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DENSITY BASED SMART TRAFFIC CONTROL SYSTEM

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Abstract: In recent years automation technology has done its advancement as it makes life easier and simpler. Internet of things (IoT) is the latest and growing internet technology which has influenced human day to day activities.

Smart Traffic control and announcement system using IoT is a reformed technology that uses a new technology named as "traffic density and free turn line sensing". This technology uses either IR based sensing or DIP (Digital Image processing) sensing and activates traffic controlling system like signal lights and announcements, this system can be extended such that we can issue online challans to the rule violators.

This system is intended to minimize human intervention and optimise the signal waiting time by implementing traffic density based signal time (Red and Green) which changes the signal time based on the traffic density.

In this paper, I present a smart Traffic control and announcement system that employs the integration of micro-controller, sensors and wireless communication. It is designed to be running on a low budget platform and minimize the day to day traffic issues with minimum human intervention.

Keywords: Internet of Things, Smart Traffic control and announcement, Traffic density based signal, Traffic density and free turn sensing, IR based sensing, Wireless connectivity

INTRODUCTION

With the rise in issues related to traffic management in cities, this is a perfect opportunity to introduce the technology in sensing, analysing and controlling the traffic especially in smart cities. The legacy traffic management is not suitable for the present traffic conditions, it need a system where it can minimise the manual intervention, where it can adopt a dynamic traffic signalling system based on the density and time, where it is capable of analysing the traffic conditions and control and which is also capable of communicating with the control centre over the internet.

The aim of this project is to propose a new traffic control system by utilising the power of IoT and which is perfect for building smart cities in countries like India.

This report presents the designs for two such technologies where we can control the traffic signal lights based on the density and where we can monitor the traffic for rule violations and take actions accordingly.

In this design we propose to use a Microcontroller based IoT which collects the data about the traffic density using the sensors and also from the other IoTs. IoTs will share the data over wireless medium and perform the traffic signal operations based the data collected from the sensors and from the other IoTs.

RELATED WORK

We propose a robust model blended with a cutting edge technology for most reliable, secure and intelligent traffic control system for smart cities.

Amitha Marram [1], the first author will develop an artificial intelligence for smart traffic signal decision making. The algorithm behind the intelligence will gather the data related to the traffic from other IoTs in the mesh and analyses the data, the analyzed data will be used for anticipating the traffic congestions to avoid the bottlenecks. This author will be the architect of the entire backend programming.

Venu Dhanraj, Puduchery [2], the second author is responsible for designing the physical topology of the IoTs & sensors and designing the sensor based traffic density assessment. This author also takes care of secure wireless communications between IoTs for sharing the data related to the traffic density.

PROPOSED MODEL

Estimating the traffic density

Overview:

Estimating the traffic density at each junction will be the crux for this design, for this we propose two different technics,

a. Deploying IR (infra-red) based traffic sensors at both sides of the dividers.
b. Deploying HD cameras facing all sides of the junctions and estimating the traffic using DIP (Digital Image Processing)

Note: We are considering the second option as an alternative and will not be discussed anything about it in this article.

Sensor deployment:

IR sensors will be deployed on both sides of the divider of the road as shown in the following layout,

a. Sensors facing to the left side will sense the density of the traffic waiting for the green signal

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b. Sensors facing to the right side will sense the free flow traffic after the green signal (in other terms, it will sense the traffic jam after the green signal)
c. Sensors will be deployed within 300/400 meters from the junction.
d. One meter (100 cm) space between sensors and 50 cm height from the road level will be maintained.

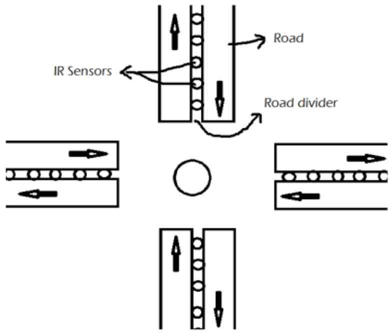


Fig 3.1, showing the high level layout of sensor deployment

Reading the traffic:

Traffic density will be estimated based on the number of sensors receiving the reflected IR light as shown in the following figure,

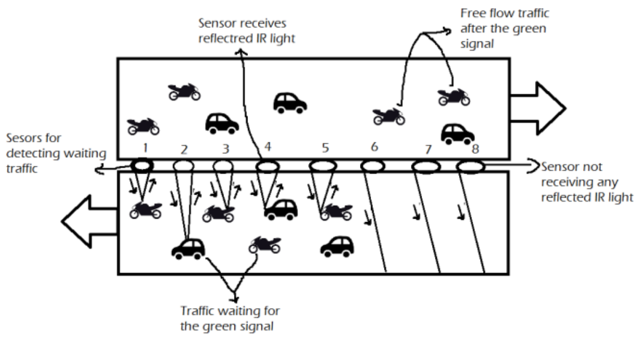


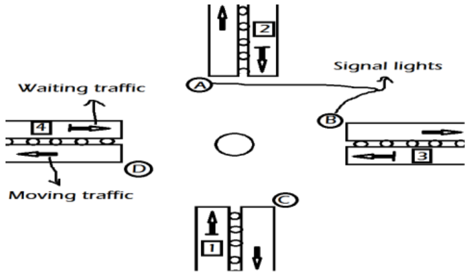
Fig 3.2, estimating the waiting traffic using the reflected IR light by the IR sensors.

