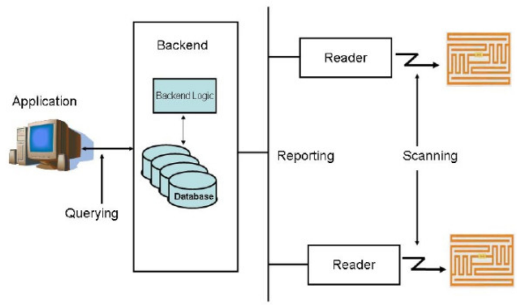


Fig. 1. Illustration working of RFID System.

There are many uses of this technology around us today, although they are often invisible to users by Kaur et al. (2011). We may find that you are already carrying and using a RFID tag or even several. At its most basic level RFID is a wireless link to uniquely identify objects or people. It is sometimes called dedicated short range communication (DSRC). RFID systems include electronic devices called transponders or tags, and reader electronics to communicate with the tags. These systems communicate via radio signals that carry data either unidirectional or bidirectional. As shown in figure 1, when a transponder enters a read zone, its data is captured by the reader and can then be transferred through standard interfaces to a host computer, printer, or programmable logic controller for storage or action.

- The antenna emits radio signals to activate the tag and to read and write data to it.
- The reader emits radio waves in ranges of anywhere from one inch to 100 feet or more, depending upon its power output and the radio frequency used. When an RFID tag passes through the electromagnetic zone, it detects the reader's activation signal.
- The reader decodes the data encoded in the tag's integrated circuit (silicon chip) and the data is passed to the host computer for processing.

The purpose of an RFID system is to enable data to be transmitted by a portable device called a tag, which is read by an RFID reader and processed according to the needs of a particular application.

The data transmitted by the tag may provide identification or location information, or specifics about the product tagged, such as price, color, date of purchase, etc. RFID technology has been used by thousands of companies for a decade or more. . RFID quickly gained attention because of its ability to track moving objects. As the technology is refined, more pervasive and invasive uses for RFID tags are in the works.

A typical RFID tag consists of a microchip attached to a radio antenna mounted on a substrate. The chip can store as much as 2 kilobytes of data. To retrieve the data stored on an RFID tag, we need a reader. A typical reader is a device that has one or more antennas that emit radio waves and receive signals back from the tag. The reader then passes the information in digital form to a computer system. Once a link is established with a unique ID on an item, then automation of an assortment of processes ensures.

However this type of methods still has the problems that under certain circumstances, the excessive computation requirement makes some systems based on dynamic programming and Markov decision process require accurate traffic arrival information for the next one or two minutes to determine the best control plans. This information is very difficult to obtain. These systems take ordinary variable in computation. Therefore it is necessary to improve the traffic controller for effective traffic management and better traffic flow, we use linguistic variable in place of ordinary variable.

Fuzzy logic enables the implementation of rules very similarly to what goes on in the human thinking process. In other words, fuzzy controllers have the ability to take decision even with incomplete information. More and more sophisticated controllers are being developed for traffic control. These algorithms are continually improving the safety and efficiency by reducing the waiting delay of vehicles on signals. This increases the tempo of travel and thus makes signals more effective and traffic flow smooth. The key motivation towards fuzzy logic in traffic signal control is the existence of uncertainties in signal control. Decisions are taken based on imprecise information and the effect of evaluation is not well known.

In this paper we discuss an integrated traffic light control system (ITLCS) for isolated intersection using fuzzy logic based technology which has the capability of mimicking human intelligence for controlling traffic light. We used fuzzy logic tools available with MATLAB and developed software to simulate the situation of traffic at an isolated junction.

The simulated model used for the analysis of efficiency of traffic light controller. RDIF reader has been used in order to identify vehicles and hence we evaluate the average speed of the vehicles, queue length and waiting time. The software can also be used as an exercise for undergraduate and graduate students to understand the concept of fuzzy logic and its application to a real life environment. The rules and membership functions of the fuzzy logic controller can be selected and changed their outputs can be compared in terms of several different representations.

