Autonomous Quadcopter Altitude for Measuring Risky Gases in Hazard Area

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***Abstract*—The increased awareness of environmental monitoring has led to the development platforms for measuring gases concentration in the risk environment. In this paper, we focused on the altitude of quadcopter flying, not to be random but will be at a certain height depending on the application and the area of implementation for a quadcopter robot. A practical implementation is recorded to know the suitable height of flying. The quadcopter is also developed to fly manually with automatic height adjustment in order to measure gas concentration reliably.**

***Index Terms*— Quadcopter, Risk, Landfill, Altitude.**

I. INTRODUCTION

Nowadays, robots are widely used in various missions [1] [2]. UAVs type quadcopter plays an important role in military and civil aspects, and one of the promising applications is the mission in risky environments [3]. There are areas designated as risky environments which required a periodical test for the emitted gases. These types of area are known as landfill [4] [5]. Waste disposal sites designed to be safely isolated from the environment are called sanitary landfill sites. They are engineered as a depression in the ground, often to a similar scale to a football stadium, and over time, this land is filled with waste [6]. The landfill will emit gas, and the amount of gas depends on the ability of the waste to decompose, the ability of microbial organisms to access oxygen and the humidity or water content. Typically, the biogas produced consists of 55% methane, 40% carbon dioxide, with the residual 5% comprising of components, such as H_2, N_2, O_2, CO, and H2S [7]-[9]. Studies focusing on the health effects on communities in close proximity to landfills indicate there is a difficulty in distinguishing between solid urban waste and other types of waste. Regulations and enforcement of dumping rules may change over time. Therefore, the dumping of dangerous, toxic or special waste is possible in any countries landfill site. This aberrant practice is linked with respiratory disease, congenital disabilities, shorter lifespan and cancer [5],[7],[10]-[12].

II. MEASUREMENT IN LANDFILL SITE

The law requires it for the landfill management perform measurement of methane concentration periodically. Since the methane and carbon dioxide have concentration percentage close together in the emitted gas in a landfill site, so in most cases, the methane gas concentration is focused [13]. The test is carried out monthly or even weekly using traditional methods by hand-held equipment or fixing platforms in certain positions [7][14]. All these methods required exposing the workers to the risky environment of the landfill with various difficulties, e.g. terrain and water swamps [15][16]. Exposure or fire may happen instantly since a concentration of 5–15% methane gas is extremely flammable [17].

These tests are not only to identify the concentration, but also to overcome the area that has high gas emission by dumping extra soil. To mitigate the risk of harm from gas emissions, the monitoring of gas generation is beneficial for efficient landfill site management. Collected methane gas can also be used for electric power generation [5].

In this paper, the quadcopter is directed to do measurements in a landfill site and overcome the geographical difficulties faced by the landfill management.

III. OVERALL DESIGN

For the gas monitoring, the developed model of the quadcopter is the Tarot 650, as shown in Figure 1. It was equipped with various sensors for our required application which are: GPS sensor model NEO-6, SONAR sensor model LV-MaxSonar, gyroscope sensor model MPU 6050, methane sensor model TGS 2611 and temperature/humidity sensor model DHT11. These sensors were assembled on the quadcopter as shown in Figure 2. Figure 3 illustrates a block diagram of the system. To operate the system, the quadcopter uses a special algorithm, which enabled the quadcopter to be flown manually but within specific height. The precise height is required in order to measure the methane concentration with respect to the coordinates position, as well as to measure the temperature and humidity.

Figure 1: Quadcopter Tarot 650

Figure 2: Quadcopter equipped with sensors

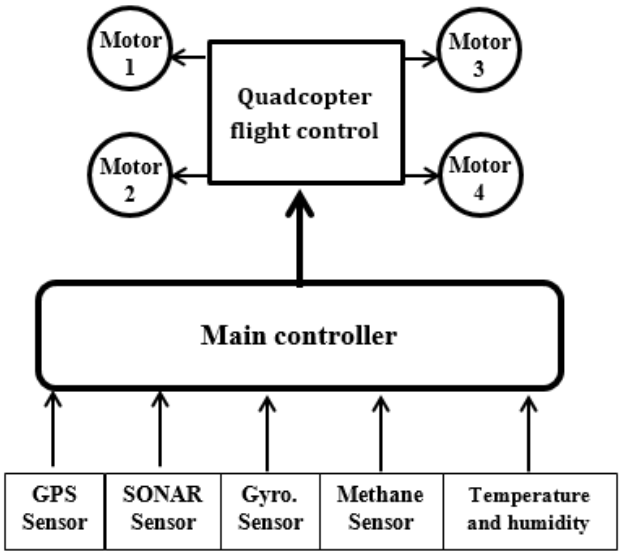

Figure 3: Quadcopter equipped with sensors

IV. Practical Work and Results

The developed quadcopter was tested in a real landfill site in Malaysia. The first step detecting at the landfill site for certain sectors with has high methane gas concentration by using the developed quadcopter (without flying - holding it by hand and walking within the landfill) and by using a portable measuring device. Figure 4 shows the top view of a sanitary landfill site showing the line of the test.

Figure 4: Top view of sanitary landfill site showing the line of the test

A certain area is recognised with a methane concentration at 7ppm, of a sector with longitude 11 m. The test was performed on 16/11/2016 with time duration from 1 pm to 3:30 pm. The weather was perfect to do the experiment where wind speed is 4 km/h and no rain.

Table 1 shows the results at the selected position are obtained without turning on the propeller, which means without the effect of disturbance that may be happened due to air generating by the propeller. The methane gas concentration distribution versus the flying altitude of the quadcopter that obtained from Table 1 was plotted as shown in Figure 5.

