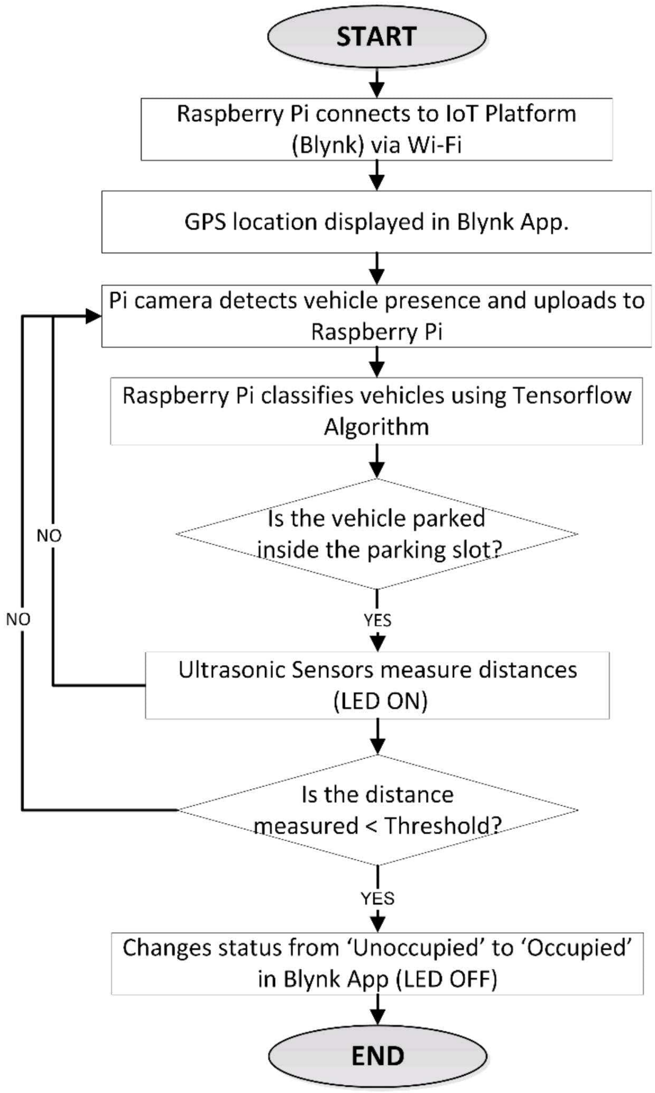

Figure 12. Flowchart of the system

Experimental Results

In this section, we present the system validation and discuss the results. As a result, we have successfully implemented the IoT-based smart parking system into the prototype model. The finalized prototype can be seen in Figure 13. Our smart parking system consists of four ultrasonic sensors, four green LEDs, one GPS module, one Pi camera, and one Raspberry Pi 4 board. The ultrasonic sensors would sense the presence of the vehicle in front of it, with a green LED mounted on top of it to indicate the occupancy of the parking slot. The GPS module is used to locate the parking facility, and the Pi camera is used to detect and classify objects detected using TensorFlow Algorithm. Each ultrasonic sensor has its dedicated number according to the slot number. The numbering helps tracking down the corresponding number of sensors and also its location. The mini car model is used to simulate a real car in the parking facility.

The Raspberry Pi board is placed inside the designated box on top of the pole. A Pi camera is placed facing towards the prototype to cover the view of the whole model. The GPS module is mounted on top of the box cover to broadcast the location data so that users can track the location of the parking facility. The wires connecting the sensors with the Raspberry Pi board runs underneath the prototype model and are covered up using plastic pipes. The wires then run through the hollow content of the pole then reach the Raspberry Pi board inside. When the system is turned on, the operation of the IoT-PiPMS will start eventually. The Blynk automatically connected through Wi-Fi and received data from Raspberry Pi to Blynk cloud and updated it in the Blynk App. Graphical User Interface (GUI) as shown in Figure 14. The GPS module will automatically detect the location of the parking lot and shown on the map as shown in the figure. Next, the Pi camera stream the video of the parking area and displays it in the live streaming widget of the Blynk App dashboard.

Figure13. Finalized Prototype.

