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Design Of Multi Sensor Quadcopter Navigation Data Acquisition For Early Fire Detection and Treatment

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Abstract:

Recently, forest and land fires have become an event that has become a concern for the national and international community. This research creates a quadcopter as a tool for detecting forest and land fires. This system is an alternative tool for detecting forest and land fires that already exist. The advantage of this quadcopter is that it can collect data before the fire, during the fire, and after the fire. This quadcopter is designed and realized the development of an automatic navigation system for unmanned aircraft. This system is controlled by a microcontroller that processes IMU (Inertial Measurement Unit) sensor data in which there is a gyroscope and accelerometer, GPS, and magnetometer so that it can fly automatically. The purpose of this study is to acquire data on the navigation sensors used in the unmanned aerial vehicle (UAV) design, then the data from the navigation sensors will be combined using complement and median filters as position control input for the quadcopter. Based on this research, processing from sensor readings to sensor integration is able to produce better data, where the quadcopter's angle of view has an error percentage of 1.10° and 0.68°. This value is smaller than the percentage error of the magnetometer sensor alone or the IMU sensor alone which results in an error percentage of 1.18° and 0.76°.

Keywords: *microcontroller, forest, quadcopter, GPS, sensor.*

Introduction

Indonesia is one of the tropical countries that has the second largest forest area in the world, and is nicknamed the lungs of the world because the amount of vegetation in forest areas can recycle and produce a healthier environment for humans, but recently forest and land fires have become events of concern to the national community.

Forest fires often occur as a result of the use of fire in clearing forests to function as Industrial Plantation Forests, oil palm plantations, agriculture and illegal logging (Baskoro, Syarif & Kosar, 2013).

The most developed technology for monitoring and handling forest fires is using satellite imagery and fire detection tools which are spread out at several points in the forest. Forest fires are detected by satellite as hotspots which are then indicated as hotspots. Hot spots are the surface of the earth that has a relatively higher temperature than other surfaces (LAPAN, 2014; Pengcheng et al., 2016)).

As technology develops, unmanned aircraft can be controlled using a computer device so that their flight range can be controlled and limited to the required area (ATMEL, 2015; Austin, 2010; Sikiric, 2008; Hatem, Ebrahim, & Abdelrady, 2022).

Speed settings on each copter can cause changes in the attitude of the Quadcopter, which is defined by the parameters of roll, pitch, and yaw angles, where changes in attitude cause lateral and longitudinal movements (Domingues, 2009; Arifin & Fathoni, 2014).

This research designed and realized the development of an automatic navigation system for UAVs with GPS waypoints. This system uses autopilot mode, the aircraft is controlled by a microcontroller that processes IMU (Inertial Measurement Unit) sensor data (Bejo, 2008).

In addition, this forest fire detection tool is designed to use a quadcopter with an IMU sensor with a complement filter (Milano, 2015; Al-Fadli, 2017).

Materials and Methods

The design of a multi-sensor navigation data acquisition system consists of hardware and software design. The hardware design includes the design of the mechanical and electronic systems which include the microcontroller module. Software design includes reading and merging sensor data.

In general, the electronic system on the quadcopter can be seen in the block diagram in Figure 1.

