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Air Condition Monitoring Using Waypoint Based UAV (Unmanned Aerial Vehicle)

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A B S T R A C T

The lack of attention to the harmful gas such as karbonmonoksida (CO) and particulate matter (PM10) dust can give impact to the environment and living creatures that inhale it. With increasing industry the greater the level of air pollution. Monitoring the air condition industry is generally done by placing the sensor at certain points so inefficient and throwing out a lot of costs. Therefore it needs a tool that can monitor the State of the air in places hard that cannot be reached by a human being implemented on the Unmanned Aerial Vehicle (UAV). Unmanned Aerial Vehicle (UAV) or quadcopter is one of the types of aircraft used to fly and can move automatically in accordance with the navigation system based on compass and positioning of Global Positioning System (GPS) waypoint called so quadcopter can run automatically without the remote. The use of karbonmonoksida gas sensor (MQ-7) and sensor dust particles (GP2Y1010AU0F) can help quadcopter to automatic air condition monitoring. Testing the results of monitoring carried out by comparing the measuring tool on Dinas Lingkungan Hidup Provinsi Jawa Timur as a reference. The data generated from gas sensor MQ-7 and the dust sensor GP2Y1010AU0F emailed using telemetry 915 MHz are then processed on the PC/Laptop using fuzzy sugeno method to determine the output of air quality. The test results showed the average error monitoring for gas karbonmonoksida 3.31% and 8.47% of the dust particles. And a waypoint error of 2-5 meters.

Keywords: quadcopter, waypoint, gas sensors, dust sensor, air condition.

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1. Introduction

Air pollution is the entry or inclusion of energy, substances, and / or other components into ambient air by human activities, so that ambient air quality drops to a certain level that can cause ambient air to not fulfill its function [1].

The cause of air pollution is usually caused by motor vehicle exhaust fumes, cigarette smoke, smoke from factory chimneys, combustion, or forest fires so that carbon dioxide gas can be released into the air. Smoke from the results of volcanic activity that causes dust particles scattered in the air. Industrial emissions and vehicle exhaust fumes are the main contributors to the decline in air condition. In general, industries still do not have adequate air pollution control devices, causing air conditions to become increasingly out of control.

In accordance with the decision of the Minister of Environment (MENLH) Every industry should have an air pollution control device. Generally, air pollution control devices still use manual tools, namely placing sensors at each particular point so that it can take a lot of time and a large cost. Therefore we need a tool that can monitor the state of the air in difficult places that cannot be reached by humans which is implemented on Unmanned Aerial Vehicles (UAVs).

Unmanned Aerial Vehicle (UAV) or commonly called a quadcopter is one type of aircraft that has four motors that are used to fly and can move automatically in accordance with a navigation system based on a compass and Global Positioning System (GPS) position or called a waypoint so that the quadcopter can run automatically automatically without the remote and can reach a radius of □100 m depending on battery capacity. The use of carbon monoxide gas sensors (MQ-7) and dust particle sensors (GP2Y1010AU0F) can help quadcopter to monitor air condition automatically. This is to be more effective and efficient in monitoring air pollution and the costs incurred can be minimized.

1.1. ISPU (Air Pollution Standard Index)

The air pollution standard index is determined based on the measured levels of air pollution into a dimensionless number. Air pollution standard index range is said to be Good 0-50 (does not give any effect), being 51-100 (can be detrimental to plants), dangerous than 101-more (can be detrimental to health and the environment).

The standard air pollution index parameters include [2]:

a) Particulate / PM10 (mg / m3)
b) Carbon monoxide / CO (ppm)
c) Sulfur dioxide / SO2 (ppm)

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d) Nitrogen dioxide / NO2 (ppb)
e) Ozone / O3 (ppm)

1.2. Quadcopter

Quadcopter is a drone development from helicopter that uses synchronization between 4 motors that are configured in the form of frame plus (+). Quadcopter can take off and landing vertically so it is usually called VTOL (Vertical Take off and Landing). The configuration of the quadcopter movement is that the front and rear propellers rotate in the same direction, and the right and left propellers rotate in the same direction. Variations in motor speed can change lift and create motion. Thus, increasing or decreasing the speed of all four blades together results in vertical motion [3].