a. Sensors 1 to 8 are sensing waiting traffic.
b. Sensors 1 to 5 are able to receive the reflected IR light.
c. Sensors 6 to 8 are not receiving any reflected IR light
d. In this design, first 20 sensors are known as minimum waiting traffic sensors zone (MWTZ) and 21 to 200 known as Standard traffic density zone (STDZ) and above 200 is known as heavy traffic density zone (HTDZ).
e. As per the above data (sensor data), density of waiting traffic is about 6 meters.
f. The sensitivity of the sensors should be adjusted such that they ignore the moving traffic.

Dynamic signal (Green) time:

Now, the real-time implementation of the design comes into picture, the time duration for the signal (Green) needs to be changed based on the waiting traffic. The following algorithm will help the IoT to take such decision.

Fig 3.3, showing the deployment layout of Traffic signals



a. TWT (Traffic waiting time)=MWT (Minimum Waiting Time)+TD(Traffic density)

b. In this model, minimum waiting time will be fixed based on multiple parameters such as, Location, time (Office School time), Weeksday and festivals.
c. TD value will be calculated based on the sensor data.
d. TD=0 when only sensors in MWTZ zone are reporting.
e. When sensors in STDZ zone also stats reporting, 5 seconds will added to MWT for every reporting sensor.
f. When sensors in HTDZ zone started reporting, IoT will send a warning message to the upward and downward control systems (IoTs).
g. Time duration for green signal of signal ‘A’ depends on reporting sensors of road ‘1’ similarly, signal ‘B’ depends on road ‘4’, signal ‘C’ depends on road ‘2’ and signal ‘D’ depends on road ‘3’

IoT Grid :

IoT Grid is another important module of this design, which allows IoTs deployed within the same grid exchange the data related to the traffic and make the smart decisions such as, Traffic diversions, traffic announcements and sharing the alarming signals to the control-room.

IoT grid is a collection of IoTs deployed at different junction of a particular route. IoTs within a grid will communicate and exchange the data related to the traffic over wireless communication. In order to segregate the grid, we will use a unique code along with the sharing data. IoTs within the same grid will be able to decode the data and process it.

Formation of the grid is purely based on the traffic conditions and traffic diversion possibilities. Each grid must have at least one diversion route.

Coding IoTs :

Coding IoTs plays very critical role in designing the algorithm. Format of the code will be as follows,

G#J#IOT#CODE

G# → Grid id
J# → Junction id
IOT# → IoT id of the junction
CODE → status of the traffic in the form of a code.

CODEs :

TFF : Traffic Free Flow
MWT : Minim Waiting Traffic
SWT : Standard Waiting Traffic
HWT : Heavy Waiting Traffic
TJ : Traffic Jam
TDM : Traffic Diversion Mandatory
TDO : Traffic Diversion Optional
THA : Traffic Halt for Ambulance
THV : Traffic Halt for VIP

Free Left turn line detection:

This is one of the major causes for the traffic jams, most of the people do not leave space for the vehicles tends to left turn. This issue can be addressed by deploying a separate divider which guides the vehicle to the left side but it may not be feasible to deploy dividers at all the junctions.

We propose to use the DIP (digital Image processing) method for detecting the free left clearance and announcements. In this method, a HD cameras facing to the left turn of each road of the junctions will be deployed for constantly monitoring. When the controller detects a stalled traffic at the left turn lane, it will trigger a message to the IoT for warnings/announcements.

This can be extended such that, we can issue e-Challans to all the traffic violators.

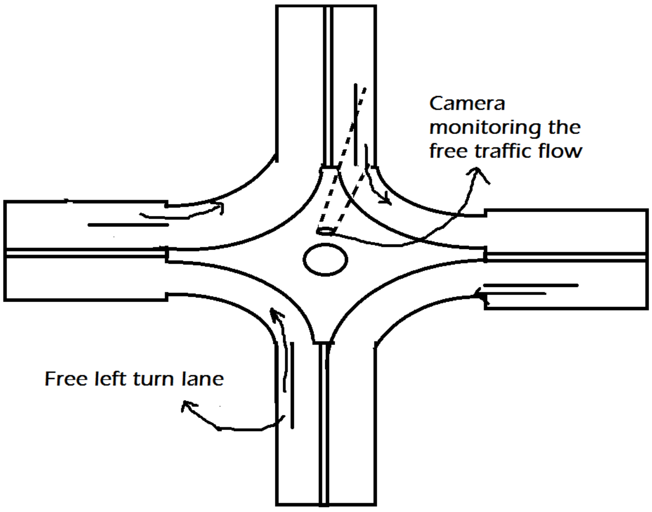


Fig 3.4, showing the deployment layout of free left turn traffic

Algorithm :

