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A Novel Approach for Adaptive Traffic Light Control System

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ABSTRACT: ***Nowadays, the number of vehicles has increased exponentially, but the capacities of roads and transportation systems have not developed in an equivalent way to efficiently cope with the number of vehicles traveling on them. A static control system may block emergency vehicles due to traffic jams. Wireless Sensor networks (WSNs) plays a vital role in developing a dynamic traffic control system. Various researches on different Traffic Management System has been done to avoid congestion, ensure priority for emergency vehicles and reduce the Average Waiting Time (AWT) at the road junctions. In recent times researchers have started to monitor the traffic congestion using WSNs, RFIDs, ZigBee, VANETs, Bluetooth devices, cameras and infrared signals. In this paper a survey on different traffic control strategies that reduce congestion and chaos are discussed.***

Keywords: Traffic Control, Traffic Light Control, Density based traffic control, Traffic sensing, Wireless sensor networks

I. Introduction

Over the years vehicle usage has increased widely. Road traffic control is a most elemental level technique that is achieved through the use of signs, signals, and markings. In early days stop signs always have a red background and are octagonal in shape. This design standard allowed the motorist to quickly perceive the sign in the visual field along the road. Standard use of colours and shape aids are the identification in deciding the appropriate course of action. The location of warning signs for a dangerous intersection were placed sufficiently in advance to compensate the vehicle longer stopping distance. The traffic conditions had become complicated. Traffic Lights are used to control traffic at road intersections. The traffic light mechanism on the road operates according to a fixed periodic schedule. In the junction of 4 roads the traffic light function in a timely fashion. When one lane has green signal, the other lanes should wait for particular amount of time. This process is repeated in regular fashion. In this process, even the lane with heavy traffic should also wait for the same amount of time and this leads to chaos. Traffic signals may be controlled based upon the density of the vehicles. The early signs of road traffic control devices are Regulatory, Stop, Yield, Speed limit, Minimum speed, Do Not Enter, Wrong Way, One Way etc. It also includes some of the markings such as pavement and curb making, object marking, delineation, coloured pavement. In advanced systems, the timing of traffic signals at intersections and ramps will be coordinated with the routing advice. The system will cause patterns of travel to be altered rather than simply accommodating vehicles that travel through the network. Computers and sensors within the vehicle will monitor the operation of critical safety systems (*e.g.,* brakes, steering), warning the driver when conditions exceed nominal values

The main objective is to reduce the traffic and congestion at the traffic signals and it should be time saving. Congestion occurs mainly due to the inadequate capacity of the road. It can be monitored using sensors. The Sensor is a key element of any smart system and a course of action is taken based on its location. The control system gathers the data from a group of sensors and it uses different variables to distinguish its location and modifies its actions consequently. A sensor is a transducer which transforms the physical nature parameters like light, temperature, velocity, pressure, moisture, etc. to an electronic signal. This electronic signal can be understood by humans or fed into a control system. The inductive-loop sensor detects the vehicle or conductive metal object by sensing the loop inductance, which is dropped by inducing currents in the object. It is

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Flexible design to fulfill a great variety of applications. Unresponsive to bad weather and Offers accurate count data. But the detection accuracy drops with vehicle classes[29]. The next technology used is RFID. It uses radio waves to give and take data between a reader and an electronic tag attached to a vehicle for the purpose of tracking. It is economical, but it senses only the equipped vehicles at a point on the road[29]. Microwave radar is a another technology that transmits in the recognition regions and captures the echoed signals from vehicles. The reflected signal is processed to find the speed and direction of the vehicle. Acoustic sensors detect audible sounds produced by vehicular traffic and there by vehicle presence, and speed are measured. Magnetometers have sensors that sense the horizontal and vertical components of the Earth's magnetic field. A magnetic sensor is used to detect the presence of a vehicle by measuring the anxiety in the Earth's magnetic field because of a ferrous metal object[29]. The infrared sensor illuminates the low powered infrared energy in the recognition regions and captures the echoed energy from the vehicles. The echoed energy is focused onto an infrared-sensitive material, which transforms the echoed and illuminated energy into electrical signals. These signals are processed and analyzed to obtain the presence of a vehicle[29]. VIP(video image processor), this system normally consists of a camera,processor-based workstation for analysing the images, and software for understanding the imageries and transforming them into traffic data[29]. The wireless communication has numerous technologies and standards, including Zig Bee, Bluetooth, GPRS, GSM, Wi-Fi and Wi-MAX .Wi-MAX is a standard for data transmission via radio waves. It is high speed and serves number of users. ZigBee Specification is a set of complex wireless communication protocols for use with low consumption digital radios, based on WPAN standard IEEE 802.15.4. It has multiple protocol availability. Bluetooth Standard for the data and voice transmission between many devices via a safe and free radio link. UWB is merely a radio technology that can be used as part of an overall standard. It has extremely fast transfer of files between server and portable devices. Wi-Fi System of wireless data broadcast over computational webs. RFID Uses radio waves to detect objects carrying tags. In this paper we collected a survey on different technologies that are used to detect the vehicles in the lane using sensors.

