The Hong Kong University of Science and Technology

COMP 4971C Project Report

Project Title:

Web and Hardware Development for a Network of Smoke and Radiation Detectors

AGATHA, Felicia

Supervised by Prof. David Rossiter

Abstract

In a country where air pollution is a major health concern, it is important for the public to know about specific locations where the pollution is too high and too dangerous. Besides air pollution, Hong Kong is also located only 50 km from Daya Nuclear Power Plant in Shenzhen, and has a risk of getting contaminated by dangerous radioactive substances if there is a disaster such as a nuclear meltdown. Having information about smoke and radiation level would help the public because by knowing this information they can take appropriate action, such as evacuating as early as possible or cancel their visit to the particular area. The main goal of this project is to provide the appropriate information in a user-friendly manner. This project has successfully implemented the system that can take signals from sensors, process the reading into a numerical data with appropriate unit, transfer the data to the Internet and display the data on a webpage. This system serves the purpose of providing the appropriate information about smoke and radiation level to the public so that they can take appropriate actions if danger arises.

Introduction

Background

Air pollution has always been a major problem in many parts of the world, including Hong Kong. Every year, thousands of people die due to huge amounts of air pollution in Hong Kong[1]. Hedley Environmental Index has shown that even from midnight to 12 p.m. on 2 May 2016, 229 patients have to be confined to bed because of health impairment due to severe level of air pollution in Hong Kong[2]. Not only has Hong Kong, the rest of the world also suffered from the danger of air pollution. Recently, Indonesia experienced a massive disaster due to a haze caused

[1] Y. Lai. (2015, May 7). Hong Kong air pollution causes 3,000 deaths, costs billions annually. *South China Post* [Online]. Available: http://www.scmp.com/news/hong-kong/article/1128685/hong-kong-air-pollution-causes-3000-deaths-costs-billions-annually

[2] School of Public Health, The University of Hong Kong. (2016, May 2). Hedley Environmental Index [Online]. Available: http://hedleyindex.sph.hku.hk/html/en/

by forest fires. Ten people have died from haze-related diseases and more than 500,000 cases of acute respiratory tract infections have been reported since July 1, 2015[3].

In addition to air pollution, radiation also plays a major role in causing an increase in death tolls. Up to 2014, the official number of fatalities caused by the Fukushima nuclear disaster in 2011 has reached 1,232[4]. In Hong Kong, a possible cause of radiation is from Daya Bay Nuclear Power Station located in Shenzhen, 50 km away from the center of Hong Kong area. It poses a huge risk to the Hong Kong residents if there was a leak from the station.

Overview

Based on these problems, a network of smoke and radiation detectors were built in order to give early warning to the public when the level of smoke or radiation in a certain area gets dangerous. Each set of detectors includes both smoke and radiation sensors, and having multiple sets of these detectors spread around the country would enable us to obtain relevant information about the level of smoke and radiation in the area. To show the data to the public, each set of detectors sends the data collected to a server in the Internet on a real-time basis. When the level of either smoke or radiation gets dangerous, the detector would give an alarm sound to warn the people nearby. The data is send to the server, and a program in a webpage reads the data and shows the data on the page. The data is shown in the form of a map, and several markers are displayed on the map, indicating the location of the detector and the level of smoke and radiation at the corresponding area.

[3] K. Lamb. (2015, Oct. 26). Indonesia's fires labelled a 'crime against humanity' as 500,000 suffer. *The Guardian* [Online]. Available: http://www.theguardian.com/world/2015/oct/26/indonesias-fires-crime-against-humanity-hundreds-of-thousands-suffer

[4] D. Gutierrez. (2015, Apr. 7). Fukushima Disaster Caused at Least 1,232 Fatalities in 2014 as Radiation Death Rate Accelerates. *Global Research* [Online]. Available: http://www.globalresearch.ca/fukushima-disaster-caused-at-least-1232-fatalities-in-2014-as-radiation-death-rate-accelerates/5441390

