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Intelligent transportation system and smart traffic flow with IOT

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There has been an increase in vehicles across the globe. Also, the congestion due to traffic has leapfrogged in India. The traffic flow information has been required to find out the route with minimum congestion and forecast the traffic. And this has been a part of the Intelligent Transportation System (ITS) which would help build smart cities. A lot of work has been done on the traffic measurement system. But the integration of emerging techniques such as the Internet of Things (IoT) and cloud computing has provided a lot of research scope in ITS. This paper has proposed an IoT-based method to determine the real-time traffic flow in a road section with ultrasonic sensors, Arduino, ESP8266 Wi-Fi module, and an open-source cloud. There has been an average traffic flow every five minutes to be displayed in the cloud platform. This method can be very much cost-effective with less power consumption and improved accuracy. Hence, the proposed IoT-based technique has provided the traffic flow data, and this data shall further be used for traffic predictions using machine learning algorithms.

Keywords: Intelligent transportation system, Internet of Things (IoT), traffic flow, ultrasonic sensor, arduino Uno

1 Introduction

With a rapid advancement in IoT technology, digitalization has been possible in all aspects of life[1]. With IoT technology involving sensor, communication, controllers, cloud computing, Artificial Intelligence (AI), etc. smart and intelligent systems shall be built[2]. IoT has gained attention in various areas such as smart cities, Industrial IoT, healthcare, smart homes, smart buildings, connected cars, smart wearable devices, smart utilities etc[3-4]. ITS requires traffic data such as traffic flow, speed and occupancy[5]. With the cloud platform it is easy to handle such traffic related information as big data for the traffic management including travel time estimation, optimum route planning, traffic forecasting, etc.[6-8].

With development in the micro manufacturing techniques, sensors have become cheaper nowadays. Also, low cost controller boards such as Arduino Uno and Raspberry pie are available in the market. The development in wireless communication technology has resulted in low powered and low-cost communication protocols such as Wireless HART, Zigbee, Digimesh, WiFi, Bluetooth LE, Long Range Wireless Area Network (LoRaWAN) etc[9]. The open source cloud platform has provided a utility service for managing the data collected from the system.

In recent years many researchers have been working on traffic measurement system. O' Appiah[10] has proposed an ultrasonic sensor-based traffic information acquisition with ultrasonic sensor (HR-SR04) and Arduino Uno. Youngtae[11] has experimented with ultrasonic sensor, ATMega 128L microcontroller and three phase routing protocol for vehicle detection. Another work by Youngtae[12] has analysed the vehicle detection an algorithm to find vehicle count with distance map and vector map. A custom made Wireless Ultrasonic Sensor Mote (WUSM), ultrasonic sensor and ATMega 128L microcontroller have been used by Soobin Jeon[13]. Roni Stiawan[14] has used ultrasonic sensor and Arduino uno for detecting number of vehicles passing through the sensor. Vatsal Chauhan[15]has proposed an IoT enabled method with ultrasonic sensor, Arduino, Raspberry Pi and drone for real-time smart parking system (iERS) to reduce traffic congestion, to make an optimal resource consumption-based parking space allotment and to minimize the carbon footprints. Magnetic sensors have been used by Mohammed Sarrab[16] to build an IoT based vehicle detection technique. Elizabeth Basil[17] has proposed a solution with CCTV camera, Raspberry Pi, bluetooth module and android-based application to control the traffic light.

Most of these works have used ultrasonic sensor and a microcontroller to detect the vehicle. But only

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very few have worked on implementing IoT based traffic monitoring system. Hence we have proposed a cost effective IoT based system using sensors, Arduino Uno, ESP8266 WiFi Module and an open source cloud platform to determine the vehicle flow for every five minutes in a particular road section. To increase the accuracy of detection of the vehicle we have placed multiple ultrasonic sensors with a few meters gaps parallel to the lane and we have taken the average count of them for determining the traffic flow of a particular road section. Thus our proposed method has detected vehicle with increased accuracy and has provided a dashboard with cloud platform for real time monitoring of traffic in a particular road section.

