Poster: An Internet of Things-based Vehicle Counting System

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Abstract

Difficulty in finding parking spaces in free parking lots wastes time, fuel, and emissions. We design and implement a wireless system to count the number of cars and motorcycles in a parking lot based on Internet of Things. We deploy two sensor devices – one at an entrance and the other one at an exit of a parking lot. Each device consists of a NodeMCU ESP8266, an HC-SR04 ultrasonic sensor, and an MPU-9266 accelerometer. We use REST API to connect the sensor devices and users, who can get the parking status information from a web browser. To classify detected objects as cars, motorcycles, or people, we utilize a decision tree constructed using the C4.5 algorithm.

1 Introduction

Urban mobility has an impact on increasing the number of land transportation, especially four-wheeled (cars) and two-wheeled vehicles (motorcycles). The increase in the number of vehicles causes congestion – a result of the large number of vehicles park carelessly on the street. To reduce congestion due to illegal parking, a parking lot is needed to accommodate the vehicles. A parking lot is a dedicated place to park vehicles, such as cars and motorcycles, so that they are not parked on the shoulder of the road. Paid parking lots are either equipped with vehicle parking systems or attended by parking operators. On the other hand, free parking lots, such as nearby parks, are usually unattended and have no parking system. Drivers usually have troubles finding unoccupied parking spaces during busy hours. They can spend some time circling around with no success. Thus, it wastes time, fuel, and emissions.

The Internet of Things (IoT) offer an inexpensive solution to this problem. Sensor devices – with or without batteries [2] – can detect physical phenomena and transmit data using wireless technology. They have been used in a variety of applications [5, 6, 1], including smart parking system [4, 3]. While previous research focuses on cars and emphasizes on finding unoccupied parking spaces, in this work, we design and implement a wireless system to count the number of cars and motorcycles in a parking lot. We use two sensor devices, where one device is deployed in an entrance of a parking lot and the other one is deployed in an exit. Each device consists of a NodeMCU ESP8266, an HC-SR04 ultrasonic sensor, and an MPU-9266 accelerometer. We utilize the C4.5 algorithm to construct a decision tree to classify detected objects as cars, motorcycles, or people.

2 Design and Implementation

We show our wireless vehicle counting system in Figure 1. A sensor device is equipped with two kinds of sensors, *i.e.* an HC-SR04 ultrasonic sensor to measure distance to an object in front of it and an MPU-9266 accelerometer to measure vibration of a moving object. When an object is detected, data from the two sensors is sent wirelessly using NodeMCU ESP8266's ESP-12E WiFi module. This data is then received by REST (Representational State Transfer) API (Application Programming Interface) and forwarded to the application. Note that we use two sensor devices – one is deployed at an entrance and the other one is at an exit of a parking lot.

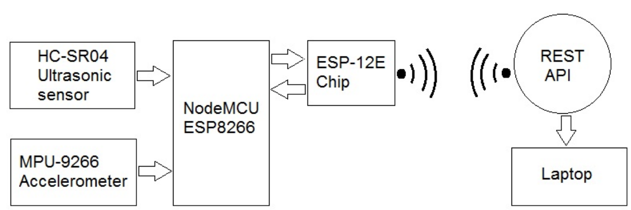

Figure 1. The vehicle counting system.

A sensor device consists of a NodeMCU ESP8266 and an HC-SR04 ultrasonic sensor placed on a breadboard, and an MPU-9266 accelerometer attached to a rope as a medium to carry vibrations. The ultrasonic sensor and NodeMCU are powered by external batteries, while the accelerometer gets power from NodeMCU. NodeMCU's D5 pin is connected to the accelerometer's SDA pin, D6 pin to SCL pin, GND pin to GND pin, 3V pin to VCC pin. NodeMCU's D7 pin is connected to the ultrasonic sensor's echo pin, while D8 pin is connected to the trigger pin.