II TECHNOLOGIES USED IN TRAFFIC LIGHT CONTROL

There are different technologies used to detect density of vehicles. Some of them are as follows-:

A. Wireless Sensor Networks (WSN s)

Wireless sensor network is also called as (WSAN)wireless sensor and actuator networks. These sensors are used to monitor physical as well as environmental conditions, such as temperature, pressure, sound etc. The modern networks are bidirectional and also enable control for sensor activity. The microcontroller uses input from these sensors that inform the controller processor whether, to change the signal timing and phasing within the limits set by the controller's programming. Microcontroller can give more time to an intersection approach which experiences heavy traffic, or shorten or even skip a phase that has little or no traffic waiting for a green light.The unique characteristics of Wireless sensor networks include the mobility of sensor nodes, the ability to withstand harsh environmental conditions, node failures, low power and scalability.

fig 1 Wireless sensor networks

Ossama Younis *et al* [1] proposed a model in which DTLC (Dynamic Traffic Light Control) is applied where the protocols are used to handle congestion for efficient traffic flow. Using these control protocols and proposed low-overhead algorithms we can optimize the traffic flow metrics, and practically deploy live traffic flow scenarios. the benefits of DTLC are low processing complexity, low communication overhead, fast decision-making, low cost for

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deploying the proposed protocols. A major advantage of the DTLC framework is that it makes independent decisions at each traffic light to achieve optimization of traffic flows. But the cost is also a determining factor because the communication complexity is expected to be much more expensive than the processing complexity. Future enhancements is to determine the best hardware options and to further reduce the cost per road segment .Also CPS can be used for traffic safety and health issues like avoiding accidents and reducing pollution.

Gabriel Rodrigues de Campos *et al* [2] focus on the traffic coordination problem at traffic intersections. the goal is to find the best individual control input and allow each vehicle to safely reach its destination in finite time. This is implemented using decentralized coordination approach where the decentralized solution of the local optimization problems is divided two parts such as a finite-time problem where collision avoidance is applied as terminal constraints, and an infinite horizon problem which defines the *cost-to-go* that can be calculated offline. using decentralized coordination we combine optimal control with model-based heuristics. The advantage of model-based heuristics is that it can lead to low-complexity solutions. Those low-complexity solutions are suitable for fast online implementation, which results in efficiency, feasibility and optimality. Finally, results for different scenarios can be obtained. But, the disadvantage is this technique more complex for the scenarios such of non- trivial solution. The future enhancements is avoiding rear-end collision between vehicles on the same lane, or to handle continuously traffic flows. In such case we require the adaptation of the current approach, as the information given by the occupancy intervals is no longer sufficient to avoid rear-end collisions.