2 Materials and Methods

We used Arduino UNO, ultrasonic sensors and an ESP8266 (WiFi Module) to setup the IoT based traffic flow detection system as shown in Fig. 1(a).

- Arduino Uno: The Arduino Uno[18] is an open-source microcontroller board which is based on the Microchip ATmega328P microcontroller. The board is equipped with a set of digital and analog input/output pins that may be interfaced to various components and expansion boards.
- Ultrasonic Sensor: An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Two of these sensors are used in this project to get an accurate number of vehicles that crosses in a particular time limit.
- ESP8266 (WiFi Module): The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability. This microchip converts the overall system as an IoT device. We could access the vehicle counter from any place and anytime.

The ultrasonic sensor emits ultrasonic waves and converts the reflected waves into electrical signal from which the distance of the vehicle shall be determined. Distance of the vehicle from the sensor is calculated by using Eq. (1)

$$distance = \frac{\left(\frac{duration}{2}\right)}{29.1} \quad \ldots (1)$$

The setup was done in such a way that the sensor senses only when the vehicles at a distance of 0.15 metre to 3.5 metre according to the lane's width. On sensing a vehicle, the counter value was incremented. The circuit connections made using circuito[19] were given as shown in Fig. 1(b). Two ultrasonic sensors and the ESP8266 microchip were connected to the Arduino Uno. These two sensors were placed apart at a distance of 6m and these two sensors counted the number of vehicles separately by incrementing counter 1 and counter 2. The average of the counter values was determined and uploaded to the internet using the WiFi module to increase the accuracy of detection. This setup was used for single lane roads.

For two lane roads we used two ultrasonic sensor for each lane, i.e. ultrasonic sensor 1 and 2 is for lane 1 and sensor 3 and 4 for lane 2 and these two lane is of same direction as shown in Fig. 1(c) so that if two vehicles crosses in each lane at a time in same speed then it would be counted accurately.

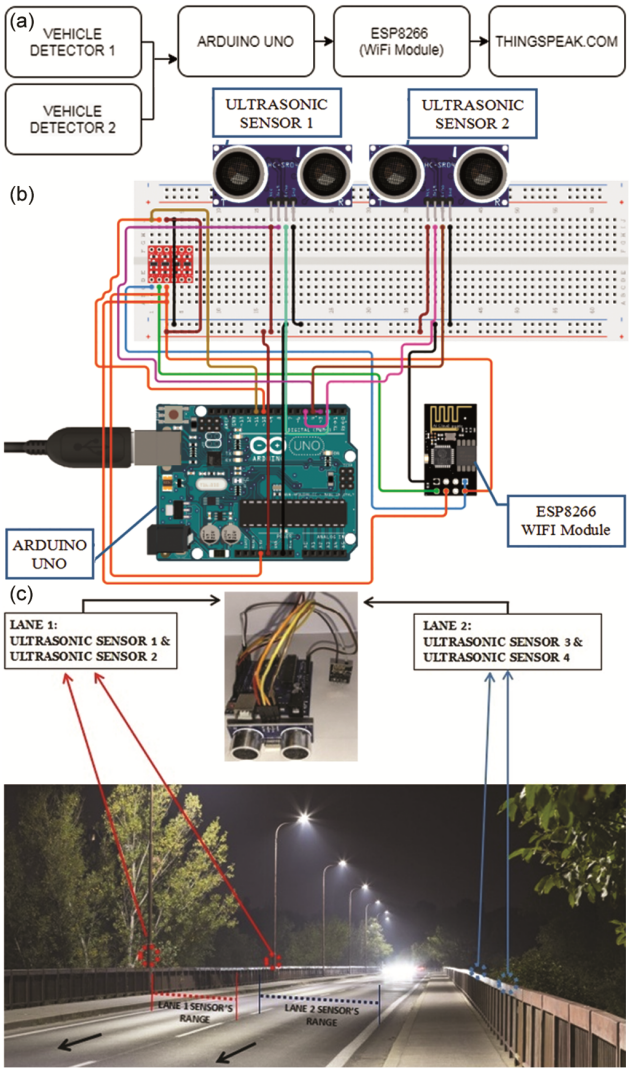

Fig. 1 — (a) Block diagram of the proposed system, (b) circuit connections of the proposed system, and (c) proposed experiment set up placement in a two-lane road.