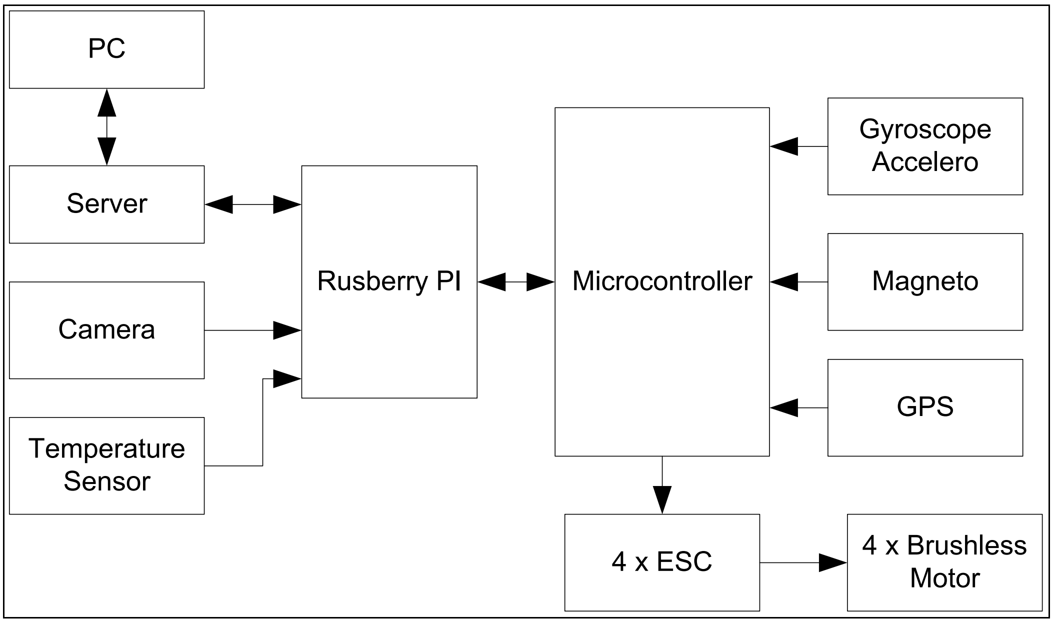

Figure 1. Hardware System Design

The mechanical system on the quadcopter produced in this study uses mild steel material with a galvanized coating, with a microcontroller as the controller (Prasetya, 2017). This system is also equipped with a Raspberry Pi as an additional controller to connect to the internet and image processing.

In designing and manufacturing, the quadcopter frame is square in shape with a size of 43 cm x 43 cm. At the four ends of the side used to attach the motor mount. The material for the sensor holder uses transparent colored acrylic in the shape of a rectangle with a size of 21 cm x 14.5 cm and a thickness of 3 mm.

Furthermore, software design includes data acquisition algorithms and the process of combining sensor data, the process of measuring longitude latitude altitude position x,y,z, and roll, pitch, yaw. The process of combining sensor data that is applied to the microcontroller programming (Rengrajan & Anitha, 2013; Hakim, 2015). The algorithm of the above system can be seen in the flowchart as shown in Figure 2.

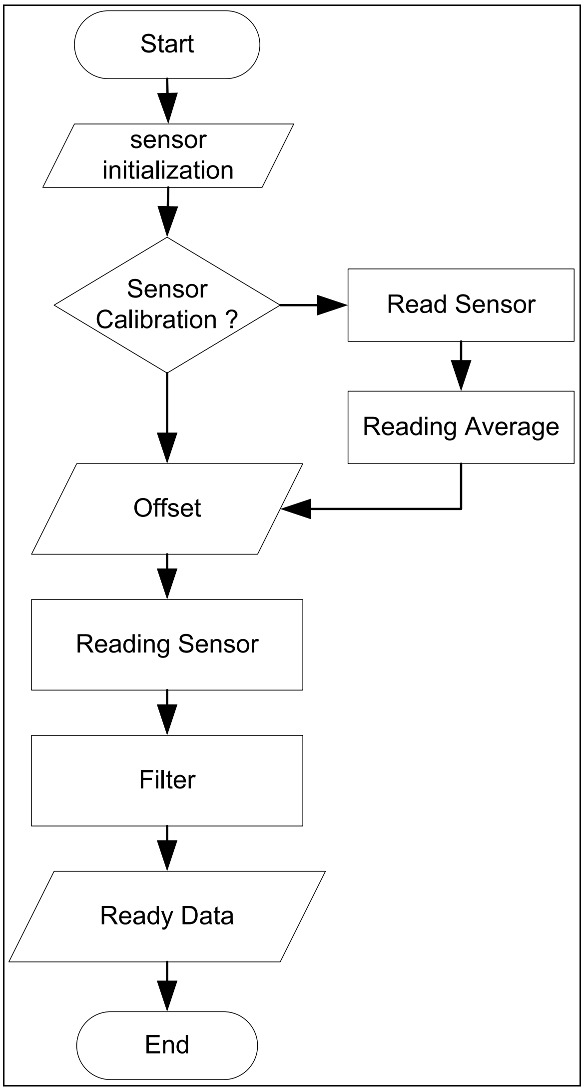

Figure 2. Sensor Data Acquisition Flowchart

Results

Testing the reading of the pitch angle on the quadcopter by the IMU sensor is carried out by testing it using the gyroscope and accelerometer sensors. The test was carried out by rotating the quadcopter on its central axis with varying angles between -40 degrees to 40 degrees. This test aims to determine whether the IMU sensor needs to be calibrated so that the sensor performance becomes precise. Sensor reading data can be seen in Table 1.