. Eleni Christofa and yet others represents a person-based traffic responsive signal control system for transit signal priority (TSP) on conflicting transit routes**.** A mixed-integer nonlinear program (MINLP) is formulated, which minimizes the total person delay at an intersection while assigning priority to the transit vehicles based on their passenger occupancy. The system has been tested for a complex signalized intersection which is characterized by multiple bus lines traveling in conflicting directions. Two types of tests have been performed are deterministic arrival tests and stochastic arrival tests .The results show that the proposed person-based traffic signal control system reduces the total person delay at the intersection and effectively provides priority to transit vehicles. The proposed traffic responsive signal control system is generic and offers flexibility to weigh the relative merit of the passenger and vehicle delays. The major advantage is it can reduce the overall person delay and transit passenger delay, and it can effectively provide priority to transit vehicles while increasing the auto passenger delay . the future enhancements includes improving the robustness of the system by accounting for input inaccuracy in the mathematical program and developing improved prediction algorithms. Also ,pedestrian delays in the objective function and to extend the system to signalized arterials and grid networks by taking into consideration that autos will be arriving in platoons, whose size and arrival times depend on the signal settings.

.Xiao-Yan Ge and others [6] proposes a model to address the energy-efficient traffic signal timing problem for a congested road network with heterogeneous users. In this model, two types of agents such as the authority and road users, are considered together with the interaction between traffic signal settings and energy policy. the interaction between traffic signals and fuel surcharges and their effects on the travel decision behavior of heterogeneous travelers were explicitly considered. The authority aims to maximize social welfare of the transportation system by optimizing the traffic signal timings and fuel surcharges. A simulated annealing- based solution algorithm is developed to solve the proposed model. In future we can extend the proposed model to incorporate the spatial and social inequity constraints in the optimization problems of the fuel surcharges and/or traffic signals, to consider the effects of network uncertainty using a stochastic or robust optimization approach, to develop a more efficient solution algorithm for coordinated traffic signal control, to develop a multiclass multimodal transportation model, in which the road users are categorized by their VOTs and types of vehicles, to investigate the redistribution issue of the fuel surcharges and to calibrate empirically the parameters of the proposed model in order to make use of the model for practical applications.

K. M. Yousef, J. N. Al-Karaki, and A. M. Shatnawi[21], proposed an intelligent traffic control system for changing the traffic phase's sequence using Wireless Sensor Network (WSN). A WSN is used as a tool to instrument and control the traffic signals at roadways. A traffic light controller is developed to control the operation of the traffic signal using traffic system communication algorithm (TSCA) and the traffic signals time manipulation algorithm (TSTMA). This embedded algorithms results in solving the congestion in terms of average waiting time and average queue length.

Binbin Zhou, Jiannong Cao[22]**,** proposed an approach for adaptive traffic light control for isolated and

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multiple intersections. This paper investigates the algorithms and design method for adaptive traffic light control in a WSN-based ITS. It deals with the real-time traffic information that is collected by WSNs to achieve high system throughput, low waiting time for the vehicles. Another scheme is used for Intelligent Services with WSNs, iSensNet to evaluate and demonstrate the performance.

. W. Chen, L. Chen, Z. Chen, and S. L. Tu [24], introduces an WSN technology that takes advantage of low energy consumption and full-road coverage to improves the efficiency of Intelligent traffic system. WSN technology integrates the surveillance sub-system and the communication sub-system to reduce the communication load, which satisfy the requirement of a narrow bandwidth. It uses solar cell as the power supply which reduces the requirement of power-consumption,complexity of the algorithm,saves the memory space and improves the response speed. [4] discussed about a project, in this project an automatic meter reading system is designed using GSM Technology. The embedded micro controller is interfaced with the GSM Module. This setup is fitted in home. The energy meter is attached to the micro controller. This controller reads the data from the meter output and transfers that data to GSM Module through the serial port. The embedded micro controller has the knowledge of sending message to the system through the GSM module. Another system is placed in EB office, which is the authority office. When they send "unit request" to the microcontroller which is placed in home. Then the unit value is sent to the EB office PC through GSM module. According to the readings, the authority officer will send the information about the bill to the customer. If the customer doesn't pay bill on-time, the power supply to the corresponding home power unit is cut, by sending the command through to the microcontroller. Once the payment of bill is done the power supply is given to the customer. Power management concept is introduced, in which during the restriction mode only limited amount of power supply can be used by the customer.