And we used two sensors for each lane to increase the accuracy and to get the most approximate number of vehicles passing by.

For instance, if a vehicle slowed down near ultrasonic sensor1 and there may be chance of multiple increment of count value by the sensor. So to reduce this kind of error we made this kind of placement for two ultrasonic sensors. By this we got the most approximate number of vehicles that were passing by.

Figure 2 shows the flow chart of the process for our proposed traffic flow measurement system. The ESP8266 WiFi module was used to build the IoT. The detected vehicle count data was uploaded to Thing Speak[20] (thingspeak.com), an open source cloud. This uploading process occurred every 5 minutes that can be accessed through smart phones or computers from anywhere and anytime.Thus in our proposed system the ultrasonic sensor was interfaced with Arduino Uno for detecting the vehicle. The vehicle flow data was uploaded to the cloud every 5 minutes using the ESP8266 WiFi module.

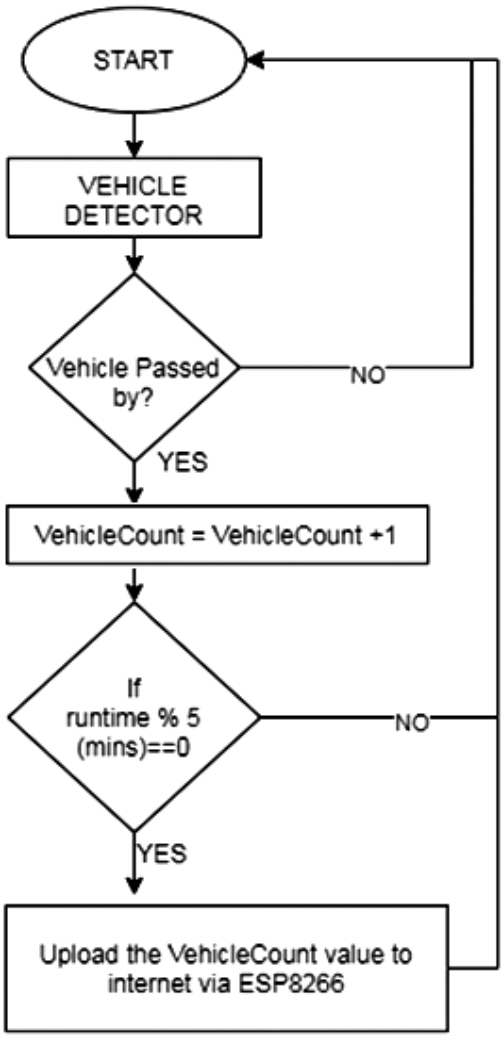

Fig. 2 — Flow chart of the proposed system.

3 Results and Discussion

We chose a busy road section in Madurai, the temple city in India for conducting the experiment. Due to heavy traffic, the roads in the city are very much congested especially during the peak hours. The experiment was carried out by placing the setup consisting of ultrasonic sensors, Arduino board and the ESP8266 WiFi module on the road sections.

As shown in Fig. 3 the two sensor stations were placed separately on the roadside at a distance between them. The sensors detected the vehicle passing by the road and vehicle count was determined based on both sensors. Then the average count was determined and uploaded to the cloud. The vehicle flow was plotted as graph in thingspeak.com.

The bar graph of traffic flow in terms of number of vehicles per min was also plotted as shown in Fig. 4(a). The graph was plotted for every five minutes of data.