Then immediately the quadcopter flew (Figure 6), and it swept with different heights starting from 0.5 m to 3.8 m in order to know the suitable altitude of flight for measurement methane gas concentration for the exact previous location. This time with the propellers turning on. The results are shown in Table 2. The methane gas concentration distribution versus the flying altitude of the quadcopter that obtained from Table 2 was plotted and is shown in Figure 7.

From the results, it became clear that the accepted limit of height for methane gas concentration measurement was reduced when the quadcopter propeller was turned on. The limit of the height without turning on the quadcopter propeller is between 95-190cm. When turning on the propeller, the limit of height is approximately 100-150cm. So, the parameter of flight that we set in the mentioned algorithm is 125cm ±10cm to fly the quadcopter within specific altitude and perform the measurement of methane gas concentration with reliable values.

Table 1
The Results for Selected Position without Turning on the Propeller

Position	Latitude	Longitude	Altitude (cm)	Distance (m)	Methane concentration (ppm)	Humidity (%)	Temp. (°C)
1	2.7312199	101.6053620	51	0.00	6.402	49	31
2	2.7312099	101.6053621	49	0.83	6.421	49	31
3	2.7311999	101.6053620	51	1.87	6.408	49	31
4	2.7311999	101.6053471	95	2.48	6.991	49	31
5	2.7311899	101.6053471	102	3.51	7.019	49	31
6	2.7311799	101.6053471	148	3.56	7.010	49	31
7	2.7311699	101.6053688	153	3.71	7.010	49	31
8	2.7311599	101.6053770	152	4.45	7.012	49	31
9	2.7311499	101.6053770	152	5.49	7.011	49	31
10	2.7311401	101.6053770	189	6.51	7.010	49	31
11	2.7311301	101.6053920	195	6.96	6.095	49	31
12	2.7311201	101.6053921	201	8.00	6.213	49	31
13	2.7311100	101.6053921	206	9.04	2.009	49	31
14	2.7311000	101.6054000	223	9.78	1.954	49	31
15	2.7310900	101.6054000	233	10.83	1.422	49	31

Table 2
The Results for Selected Position with Turning on the Propeller

Position	Latitude	Longitude	Altitude (cm)	Distance (m)	Methane concentration (ppm)	Humidity (%)	Temp. (°C)
1	2.7312199	101.6053619	49	0.00	1.385	49	31
2	2.7312099	101.6053619	48	0.83	1.401	49	31
3	2.7311999	101.6053619	55	1.87	1.408	49	31
4	2.7311999	101.6053466	96	2.48	6.842	49	31
5	2.7311899	101.6053466	100	3.51	7.105	49	31
6	2.7311799	101.6053466	141	3.56	7.125	49	31
7	2.7311699	101.6053695	154	3.71	7.067	49	31
8	2.7311599	101.6053771	154	4.45	7.028	49	31
9	2.7311499	101.6053771	153	5.49	6.999	49	31
10	2.7311401	101.6053771	180	6.51	6.952	49	31
11	2.7311301	101.6053924	195	6.96	5.795	49	31
12	2.7311201	101.6053924	223	8.00	5.021	49	31
13	2.7311100	101.6053924	245	9.04	1.972	49	31
14	2.7311000	101.6054000	256	9.78	1.655	49	31
15	2.7310899	101.6054000	310	10.83	1.420	49	31

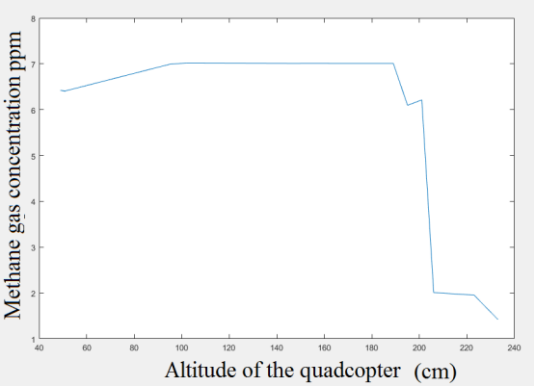

Figure 5: The methane gas concentration distribution versus the flying altitude of the quadcopter without turning on propellers

Figure 6: Quadcopter flights within the landfill site

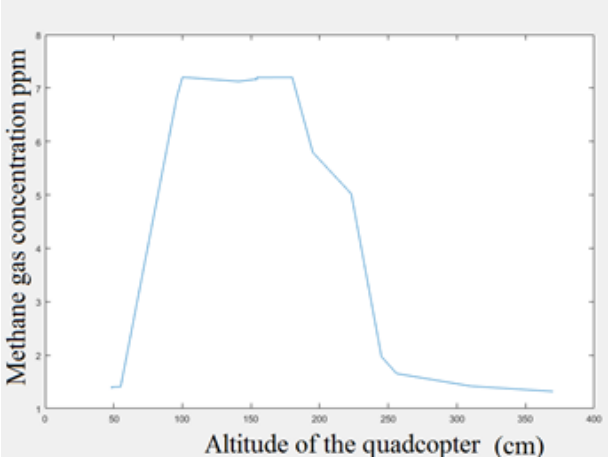

Figure 7: The methane gas concentration distribution versus the flying altitude of the quadcopter with turning on propellers

V. CONCLUSION

This paper outlines a successfully developed UAV quadcopter-sensing system used for measurements in a real sanitary landfill site. The system overcomes the difficulties that face the landfill management while performing their task of measurements. Also in this paper, we obtained the suitable height of flying for reliable measurement of methane gas concentration. Finally, quadcopter flying system was developed to fly the quadcopter at certain height automatically. To our best knowledge, we are the first to take quadcopter measurement mission for a landfill site.

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