B. Video Image Processing

VIP (video image processor) is a system that normally consists of a camera, processor-based workstation for analyzing the images, and software for understanding the imageries and transforming them into traffic data. The high performance image processing meet the demands of large scale Intelligent Transportation System applications. The VIP is mostly used for toll gate violation enforcement, video tolling, ticketless parking or controlled access monitoring, segment speed enforcement, and travel time analysis.

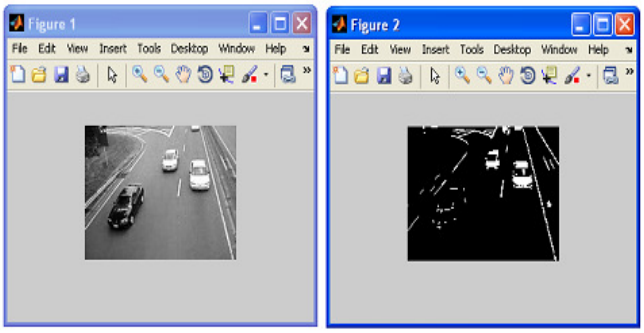

fig 2 Image processing using MATLAB

Markos Papageorgiou and Christina Diakaki[10] implemented control strategies in three areas: urban road networks, freeway networks, and route guidance. The efficient, safe, and less polluting transportation of persons and goods calls for an optimal utilization of the available infrastructure via suitable application of a variety of traffic control measures is discussed in this paper. The task of the *surveillance* is used to enhance and to extend the information provided by suitable sensors as required by the subsequent control strategy and the human operators The results are, obtained from either simulation studies or field implementations give us various control actions and strategies .Future enhancements include the Theory–Practice Gap, Road Traffic Control, Freeway Traffic Control, Driver Information and Route Guidance Systems, A Potential Limitation.

Dongfang Ma1 and Xiaoqin Luo [13] presented an improved model of the relationship between traffic demand and the reduction in travel time of delayed vehicle . This is a new method has then been presented to estimate lane-based demand using travel time data. This model is capable of computing traffic demands in different lane groups both under unsaturated and over saturated significantly superior to methods based on data collected by loop detectors. We calibrated the parameters that were included in the models using field survey data, and selected the average values of traffic jam density and start wave speed during the overall survey period as practical values that could be used to evaluate the precision of the models. The results showed that the maximum and average relative errors in 12 cycles were approximately 38.50 and 16.19%, respectively, which demonstrates that the models have an acceptable precision. The results also indicate that the calibrated values of the traffic jam density and start wave speed can be set as

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recommended defaults when these parameters cannot be updated without difficulty.

Ye Li, Meng Joo Er, and Dayong Shen [14] proposed a novel approach for detection of multiscale vehicles with time-varying vehicle features based on a multiscale AND–OR graph (AOG) model is proposed. This approach consists of two steps, i.e., construction of a multiscale AOG model and an inference process for vehicle detection. Their Experimental results show that our method can effectively and efficiently deal with multiscale vehicles, which benefit from the combination of AOG and the global and local processes.

I. Robertson and R. D. Bretherton [23] proposed an SCOOT method for urban traffic light control system. TRANSYT is a method used for optimizing the fixed time signals. Urban traffic control (UTC) system is used to coordinate the operation of the signals. The central computer controls the signal sequences and monitor the operation. The signals and computer are connected by voice grade data transmission lines. This results in the minimization of sum of the average queues in the area.

C. Radio Frequency Identification(RFID)

RFID identifies the tags attached to objects automatically. The tags will contain electronical information. Passive tags collect energy from radio waves emitted by nearby RFID. For instance, the emergency vehicles such as, fire engine, ambulance etc. will be attached with RFID tag and the RFID readers placed at traffic signals will detect the tags and knows that there is emergency vehicle in that lane and gives green signal to that lane first. The RFID technolgy is also used at tollgates to detect the vehicle that has already paid the toll fee automatically open the barrier gate for that vehicle.

