

iRovers: real-time unmanned four-wheel iot vehicles for air and noise pollution monitoring

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Abstract— Knowing the exact amounts of hazardous gases as well as the noise levels in an indoor setting is vital for a healthy green community. With most people in communities spending time indoor, the quality of the air indoor, as well as the noise levels there play an important role in the health life style of the occupants. Additionally, with the number of road users increasing, as well as with more industries growing, the level of gas emissions into the environment increase. This prompts the need for fully autonomous systems that can move uncontrolled through various places to detect the levels of dangerous gas emissions, the noise levels, and thus monitor the overall air and noise quality for future clean and smart green societies. Work done in the development of mobile robots that can autonomously move around avoiding obstacles and reaching several areas of an indoor setting monitoring the air and noise quality is presented.

Keywords— rover; mobile robot; air pollution; and noise pollution;

I. INTRODUCTION

CO₂ emissions (metric tons per capita) in the United Arab Emirates were reported at 24.98 in 2008, according to the World Bank [1-3]. In 2013, the UAE released 199.65 million tonnes of carbon dioxide and other greenhouse gases, with electricity and water generation contributing 64.89 million tonnes of greenhouse gases, road transport 44.25 million tonnes, and oil and gas sector 29.6 million tonnes [4]. From this data, it is evident that CO₂ emissions are rising every year, and it is important to develop a system that can monitor and synthesize this data for decision makers in cheap and cost-effective way. The main aim of this project is to develop prototype systems that will monitor the air and noise quality in UAE communities using unmanned autonomous vehicles with real time internet of things monitoring. This aim will be achieved through several objectives like research surveys in communities, design, modeling and simulation, design for manufacturing/assembly, implementation, testing and deployment.

Other prototypes have been presented before [5-7], with obstacle avoidance [8,9] and using an application [10], for gas detection [11-12]. However, they all seem to be inadequate when various locations must be monitored at the same data, and plotted out. This system will monitor wireless sensor networks located at various sites while logging the emissions data on the internet in a real time.

The system will employ the Intel Edison as the core micro-controlling device equipped with a WIFI interface. On board

will be a micro SD card running real time operating systems in Linux or windows for internet of things (IoT) applications. Sensors for monitoring air and noise pollution as well as gas emissions, will be interfaced wirelessly through WIFI or zigbee networks or to the system delivering readings from different locations. At the output, the data will be logged in real time and plotted on the internet and through mobile applications to show the emissions per location.

II. METHODOLOGY

The following design methodology was used in this project. The methodology used in this research will follow a modular top-bottom approach with emphasis on the quality function deployment where the needs of the customers and product users in communities will be sought through research surveys, one on one meetings, to understand their requirements and expectations for a green community. These findings will then be used in defining the product specifications, that will then be transformed into a detailed design, system model and simulations aimed at a design for assembly as well as design for manufacture as shown in workplan.

A. Mathematical Model

The mathematical model of this project is based on finding the shortest time path for the robot as the robot is expected to move in straight path and semicircular arcs [13]. The shortest length l .

$$\min l = \sum_{i=1}^n s_i + \sum_{j=1}^m l_j \quad (1)$$

With S_i and L_j being the semi-circular and straight sections respectively along the direction of the robot to avoid obstacle. This minimum length could be found by minimizing the time spent along the path of the robot by relating time to distance and velocity of each section.

B. Block Diagram

After studying the working principle of all the components both individually and the collective behavior or expectation when working together while not forgetting the requirement of our project, we concluded on the block diagram shown below in Figure 1.

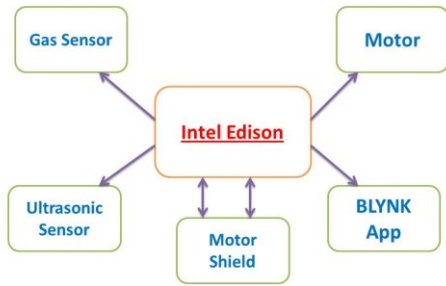


Figure 1: Block diagram of the project

Block 1 Gas Sensor

This helps to measure the level of poisonous gas in the air, in particular, the CO level.

Block 2 Ultrasonic Sensor

This serves as the proximity sensor sensing ultrasonic sound waves and using the reflected waves later received by it to measure the distance between it and an approaching obstacle. Such information is important for our robot car to decide on continuing its movement in such direction or consider a change of path.

Block 3 Motor

This serves as the wheel of the robot car. Its rotation leads to the movement of the car. We used 4 motors in our design to represent the four wheels of a robot car. All these motors must rotate in cohesion to ensure seamless movement of the robot car. Such cohesion is an important part of the program code used to drive the project.

Block 4 Motor Shield

This is the framework that we connected all hardware components with. It also has the capacity to send and receive signals needed to control the hardware connected to it as well as the capability to send a signal to the mobile App (BLYNK).