Materials

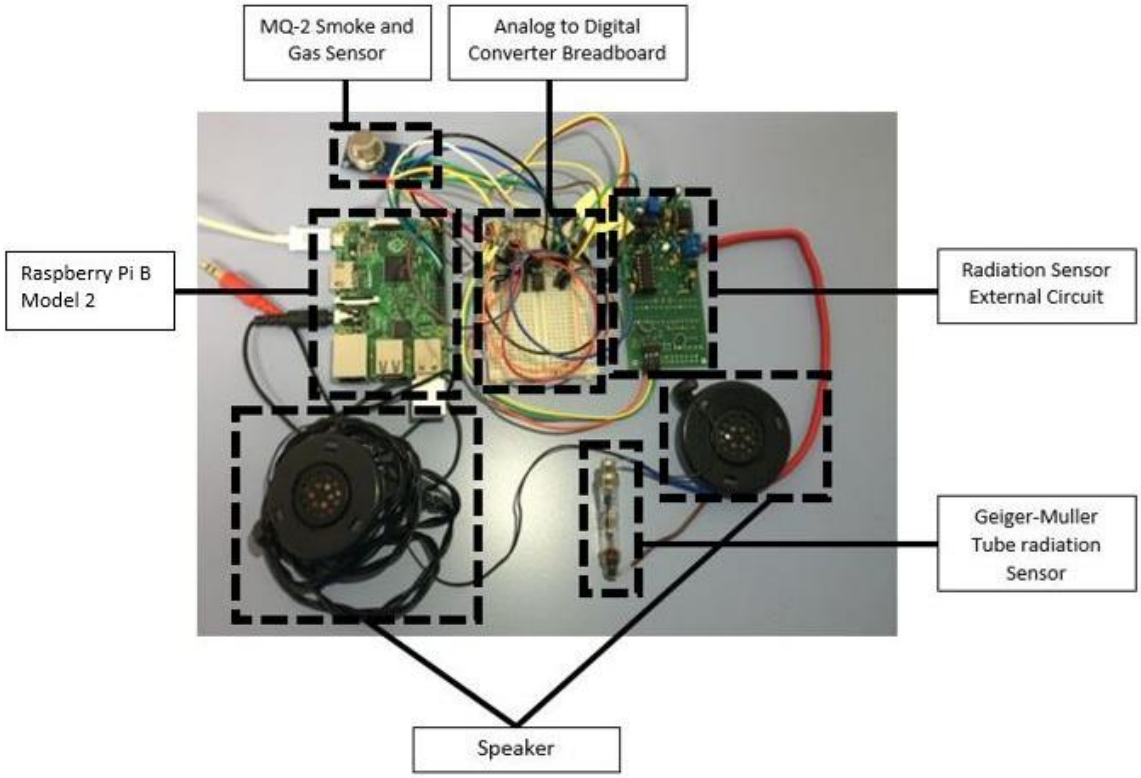

Figure 1: One Set of Smoke and Radiation Detector

Each set of detectors consist of:

1. Raspberry Pi computer: The data from the sensors which are transferred through GPIO pins of the Raspberry Pi, and a program in the computer would process the data and send it to server.

2. WiFi dongle for Raspberry Pi: Enables the Pi to connect to the Internet.

3. MQ-2 Smoke Sensor: Reads the level of smoke in the vicinity and outputs the data in the form of analog data.

4. Geiger-Muller Tube: Reads the level of radiation in the vicinity.

5. Radiation Sensor Board: Interacts with the Geiger-Muller tube and converts the reading from tube into a voltage (analog data).

6. MCP 3002 Analog to Digital Converter: An integrated circuit (IC) that converts analog data to digital data. Since both the smoke and radiation sensors give analog data, this IC is needed since Raspberry Pi only reads digital data.
7. Breadboard: All electronic components, including the MCP 3002 analog to digital converter are connected on the breadboard.
8. DuPont Wires: Used to make the connections between components on the breadboard.
9. Speaker: Makes an alarm sound when the level of either smoke or radiation gets dangerous.