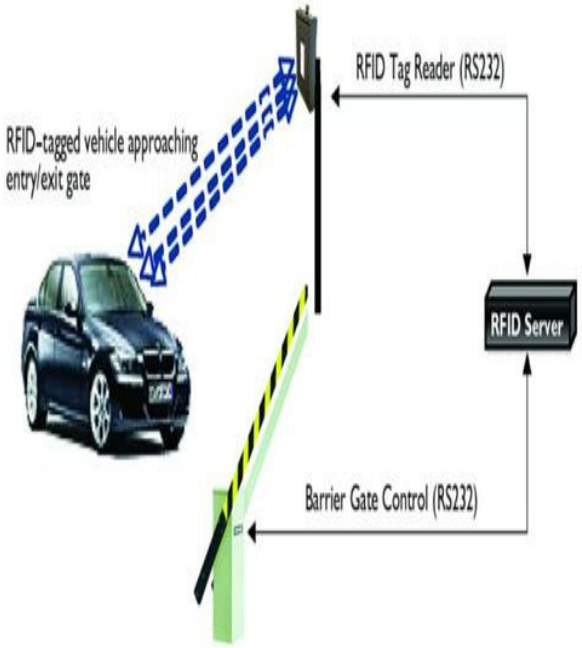

fig 3 RFID technology for vehicle detection

Abduladhem Abdulkareem Ali *et al* [30] proposed approach to avoid the issues that usually appear with the ordinary traffic lights recognition systems, especially with systems that employ image processing techniques to recognize the traffic lights status. The approach provides a high performance and a low-cost system. The paper also presents a RFID based system used to recognize road signs. In order to prove the systems performs properly, the system has been experimentally tested for both based traffic light system and road signs. During run tests all signals are recognized correctly. In order to test the performance of the presented method, an autonomous driving robot has been adopted. The robot is equipped with XBee module connected to ATmega microcontroller board to communicate with the traffic light system. During the test it is arranged to record the sign of the road detected inmemory and stops a bit, if it found one, and responds correctly to the roads traffic light when detected.

D. Inductive loop sensor

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An inductive loop traffic sensors consists of three components: a detector,a loop (preformed or saw-cut), and loop extension cable. The loop is a continuous run of wire which enters and exits from the same point. The two ends of the loop wire are connected to the loop extension cable, which connects to the vehicle detector. The loop is powered by the detector causing a magnetic field in the loop area. The loop resonates at a constant frequency that the detector monitors. A base frequency is established when there is no vehicle over the loop. The resonate frequency increases When the vehicle moves over the loop. This frequency increase is sensed and depending on the design of the detector, forces a normally open relay to close. The relay will be closed until the vehicle leaves the loop and thus the frequency returns to the base level. The relay can trigger any number of devices such as a gate, an audio intercom system, a traffic light, etc.

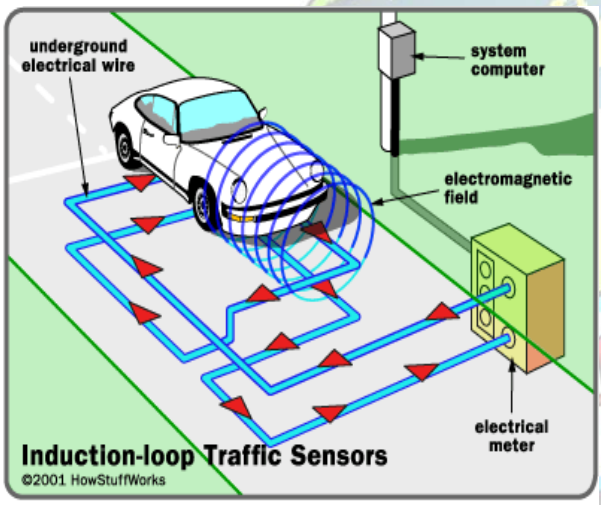

fig 4 Inductive loop sensor

Pengfei Li and Pitu B. Mirchandani[9] presented a new hardware in the loop traffic signal simulation framework, which is referred to as HILS-NG. The advantages of this framework is pioneering traffic signal logic only needs to be programmed once for simulation and the same code can be deployed to the field with minimal porting efforts. It does not require replacing traffic signal controllers in the field. Thus the proposed framework will not compromise the existing signal safety protections in signal cabinets, such as phase conflict monitor.A set of new signal control strategies is presented to demonstrate how to design control functions and the corresponding NTCIP communication stacks. The HILS-NG framework extends the current software in- the-loop (SILS) and hardware-in-the-loop (HILS) signal simulation and places the control logic in a hardened single board computer (SBC). The HILS-NG framework can greatly bridge traffic signal research and practice because the same host SBC can be coupled with both simulation and the traffic signal controller in the field .Further we can also host them in a central traffic management system and remotely access traffic signal controllers in the field via reliable and low-latency network connections .Thus the proposed framework is the same helpful to practitioners to explore more innovative traffic management measures.