Figure 1. Caption Centered

1.3. ArduPilot Mega (APM)

Ardupilot Mega is a product developed by Chris Anderson and Jordi Munoz from DIY Drones. This module is based on the most developed open-source module for autopilot. Both autopilot for aircraft (Arduplane), Multicopter (Arducopter) and land vehicles (Ardurover). This module uses an arduino microcontroller which is very popular in the field of instrumentation. Therefore a multicopter that uses this module is often also called an arducopter. [4].

Figure 2. ArduPilot Mega (APM) 2.6

1.4. Sensor Gas MQ-7

MQ-7 gas sensor is a gas sensor that serves to determine the concentration of CO gas. The output produced by this sensor is in the form of an analog signal. This sensor has a sensor resistance value (Rs) that can change when exposed to gas and also a heater that is used as a sensor room cleaning from outside air contamination. The sensor output is connected to the analog digital converter (ADC), so the output can be displayed in the form of a digital signal [3].

Figure 3. Sensor Gas MQ-7

1.5. Dust Sensor GP2Y1010AU0F

An infrared based dust sensor. The working principle of this sensor is that light is reflected on particles passing through the entire surface, then the photodiode is converted to voltage. The voltage must be strengthened to be able to read the changes. The output of the sensor is an analog voltage proportional to the measured dust density, with a sensitivity of 0.5V / 0.1 mg / m3, meaning that every 0.1 mg / m3 the measured dust density, the voltage rises by 0.5 V [5].

Figure 4. Sensor Debu GP2Y1010AU0F

1.6. Fuzzy Sugeno Method

One method of fuzzy inference system that can be used for decision making is the Sugeno method. To obtain the output of the Sugeno fuzzy method requires 4 stages, namely:
1. Formation of fuzzy set (fuzzification)
2. Application function implications
The basic fuzzy rules define the relationship between membership functions and the shape of membership membership outcomes. In the Sugeno method, the system's (not consistent) output is not a fuzzy set but rather a constant or linear equation [6].

2. Methodology

2.1. Research Methods

The tool made is a tool for monitoring the state of the air using a waypoint-based quadcopter. Quadcopter is used to help the process of monitoring the state of the air at certain points using GPS. GPS coordinate point data sent via 433 MHz telemetry is displayed in the mission planner application. Micro data consists of gas sensor data and dust sensor, dust data output and gas data are processed using the Sugeno fuzzy method. Then the micro outputs are sent via other telemetry connected to a PC that has an air condition monitoring application installed. Block diagram of the system can be seen in Figure 5.

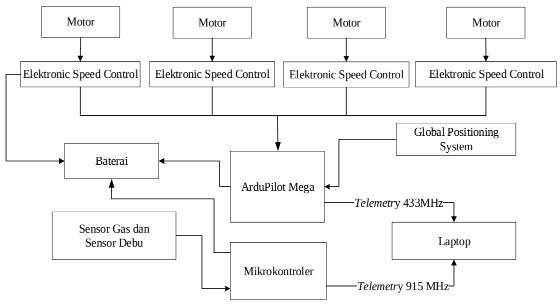

Figure 5. System Diagram Blocks

2.2. Overall System Algorithm

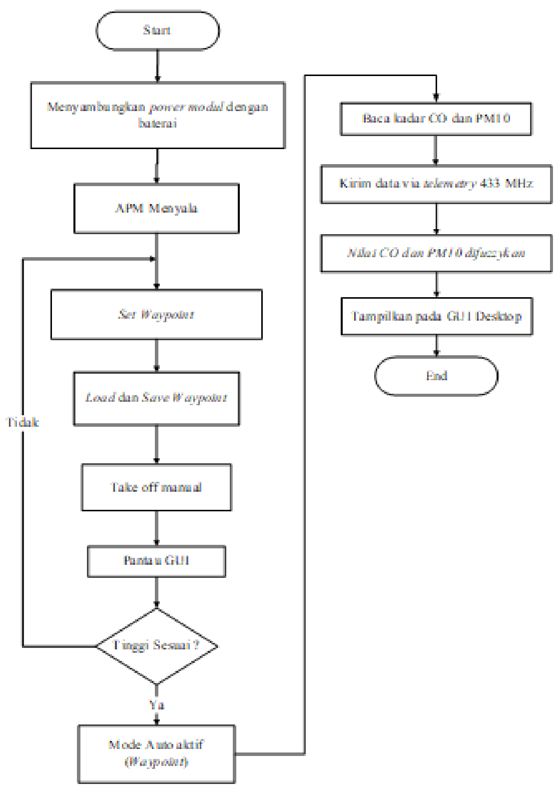

Figure 6. Overall System Flowchart

2.3. Overall System Design

The overall system design consists of quadcopter design and placement of sensors for monitoring the state of the air, namely the MQ-7 gas sensor and the GP2Y1010AU0F dust sensor programmed through MIMSIS ATMEGA 16 using telemetry for long distance data transmission. The overall system circuit that is composed of all system devices. In the whole series the gas sensor and dust sensor systems are placed in the top position so that data retrieval is easier because the wind from the propeller will suck carbon monoxide gas or dust particles.