II. RELATED WORKS

In this section, we discuss different research work in the field of traffic light system using RFID technology and fuzzy logic. The first attempt made to design fuzzy traffic controller was in 70s by Pappis and Mamdani (1977). Kelsey and Bisset also designed a simulator for signal controlling of an isolated intersection with one lane. Same work was also done by Niittymaki and Pursula (2000). They observed that Fuzzy Controller reduces the vehicle delay when traffic volume was heavy. Niittymaki and Kikuchi developed Fuzzy based algorithm for pedestrians, crossing the road.

Initially fuzzy logic was used to control traffic in multiple intersections by Chui (1992). In this research only two way streets are evaluated without considering any left or right turn. A two stage traffic light controller proposed by Trabia *et al.* (1999). In the first stage, observed approach traffic flows are used to estimate relative traffic intensities. These traffic intensities are then used in the second stage to decide current green signal should be extended or terminated for through movements without considering any left or right turn. The isolated intersection model proposed by Soh, A. C., Rhung, L. G., and Sarkan, H. M. (2010), used consists of two lanes in each phase. There are two inputs i.e. vehicles queue length and waiting times for each phase. The maximum values of these inputs are selected for controller to optimized control of traffic flows. A fuzzy logic traffic system proposed by Zaied, A. N. H., and Othman, W. A. (2011), that considers the two two-way intersections and is able to adjust changes in time intervals of a traffic signal based on traffic situation level.

Indrabayul *et al*. (2014), an adaptive timely traffic light is proposed as solution for congestion in typical area in Indonesia. Makassar City, particularly in the most complex junction is observed for months using static cameras.

Shahraki *et al.* (2013), a new fuzzy logic based algorithm is proposed there are three stages i.e. next green phase, green phase extender and the decision stage.

Collotta *et al*. (2015), a novel approach to dynamically manage the traffic lights cycles that combines Wireless Sensor Network for real time traffic monitoring with multiple fuzzy logic controllers, one for each phase that work in parallel.

Mohammadia *et al*. (2012), discuss a paper entitled "Controlling of Traffic lights Using RFID Technology and Neural Network" in this paper RFID technology has been used in order to identify vehicles. They have been used neural network for making the best decision throughout the process of finding out duration of the cycle and percentage of green time for each of the access point.

Al-Zewairi *et al.* (2016), discuss a paper entitled "Multilevel Fuzzy Inference System for Risk Adaptive Hybrid RFID Access Control System." In this research, a multilevel fuzzy inference system is designed as a supplementary risk assessment model where risk is estimated using fuzzy logic controller.

Jomaa *et al.* (2017) discuss a paper entitled "An Integrated Model to Control Traffic Lights: Controlling of Traffic Lights in Multiple Intersections using Fuzzy Logic and Genetic Algorithm," In this paper author proposed a model to adjust the timing and the green phase of traffic light according to the current situation in multiple intersections, every intersection will be controlled by traffic signals. The green light interval time length shall provide at an intersection will be decided by FL. the outputs of fuzzy logic will be optimized by genetic algorithm in order to obtain a higher performance. This performance can be measured considering the reduction in the waiting time and the total amount of vehicles that arrived to the queue of the three intersections. The model will decide how long the green light interval time shall be provided in each road at an intersection in order to decrease the traffic congestion.

In the case where other than RFID are used in the system such as image processing or traffic sensor are no so efficient due to computational overhead. The algorithm proposed in this work will improve their performance by reducing the size of computational data, since the size of RFID tag data only several bytes long and provides proper basis for the estimation assume in normal fuzzy logic analysis procedure discussed in Collotta *et al.* (2015), Indrabayul *et al.* (2014) and Shahraki *et al.* (2013) etc. as well as this study improves and optimizes traffic flow.

III. DESCRIPTION OF THE PROPOSED INTEGRATED TRAFFIC LIGHT CONTROL SYSTEM (ITLCS)

Investigation on the driving behaviors indicates that it is dangerous to change dynamic phase composition because this may disturb the drivers' mental status and may get nervous. In our proposed integrated traffic light control system using RFID technology and fuzzy logic model it is assumed that phase composition is predetermined and the phase sequence as well as signal timing is changeable.