E. Acoustic Sensor

Acoustic wave sensors are so named as mechanical, or acoustic wave because their detection mechanism. The acoustic wave will travel through the surface of the material .The changes in the characteristics of the propagation path affect the amplitude and velocity of the wave. The velocity changes can be monitored by measuring the phase characteristicsbor frequency of the sensor and can be correlated to the corresponding physical quantity being measured.

Yueyue Na Yanmeng Guo Qiang Fu[26] proposed an acoustic based traffic monitoring system that utilizes a cross microphone array to collect road-side acoustic signals. The lane positions are automatically detected by the built-in lane detection module. The road condition and traffic quality are derived according to the collected signals and the detected lanes. The acoustic sensor is less expensive such that the proposed acoustic traffic monitoring system will have lower hardware cost, and become a good complement to the existing traffic monitoring techniques.

F. Fuzzy Systems

A fuzzy logic system is a mathematical system with the analog input values as of logical variables which take continuous values between 0 and 1, in contrast to digital logic. The digital logic operates on discrete values of either 1 or 0.

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Technology	Principle	Advantages	Disadvantages
Inductive Loop Sensor	The inductive-loop sensor detects the vehicle or conductive metal object by sensing the loop inductance, which is dropped by inducing currents in the object.	• Flexible design to fulfill a great • variety of applications. • Unresponsive to bad weather. • Offers accurate count data.	• Installation and maintenance require pavement cut and lane closure. • Many loops are required to cover a location. • The detection accuracy drops with vehicle classes.
RFID(Radio Frequency Identification)	RFID technology uses radio waves to give-and-take data between a reader and an electronic tag attached to a vehicle for the purpose of tracking.	• RFID is economical. • It does not disturb traffic.	• RFID only senses equipped vehicles at a • point on the road.
Acoustic Sensor	Acoustic sensors detect audible sounds produced by vehicular traffic and there by vehicle presence, and speed are measured.	• Unresponsive to precipitation. • Multiple lane operation.	• Transducer, filters, microphones, pre amplifier, storage equipment.
VIP (Video image processor)	This system normally consists of a camera, processor-based workstation for analyzing the images, and software for understanding the imageries and transforming them into traffic data.	• Monitors multiple lanes. • Simple to add and change detection areas. • Offers broad-area detection.	• Performance is sensitive to bad weather, vehicle shadows, and dusts on the camera lens. • Requires specific camera mounting height for finest vehicle presence.

Table 1 Comparison of different Technologies [29]

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Technology	Vehicle Count	Presence	Speed	Output Data	Classification	Multiple Lane, Multiple Detection Zone Data	Communication Bandwidth
Inductive loop	✔	✔	✔*	✔	✔&		Low to modest
Magnetometer	✔	✔	✔*	✔			Low
Magnetic induction coil	✔	✔$	✔*	✔			Low
Microwave radar	✔	✔#	✔	✔#	✔#	✔#	Moderate
Active infrared	✔	✔	✔@	✔	✔	✔	Low to modest
Passive infrared	✔	✔	✔@	✔			Low to modest
Ultrasonic	✔	✔		✔			Low
Acoustic array	✔	✔	✔	✔		✔*	Low to modest
Video image processor	✔	✔	✔	✔	✔	✔	Low to high

Table 2 Traffic output data of commercially available sensors

CONCLUSION:

In this paper we have discussed about different technologies used to detect the density of vehicles and then control the traffic light accordingly. Among the different technologies discussed above the most effective technologies are WSN(Wireless Sensor Networks) and Infrared Sensors. Thus we have proposed a model to detect the density of the traffic using IR Sensor. Based on this information, the time allotted for the green light will be extended to allow large flow of cars in case of traffic jam, or reduced to prevent unnecessary waiting time when no cars are present at the opposite route. The system is complemented by portable controller for the emergency vehicles stuck in the traffic. By means of secure communication using XBee wireless system, the portable controller triggers the traffic master controller to the emergency mode and provides an open path until the stuck emergency vehicle traverses the intersection.