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The vehicle counting system consists of two parts, *i.e.* the client side and the server side. The client side consists of the two sensor devices and an Arduino program. If all sensors are connected and the Internet connection is available, the Arduino program uploaded to NodeMCU read sensors' data and send it wirelessly if an object is detected. The server side consists of REST API as back end and a PHP (Hypertext Preprocessor) program as front end. If the Internet connection is available and the data is delivered successfully, it is then processed and saved to database. Users can retrieve the information regarding the parking status from a web browser. To process data, we use the C4.5 algorithm to build a decision tree to classify objects as cars, motorcycles, or people. Then we calculate the number of cars and motorcycles that enter and exit the parking lot.

3 Preliminary Result

To count the number of cars and motorcycles, we deploy two sensor devices – one at an entrance and one at an exit of a parking lot. Note that in this work, we do not detect the direction of moving objects as we assume that they enter the parking lot through the entrance gate and leave through the exit gate. Each device is placed at approximately 0.5 meters from the ground as depicted in Figure 2. We choose this height so that the ultrasonic sensor can detect the presence of vehicles in front of it. We attach the accelerometer of a sensor device on a rope, which is put on the ground across the road. When the wheels of a car or a motorcycle touch the rope, the accelerometer can sense changes in vibration.

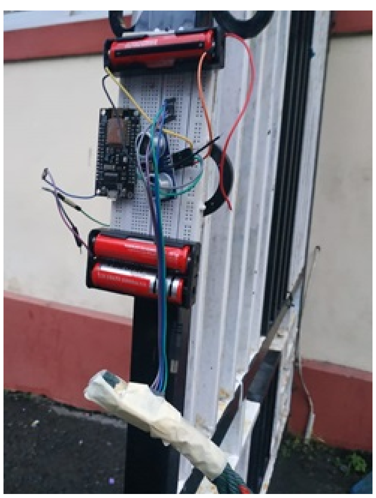

Figure 2. Hardware implementation.

In the evaluation, we assume that two objects are separated by at least one second and the speed of an object is at most 10 km/hour. When the readings of the ultrasonic sensor and the accelerometer change, it means an object is detected. Hence, NodeMCU sends the readings to the web server. We use a decision tree constructed using the C4.5 algorithm to classify detected objects. Our system classifies the objects as either cars, or motorcycles, or people. When a car or a motorcycle is detected, its counter is updated and users can retrieve the information regarding the parking status from a web browser as depicted in Figure 3.

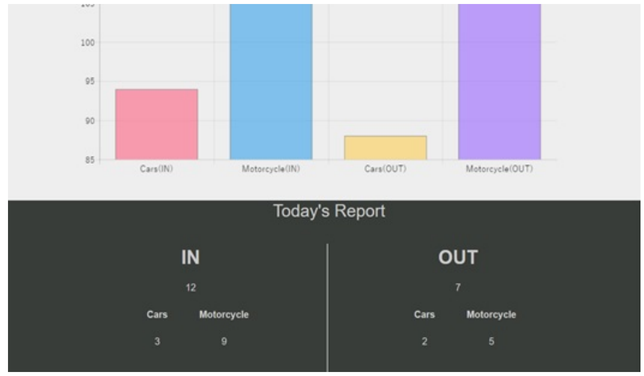

Figure 3. Software implementation at the server side.

For training purposes, we collect some data and label them. Each object has several data points, which are grouped together, then the values for each attribute are added. We then convert the numeric value into three categories, *i.e.* low, medium, and high, based on each attribute's value range, and label the data. However, due to the COVID-19 pandemic and social restriction that has been in place when this evaluation was carried out, we were unable to conduct a thorough experiment. We will continue to acquire more data over a longer period of time once we are able to do so.

4 Conclusion

In this work, we design and implement an Internet of Things-based vehicle counting system to count the number of cars and motorcycles in a parking lot. We use one sensor device at an entrance and one at an exit of a parking lot. Each sensor device consists of a NodeMCU ESP8266, an HC-SR04 ultrasonic sensor, and an MPU-9266 accelerometer. To connect the sensor devices and users, we use REST API as the web service. We utilize the C4.5 algorithm to construct a decision tree to classify detected objects as cars, motorcycles, or people. Users can obtain the parking status information from a web browser.

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