From the review of literature related with traffic light system it has reported that fuzzy logic controllers perform better than pre-timed, actuated and adaptive controllers. However the phase changes in sequential order without considering the urgency of the red phases. In this paper, an integrated traffic light control system (ITLCS) using RFID technology and fuzzy logic will not only decide whether to extend or terminate a current green phase but also decide which red phase will be set as green phase then determine the extension time of green phase. Therefore in this integrated traffic light system the phase sequence is uncertain. The general structure of intersection is illustrated as in figure 3. Each lane equipped with three RFID readers. In integrated traffic light control system there are RFID tags, RFID reader, wireless network, server, knowledge base and data bank as shown in figure 2 .In this system each vehicle has got to have an RFID tag. In this database each vehicle including the made, size, PUC, validity of vehicle, number, insurance validity driver's identification, etc. will be saved and as soon as it passes first RFID reader the data would be read. System checks this data and forward to control system. Firstly the most important thing is to specify the vehicles arriving at an intersection and evaluate average speed of vehicles at each lane of intersection. The system must be so intelligent that it schedule each side on its conditions in a way that vehicles can leave intersection as fast as possible. The other important parameter for decision making in this model is the average waiting time of vehicles which is recorded by passing of the vehicle by RFID reader in this system. Once they reach at the intersection their arrival time is recorded and until they have not left the intersection the waiting time increases and the more this time increases it has a direct effect on decision making.

The other parameter is the waiting queue length which unlike the previous systems can be effortlessly calculated in a way that the size of vehicle is retrieved from backend database as per the RFID tag read and finally by some uncomplicated calculations the queue length is estimated and it has a direct effect on decision making for traffic lights timing.

There are two different modules namely traffic urgency decision module (TUDM) and extension time decision module (ETDM). In the first stage TUDM, calculates urgency for all red phases. On the bases of urgency degree, proposed system selects the red light phase with large traffic urgency as the next phase to switch. In second stage ETDM, calculates green light time i.e. extension time of the phase which has higher urgency according to the number of vehicles.

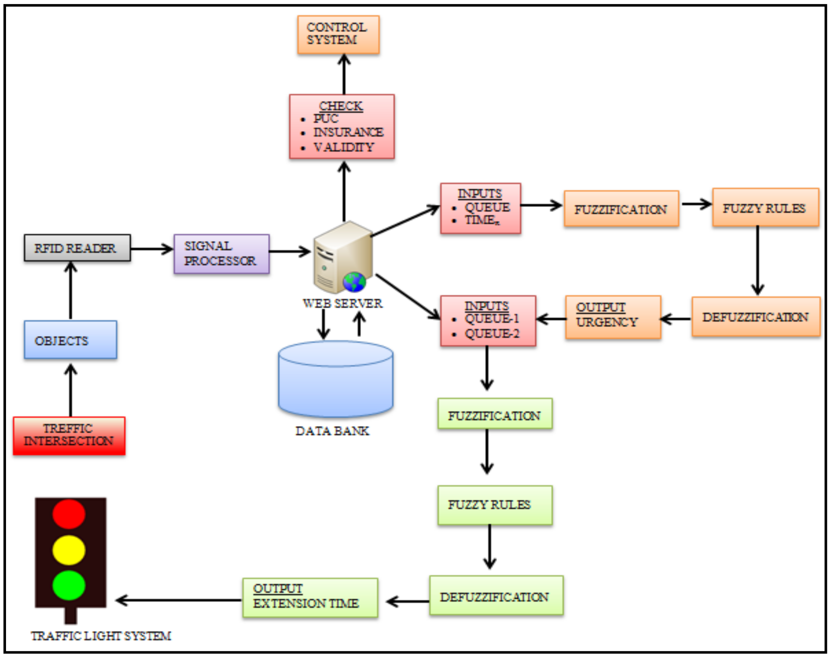


Fig. 2. General Structure of Integrated Traffic Light Control System.