Table 1. Pitch Angle Reading

Facing Angle (°)	Gyro Angle (°)	Accel Angle (°)	Error (°)
-40	-41.82	-41.79	1.80
-30	-29.27	-29.42	0.65

-20	-18.99	-18.95	1.03
-10	-9.09	-9.12	0.89
0	0.14	0.68	0.41
10	13.27	13.33	3.3
20	19.43	19.37	0.6
30	29.91	29.88	0.1
40	41.84	41.83	1.83
Error Average			1.18

Testing of Quadcopter Pitch Angle Readings by IMU Sensors Using Filters is shown in Table 1. In addition to obtaining data, this test also aims to determine whether the IMU sensor needs filtering or not.

Table 2. Pitch Angle Reading with Complement and Median Filters

Facing Angle (°)	Complementary Angle (°)	Median Facing Angle (°)	Error (°)
-40	-41.82	-41.78	1.8
-30	-29.27	-29.24	0.74
-20	-18.99	-19.9	0.55
-10	-9.09	-9.1	0.90
0	0.14	0	0.07
10	13.27	13.26	3.26
20	19.42	19.44	0.56
30	29.97	29.93	0.08
40	41.82	42.15	1.99
Error Average			1.10

The reading of the roll angle on the quadcopter by the IMU sensor is carried out using the gyroscope and accelerometer sensors. Sensor reading data can be seen in Table 3.

Table 3. Roll Angle Reading

Facing Angle (°)	Gyro Angle (°)	Accel Angle (°)	Error (°)
-40	-43.21	-41.99	1.79
-30	-29.42	-29.07	0.58
-20	-18.95	-20.26	1.05
-10	-9.12	-10.53	0.88
0	0.68	0.20	0.68
10	13.33	9.87	3.33
20	19.37	19.45	0.63
30	29.88	29.81	0.12
40	41.83	41.27	1.83
Error Average			0.7695

Following are the results of testing the roll angle with the filtering process, as shown in Table 4.

Table 4. Roll Angle Reading

Facing Angle (°)	Complementary Angle (°)	Median Facing Angle (°)	Error (°)
-45	-42.59	-45.02	-1.195
-30	-29.10	-29.25	-0.825
-20	-20.22	-20.15	0.185
-10	-10.46	-10.48	0.47
0	0.61	0	-0.305
10	9.94	9.94	0.06
20	19.58	19.58	0.42
30	29.69	29.69	0.31
40	40.77	40.77	-0.77
Error Average			0.5

This test is to obtain data from the IMU sensor fusion process with the magnetometer sensor using complementary and median filter processes.

Table 5. IMU Sensor Yaw Angle Reading and Magnetometer

Facing Angle (°)	Readable Angle (°)	Error (°)
0	1.85	1.85
80	77.78	2.22
100	96.48	3.52
180	178.16	1.84
Error Average		2.3

The purpose of this test is to get data from the GPS sensor using a serial communication process (u-blox.com, 2020). The data in the form of longitude, latitude and altitude of the quadcopter obtained will be compared with those measured using the Google Maps and Compass applications on iOS.

Table 6. Experimental Longitude, Latitude, Altitude Values

	Data Real	Data Yang Terbaca	Galat (%)
Lattitude	7.06002	7.0593	0.072
Longitude	110.4238	110.42281	0.099
Altitude	230	237.20	3.1
Error Average			1.1

Discussion

Readers need to know what they have read and why it was significant. Remind the reader why this article was worth reading and publishing. This is where you describe the meaning of your results, especially in the context of what was already known about the subject. You can present general and specific conclusions, but take care not to summarize your article – that's what the abstract is for.

You should link this section back to the introduction, referring to your questions or hypotheses, and cover how the results relate to your expectations and cited sources. Do the results support or contradict existing theories? Are there any limitations? You can also suggest further experiments, uses and extensions.

Above all, the discussion should explain how your research has moved the body of scientific knowledge forward.

Based on Table 5 of the yaw angle, the error generated by the magnetometer sensor reading is 1.1%. Furthermore, Table 6 shows an average error of 2.3% for GPS sensor testing.

Conclusion

The IMU sensor has good performance, the average error readings at the pitch angle and roll angle from the gyroscope and accelerometer sensors are 1.18° and 0.76°.

Combining the readings of the IMU sensors using a filter obtains the quadcopter's angle of view with an error percentage of 1.10° and 0.68°. Combining the reading value of the magnetometer sensor with the IMU obtains a yaw angle with an error percentage of 2.3%.

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Conflict of interests

No conflict of interest.

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