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Flying weather network system based on wireless sensor, a flights investigation

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Abstract. The most basic problem for the Flying Weather Network (FWN) System is the flight of the sub-system. The use of a sub-system Unmanned Aerial Vehicles (UAV) or modified drone quadcopter, employed in a consistent work together along a predetermined route. Cooperation in the FWN system, the system consists of several sub-systems ie drones, some Sensor Nodes (IoT devices), weather monitoring stations. When the drone starts to fly it is in a state connected to FWN using wireless network media. Some Sensor Nodes record meteorological data and then send data to a weather monitoring station after that sent to cloud computing, sending meteorological data to a weather monitoring station via the drone subsystem. Investigation of drone flight as a sub-system which is a telemetry, medium is necessary to maintain consistency and accuracy for recording data. The investigation is carried out into several parts of testing and investigation, namely flight mode testing, quadcopter balance test for tensile disturbances, investigation of autonomous mode and investigation of drone rate point in autonomous mode of state or actual coordinates, and failsafe system investigation of failure condition experienced ie failure on voltage and RC signal transmitter.

1. Introduction

Unexpected atmospheric changes, the rapid spread of epidemiologic viral and bacterial diseases from rice fields, green plantations, and agricultural crops demonstrate a strong need to create full-scale and next-generation sensor devices to reveal progressive diagnoses and to evaluate climate levels altering impacts, increasing the number of viruses and bacteria, encouraging regular. The absence of an estimate of everyday climate information such as measured daily weather data (MWD) on the appropriate spatial determination is a real need to illustrate the current and future impacts of climate on yields and to create and utilize the preferred agricultural aid instruments for products and sources of information.

An unmanned aerial vehicle (UAV), commonly known as a drone, it is an aircraft without a humanpilot aboard, the drone can operate autonomously or can be remotely worked, decades ago a drone was originally defined as a pilotless, radio-controlled military target-towing aircraft. UAV is a component of unmanned aircraft systems (UAS); Based on that reference, then for a further discussion called drone, which includes drone is a ground-based controller and communication systems in between. Drones Flight can operate with varying degrees of autonomy: either under the remote control by the human operator or autonomously by the onboard computer. Drones are being used in increasing number of civil applications, such as policing and fire-fighting, non-military security work, disaster, and environmental search and monitoring. Due to its adaptability, flexibility, simple stance, and low
work costs. Drone utilization guarantees new routes for nonmilitary personnel applications such as, some drones are deployed that work together with other search performance tasks, detecting agents assigned to relays and routing protocols for Ad hoc networks, traffic monitoring, disaster monitoring, and forecasts of wind.

The convergence of the internet, communication, and information technology, coupled with the recent advances in technology, paved the way for a new generation of cheap sensors and actuators, capable of achieving high spatial, temporal order, and resolution. Detection and progress control incorporates cluster sensors, electric and magnetic field sensors, seismic sensors, repeated radio waves and infrared sensors, laser radar, area sensor, and navigation. Immediately, it is possible to coordinate multiple sensors into the sensor network framework to improve execution and lifetime, and reduce lifecycle costs.

The output of this paper, which is an investigation, is ultimately an input to design and build a an FWN that will generate MWD. The Flying Weather Network (FWN) system consists of subsystems called drones, some Sensor Nodes (IoT devices), weather monitoring stations (WMS). FWN works to measure weather conditions with the final results, the results will be sent to the cloud computing server to be shared to the parties in need. The FWN system through sensor nodes obtains air temperature, soil temperature, humidity, and air pressure data. Drones over a wireless connection retrieve data from sensor nodes then resume data to WMS. The problem of drone flight is expected to emerge from the weather to be measured itself influenced by several factors of air temperature, soil temperature, humidity, and air pressure. Air temperature is the scale of how hot or cold the air, the temperature describes the kinetic energy or the motion energy of the gases that make up the air. The temperature on the earth's surface is relative. Another factor that can affect is air pressure, the two factors can cause the movement of air or wind pressure. Depending on the intensity factor of sunlight, the temperature will change due to the duration of sun exposure. Referring to the problem requires flight investigation on some parameters. Test and investigation parameters ie the investigation is carried out into several parts of testing and investigation, namely flight mode testing, quadcopter balance test for tensile disturbances, investigation of autonomous mode and quadcopter rate query in autonomous mode state or actual coordinates, failsafe system investigation of failure condition experienced failure on voltage, and RC signal transmitter. The investigation of the system is not dependent on one test with another, in other words testing or investigation can be done by random testing steps or can be done any test first but to optimize battery usage in one investigation.

The ultimate goal is to develop a Flying Weather Network (FWN) System, based on low-cost wireless sensors. Application in case of early warning of the rapid spread of epidemiological diseases, viruses and bacteria from rice fields, green plantations and agricultural crops, and the impact of climate change. Unexpected atmospheric monitoring schemes are continuous using daily weather data measurements, in the form of sensor nodes (IoT devices). This paper describes the results of the investigation and testing of the drone flight, the FWN sub-system. The drone flies across the sensor nodes at a predetermined location thus the drone flies with a static route.

