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CROWD ESTIMATION USING SENSORS FOR PUBLIC TRANSPORT (BUSES)

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Abstract -*Population has been growing at a rapid rate in metropolitan cities like Mumbai and has reached saturation levels as far as population is concerned. Public transport plays an important role in order to transport people efficiently as well as reduce traffic congestion and vehicular pollution. In these cities, buses are generally the preferred last mile travel, due to their cheap rates and extensive routes. The major obstacles to their usage are: 1) overcrowding and 2) uncertainty in arrival time. Crowd estimation techniques using cameras inside the buses are not suitable. Hence, we have implemented a solution leveraging Internet of Things. Two IR sensors which can detect an object (person) in its range would be connected to a NodeMCU module in order to detect the inbound and outbound movement of passengers and subsequently update the count in the cloud. The real time data of buses would be stored in the cloud, which can be further used for analysis of bus routes and average passengers on a particular route. The Global Positioning System (GPS) receiver is used for real time tracking of the buses thereby notifying passengers about the bus arrival time. The crowd information and location of the bus are displayed on the client side android application embedded with Google Maps. This solution empowers passengers to take better decisions by bridging the information gap between passengers and bus operators. This system would also help in the planning and implementation of transport systems in Smart Cities across the country.*

Key Words: **Public bus transport, Internet of Things, Sensors, NodeMCU, Crowd estimation, Cloud, Location, Smart city**

1. INTRODUCTION

The Population in Indian metropolitan cities has been growing at an alarming rate. People from rural parts of the country migrate to cities for good jobs and higher salary. Due to this migration of people, cities have become overcrowded and due to this overcrowding the number of deaths as well as other health issues have rose in the past few years. Trains have always been the preferred mode of transport in the country but in cities where there is no suburban network people prefer buses to commute from office to home as well as last mile travel. Overcrowding of trains and buses has been a major concern over the years due to increase in population. In cities like Mumbai rickshaws and taxis are preferred by people as the trains and buses in such cities are over-crowded. Some people also prefer to drive their own vehicledue to the overcrowding and unpunctuality of public transport. People should be encouraged to use public transport so as to decrease the pollution generated by vehicles. People aren't aware of how crowded the bus or train is and how far is it from their location for which they are waiting. This increases the risk of them boarding an overcrowded train or bus and eventually they risk their lives.

Our application solves both these problems by providing passengers the location of the bus as well as indicates how crowded is the bus. Internet of Things (IoT) is being used across the globe in order to develop dynamic, real time and efficient techniques and technologies. IR Obstacle Detecting Sensors along with NodeMCU module would be used to count the number of people in the bus. Location of the bus would tracked by getting the conductor/driver'slocation using their phone's GPS (Location Service). Sensors would give us the count and the GPS module would help us obtain the location of the bus. All the real time data would be stored in the Cloud for further analysis. Only the relevant data that the user/client needs to look at would be shown to the client on his/her handset. Internet connectivity would be required for the user to access the application and locate their bus.

2. LITERATURE REVIEW

To address overcrowding issues a new algorithm and structure are proposed to count the number of inbound and outbound people using the impulse radio ultra-wideband (IR-UWB) radar sensors.Two IR-UWB radar sensors are used which are equipped with the narrow beam antenna [2]. Two radar sensors make two adjacent thin layers vertically with the moving direction of the people [2]. The total number of people who go through the radar's layer is counted by finding the effective peaks from the output values after a cross-correlation between the

representative values of the corresponding intervals of the two radars[2].

A solution to counter overcrowding in buses was proposed that simulated the handheldElectronic Ticketing Machines (ETMS) used by Tamil Nadu State Transport Corporation (TNSTC) conductors via an android application [1]. Crowd estimation is done by maintaining a list of "live" tickets (on-board passengers) of each bus at the server side [1]. The ETMs communicate with the server via an Application Programming Interface (API) [1]. The GlobalPositioning System (GPS) receiver built into the ETM is used for real time tracking of the buses thereby notifying passengers about the bus arrival time [1].

3. SYSTEM DESIGN

The System would be designed as shown in Figure 1. Data from the buses (sensor data and GPS) would be stored in the cloud. The relevant data would be displayed on the client side application. The client side application would contain a Google Map which would contain bus markers, these bus markers would indicate the location of the bus and the color of the marker would indicate the crowd present inside the bus.

