Development of a Vehicle Air Pollutant Monitoring Device

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Philip D. Geneta
College of Industrial Technology, Batangas State University, Rosario, Batangas, Philippines
pdgeneta@gmail.com

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Abstract *–The Vehicle Air Pollutant Monitoring Device was developed to mobilize the roadside anti-smoke belching operations and strengthen the capacity of the Local Government Units in developing local policies and programs on air quality. The prototype has a mobile application that enables the device to sense the carbon monoxide emission of the vehicle being tested, captures the plate number, locates the vehicle in real-time and sends the emission report via SMS and e-mail. Locally available materials were used in the fabrication of the prototype such as Arduino ATmega1281 microcontroller, MQ-2 gas sensor, serial camera and HC-05 Bluetooth module. The mobile application was developed using Basic4Android software. The prototype was tested for its distance sensitivity, accuracy and functionality. The result of the distance sensitivity test showed that distance was directly proportional to the carbon monoxide emission of the vehicle. Moreover, the emission reading of the prototype was 99% accurate as compared to the emission reading of the digital analyzer used in emission testing center. The functionality of the device showed that the serial camera, SMS and GPS were operational. Its performance was evaluated by fifteen (15) IT experts and environmentalists and fifteen (15) possible end-users which composed of motorists, emission testing technicians and law enforcement agency, according to its functionality, aesthetic, workability, durability, economy, safety and salability. The prototype gained an overall mean score of 4.58 with a descriptive rating of "Excellent" signifying that the prototype met its objectives and that the evaluators were satisfied of the outcome and capabilities of the device.*

Keywords *–air pollution, carbon monoxide, vehicle emission*

INTRODUCTION

Air pollution is a global condition which causes deterioration of the atmosphere. Over the past years, it has been the point of discussion when significance for environmental awareness is concerned. The drive for a cleaner environment continues as the world embraces industrialization. As countries become industrialized, air pollution has been provoked by developments of emergent cities, fast economic development, elevated levels of energy utilization, and increasing traffic.

The escalating population in Metro Manila which brings traffic congestion has led to the problem of air pollution. Air pollution contributes to the green house gases, which causes the green house effect. Air pollution is not only detrimental to the environment, but also to all other living beings on earth. Air pollutants when inhaled have serious impact on human health consistently affecting the lungs and respiratory system [1]. These contaminants are also deposited on soil, plants, and in the water, further contributing to human exposure and also affecting the marine life.

In Metro Manila, motorized vehicles are one of the top contributors to air pollution [2]. The main contaminants from these vehicles are the oxides of carbon and nitrogen, which can be easily detected with the aid of semiconductor gas sensors [3]. Carbon monoxide (CO) emission is relatively caused by the increasing number of motorized vehicles such as cars, utility vehicles, trucks, buses, motorcycles and tricycles. These motor vehicle exhausts contribute roughly75 percent of all CO emissions nationwide, and up to 95 percent in cities [4]. Air concentrations of CO can be high in areas with heavy traffic congestion.

According to the 2015 statistical report of the Land Transportation Office, there were 2, 317, 204 registered vehicles in the National Capital Region; 477, 320 of these were cars, 643, 686 UVs, 83, 735 trucks, 15, 278 buses, and 860, 517 motorcycles/ tricycles [5]. Every vehicle has emission but the problem occurs when it is beyond the standardized values. The major cause behind this breach of emission level is the incomplete burning of fuel supplied to engine, which is due to the improper maintenance of vehicles [6]. This emission from vehicles cannot be entirely avoided but, it can be controlled.

The requirement of passing an emission test before registration was implemented starting January 1, 2003 as stated in a Case Study on Knowledge Management on Air Quality conducted by the Asian Development Bank and CAI-Asia Center in 2010. Emission tests of private vehicles were conducted in PETCs authorized by the DOTC and duly accredited by the DTI. Public utility vehicles were given the option to have their vehicles tested in the LTO's Motor Vehicle Inspection System (MVIS) at a reduced rate [7].