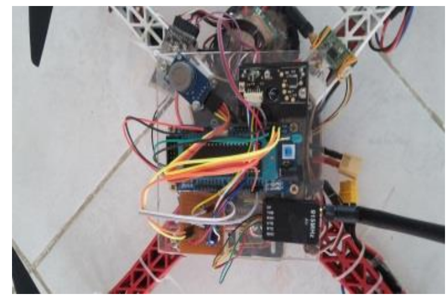

Figure 7. Placement of the Air Condition Sensor on the Quadcopter

3. Result and Discussion

3.1. Quadcopter Testing

The quadcopter flying test is done manually using the stabilize and altitude hold modes and can fly on autopilot / waypoint. Before testing the quadcopter set up first, use the Mission Planner software which includes installing firmware, compass calibration, remote control calibration, determining waypoint points, etc.

3.2. MQ-7 Gas Sensor Testing

This testing process uses artificial carbon monoxide gas, which is by burning the paper that is inserted in a closed tube jar. From the results of the calibration of the MQ-7 gas sensor the results of the comparison of the MQ-7 gas sensor reading with the CO-meter can be seen in table 1.

Tabel 1. MQ-7 gas sensor test results

No.	Measuring instrument (ppm)	Gas sensor (ppm)	Difference
1.	5.07	5.19	0.12
2.	5.07	5.19	0.12
3.	5.04	5.13	0.09
4.	5.01	5.04	0.03
5.	5.01	4.95	0.06
6.	4.98	4.89	0.09
7.	4.98	5.04	0.06
8.	4.95	4.95	0
9.	4.95	4.95	0
10.	4.92	5.01	0.09
	Average error		0.066

The results of testing the MQ-7 gas sensor readings show measurements with an average error of 0.32%. The level of precision of the sensor reading with the measuring instrument is influenced by the sensitivity of the sensor itself.

3.3. Testing the GP2Y1010AU0F Dust Sensor

This test uses artificial dust that is from flour and clean air. This dust sensor is calibrated by measuring dust density, namely dust truck. The comparison results from this test can be seen in table 2. The formula of the dust sensor is as follows:

Voltage = ADC x (5.0 /1024) (1)

DustDensity = 0.17 x Voltage + 0.1 (2)

Tabel 2. GP2Y1010AU0F dust sensor test results

No.	Condition	Measuring instrument (mg/m3)	Dust Sensor (mg/m3)	Error (%)
1.	Clean air	0.16	0.16	0
2.	Flour	0.63	0.60	0.03
		Average error		0.015

From table 2 the calibration results of the dust sensor and measuring instrument show an error difference of 0% for clean air and 0.03% at the time of flour application. Testing the GP2Y1010AU0F dust sensor showed an average error of 0.015%.

3.4. System Testing

a. First try

Table 3. Testing Using MQ-7 Gas Sensor

Time	Dust Sensor (mg/m3)	Gas Sensor (ppm)	CO-Meter (ppm)	Air Condition
14:49:22	22.55	3.6	1	Well
14:49:23	22.55	3.6	1	Well
14:49:24	22.55	3.6	1	Well
14:49:25	22.62	3.6	1	Well
14:49:26	22.62	3.6	1	Well
14:49:27	22.55	3.6	1	Well
14:49:28	22.55	10.26	15.33	Dangerous
14:49:29	22.55	15.39	15.40	Dangerous
14:49:30	22.45	16.08	17.08	Dangerous
14:49:31	22.45	17.13	18.21	Dangerous
14:49:32	22.55	16.83	18.46	Dangerous
14:49:33	22.54	16.53	19.91	Dangerous
14:49:34	22.62	15.26	19.23	Dangerous
14:49:35	22.62	12.24	18.60	Well
14:49:36	22.62	11.61	16.54	Well
14:49:37	22.62	11.04	15	Well
14:49:38	22.62	10.56	14.67	Well
14:49:39	22.62	10.05	14	Well
14:49:40	22.62	9.69	13.87	Well
14:49:41	22.62	9.33	13.02	Well
Error (%)		3.14		