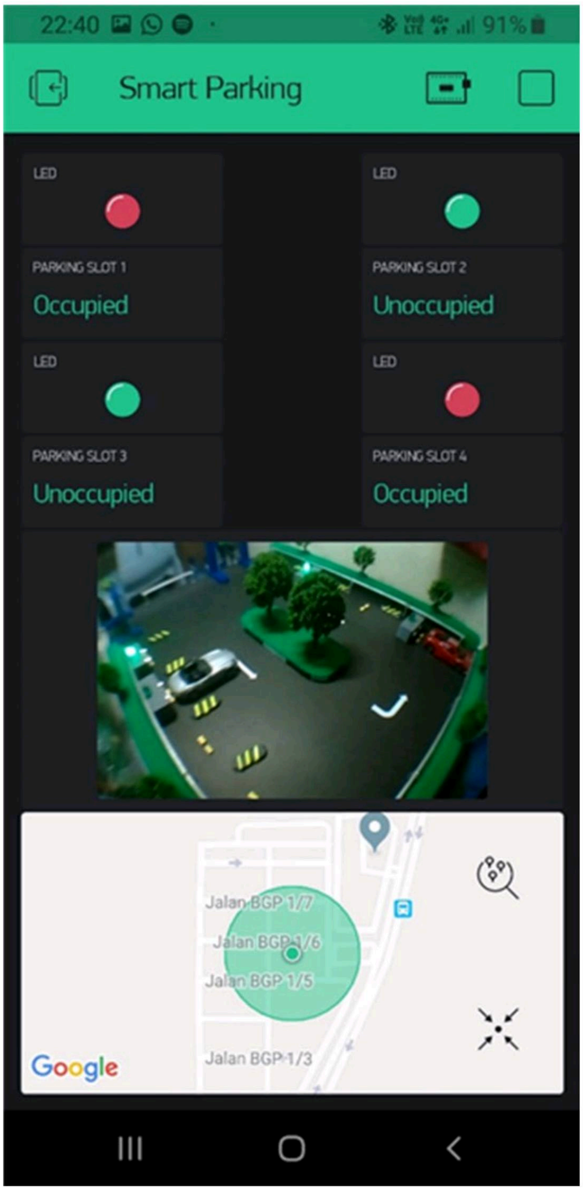

Figure14. IoT-PiPMS user interface on Blynk.

Users could check the occupancy of the parking slot on the Blynk App. on their smart devices. Other than that, they also could locate the location of the parking facility by looking at the map widget. The map widget displays the location data that it received from the GPS module. Users could also watch the camera footage live stream on the Blynk dashboard to confirm the capacity of the parking slot. When the ultrasonic sensor has detected a vehicle close to it, it would then update the user interface to show 'Occupied' on the Blynk App. The green LED will also be changed to a red LED on the Blynk dashboard. This will let the user know that the parking slot is currently occupied. On the real LED in the site, the green LED will turn OFF instead. When the vehicle starts leaving the parking slot, the ultrasonic sensor would no longer detect an object in front of it; thus, it would then update the user interface by changing the red LED back to green LED, and also the occupation status from 'Occupied' to 'Unoccupied'. Each of the parking slots is tested by placing a mini car model in front of the ultrasonic sensor. We confirm that our system is functioning well and the data transmitted in real-time to update the parking slots status to the cloud and can be accessed from anywhere at any time over the Internet via the Blynk App. Our system functionality and applicability in the real scenario of outdoor parking are proved as well.