Overview of Data Flow

The data flow consists of three main parts: recording sensor inputs, reading and processing sensor inputs, and analysing and displaying the data on website. In the first part, the smoke/gas, and radiation levels are detected by a MQ-2 sensor and a Geiger-Muller tube sensor, respectively. The data collected is then stored using a Raspberry Pi 2 Model B. Furthermore, the data is extracted from `current.JSON` by using a Python program and the program will determine whether the area is safe. The current data recorded is stored in `record.JSON` file, which consists of the record of previous data. In the last part, the data is extracted from `current.JSON` and displayed on a map in the website.

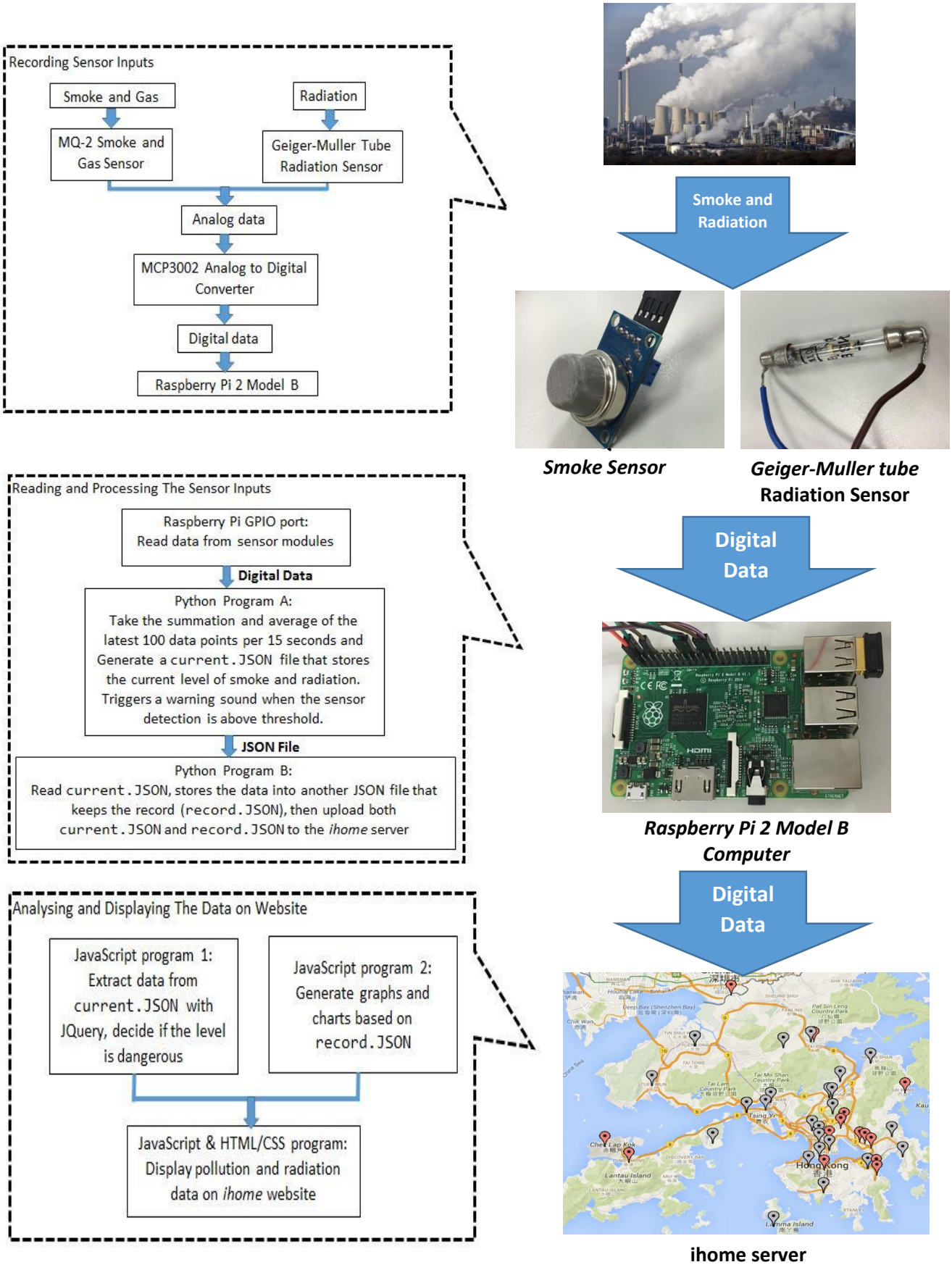

Figure 2: Data Flow

Hardware Development

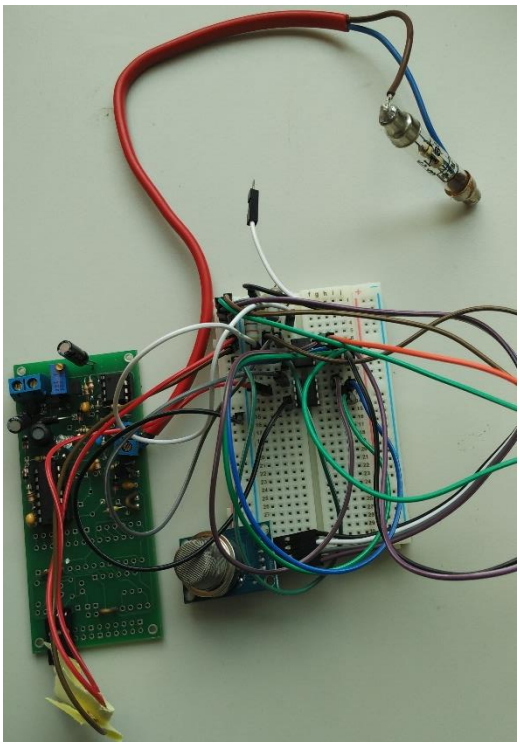

Figure 3 Breadboard (middle), Radiation Sensor (top right), Radiation Sensor Circuitry (left) and Smoke Sensor (middle left)

The circuit on the breadboard is connected in a way that the analog signal from each sensor can be converted into digital signal, because the Raspberry Pi can only receive digital signal. Firstly, the signal is passed to a voltage divider, because the maximum voltage output from both sensors are 5V, while the MCP 3002 analog to digital converter can only accept up to 3.3V. After that, the signal that has been divided down is passed to MCP 3002. The outputs of the MCP 3002 are then transferred into the Raspberry Pi through the GPIO pins. In the Raspberry Pi, Python program A was written for the purpose of reading the inputs from these pins. Based on the inputs of these pins, the Python program would generate a number ranging from 0 – 1023. This number can then be converted to an appropriate unit such as micro Sieverts for radiation or ppm (parts per million) for smoke.