Table 4. Sensor Output Results for Each Waypoint Point

No.	Mission Type	Gas Sensor (ppm)	Dust Sensor (mg/m3)	Air Condition
1.	Waypoint 1	3.63	22.62	Well
2.	Waypoint 2	16.08	22.45	Dangerous
3.	Waypoint 3	3.60	22.53	Well

b. Second try

Table 5. Testing Using Dust Sensors GP2Y1010AU0F

Time	Gas Sensor (ppm)	Dust Sensor (mg/m3)	Dust Trak (mg/m3)	Air Condition
15:00:31	5.01	22.95	16.2	Well
15:00:31	5.01	72.67	60.0	Dangerous
15:00:33	5.01	71.84	60.0	Dangerous
15:00:34	30.69	75	62.5	Dangerous
15:00:35	4.68	73.58	62.5	Dangerous
15:00:36	5.22	74	62.5	Dangerous
15:00:37	4.26	72.5	63.3	Dangerous
15:00:38	4.29	71.34	63.3	Dangerous
15:00:39	4.98	71.84	62.0	Dangerous
15:00:40	4.41	72.09	62.0	Dangerous
15:00:41	4.44	72.09	61.5	Dangerous
15:00:42	4.5	26.19	61.5	Dangerous
15:00:43	5.7	26.68	60.3	Well
15:00:44	5.31	27.18	50.0	Well
15:00:45	5.52	26.52	50.5	Well
15:00:46	5.79	26.19	30.3	Well
15:00:47	6.12	30.83	16.0	Well
15:00:48	6.21	25.27	15.0	Well
15:00:49	6.48	25.27	15.0	Well
15:00:50	5.01	22.95	15.1	Well
Error (%)		13.85		

Table 6. Sensor Output Results for Each Waypoint Point

No.	Jenis Misi	Gas Sensor (ppm)	Dust Sensor (mg/m3)	Air Condition
1.	Waypoint 1	5.01	22.95	Well
2.	Waypoint 2	4.98	71.84	Dangerous
3.	Waypoint 3	5.01	22.95	Well

c. Third Trial

Table 7. Sensor Output Results for Each Waypoint Point

Time	Gas Sensor (ppm)	CO-Meter (ppm)	Dust Sensor (mg/m3)	Dust Trak (mg/m3)	Air Condition
15:14:46	7.71	3.06	22.53	16.1	Well
15:14:47	7.56	3.45	22.45	16.1	Well
15:14:48	7.47	4.95	71.84	60.8	Well
15:14:49	7.44	5.05	68.27	60.8	Dangerous
15:14:50	7.44	5.25	67.61	63.0	Dangerous
15:14:51	7.38	6.02	71.67	63.0	Dangerous
15:14:52	10.44	15.21	69.6	63.0	Dangerous
15:14:53	18.33	16.91	67.44	62.5	Dangerous
15:14:54	16.11	18.47	69.43	62.5	Dangerous
15:14:55	14.76	19.32	71.18	60.0	Dangerous
15:14:56	13.65	19.02	71.34	60.0	Dangerous
15:14:57	12.87	16.77	59.89	60.0	Dangerous
15:14:58	12.36	17.87	69.18	60.0	Medium
15:14:59	11.97	16.32	66.03	50.5	Dangerous
15:15:00	11.7	15	71.59	50.5	Dangerous
15:15:01	11.37	15	68.69	50.1	Dangerous
15:15:02	11.13	13.20	22.62	16.1	Well
15:15:03	10.92	13	22.53	16.1	Well
15:15:04	9.74	12.89	22.00	16.1	Well
15:15:05	9.72	12.34	22.62	16.1	Well
Error (%)	3.31		8.47		

Table 8. Sensor Output Results for Each Waypoint Point

No.	Mission type	Gas Sensor (ppm)	Dust Sensor (mg/m^3)	Air Condition
1.	*Waypoint 1*	7.71	22.53	Well
2.	*Waypoint 2*	16.11	69.43	Dangerous
3.	*Waypoint 3*	9.72	22.62	Well