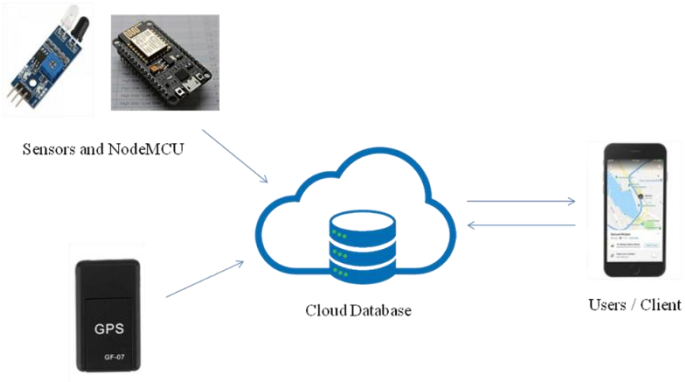

Fig -1: System Design

4. PASSENGER COUNT ALGORITHM

Counting the passengers inside the bus can be done in various ways such as: 1. Using Machine Learning in order to count the number of people captured by a webcam placed inside the bus; 2. Counting and predicting the number of passengers as per the tickets issued by the Conductor; 3. Counting with the help of sensors by detecting inbound and outbound movement; and many more. We have decided on using the third method since it is cheaper and much more effective. The basic concept of an Infrared Obstacle Detecting Sensor is to transmit an infrared signal, this infrared signal bounces from the surface of an object and the signal is received at the infrared receiver. A pair of 2 sensors placed on both the doors of the buses would be used in order to count the inbound and outbound passengers. All the sensors would be connected to theNodeMCU. The NodeMCU would be programmed so as to detect whether the movement of passengers is inbound (getting in the bus) or outbound (going out of the bus). The program would be based on the following algorithm:

1. Initialize all the sensor flags and count to 0
2. If sensor1 detects an object:
   If sensor2_flag=0:
   sensor1_flag=1
   If sensor2_flag=1: (Indicates outbound)
   count = count-1
3. If sensor2 detects an object:
   If sensor1_flag=0:
   sensor2_flag=1
   If sensor1_flag=1: (Indicates inbound)
   count = count+1
4. Return Count
5. Go to Step 2 until switched off

In the algorithm sensor1 is placed near to the door and sensor2 is placed at some distance after sensor1 inside the bus. Similar configuration and algorithm would be used for other two sensors placed on the other door.

5. IMPLEMENTATION

The system requires three modules to run simultaneously for smooth and effective functioning. The first is the NodeMCU and Sensor module which would get us the count of passengers in the bus. Second is bus conductor/driver application which would be accessed by the conductor/driver for providing us information such as bus number, source, destination and location of the bus. Third would be the client side application which would eventually show the information gathered by the other two modules to the user/client.

5.1 NodeMCU and Sensors

The NodeMCU and the Sensors would be placed inside the bus as shown in Figure 2. The sensors used in the system are Infrared Obstacle Detecting Sensors. These sensors consist of a transmitter and a receiver, both placed on the sensor. The transmitter transmits an infrared ray, when a reflective surface (person or object) is hit by this infrared ray, it reflects and is received by the receiver placed on the sensor. The working is illustrated in Figure 3.

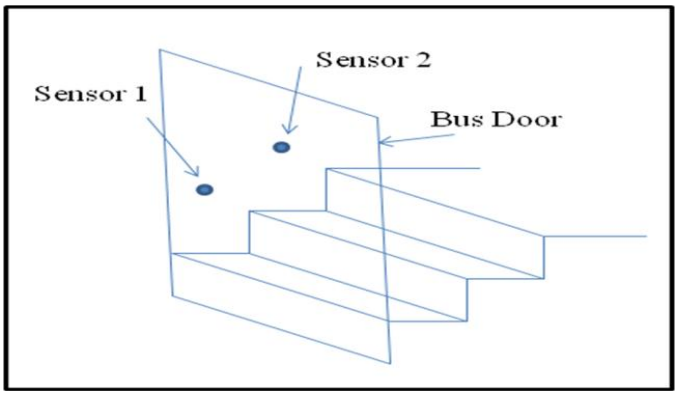

Fig -2: Sensor Placement on Bus Doors

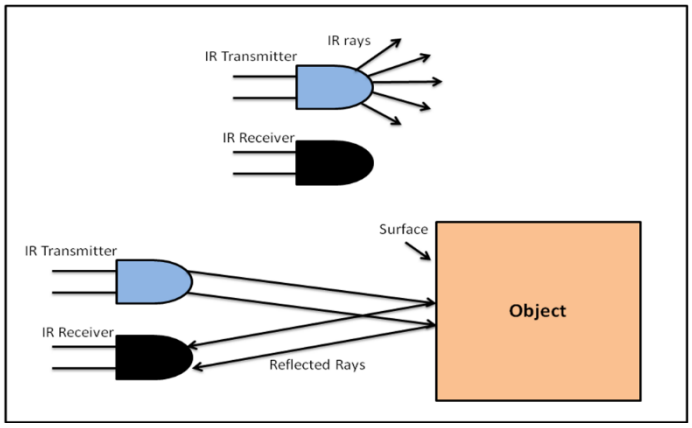

Fig -3: Sensor Working

NodeMCU is an open source IoT platform that is based on ESP-12 module [3]. It is used as a Wi-Fi module to send data over the Internet. The count generated by the program based on the algorithm would be sent to the Cloud where it would be stored.