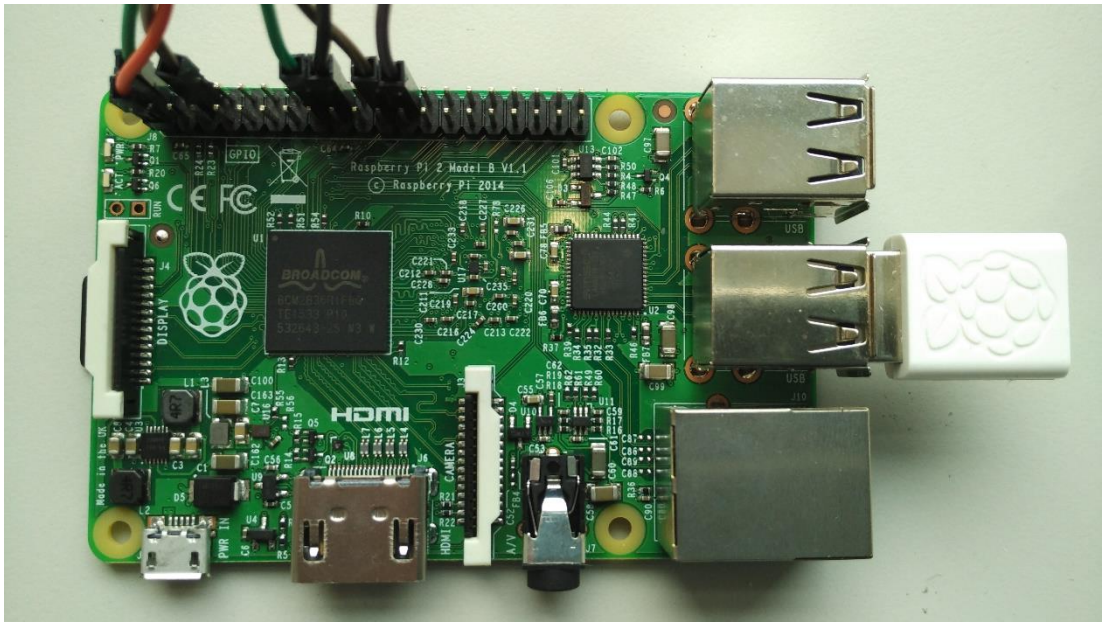

Figure 4 Raspberry Pi 2 Model B, GPIO Pins Receiving Input from MCP 3002 (shown at top)

After getting the numerical data, the program will then store the data in the form of a `.JSON` file. The data stored includes the name of the place, latitude and longitude of the device's position, the time in which the data is recorded, smoke level and status (whether the level is dangerous or not), radiation level and status. After doing all these, program A will sleep for 15 seconds, and after 15 seconds it will do the whole process of processing data and writing to `.JSON` file again. So the `.JSON` file is updated every 15 seconds.


```
[
{
"name": "saikung",
"latitude": 22.3816,
"longitude": 114.2733,
"time": "Mon Apr 11 04:40:56 2016",
"MQ2_level": 0.0947599642121,
"MQ2_status": "safe",
"radiation_level": 0.0947599642121,
"radiation_status": "safe"}
]
```


Figure 5 An Example of a .JSON File

This file will then be read by Python program B. This program deals mainly with the transfer of data from local storage to the ihome server in the Internet. There is a WiFi dongle plugged

into one of the USB ports in the Raspberry Pi, this allows the Raspberry Pi to have an Internet connection. Using the file transfer protocol (FTP) library for Python, the program connects to an ihome server and sends this file to the server. Program B also sleeps for 15 seconds after sending the `.JSON` file to the server, so the file in the server is also updated every 15 seconds.

