Bike Sensor System Design for Safety and Healthy Riding

Pin-Cheng Lai, Hao-Zhe Huang, Ming-Hwa. Sheu, Chien-Ming Wu, Ji-Ting Le, Tzu-Hsiung Chen

***Abstract*–In view of the growing popularity and increasing presence of public bicycle sharing systems and of the fact that bikes are widely used as a convenient means of transportation as well as an equipment for exercise. This proposed system is based on IoT sensor network in which the data of PM2.5 is collected and sent to the cloud for monitoring use. Each bike user with this mobile app contributes to the data collection and enjoys the benefit of staying informed of the air quality along various routes from big data retrieved in real time from the cloud. In addition, the integrated IoT sensor platform device mounted beneath the bike seat contains three ultrasonic sensors for the rear, left and right sides, aimed at providing extra security for the cyclists in the form of graphic reminder and warning sound as alerts on smartphone.**

I. INTRODUCTION

As increasing emission of carbon dioxide is proving itself a catastrophic menace to the earth[1], governments all over the world are joining efforts to tackle this insidious threat. One of the endeavours contributing to the reduced carbon footprint is the widespread development and promotion of bicycle sharing infrastructures. The commonplace and large-network qualities of the public bicycle system offer an unprecedented opportunity for IoT applications. Taking advantage of this opportunity, the proposed system is an IoT solution to the two problems that jeopardize the safety and health of the public.

Firstly, in collisions involving a bicycle and another vehicle, the common key contributory factors to this type of traffic accidents recorded by police are negligence and failure to have a clear sight by either the driver or the rider. As a one of the precautionary measures, ultrasonic sensors are employed to detect tailgating cars; therefore, the blind spots, the common cause of accidents, are eliminated, thus securing extra safety.

Secondly, in comparison to the PM2.5 data collected by local monitoring stations and published by the Environmental Protection Administration that encompasses a wide area on an hourly basis, this proposed system allows the contributors to access the data shared collectively in real time[2]. The advantages of this collaborative implementation include not only the data transparency, where the data is available to everyone, but instantaneous synchronization, where cyclists receive updates with the latest data while biking on the healthies path. All the data from the cloud is displayed on Google Maps app on smartphone tagged with the collection time information[3]. Therefore, the riders can conveniently refer to the balloons indicating various degrees of air pollution plotted on Google Maps app, stay informed and choose the best route to take.

This device can be used not only in public bicycle systems, but also in electric bicycles[6] or smart bicycles.

II. SYSYEM ARCHITECTURE

The proposed system architecture consists two main parts. The MCU is responsible for communication via BLE between sensors and smart phone while the Android app on smart phone is for data transmission through 4G network between app and Firebase Realtime Database in Google Cloud.

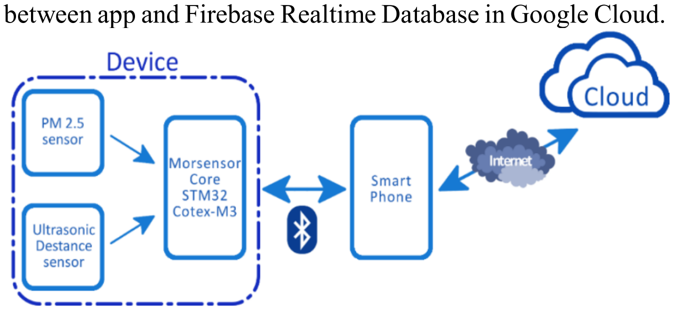

Fig. 1. Block diagram of the overall system architecture.

A. Hardware Setup

Fig. 2 illustrates the employed electronic devices and interfaces through which communication between different devices take places. The sensors are responsible for collecting data from the environment while the Bluetooth 4.0 Low Energy is for communication between the MCU and smart phone. The four sensor devices are connected to ADC. The converted values in digital form then go through Serial Peripheral Interface bus (SPI) to FPGA. FPGA here is used as a bridge between ARM Cortex-M3 and ADC, able to connect up to four different sensor devices. The interface between FPGA and MCU is SPI. The MCU connects to Bluetooth thorough SPI as well as to an inertial measurement unit (IMU) via I2C interface.