REFERENCES

[1] Osama Younis, Nader Moayeri, "Employing Cyber-Physical Systems: Dynamic Traffic Light Control At Road Intersections", National Institute Of Standards And Technology(NIST), Gathersburg, MD(USA).

[2] Gabriel Rodrigues De Campos, Paolo Falcone, Robert Hult, Henk Wymeersch And Jonas Sjoberg, " Traffic Coordination At Road Intersection", IEEE 19th January 2017.

[3] Dongbin Zhoa, Yujie Dai, And Zhen Zhang,"Computational Intelligence In Urban Traffic Signal Control: A Survey" Ieee Transactions On Systems, Man, And Cybernetics—Part C: Applications And Reviews, Vol. 42, No. 4, July 2012

[4] Christo Ananth, Kanthimathi, Krishnammal, Jeyabala, Jothi Monika, Muthu Veni, "GSM Based Automatic Electricity Billing System", International Journal Of Advanced Research Trends In Engineering And Technology (IJARTET), Volume 2, Issue 7, July 2015, pp:16-21

[5] Alessandro Colombo, *Member, IEEE,* Gabriel Rodrigues De Campos , Fabio Della Rossa," Control Of City Road Network: Distributed Exact Verification Of Traffic Safety", IEEE Transaction On Automatic Control.

[6] Xiao-Yan Ge, Zhi-Chun Li, William H. K. Lam, And Kheecho Choi, "Energy-Sustainable Traffic Signal Timings For A Congested Road Network With Heterogeneous Users", Ieee Transactions On Intelligent Transportation Systems, Vol. 15, No. 3, June 2014.

[7] Ali Hajbabaie And Rahim F. Benekohal," A Program For Simultaneous Network Signal Timing Optimization And Traffic Assignment", Ieee Transactions On Intelligent Transportation Systems, Vol. 16, No. 5, October 2015.

[8] Tsin Hing Heung, Tin Kin Ho, And Yu Fai Fung, " Coordinated Road Junction Traffic Control By Dynamic Programming", Ieee Transactions On Intelligent Transportation Systems, Vol. 6, No. 3, September 2005.

[9] Pengfei Li And Pitu B. Mirchandani," A New Hardware-In-The-Loop Traffic Signal Simulation Framework To Bridge Traffic Signal Research And Practice", Ieee Transactions On Intelligent Transportation Systems.

[10] Markos Papageorgiou, Fellow, Ieee, Christina Diakaki, Vaya Dinopoulou, Apostolos Kotsialos, And Yibing Wang," Review Of Road Traffic Control Strategies", Proceedings Of The Ieee, Vol. 91, No. 12, December 2003.

[11] Yan1, Fuli Tian1, Zhongke Shi1," Iterative Learning Approach For Traffic Signal Control Of Urban Road Networks", E-First On 29th November 2016.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 23, December 2017

[12] Fangfang Zheng, Henk J. Van Zuylen, Xiaobo Liu, And Scott Le Vine, "Reliability-Based Traffic Signal Control For Urban Arterial Roads", Ieee Transactions On Intelligent Transportation Systems.

[13] Dongfang Ma1, Xiaoqin Luo," Traffic Demand Estimation For Lane Groups At Signal-Controlled Intersections Using Travel Times Transport Systems" (Volume: 11, Issue: 4, 5 2017). From Video-Imaging Detectors", IET Intelligent.

[14] Ye Li, Meng Joo Er, And Dayong Shen, "A Novel Approach For Vehicle Detection Using An AND–OR-Graph-Based Multiscale Model", IEEE Transactions On Intelligent Transportation Systems (Volume: 16, Issue: 4, Aug. 2015).