Web Development

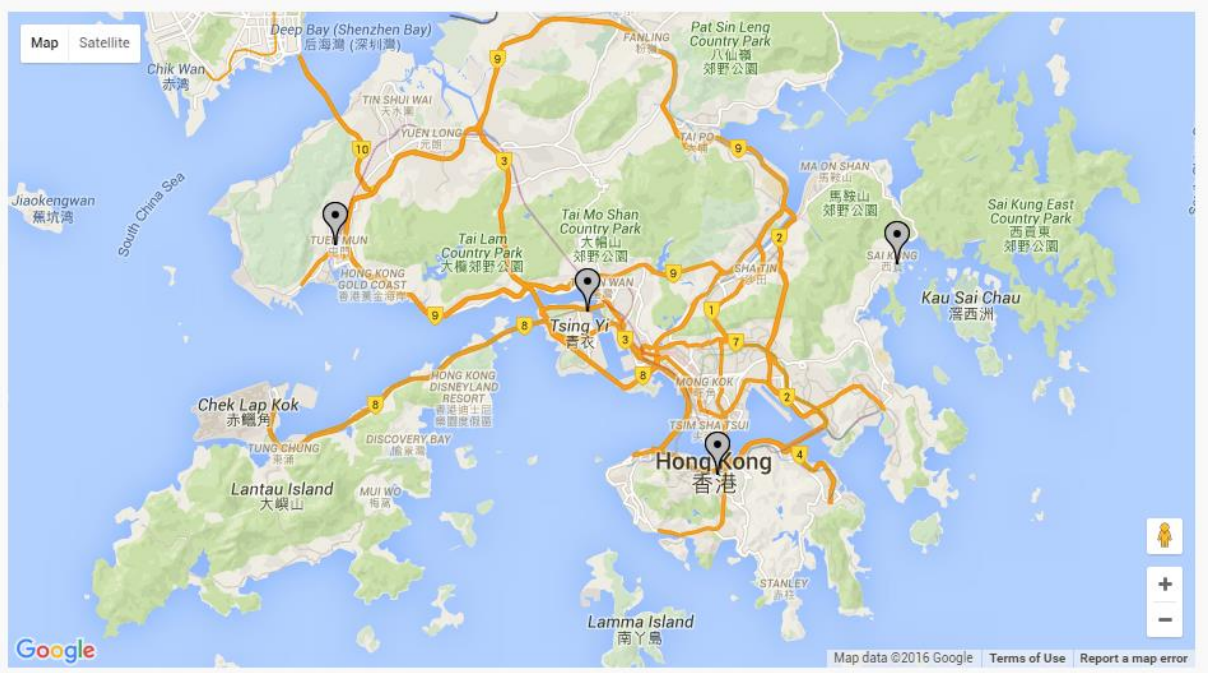

Figure 6 Markers shown on the map indicates a set of detectors

The front-end part of the website uses HTML, CSS and PHP; while the back-end is handled using JavaScript. Google Maps API was used inside the JavaScript program to display the map on the webpage.

On Figure 6, it can be seen that there are 4 markers on the map, indicating the proposed location of the detectors. When the marker is grey, it means both the radiation and smoke level in the area is safe.

The way the data is handled is that in the JavaScript program, there is a 2-dimentional array storing the details of each location, such as location name, latitude and longitude, radiation and smoke level, etc. The program the extracts the `.JSON` file in the server and updates the array

based on the data retrieved. Since the map uses the data in the array to display the markers and info window, a function that updates the map will be called after the program finishes updating the array.

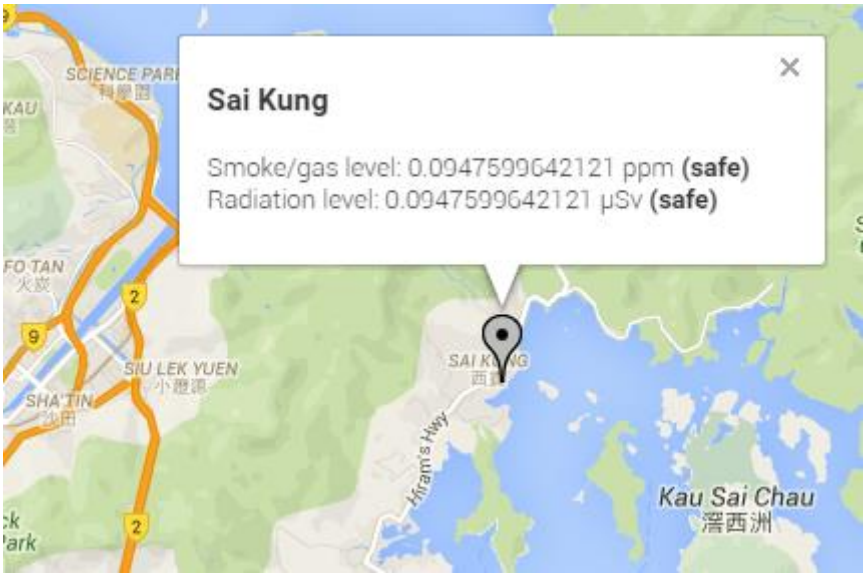

Figure 7 Info Window Showing Smoke and Radiation Level at Sai Kung

However, when either the radiation or smoke level in the area is unsafe, the marker will be flashing red and orange. The device will also produce an alarm sound that will give a warning.