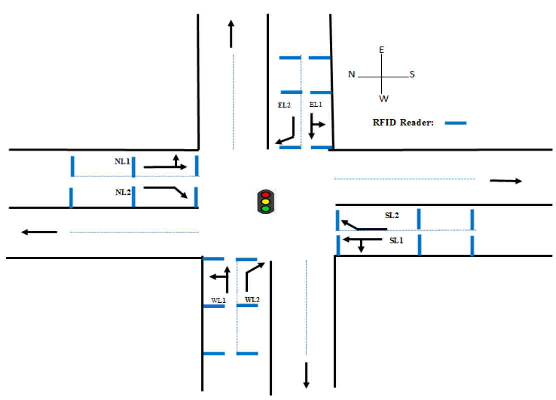


Fig. 3. General Structure of intersection.

The isolated intersection considered as in figure 3 is characterized by four phases as in figure 6 with eight lanes. Each phase has two lanes. As we discuss earlier the objective of phase design is to separate the conflicting movements in an intersection into various phases so that movements in a phase should have no conflicts.

For example, when Phase 1 is enabled, only the cars of Lane EL1 of the Road direction E (East) and Lane WL1 of the Road direction W (West) can go straight or turn left, while all the other lanes will have the red light to stop. Table 1 summarizes the notation adopted in integrated traffic light control system (ITLCS). As shown in figure 3 the length of each phase is obtained as the maximum of the queue lengths intended as the number of vehicles during the green/red light in their respective lanes as shown-

Phase1= maximum (WL1, EL1)
Phase2 = maximum (WL2, EL2)
Phase3 = maximum (NL1, SL1)
Phase4 = maximum (NL2, SL2)

Table 1: Notation.

SYMBOL	LANE	MOVEMENT ALLOWED
EL1	EAST LANE-1	STRAIGHT AND LEFT
EL2	EAST LANE-2	RIGHT
WL1	WEST LANE-1	STRAIGHT AND LEFT
WL2	WEST LANE-2	RIGHT
NL1	NORTH LANE-1	STRAIGHT AND LEFT
NL2	NORTH LANE-2	RIGHT
SL1	SOUTH LANE-1	STRAIGHT AND LEFT
SL2	SOUTH LANE-2	RIGHT

First we calculate the speed of vehicles between RFID readers using equation [1] and equation [2]. Therefor we calculate average speed of vehicles using equation number [3].

$$speed_1 = \frac{Location_{RFID-1} - Location_{RFID-2}}{Time_{RFID-1} - Time_{RFID-2}} \quad \text{.........................[1]}$$

$$speed_2 = \frac{Location_{RFID-2} - Location_{RFID-3}}{Time_{RFID-2} - Time_{RFID-3}} \quad \text{.........................[2]}$$

$$Average\ speed = \frac{speed_1 + speed_2}{2} \quad \text{.........................[3]}$$

A. Traffic Urgency Decision Module

Traffic urgency decision module (TUDM) calculates urgency for all red phases as shown in figure 4. On the bases of urgency degree, proposed system selects the next red light phase to switch. There are two input variables namely *Queue, $Time_r$* and one output variable namely *Urgency*.

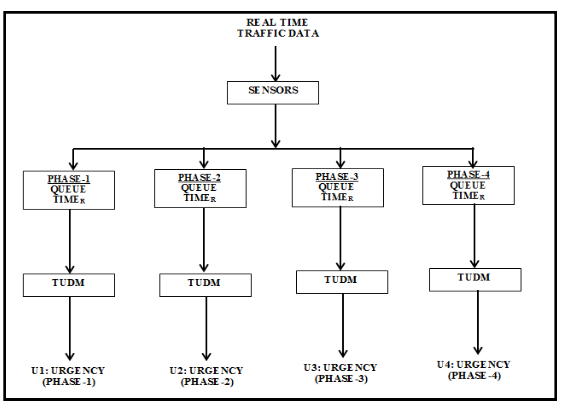


Fig. 4. Proposed Traffic urgency decision module.

The input variable *Queue* count the number of vehicles of current red light phase and variable *$Time_r$* count the duration of red light since the last end of the green light. The output variable *Urgency* is traffic urgency of red light phases. Therefore for instance in the case of Phase 1, TUDM will determine the urgency (U1) by processing the queue length and duration of red light since the last end of the green light of phase 1. Similarly, for phase 2, TUDM will determine the urgency (U2) by processing the queue length and duration of red light since the last end of the green light of phase 2 and so on.