Block 5 Blynk

This is the mobile App package that is used to control the robot car and also have the ability to display information on a screen. This ensures easy communication with the robot car.

C. Hardware Circuit Design

We wired up our design as shown in Figure 2, following all the wiring requirements of all its components. Also, the schematic representation of the design resulting from this wiring on a software (fritzing) is shown in .

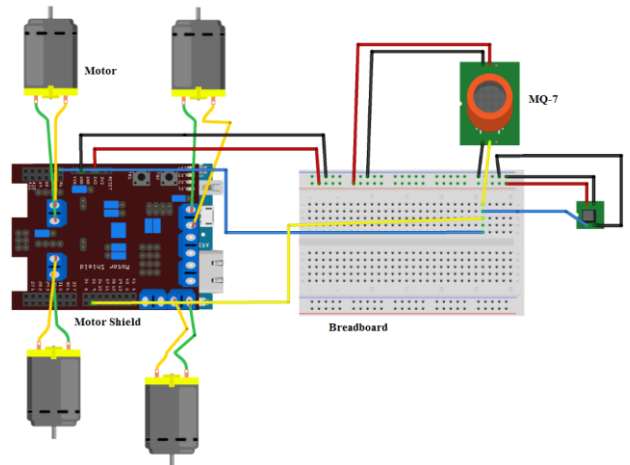


Figure 2: Breadboard circuit wiring

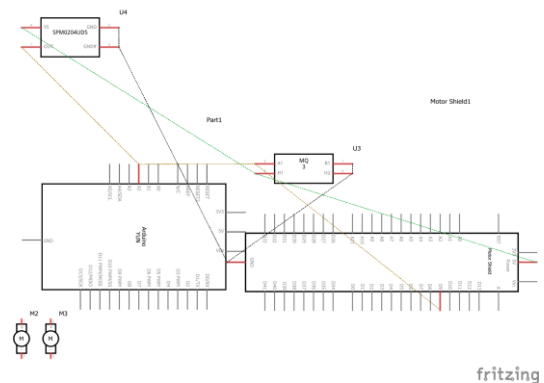


Figure 3: Schematic diagram

D. Flowchart

Our project requires more than wiring to work. We have to design a flowchart of its working principle or a pseudocode before embarking on programming. This makes the programming aspect of the work intuitive and easy as we know the layout of the code from such flowchart. Following in Figure 4 shows the flowchart for the project.

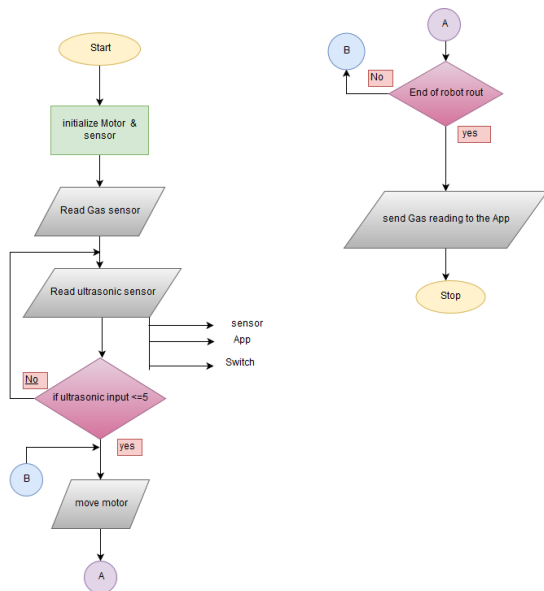


Figure 4: Project Flowchart

As shown in Figure 4, our design starts with the initialization of the motors and all sensors. Next to that is reading from the gas sensor which is used in making a decision as to move the robot car or not. Because we have to sure that the route of the robot car is safe for it to pass, we read from the ultrasonic sensor before starting the motor.

The motor will be moved only if we can ascertain that the gas sensor level of CO is safe, a metric which we used a maximum of 200 to decide on. While moving, we keep track of the reading from the ultrasonic sensor reading as well to know when the robot car is close to an approaching obstacle.

Each of the symbols on the flowchart shown above carries out the following task:

Symbol 1 **Initialize Motor and Sensor**

Initialise the state of all the sensors (Ultrasonic and Gas sensor) and also the motor.

Symbol 2 **Read Gas Sensor**

Get readings from the Gas Sensor

Symbol 3 **Read Ultrasonic Sensor**

Get readings from the Ultrasonic sensor

Symbol 4 **if input << 200**

Verify if the condition is right to move

Symbol 5 **Move Motor**

Move motor

Symbol 6 **End of robot route**

Verify if the condition is right to continue moving

Symbol 7 **Send Gas reading to the App**

Send gas reading to the mobile App.