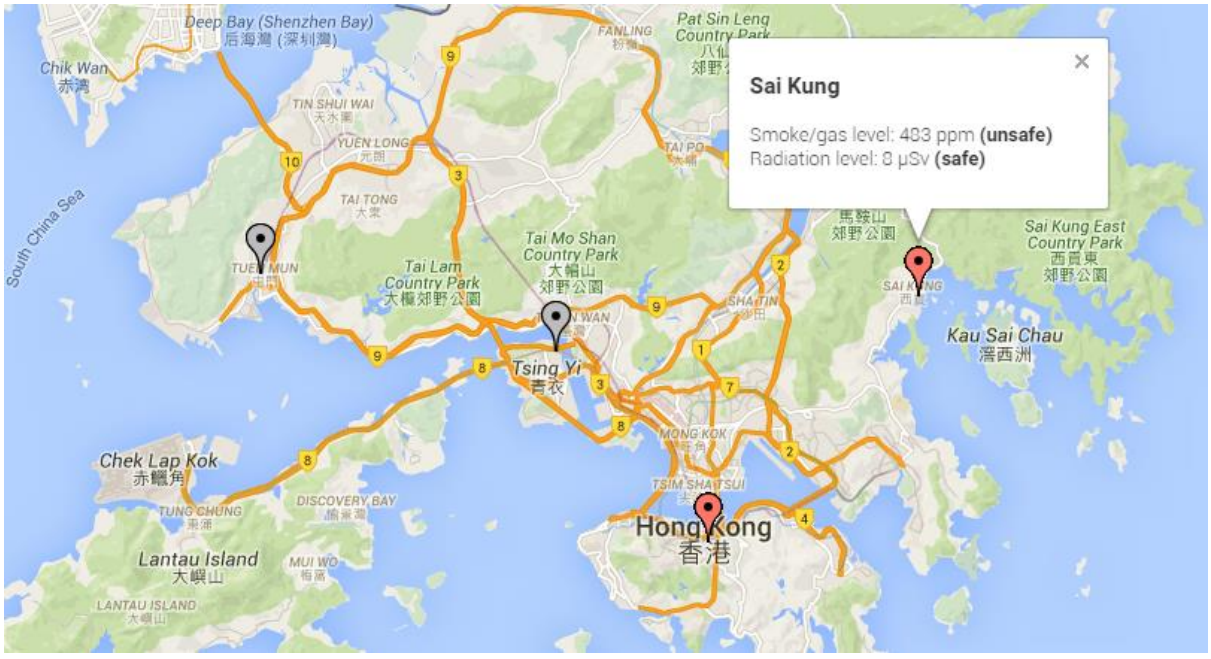

Figure 8 Hong Kong map showing two safe locations and two dangerous locations in Wan Chai and Sai Kung (indicated by orange/red flashing markers)

The data on the map is updated every 3 seconds. The sleep time is made to be shorter than the sleep in the Python programs to minimize the delay in updating data on the webpage.

Conclusion

This project has successfully implemented a system that can take signals from sensors, process the reading into a numerical data with appropriate unit, transfer the data to the Internet and display the data on a webpage in a user-friendly manner. This system serves the purpose of providing the appropriate information about smoke and radiation level to the public so that they can take appropriate actions if danger arises.

Possible Future Development

Some possible future development of this project is that to interact more with the Google Maps API so that the system does not only give information about a particular place, but users can also get directions to their desired destination. In case of danger, the system can find a safer, alternative route for the user to take, if the original route requires the user to go through an area with dangerous level of smoke or radiation.