B. Extension Time Decision Module

Extension time decision module (ETDM), calculate green light time i.e. extension time of the phase which has higher urgency can be calculated according to the number of vehicles as shown in figure 5**.** There are two input variables namely *Queue-Lane-1, Queue-Lane-2* and one output variable *Extension-Time*. The input variable *Queue-Lane-1* count the number of vehicles of lane 1 and input variable *Queue-Lane-2* count number of vehicles of other side i.e. lane 2 of red light phase which has big traffic urgency.

The output variable *Extension-Time* is the extension time of current green light phase. Therefore for instance in the case of Phase 1, ETDM will determine the green light duration i.e. extension time (E1) by processing the queue length of the Lane EL1 of the Road direction E and Lane WL1 of the Road direction W. Similarly, for phase 2, ETDM will determine the extension time (E2) by processing the queue length of the Lane EL2 of the Road direction E and Lane WL2 of the Road direction W and so on.

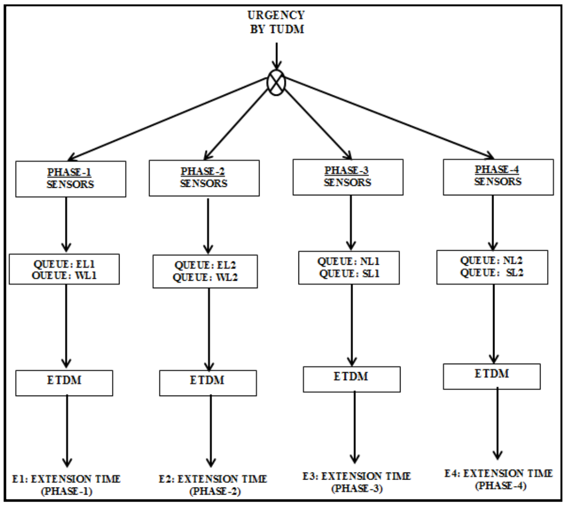
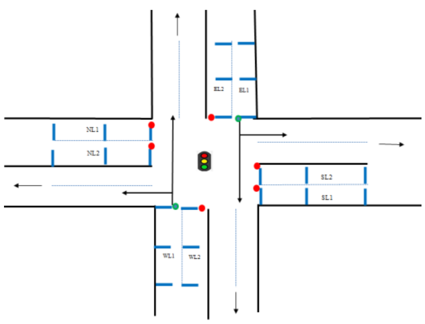
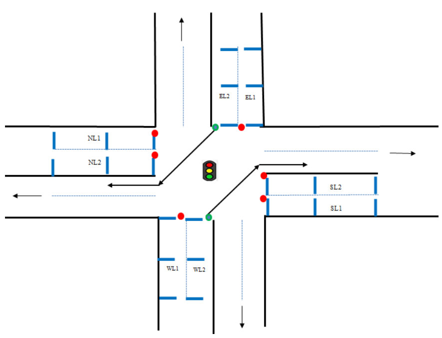


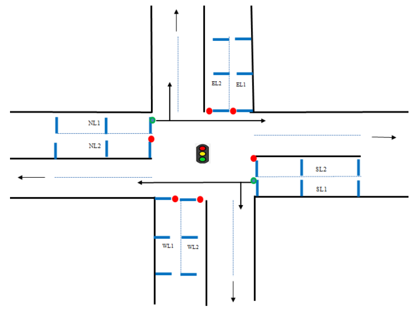
Fig. 5. Proposed extension time decision module.



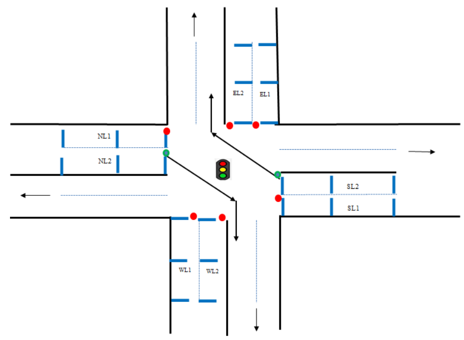
Phase-1



Phase-2



Phase-3



Phase-4

Fig. 6. Phases of Traffic light.