Also the Fig. 4(b) shows the line graph of traffic flow data which was plotted in thingspeak.com. Thus the average traffic flow data was obtained with the ultrasonic sensor and Arduino UNO and this shall be stored in the cloud platform. The dashborad in the cloud can be used for monitoring the real time traffic flow.

In this project the accuracy of detecting the vehicle was increased by placing two ultrasonic sensor in each lane with some distance apart and the average

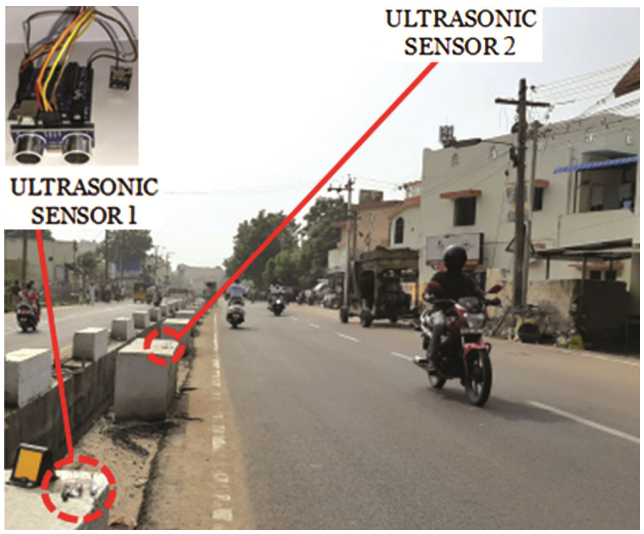

Fig. 3 — Placement of experiment set up at a road section.

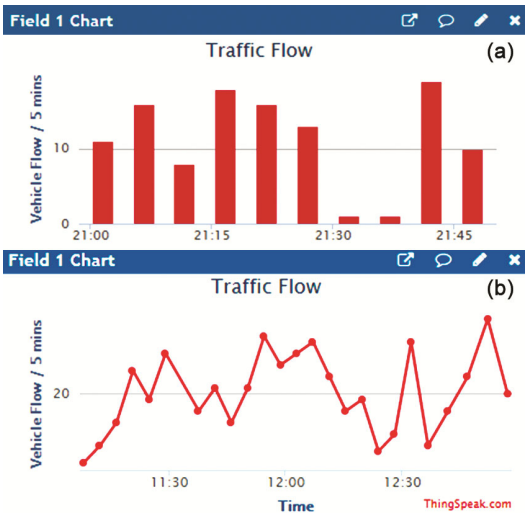

Fig. 4 — (a) Bar chart of average traffic flow for every 5 minutes, and (b) line graph of average traffic flow for every 5 minutes.

count from the two sensor was considered for traffic measurement. So that the error count due to stationary vehicles was reduced to some extent. Compared to other works in the literature, in this work we collected the real time data from the setup and it was transmitted to open source cloud (thingspeak.com) through ESP8266 WiFi module. Thus the collected data can be used by Intelligent Transportaion System for traffic monitoring, route planning, traffic forecasting with machine learning techniques. With the forcasted traffic information the driver can select the least traffic path. Also we have used Arduino Uno which was cost effective. Also it consumed less power and didn't need large scale battery backup.

4 Conclusion

In this paper an Internet of Things based traffic flow estimation system has been proposed. We have built the traffic flow measurement system with Arduino Uno, ultrasonic sensor, WiFi module and thingspeak.com, an open source cloud. We have used two ultrasonic sensors placed apart in a road section. The average count of the two sensors has been considered for the traffic flow estimation. This has increased the accuracy of the traffic flow measurement. In the proposed system the average traffic flow for every five minutes interval has been measured with the setup on the roadside and the traffic flow data have been communicated to the cloud. And the dashboard in the cloud has displayed the measured real time. Thus the traffic flow data from our proposed system can be useful intelligent transportation system.

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