III. PROJECT COMPONENTS

Over the course of research on the choice of project, we were able to not only itemize the required components but also the prices as well as quantity which made it easy to have a defined budget for the work. The listing of the prices of the components can be found in Table 1.

Table 1: Price estimation

Component	Price (Dhs)		Comment
	Unit	Total	
Gas Sensor	26.63	26.63	Available in the lab
Ultrasonic sensor	14.51	14.51	Available in the lab
Intel Edison	36.54	36.54	Available in the lab
Motor Shield	73.27	73.27	Available in the lab
Motors (DC) 4	12.34	49.36	Available in the lab
App (Blynk)	Free	0	Available free of google play store
	Total	200.31	

IV. PROJECT MANAGEMENT AND PLAN

Our work was well planned and implemented based on the planned schedule. We set up to work on the 29th of October 2017 and finalize the project on the 14th of November 2017. Details of all activities starting from the team formation, including project topic decision, up till the final writing of this report is shown in Table 2.

Table 2: Project Schedule

Task	Duration (Days)	Start Date	Finish Date
Form a team	1	10/29/2017	10/29/2017
Choose a topic		10/29/2017	10/29/2017
Research about topic		10/29/2017	10/29/2017
Make proposal		10/29/2017	10/29/2017
List components		10/29/2017	10/29/2017
Design hardware	3	11/2/2017	11/4/2017

circuit			
Write software program	4	11/5/2017	11/8/2017
Implement & Test project	4	11/9/2017	11/12/2017
Write Report	2	11/13/2017	11/14/2017

V. PROJECT PROGRAM

The program was written is to control all components of the project and ensure coherence in what each component is doing inline with the requirement of the project and also in line with the plan of the work. The programming is divided into parts based on the necessity of a good program.

```
include <AFMotor.h>
```

```
AF_DCMotor motor1(1);
```

The first part is the “include” statement to add the library of the motor to the program. This is followed by initializing all the four motors required that serve as the tire of our robot car. We equally initialize other components including the gas sensor and the ultrasonic sensor state. Parameters initialized for the motors includes the speed to control how fast it moves.

```
void motorforward() {
  ...
}
```

What next is to define the control functions or methods for the components including motorforward() and motorbackward() among others. We equally have to write the controlling function for the ultrasonic sensor and the gas sensor. Finally, we wrote the generic control of the project which depends on the requirement and relationship of every component based on the state of the robot car. Such control is to use the state of the motor based on the ultrasonic() function output to determine if the motor should continue moving or to halt. The complete program can be found in the appendix. Also in the appendix is the Blynk program code used for wireless communication with the robot.

VI. TESTING RESULTS

Component 1 *Gas Sensor*

After downloading the gas sensor library, we blow into it and check the results from the serial monitor. The ability of the result to change based on blowing into it is an indication that it is working fine.

Component 2 *Ultrasonic sensor*

We move it close to as well as far away from an approaching object and observe changes in its reading which shows that it responds to changes in obstacle closeness.

Component 3 *Motor Shield*

Connecting LED to the motor shield and sending a simple command to power the LED, we are able to observe that the LED light up based on our simple pushbutton. This shows the Motor Shield is working fine.

Component 4 *Motors (DC)*

We connect this to a simple circuit and try to start and stop its movement by a pushbutton. The motors respond to the action which shows that they are working fine.

Component 5 *Blynk (App)*

Writing a START/STOP code and using such a binary coding on the App, we are able to ON/OFF an LED connected to the motor shield by controlling the pin output where the LED is connected using the App. To achieve this, we followed the server setup documentation of BLYNK to understand how to create effective communication between the App and what will be connected wirelessly with it, which in this case is the Motor Shield.

Complete Design

After the simple test above, we wired up our design and connected all components. We equally write a program for its control. We then move the design close to or away from an obstacle and observe the change in its movement as well as a change in the output of the App. We noticed from this experiment that as the robot approaches an obstacle, it stops and then move backward in accordance with the program we wrote for it. Also, the speed of the robot is constant without an approaching obstacle which conforms to our requirement and design code.

VII. CONCLUSIONS AND FUTURE WORK

Sample examples and problems borrowed from engineering were generated that could be used in teaching and learning of mathematics courses to enable students understand and apply what they learn in engineering and while at the same time seeing the relevancy of the courses. The key criteria however was to consider that mathematics and engineering courses that are taught in the same semester or level were mapped together so that examples and problems from the engineering courses at that level or semester where the ones used in the mathematics courses at that level or semester. To generate sample examples and problems, text books, course outlines, as well as electronic archives of the courses, were used. It was found that specific topics in mathematics courses matched those in engineering courses at the same level or semester, and examples or problems could be easily integrated and used during teaching and learning.

Other courses that are not related to mathematics would also benefit from this novel technique where students apply what they learn on one side as they do another course. This is the focus of further work.

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