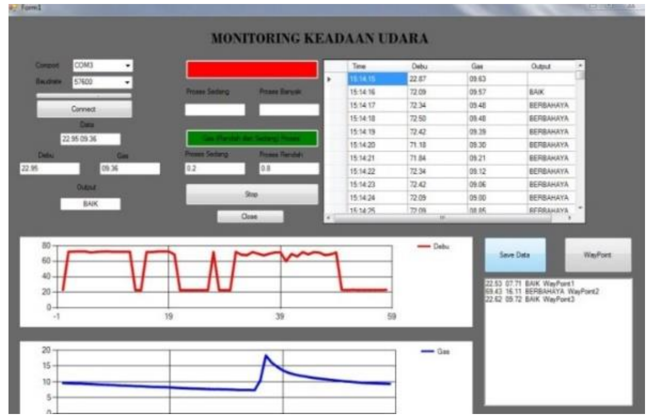

Figure 8. Display Monitoring GUI

Figure 9. Display Waypoint Mission Planner Settings

3.5. Analysis

Testing the whole system which aims to determine the level of system work. The test was carried out with three experiments using the waypoint mode conducted on the front page of the East Java Provincial Environment Office. The overall system test consists of the first experiment using carbon monoxide gas detection, the second experiment using dust particle detection, and the third experiment using carbon monoxide gas detection and dust particles. All data both air state sensor output data and quadcopter data are sent remotely in realtime using telemetry. In carbonmonoxide gas detection testing is done by spraying random cigarette smoke at the waypoints. The results of the first experiment obtained an average error of 3.14%. This is caused when testing is influenced by wind from the outside so that cigarette smoke is blown by the wind before the sensor is detected. And for testing dust by spraying flour at waypoints. The results of the second experiment found an average error of 13.85%. This is caused by the reading of measuring instruments and sensors are not the same. For the third experiment, it is by spraying cigarette smoke and flour together at the designated waypoints. The results of the overall system test found an average error for carbon monoxide gas 3.31% and dust particles 8.47%. This is caused by high winds when testing.

For quadcopter testing using the waypoint mode, it runs smoothly. By setting three coordinate points for waypoint 1 with longitude =

112.7196971 latitude = -7.3418679, waypoint 2 with longitude = 112.71967413 latitude = -7.3417961, and waypoint 3 with longitude = 112.7196608 latitude = -7.3417915. In this quadcopter test the altitude is set not too high because testing in the field is close to the airport area. And the waypoint error rate is 2-5 meters. This is due to the GPS being late in reading position because there are many obstacles such as tall buildings around UPT K3 Surabaya.

4. Conclusion

Based on the results of design, system implementation, and testing the results of the system that has been made can be danced as follows:

1. The results of this study can create a realtime air condition monitoring tool using a quadcopter. And the system that has been made can run in accordance with what is desired.
2. Delivery of gas sensor data and dust sensor in real time using 915 MHz telemetry using the Sugeno fuzzy method displayed on Microsoft Visual Studio 2010 software.
3. Flight control data transmission and quadcopter position can be sent in realtime using 433 MHz telemetry displayed on the mission planner software.
4. Quadcopter test results with waypoint mode can run as expected only there is a difference in waypoint points on the mission planner with data in the field of 2-5 meters.
5. The results of the overall system test found an average error for carbon monoxide gas 3.31% and dust particles 8.47%. This is caused by strong winds when doing testing in the field.

References

[1] Peraturan Pemerintah, http://www.cetsuii.org/BML/Udara/ pp4199%20 Penc%20udara/bab1.html, diakses 20 Desember 2017.

[2] Indeks Standar Pencemaran Udara, http://www.iku. menlhk.go.id, diakses 10 April 2017.

[3] Irfan Fachrudin Priyanta, Muhammad Rivai, Rudy Dikairono, “Pemetaan Distribusi Gas Polutan Menggunakan Quadcopter Berbasis Autonomous Waypoint Navigation”. Jurnal Teknik ITS. Volume 5, No.2, 2016.

[4] Rizki Wahyu Pratama, Ferry Hadary, Redi Ratiadi Yacoub, “Rancang Bangun Simulasi dan Pengendali Unmanned Aerial Vehicle (UAV)”.Volume 2, No.1, 2017.

[5] Membuat alat ukur GP2Y1010AU0F optical dust sensor, http://www.ddamicro.blogspot.co.id, diakses 05 Januari 2018.

[6] Ami Hilda Agustin, G.K. Gandhiadi, Tjokorda Bagus Oka, "Penerapan Metode Fuzzy Sugeno Untuk Menentukan Harga Jual Sepeda Motor Bekas", E-Jurnal Matematika. Volume 5 (4), November 2016, pp. 176-182.