[15] Li-Der Chou, Bo-Teng Deng, "A Passenger-Based Adaptive Traffic Signal Control Mechanism In Intelligent Transportation Systems" ITS Telecommunications (ITST), 2012 12th International Conference, 2012 12th International Conference On ITS Telecommunications.

[16] K. M. Udofia, 2 J. O. Emagbetere," Development Of Multi-Agent Anfis-Based Model For Urban Traffic Signal Control", 2013 International Conference On Connected Vehicles And Expo (ICCVE).

[17] Prof. Bhushan Trivedi ," Real Time Computation Of Optimal Signal Timing To Maximize Vehicular Throughput For A Traffic Junction", 2014 3rd International Conference On Eco-Friendly Computing And Communication Systems.

[18] Surekha Reddy Bandela*, Sathyanarayanan K, "Implementation Of NTCIP In Road Traffic Controllers For Traffic Signal Coordination", 2015 Fifth International Conference On Advances In Computing And Communications.

[19] Marco Tiriolo Dipartimento Di Ingegneria Universita Degli Studi Roma Tre, "Distributed Urban Traffic Signal Optimization Based On Macroscopic Model",Innovative Computing Technology (INTECH), 2016 Sixth International Conference.

[20] Bilal Ghazal, Khaled Eikhatib, Khaled Chahine, Mohamad Kherfan, "Smart Traffic Light Control System", Isbn: 978-1-4673-6942-8/16/$31.00 ©2016 Ieee.

[21] K. M. Yousef, J. N. Al-Karaki, and A. M. Shatnawi, "Intelligent Traffic Light Flow Control System Using Wireless Sensor Networks," in J. Info. Sci. and Eng., vol. 26, 2010, pp. 753-768.

[22] Binbin Zhou,Jiannong Cao"Adaptive Traffic Light Control In WSN-Based ITS: Both isolated intersection and multiple intersections" Book LAP Lambert Academic Publishing

[23] D. I. Robertson and R. D. Bretherton, "Optimizing Networks of Traffic Signals in Real Time—The SCOOT Method," in IEEE Trans. on Vehicular Tech., vol. 40, no. 1, Feb 1991, pp. 11-15.

[24] W. Chen, L. Chen, Z. Chen, and S. L. Tu, "WITS: A Wireless Sensor Network for Intelligent Transportation System," in Proc. of the First International Multi-Symposiums on Computer and Computational Sciences (IMSCCS), vol. 2, 2006, pp. 635-641.

[25] D. Srinivasan, M. C. Choy, and R. L. Cheu, "Neural Networks for Real-Time Traffic Signal Control," in IEEE Trans. on Intell. Transportation Systems, vol. 7, no. 3, Sep. 2006, pp. 261-272

[26] Yueyue Na Yanmeng Guo Qiang Fu "An Acoustic Traffic Monitoring System: Design and Implementation" 2015 IEEE 12th Intl Conf on Ubiquitous Intelligence and Computing and 2015 IEEE 12th Intl Conf on Autonomic and Trusted Computing and 2015 IEEE 15th Intl Conf on Scalable Computing and Communications and Its Associated Workshops (UIC-ATC-ScalCom.

[27] Laleh Makarem, Denis Gill" Model predictive coordination of autonomous vehicles crossing intersections" International Conference Intelligent Transportation System.

[28] Fei-Yue Wang "Parallel Control and Management for Intelligent Transportation Systems: Concepts, Architectures, and Applications" IEEE Transactions on Intelligent Transportation Systems (Volume: 11, Issue: 3, Sept. 2010) .

[29] Kapileswar Nellore * and Gerhard P. Hancke"A Survey on Urban Traffic Management System Using Wireless Sensor Networks" Advanced Sensor Networks Research Group, Department of Electrical, Electronic and Computer Engineering,

[30] Abduladhem Abdulkareem Ali, Hussein Alaa Hussein " Traffic Lights System Based on RFID for Autonomous Driving Vehicle" 2017 Annual Conference on New Trends in Information & Communications Technology Applications (NTICT)