The integrated sensor platform device as shown in Fig. 3 incorporates three ultrasonic sensors and one PM2.5 Sensor(GP2Y1014AU0F). The device can be set up underneath the seat of a bike. integrated sensor platform device is supplied with two 18650 lithium-ion batteries. The batteries are expected to be recharged every time the bike is returned to the station.

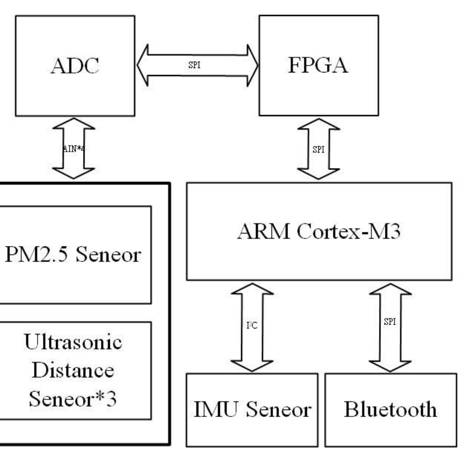

Fig. 2. Block diagram of the hardware architecture.

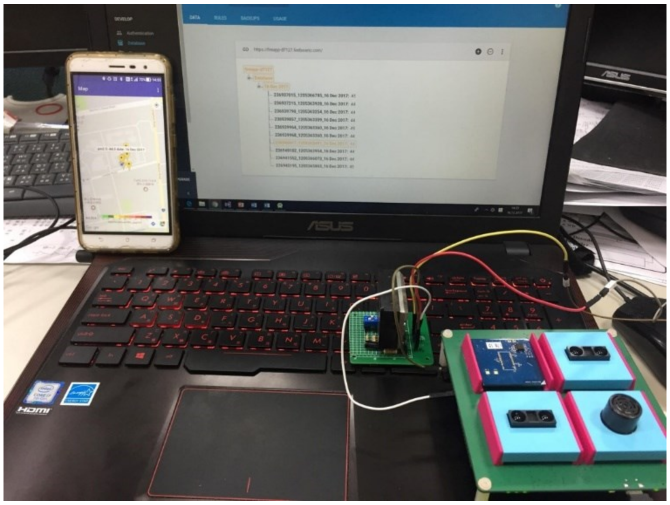

Fig. 3. Overview of the integrated sensor platform device.

B. Software Setup

The data is transferred through Bluetooth 4.0 Low Energy from the sensor node to the Android app. Numerous sensor data computations are then carried out on the app. The GPS coordinates of the current marker location information from the built-in GPS device in smartphone via Google Maps is sent to the Firebase Realtime Database. Data is stored as JSON, in which the data is structured as follows, the node standing for the current date, while GPS coordinates consisting of latitude and longitude, along with current data information, categorized as key and PM2.5 as value. The data in this format is retrieved on the app for display. Fig 4. is the algorithm for detection mechanism. Accelerometer is employed to detect if the bike is moving. On condition that the cyclist is moving, ultrasonic sensors are activated to detect tailgating cars, also mark the pm2.5 value on the map.