Due to increasing number of vehicles contributing to the amount of CO in the atmosphere, the researcher suggests a device that senses the CO emission from vehicles such as cars, utility vehicles, trucks, buses, motorcycles and tricycles if it exceeds the legal limits; captures the plate number of the vehicle; locates the vehicle in real-time; and sends the emission reading to the operator and/or authorized law enforcement agency through Short Message Service (SMS). This device may mobilize the LGUs in strengthening roadside anti-smoke belching operations, promote clean technologies for motor vehicles including cleaner fuels; and strengthen the capacity of LGUs in developing local policies and programs on air quality, specifically on anti-smoke belching.

OBJECTIVES OF THE STUDY

The general objective of the study is to develop a vehicle air pollutant monitoring device using locally available materials. Specifically, it aims to design a vehicle air pollutant monitoring device which is capable of sensing the carbon monoxide emission and capturing the plate number of the vehicle, locating the vehicle being tested in real-time, and sending the emission reading to the operator and/or authorized law enforcement agency through SMS and e-mail; to test the sensitivity, functionality and accuracy of the developed prototype; and to evaluate its performance using the evaluation instrument for prototype devised by the Technological University of the Philippines.

MATERIALS AND METHODS

This is a developmental type of research which employed thorough planning and analysis to achieve the objectives of the study. It also considered distance sensitivity, accuracy and functionality tests to evaluate the performance of the fabricated prototype. This covered the following stages:

Design Stage

This stage focused on identifying the necessary information such as knowledge, hardware and software requirements needed in the fabrication of the prototype. The specifications of the prototype were also considered. Also, the programming languages used were specified. Schematic diagram of the prototype was presented indicating the different components and dimensions. The schematic diagram of the vehicle air pollutant monitoring device is shown in Figure 1.

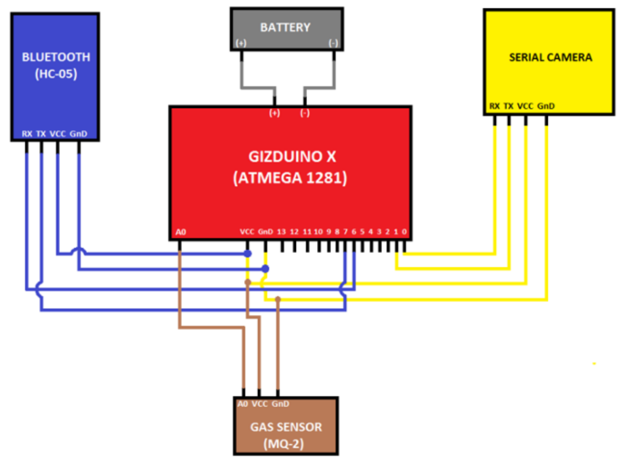

Fig. 1. Schematic diagram of the vehicle air pollutant monitoring device

Development Stage

This phase covered the fabrication of the device considering the design specifications. Locally available materials were used in the fabrication considering their availability, quality and cost.

Testing and Improvement

In this phase, the developed prototype was tested in traffic congested areas of Lipa City, Municipalities of Rosario and Padre Garcia in Batangas. The device was tested according to distance sensitivity, accuracy and functionality to ensure that it will work in accordance to the objectives of the study.

Evaluation

The evaluation instrument used by the researcher was the Technological University of the Philippines Evaluation Instrument for Prototype with seven (7) major criteria namely: functionality, aesthetics, workability, durability, economy, safety, and salability. The prototype was evaluated by thirty (30) respondents composed of fifteen (15) technical experts which include environmentalists and IT programmers; and fifteen (15) end users such as motorists, vehicle owners, emission testing technicians and authorized law enforcement agencies.

RESULTS AND DISCUSSION

The fabricated vehicle air pollutant monitoring device is presented in Figure 3. The device is composed of the following major hardware components: Arduino ATmega1281 microcontroller, HC-05 Bluetooth module, SD/MMC card shield, MQ-2 gas sensor, serial camera, and a mobile application. The microcontroller unit, HC-05 Bluetooth module, SD/MMC card shield and 3200 mAh power bank are enclosed in a 2.75" x 10.50" toy car casing with a color coded terminal block for easy installation and setup.