Calculating the Local Green signal time

IF SENSOR_LOCAL EQL MWTZ AND
IF SENSOR_DATA_TAIL EQL MWT THEN
TIME_SIGNAL_GREEN=MWT
ELSE
IF SENSOR_LOCAL EQL SWTZ AND
IF SENSOR_DATA_TAIL EQL MWT THEN
TIME_SIGNAL_GREEN = MWT + (NUMBER OF SENSORS_SWTZ REPORTING) * 5
ELSE
IF SENSOR_LOCAL EQL HWTZ AND
IF SENSOR_DATA_TAIL EQL MWT THEN
TIME_SIGNAL_GREEN = MWT + (NUMBER OF SENSORS_SWTZ REPORTING) * 5 + [(NUMBER OF SENSORS_HWTZ REPORTING) * 5]/2
SENSOR_DATA_HEAD EQL HWT + TDO

Traffic Jam detection

IF SIGNAL_RED START AND
IF SENSORS_HWTZ REPORTING THEN
TJ EQL HIGH
ELSE TJ EQL LOW
RECORD_TIME AND SEND TJ GRID, CONTROL_SENTRE

Enabling traffic diversions

IF SENSOR_DATA_HEAD EQL TJ (HIGH)
THEN
IF EVAILABLE_DIVERSION EQL TRUE
THEN
DIVERSION_SIGNALS_ON AND ***TRAFFIC JAM ANNOUNCEMENT_ON***
TILL
SENSOR_DATA_HEAD EQL TJ (LOW)

Schools connecting route priority setting

IF WORKING_DAY AND ROAD-n/N CONNECTING_SCHOOL AND TIME_730-009 OR 1430-1700
THEN
SET_PRIORITY ROAD-n/N EQL HIGH
ELSE
SET_PRIORITY ROAD-n/N EQL LOW

(N:Number of roads joining at the junction, n: Nth road of the junction)

Industrial zone connecting route priority setting

IF WORKING_DAY AND ROAD-n/N CONNECTING_INDUSTRIAL_ZONE AND TIME_730-0930 OR 1500-1700
THEN
SET_PRIORITY ROAD-n/N EQL HIGH
ELSE
SET_PRIORITY ROAD-n/N EQL LOW

(N:Number of roads joining at the junction, n: Nth road of the junction)

Setting MWT (Minimum Waiting Time)
IF ROAD_n/N EQL HIGH THEN
MWT EQL 60
ELSE
MWT EQL 10/15/20 (Depends on the number of roads of the junction)

TECHNOLOGY PLATFORMS

We propose to use the following technology platforms for materializing this model.

1. ***Arduino Mega*** : The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a power jack, a USB connection ,an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started
2. ***ESP8266 :*** The **ESP8266** is a low-cost Wi-Fi chip with full TCP/IP stack that can give any microcontroller the access to your WiFi network. ,produced by Shanghai-based Chinese manufacturer, Espressif Systems. It is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. This module comes pre programmed with an Attention Command which are derived from the Hayes Command set (or AT command set) firmware with which you can simply hook up to your Arduino device and get about as much WiFi-ability as a WiFi Shield would offer.

3. ***GP2 Y0A710K0F :*** This is a sensor unit developed by Sharp which is mainly used for distance measuring, It is an integrated combination of position sensitive detector(PSD) , infrared emitting diode(IRED) and a signal processing circuit. Because of adopting the triangulation method, the variety of the reflectivity of the object, the environmental temperature and the operating duration are not influenced easily to the distance detection..This device outputs the voltage corresponding to the detection distance and hence, this sensor can also be used as a proximity sensor.

BOTTLE NECKS

Major bottle-neck for this design could be the geography of the location. The accuracy of this control system depends on the location, it should be suitable for deploying sensors and cameras.
The other bottle neck could be the interference, as we propose to use the wireless network for sensor data sharing and it should be more immune to the wifi interference otherwise the system may malfunction due to the data loss.

The above two issues are controllable hence we can materialize this design by controlling the above.

EXTENSIONS

This design can be extended by introducing Ambulance & VIP vehicle beacon reading, sharing the traffic data with the control-centre and media so that they can send traffic announcements/notifications to the public to avoid the concessions proactively.
Even we can enhance the code such that the system start learning the traffic changes in a day and calibrate the signals and timings automatically.

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