IV. FUZZY PARAMETERS AND THEIR MEMBERSHIP FUNCTIONS DESIGN

For an integrated traffic light control system (ITLCS) using RFID technology and fuzzy logic, there are five membership functions such as Zero, Small, Medium, Large and Very-Large for each of the input as well as output fuzzy variable of the system. There are two input variables *Queue* and $Time_r$ and one output variable *Urgency* for traffic urgency decision module as shown in figure 7, figure 8 and figure 9 respectively. For extension time decision module, we designed two input variables namely *Queue-Lane-1, Queue-Lane-2* and one output variable *Extension-Time* as shown in figure 11, figure 12 and figure 13 respectively. Each input and output fuzzy variable is design using triangular membership function.

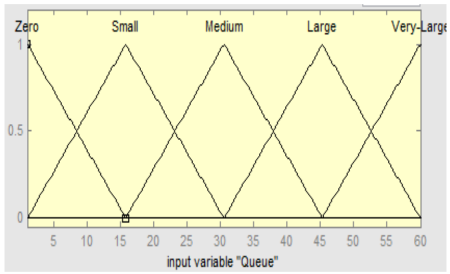


Fig. 7. Queue membership.

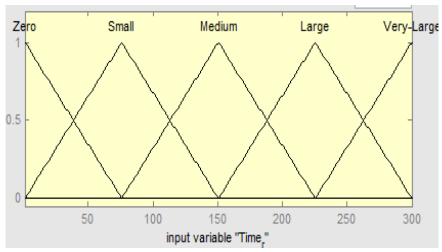


Fig. 8. Time$_r$ membership.

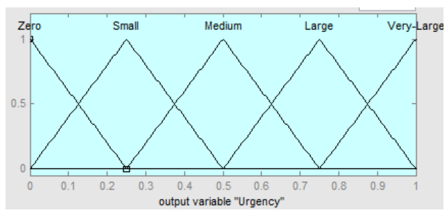


Fig. 9. Urgency membership.

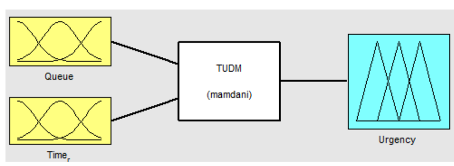


Fig. 10. The whole design structure of TUDM using Mamdani Method.

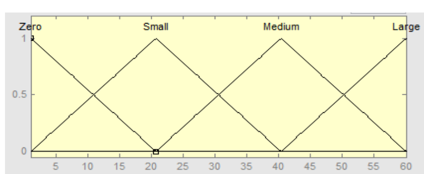


Fig. 11. Queue-Lane-1 membership.

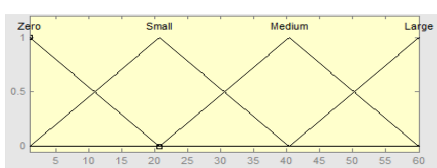


Fig. 12. Queue-Lane-2 membership.

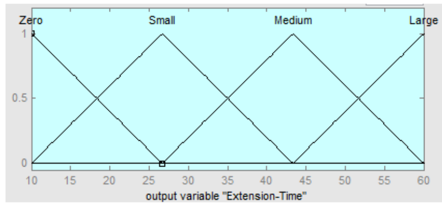


Fig. 13. Extension-Time membership.

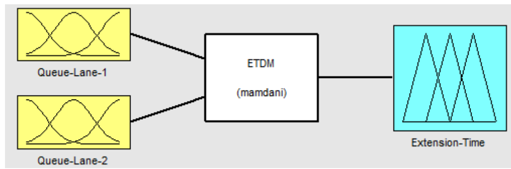


Fig. 14. The whole design structure of ETDM using Mamdani Method.