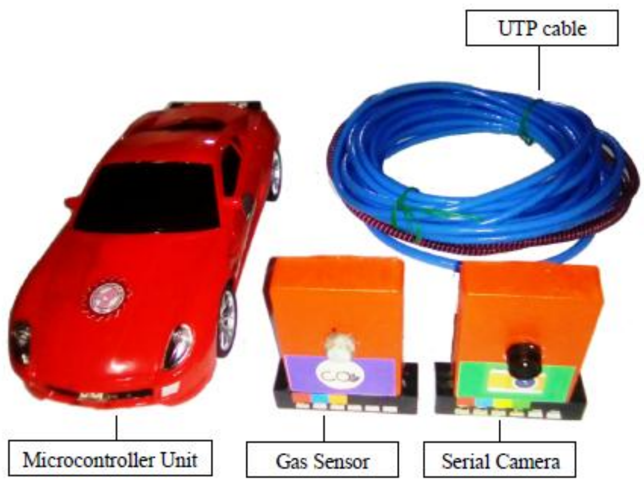

Fig. 2. Vehicle air pollutant monitoring device

Figure 3 illustrates the flow chart of the Vehicle Air Pollutant Monitoring Device. First, turn on the device, and Bluetooth, GPS, Wi-Fi or cellular data on the android phone. Launch the mobile application, and make sure the status of Bluetooth, gas sensor, serial camera and GPS are connected. Enter the plate number of the vehicle, and press the capture button. It automatically saves the image file to the memory card with the entered plate number as its filename. Press the scan button and the MQ-2 gas sensor analyzes the carbon monoxide from the vehicle being tested. The gas sensor initiates reading once every five seconds. This action takes place five times for a total of 25 seconds. The mobile application sends the highest carbon monoxide reading along with the plate number, vehicle type, emission limit for the chosen vehicle type, location, date and time and the number of violation(s).