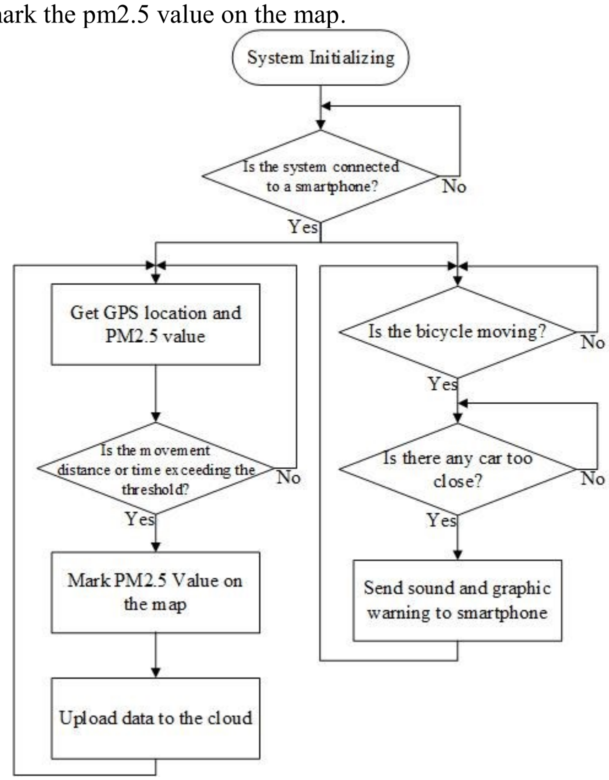

Fig. 4. Flowchart for detection mechanism

III. EXPERIMENTS

The ultrasonic sensors were programmed to detect a distance of 3 meters from the rear side and 2 meters from the left and right sides. Alert was sent once any approaching vehicles were detected as shown in Fig.5. The PM2.5 data was uploaded to the Realtime database every 30 seconds. The PM2.5 data can be monitored on the Firebase website as well as on Google Maps.

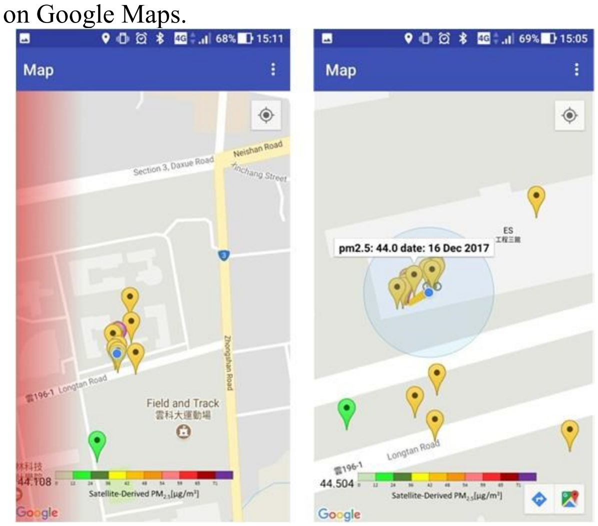

Fig. 5. Display on smartphone

IV. CONCLUSION

The air quality information in local areas is collected in a more specific way, stored in cloud in real time and synced across multiple cyclists in large-scale network of bikes.

This system is an IoT-based solution to the less than specific data provided by the local air quality monitoring stations. Historical data produced by sensors and stored in the IoT database allows bike riders to make informed decision for the route. In addition, this big data can be also used by the government for better monitoring of the environment. Future works will be oriented towards studying data management and analysis for optimal application of the big data.

REFERENCES

[1] Janice J. Kim, Svetlana Smorodinsky, Michael Lipsett, Brett C. Singer, Alfred T. Hodgson, Bart Ostro, “Traffic-related air pollution near busy roads,” American Journal of Respiratory and Critical Care Medicine, vol. 170, no. 5, pp. 520-526, 2004.

[2] Ling-Jyh Chen, Yao-Hua Ho, Hu-Cheng Lee, Hsuan-Cho Wu, Hao-Min Liu, Hsin-Hung Hsieh, Yu-Te Huang, Shih-Chun Candice Lung, “An Open Framework for Participatory PM2.5 Monitoring in Smart Cities,” IEEE Access, vol. 5, pp. 14441-14454, 2017.

[3] Yung-Sheng Lin, Yu-Hsiang Chang, Yue-Shan Chang, “Constructing PM2.5 Map Based on Mobile PM2.5 Sensor and Cloud Platform,” IEEE Intl. Conf. on Computer and Information Technology (CIT), pp. 702-707, 2016.

[4] Xiaofeng Liu, Chaosheng Xiang, Bin Li, Aimin Jiang, “Collaborative Bicycle Sensing for Air Pollution on Roadway,” IEEE Intl. Conf. on Scalable Computing and Communications, 2015.

[5] Han Zhao, Wenbin Shu, Desong Li, Siqi Li, “A novel wireless power charging system for electric bike application,” IEEE PELS Workshop on Emerging Technologies: Wireless Power, pp. 1-5, 2015.

[6] https://www.sparkfun.com/datasheets/Sensors/gp2y1010au_e.pdf

[7] http://morsensorcontest.cic.org.tw/MorSensor/about.php