5.2 Conductor/Driver Application

The conductor/driver side application provides us the bus number, source, destination and UID of NodeMCU placed inside the bus. The information gathered from this application would be stored in the cloud. There would also be a service that would run in the background which would provide the real time location of the bus(driver/conductor's phone).

In the application, once the conductor/driver has logged in, he/she needs to accept a few permissions, namely Location Permission, Camera Permission and Storage Permission. Once the permissions are accepted he/she needs to scan the QR code placed on the NodeMCU of the bus as shown in Figure 4. This QR code would contain the UID information of that NodeMCU.

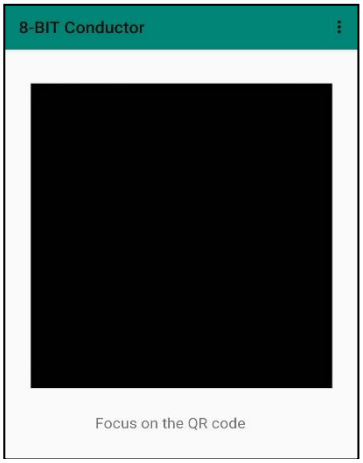

Fig -4: QR Scanning

Once QR is scanned the conductor/driver needs to fill the bus information in the next page as shown in Figure 5. After filling the information he/she needs to confirm the information.

Fig -5: Bus Details

After confirming the information, application starts the background service of obtaining the location of the bus(phone location). The information that the conductor/driver fills along with the count of passengers in the bus as well as bus's real time location co-ordinates are shown on the next page depicted by Figure 6.

Fig -6: Real Time Bus Information

Information received from this application would be stored in the cloud. Location and passenger count of the bus would be updated in real time.

5.3 Client/User Application

The client/user would be able to locate buses as well as they would get to know the passenger count in those buses. Buses would be indicated by a marker placed on the Google Map. The color of the marker would depend on the count of passengers in the bus.

The user needs to register or he/she can login if they already have an account. They can also use Google Sign-in for logging into the application. Once the user is logged in he/she needs to accept the location permission which would enable us to show buses within the vicinity of that user. The user now needs to enter the source and destination of his/her travel. Once the user clicks on 'Find' he/she would be able to see the buses that travel between the source and destination entered as shown in Figure 7.

Fig -7: Bus Search

When the user clicks 'View on Map' he/she would be able to see the real time location of the buses which they have searched as shown in Figure 8. If the user wants to see all the buses he/she can simply click 'View on Map' and view the real time location of all the buses. If any user desires to view all the buses after having searched for buses from a particular source and destination, he/she can do so by clicking on 'View all Buses' on the map page.

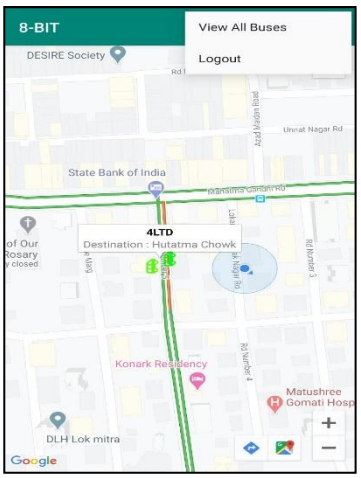

Fig -8: Bus Map

By clicking on marker information window the user would be able to see the exact number of passengers in the bus as well as number, source and destination of the bus as shown in Figure 9.

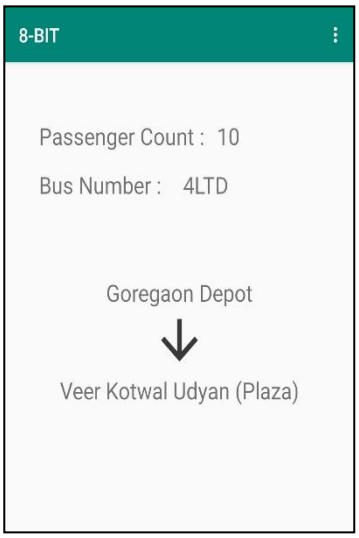

Fig -9: Bus Information for User/Client

6. CONCLUSION

The system is cost effective and can be used to manage crowd in various other transport systems. Maintenance of the system can be done when the buses return to their respective bus depots. People can see the number of passengers in the bus as well as would be able to locate the bus which would help them plan their travel. A system wherein people get to know the location and the crowd in a bus is the need of the hour, as the death of people falling

from overcrowded buses and also getting suffocated due to overcrowding have been on the rise. If the features and infrastructure of buses operating organizations is improved it would help decrease pollution and also would help in decongest roads. Effective management of crowd and buses can be done with the help of this system.

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