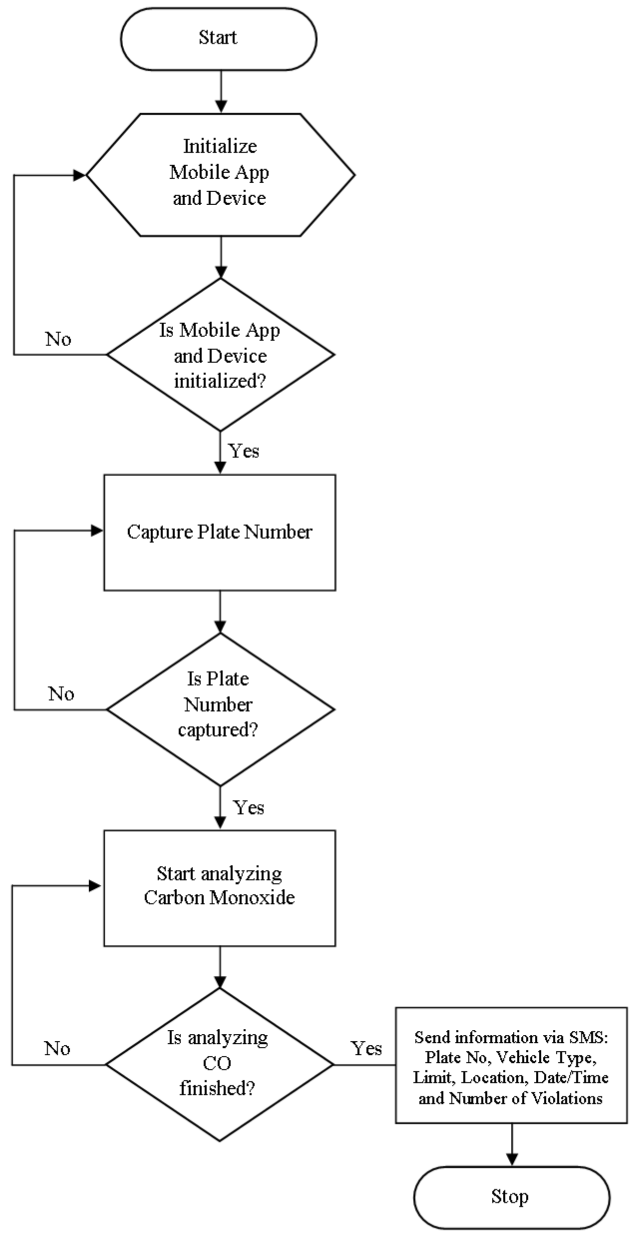

Fig. 3. Flow chart of the vehicle air pollutant monitoring device

The microcontroller unit has a power input of 8-12V external and a program memory of 128K. The HC-05 Bluetooth module was interfaced with the microcontroller to link the device to the mobile application installed in an android phone. It has a maximum connection distance of 10 meters and power input of 5VDC. The SD/MMC card shield has a 4 GB SD card for storing the captured plate number of the vehicle being tested. The MQ-2 gas sensor was used to detect the carbon monoxide emission from a vehicle. The serial camera was used to capture JPEG images. It has a 5V power supply, and VGA 640x480 image resolution. The Bluetooth module and serial camera are enclosed in an 8.90cm x 5.50 cm acrylic casing with a color coded terminal block for easy installation and setup.

The icon of the mobile application linked in the device is shown in Figure 4.

Fig. 4. The icon of the vehicle air pollutant monitoring device mobile application

The mobile application was designed and developed using the Basic4Android software. MySQL was used for the database of the mobile application.

Test Results

The device was subjected to distance sensitivity, accuracy and functionality tests in order to find out the capability of the device.

Distance Sensitivity Test

Table 1 depicts the result of Distance Sensitivity Test of the gas sensor. Three vehicles were subjected to test in one, two and three meter range from the device. It can be gleaned from the table that distance is directly proportional to the carbon monoxide emission of the vehicle. As the vehicle being tested goes nearer the gas sensor, the higher the reading of the carbon monoxide emission.

Table 1. Distance Sensitivity Test Result (Gas Sensor)

Vehicle No.	Vehicle Type	Carbon Monoxide Reading (%)		
		1 meter	2 meters	3 meters
1	UV	0.67	0.66	0.64
2	MC/TC	1.16	1.16	1.15
3	Car	0.64	0.63	0.63

Accuracy Test

Table 2 shows the result of the accuracy test of the gas sensor. Three vehicles (motorcycle/tricycle, car and UV) were tested using the Vehicle Air Pollutant Monitoring Device and the digital analyzer of Quilib Emission Testing Center, an LTO accredited emission testing center in Rosario, Batangas. Following the procedures of the emission testing center and the developed prototype in taking the carbon monoxide emission of the vehicle, the results were compared and analyzed. The emission reading of the prototype was 99% accurate as compared to the emission reading of the digital analyzer used in emission testing center.

Table 2. Accuracy Test Result (Gas Sensor)

Vehicle No.	Vehicle Type	Carbon Monoxide Reading (%)		Accuracy
		Emission Testing Center	Vehicle Air Pollutant Monitoring Device	100%-[% Emission Testing Center-% Vehicle Air Pollutant Monitoring Device]
1	MC/TC	2.45	2.46	99.99
2	Car	0.63	0.64	99.99
3	UV	0.55	0.70	99.88

Functionality Test

Table 3 depicts the results of the Functionality Test for the serial camera, SMS and GPS of the device. The sample images captured by the serial camera are shown in Figure 4.The SMS, on the other hand, can be checked on the sent items of the android phone. It includes the GPS location where the vehicle was tested.

Table 3. Functionality Test Result

Vehicle No.	Vehicle Type	Serial Camera		SMS		GPS	
		Image captured?		SMS sent?		Location tracked?	
		Yes	No	Yes	No	Yes	No
1	Car	✓		✓		✓	
2	Bus	✓		✓		✓	
3	UV	✓		✓		✓	

Figure 5 shows the sample text messages sent by the mobile application. It includes the plate number of the vehicle being tested, vehicle type, location, date and time, highest recorded CO reading and the number of violation(s) the vehicle has committed.

Figure 6 illustrates the location field of the device mobile application. The GPS of the android phone when turned on enables this location field to track the vehicle being tested.