V. FUZZY RULES AND DEFUZZIFICATION

The inference mechanism in the fuzzy logic controller resembles that of the human reasoning process. Fuzzy logic technology is associated with artificial intelligence. For example, a traffic policeman managing a junction say, one from the east and one from the north he would use his expert opinion in controlling the traffic more or less in the following way:

IF traffic from the east side of the city is VERY-LARGE and traffic from the north sides is SMALL then allow movement of traffic to the east side LONGER

In integrated traffic light control system using fuzzy logic, we develop two different modules namely traffic urgency decision module (TUDM) and extension time decision module (ETDM).

1. If (Queue is Zero) and (Time_r is Zero) then (Urgency is Zero) (1)
2. If (Queue is Zero) and (Time_r is Small) then (Urgency is Small) (1)
3. If (Queue is Zero) and (Time_r is Medium) then (Urgency is Medium) (1)
4. If (Queue is Zero) and (Time_r is Large) then (Urgency is Medium) (1)
5. If (Queue is Zero) and (Time_r is Very-Large) then (Urgency is Large) (1)
6. If (Queue is Small) and (Time_r is Zero) then (Urgency is Zero) (1)
7. If (Queue is Small) and (Time_r is Small) then (Urgency is Small) (1)
8. If (Queue is Small) and (Time_r is Medium) then (Urgency is Medium) (1)
9. If (Queue is Small) and (Time_r is Large) then (Urgency is Large) (1)
10. If (Queue is Small) and (Time_r is Very-Large) then (Urgency is Large) (1)

Fig. 15. Fuzzy rules for TUDM develop in MATLAB.

1. If (Queue-Lane-1 is Zero) and (Queue-Lane-2 is Zero) then (Extension-Time is Zero) (1)
2. If (Queue-Lane-1 is Zero) and (Queue-Lane-2 is Small) then (Extension-Time is Small) (1)
3. If (Queue-Lane-1 is Zero) and (Queue-Lane-2 is Medium) then (Extension-Time is Medium) (1)
4. If (Queue-Lane-1 is Zero) and (Queue-Lane-2 is Large) then (Extension-Time is Large) (1)
5. If (Queue-Lane-1 is Small) and (Queue-Lane-2 is Zero) then (Extension-Time is Small) (1)
6. If (Queue-Lane-1 is Small) and (Queue-Lane-2 is Small) then (Extension-Time is Small) (1)
7. If (Queue-Lane-1 is Small) and (Queue-Lane-2 is Medium) then (Extension-Time is Medium) (1)
8. If (Queue-Lane-1 is Small) and (Queue-Lane-2 is Large) then (Extension-Time is Large) (1)
9. If (Queue-Lane-1 is Medium) and (Queue-Lane-2 is Zero) then (Extension-Time is Medium) (1)
10. If (Queue-Lane-1 is Medium) and (Queue-Lane-2 is Small) then (Extension-Time is Medium) (1)

Fig. 16. Fuzzy rules for ETDM develop in MATLAB.

In TUDM 25 fuzzy rules have been found and for ETDM 16 rules have been found. The some fuzzy rules are used for designing TUDM and ETDM shown in the figure 15 and figure 16 respectively.

In the fuzzy logic controller once the appropriate rules are fired, the degree of membership of the output fuzzy variable i.e., Urgency is determined by encoding the antecedent fuzzy subsets in this case Queue, $Time_r$ and the output fuzzy variable i.e. Extension-time is determined by encoding the antecedent fuzzy subsets, in this case Queue-Lane-1, Queue-Lane-2. In integrated traffic light control system using fuzzy logic the max-min implication technique is used. Using this technique the final output membership function for each rule is the fuzzy set assigned to that output by clipping the degree of truth values of the membership functions of the associated antecedents. Once the membership degree of each output fuzzy variable is determined all of the rules that are being fired are then combined and the actual crisp output is obtained through defuzzification. The procedure of converting each aggregated fuzzy output set into a single crisp value is called defuzzification. In traffic urgency decision module and extension time decision modules we use centroid defuzzification method.

VI. SIMULATION RESULT AND DISCUSSION

After an integrated traffic light control system was carefully designed, we test the system and discuss the impact of the input variables on the output variable. With the help of simulation we show the effect of the two inputs *Queue, $Time_r$* and *Queue-Lane-1, Queue-Lane-2* to resulted *Urgency* and *Extension-Time* respectively.