In the meantime, the TensorFlow algorithm runs to detect the parking slot availability and identify the existing vehicle to be updated to the VNC Viewer and the Blynk dashboard, as shown in Figure 15. It identifies the occupied/unoccupied parking slots and displays the status as text with the number of the parking spot. This vision monitoring is used as a backup to support the ultrasonic sensor data that is displayed as LED indicators in the local parking and the Blynk dashboard as well. The programmed TensorFlow algorithm detects any object inside the rectangular shape, which indicates the parking slot. The TensorFlow was customized to specify the type of object to be detected, which in this case, the vehicle type (car, motorcycle, etc.). If a vehicle occupies a parking slot and is located inside the detection area, it will be detected and update the slot status to occupied. Any object other than vehicle type will not be detected for occupying the park. As in the figure, parking Slot 2 is occupied with a vehicle, while parking Slot 1 is unoccupied. The status of the ultrasonic sensor of Slot 2 is a red LED, and Slot 1 is a green LED, thus it is in agreement with the obtained information from the Pi camera. This double confirmed information increases our system reliability and it is among its advantages. In addition, this interface of the VNC Viewer can be accessed by the management office of the parking area. For the user, it is enough to get information from the ultrasonic sensors and access live streams of the parking area through the Blynk App. Besides, a GPS attached to the Raspberry Pi connected to the Blynk App. The ability of the TensorFlow algorithm with the Pi camera to classify the vehicle type is proved via a practical test. When the detection from the Pi camera is updated, the Blynk will also update the data in the Blynk IoT server and mobile.

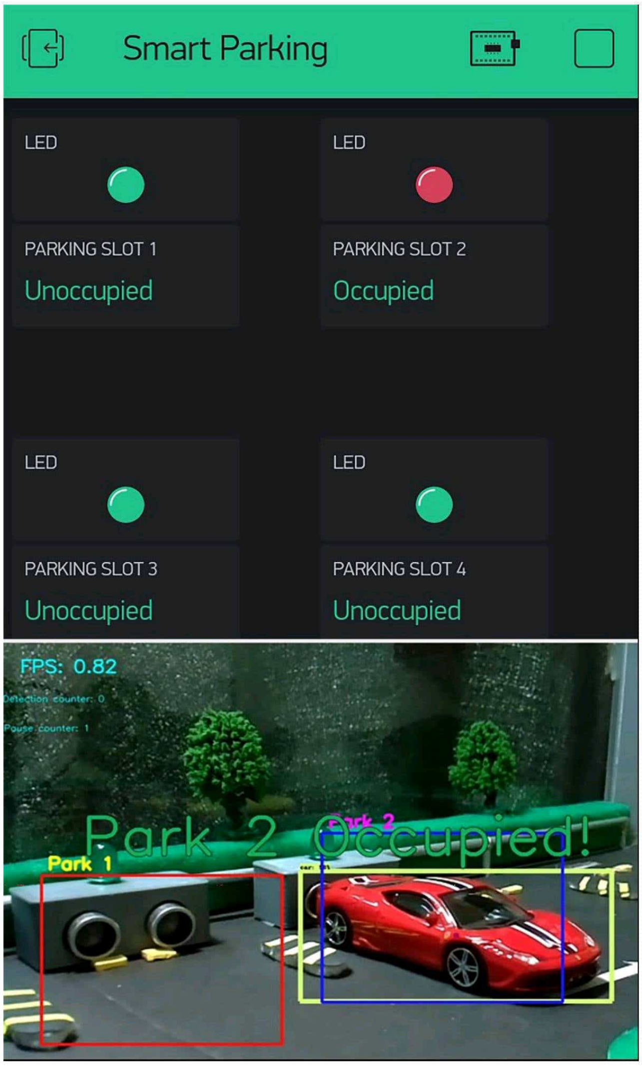

Figure 15 Pi camera object detection vs. LED status

٦. Conclusion

An IoT-based smart parking system using Raspberry Pi 4 B+ has been designed and fabricated by utilizing ultrasonic sensors, Pi camera, GPS module, LEDs, and the Blynk IoT platform. The developed system has been tested and validated to be used in the smart campus environment or similar outdoor parking lot. The system's reliability has been improved by using multiple sensors to detect the existence of vehicles. Staff/students/visitors can easily monitor the parking lot around the campus via a GUI over the Blynk App. by accessing the system dashboard on their smartphones. The GPS sensor allows drivers to easily access the parking lot. The developed IoT-PiPMS provides accessibility, intelligence, comfortable, and improves the driver user experience. For practical implementation, our system can be extended to include multiple RPi and Pi cameras. The parking lot can be divided into several sections; each can be covered by one RPi and one Pi camera. The number of ultrasonic sensors will be increased to cover the entire parking area. The camera captions and video streaming function can be specified for management only rather than users to reduce data usage and improve system privacy and safety.