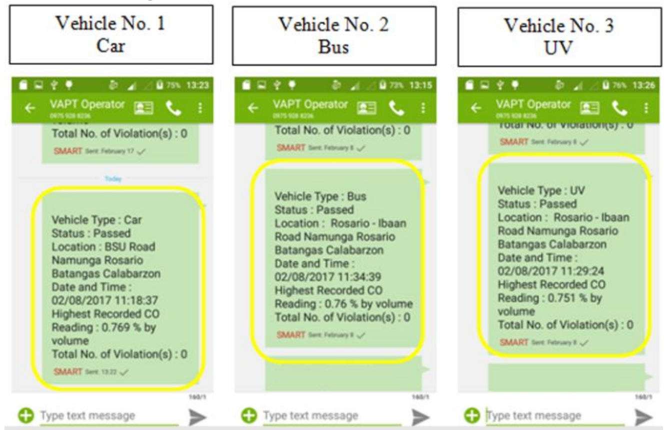

Fig. 5. Sample text messages sent by the vehicle air pollutant monitoring device mobile application

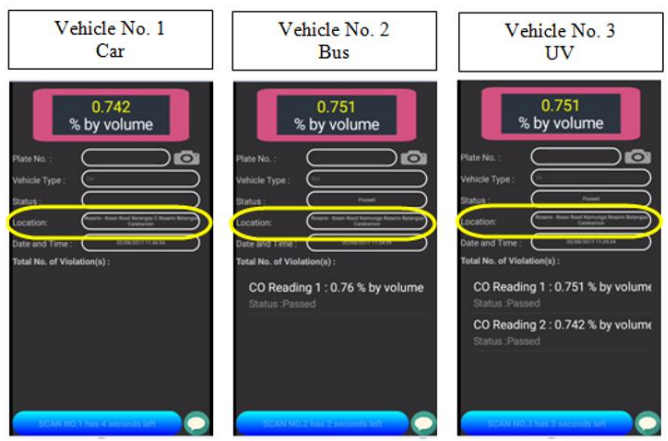

Fig. 6. Location field of the vehicle air pollutant monitoring device mobile application

Table 4. Summary of Evaluation Results

Criteria	Mean (X)	Descriptive Rating
Functionality	4.70	Excellent
Aesthetic	4.57	Excellent
Workability	4.52	Excellent
Durability	4.49	Very Good
Economy	4.59	Excellent
Safety	4.63	Excellent
Salability	4.57	Excellent
Overall Mean	4.58	Excellent

The device was evaluated by 30 respondents using the TUP Evaluation Instrument with the following criteria: functionality, aesthetic, workability, durability, economy, safety, and salability. Table 4 presents the summary of evaluation results.

The overall rating of the developed prototype obtained an overall mean score of 4.58 with a descriptive rating of “Excellent”. This indicates that the evaluators were satisfied of the outcome and capabilities of the Vehicle Air Pollutant Monitoring Device.

CONCLUSION AND RECOMMENDATION

The developed vehicle air pollutant monitoring device can be considered technically viable to mobilize the LGUs in strengthening roadside anti-smoke belching operations, promote clean technologies for motor vehicles including cleaner fuels; and strengthen the capacity of LGUs in developing local policies and programs on air quality, specifically on anti-smoke belching. Hence, it is recommended to calibrate the device quarterly for its accuracy. Further improvement of the device could be done so it could sense not only carbon monoxide emission but also hydrocarbons and other air particulates.

REFERENCES

[1] Pandey, J.S., Kumar, R., & Devotta, S.(2005). Health risks of NO_2, SPM and SO_2 in Delhi (India). Atmospheric Environment 39, 6868-6874

[2] Metro Manila air pollution exceeds tolerable level, URL: http://www.philstar.com/opinion/175428/metro-manila-air-pollution-exceeds-tolerable-level, date retrieved: February 7, 2016

[3] Prashanna, R.R. (2017). Vehicle Speed Sensing and Smoke Detecting System. SSRG International Journal of Computer Science and Engineering –NCSACT, 27-33

[4] Air Quality Index, URL: https://www3.epa.gov/airnow/aqi_brochure_02_14, date retrieved: February 10, 201Annual Report 2015,

[5] Channabasavaiah, M. S., & Shrinivas, M.D. (2014). Automated Control System for Emission Level &Rash Driving Detection in Vehicles. International Journal of Electrical and Electronics Research, Vol. 2, Issue 2, pp.96-99

[6] National Air Quality Status Report: 2003-2004. (2005). Quezon City, Philippines: Department of Environment and Natural Resources