As shown in figure 17, the urgency (z-axis) is small when the value of Queue (x-axis) and $Time_r$ (y-axis) have a small value. The urgency grows fastly and gets a maximum value when the queue side is being too many and the $time_r$ density become small. On the other hand, urgency grows fastly and gets a maximum value when the queue side is being small and the $time_r$ density become too large.

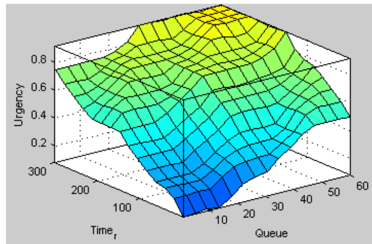


Fig. 17. Input variables Queue, $Time_r$ Vs output variable Urgency using centroid defuzzification method.

As shown in figure 18 as well as Table 2, the extension time (z-axis) is small when the value of queue-lane-1 (x-axis) and queue-lane-2 (y-axis) have a small value. The extension time grow slowly and have a long value when both the queue-lane-1 side and the queue-lane-2 go to medium to large value. If one of the queue-lane sides constant and other side increase then extension time also increase this is equivalent to actual method.

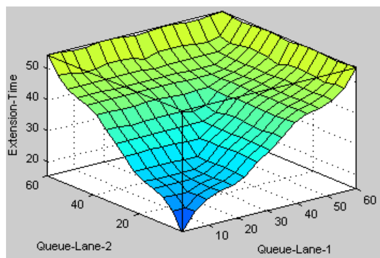


Fig. 18. Input variables Queue-Lane-1, Queue-Lane-2 Vs output variable Extension-Time using centroid defuzzification method.

As shown in Table 2 result of extension time decision module and actual method are very close. In maximum situation extension time taken by ETDM is similar to actual method. But ETDM take less time than fixed time controller without making unstable conditions in the traffic flow. Extension time of actual method are found with the help of equation [4]

$$\textbf{Extension Time} = \frac{\textbf{Average Distance}}{\textbf{Average Speed}} = \frac{\mathbf{2.67 \times n + 20}}{\mathbf{2.78}} \quad \textbf{..........[4]}$$

Where n is no of vehicles and average distance is 180 meter (160+20) the distance from last vehicle in the queue to cover the intersection and average speed is 10 km/h or 2.78 m/sec.

Table 2: Comparison of ETDM and Actual method.

No of vehicles (Maximum =60)		Extension time (in seconds)	
Queue Lane-1	Queue Lane-2	ETDM	Actual Method
4	4	19	11
6	6	22	13
12	12	25	19
15	15	25	22
18	18	27	25
25	25	31	31
30	30	35	36
35	35	38	40
40	40	42	45
15	20	27	26
15	25	31	31
15	30	35	36
15	35	38	40
15	40	43	45
20	15	27	26
25	15	31	31
30	15	35	36
35	15	38	40
40	15	43	45
50	15	45	55
60	15	54	64

VII. CONCLUSION AND FUTURE WORKS

The proposed integrated traffic light control system using RFID technology and fuzzy logic considers not only the priority of the phase but also the density of the vehicles on the road and controls the traffic light sequence efficiently, more accurately. The accuracy of the RFID is more than image processing system or sensor, so it also improves and optimizes traffic flow, hence reduces noise pollution, travel time, property damage, fuel usages, environmental pollution and alert message to the control system for PUC, validity of vehicle, insurance validity etc. The feature of integrated traffic light control system compared to other systems which are generally based on sensors or binocular implement is that it could be enabled in any place, weather condition and in the shortest time possible. The ITLCS can trace ambulance, Fire Brigades, VIP/police vehicles, criminal or illegal vehicles such as stolen vehicles that evade tickets, tolls or vehicle taxes also it is possible to consider a high priority to these types of vehicle at intersection. One of the other RFID advantage is that since the system data is read by RFID tag, in case of a driver's violation it will be recorded and hence presence of traffic police is not required. The legal issues and privacy laws relating to the monitoring of drivers all the time may cause a major public concern. Such study would need to address subjects relating to civil rights and personal freedom issues as well as social acceptance.

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