2. Flying Weather Network System
Several studies were introduced in many applications using drones, with the use of sensors (WSN), drone-network based sensors as a relay network to guarantee the delivery of data produced by WSN nodes on the ground to the users, and for remote radar sensing. Drone controlled by excessively adjustable flight control, and comes with a comprehensive embedded system for radar baseband processing and using a commercial differential GPS system used for positioning.

Unmanned aircraft systems (UASs) or Drone System have become an important option for use in dangerous and or repetitive missions. And for example, a UAS comprised of a bunch of drones is also increasingly used in applications such as military surveillance, security, environmental monitoring, crop and forest assessment, postwar or post-disaster damage assessment, search and rescue operations, geographical mapping, media weather measuring instrument, and remote sensing data acquisition.
2.1. Investigation Parameter
The investigation was carried out into several parts, namely testing flight mode, quadcopter balance testing of interference from pulling force, autonomous mode testing and testing of quadcopter speed points in a mode autonomous to the actual situation or coordinates, and investigation of the failsafe system against failure conditions experienced, namely failure of the voltage and signal of the RC transmitter.

2.1.1. Flight Mode Change investigation
Investigation of changing flight mode is done by trying autonomous flight mode, and the length of time the mode is moved to the farther distance. The flight process is in stabilized or controlled mode so that the quadcopter UAV flies in the air first, then the mode is changed by changing the channel on the remote control switch to autonomous mode.

2.1.2. Balance Investigation of Tensile Disorders
Quadcopter balance investigation is done by turning on the quadcopter and positioned to float in the air by using loiter or post hold mode to lock quadcopter coordinates. When the quadcopter floats in the air, the quadcopter is pulled or given interference from its position to disturb the balance. Tensile force applied on different sides is given a tensile force towards the left, right, up, down, front, and back sides. Quadcopter is given a tensile force on a particular side and the time of balance is calculated, whether it is resistant to the balance disturbances it experiences.

2.1.3. Autonomous Mode Flight Investigation
Investigation of an autonomous mode is done by trying to enter the flight route repeatedly with a different number of waypoints, and then the quadcopter is flown in stabilized mode first so that the air is then changed to autonomous flight mode, then the quadcopter will fly by route. An investigation is carried out to see if the autonomous flight can be performed with a certain number of waypoints, distance traveled, speed, and travel time.

2.1.4. Investigation of Quadcopter Speed Points
Investigation of quadcopter or waypoint speed points is carried out in autonomous flight mode, with the flight route being made and inserted into memory, then the quadcopter is flown in stabilize mode first and the mode is changed to autonomous mode the quadcopter will fly following the waypoint path created. The results of the quadcopter rate will be known through the mission planner so that the speed of the quadcopter and its maneuvering will be detected through the mission planner. Quadcopter rates and waypoints that have been made are then compared to precision or not.

2.1.5. Investigating the Failsafe System against Failure Conditions
The failsafe system investigation is carried out in two conditions, namely the failsafe in the battery condition below the minimum parameters and the condition where the RC receiver does not get the signal from the RC transmitter to be limited to the maximum distance. The testing process is carried out simultaneously by conditioning the quadcopter in flight or flying in the air and keeping the quadcopter with RC in accordance with the maximum distance of the RC transmitter and receiver, and maintaining the quadcopter flight conditions within a certain time until it reaches the minimum limit of the failsafe system on battery voltage.

3. Methodology of Investigation
The Investigation Methodology is carried out after the system design and realization process are complete, then analyzes the results of the system testing that has been made, to obtain data and analysis results and draw investigative conclusions. Flight investigation is a process that aims to
ascertain whether all functions of the system are working properly and in accordance with the objectives.

3.1. Description of Investigation
Investigations are carried out on the ability of the FWN flight system to carry out some of its objective functions. The functions that can run on the FWN system are that the system can do autonomous flight, the quadcopter UAV can fly in balance even though there is interference from wind pressure, the failsafe system can work in accordance with the actual conditions, the flight mode that the UAV can do can work well, and the process of quadcopter rate on the waypoints passed by the UAV in accordance with the mapping carried out.

Investigation of the FWN system was carried out to determine the system failure and whether these functions have been running as expected.

3.2. Investigation steps
System investigations carried out are not dependent on one investigation parameter with other parameters, in other words, investigations can be carried out with random steps or can be carried out beforehand, the investigation step is carried out based on flow diagrams as shown at Figure 1, the following:

![Flow diagrams methodology of investigation](image)

Figure 1. Flow diagrams methodology of investigation

4. Investigation and Testing
The investigation and testing are carried out based on the plot in Figure 1 because to optimize the use of a limited capacity battery, flight mode is carried out at the beginning of the investigation because to know the function of the mode to be executed it can be done or not. Balance investigation is carried out further because before the flight investigation with a long distance, the quadcopter must be balanced first. Autonomous research is done after the balance of the UAV is tested and declared balanced, along with testing the quadcopter rate point which is the waypoint path passed by the quadcopter UAV. Finally, a failsafe investigation because this check is performed when the battery is below the minimum parameters.

5. Results and Discussion
The test results obtained from the investigation and testing that researcher have done. The following are the results of testing obtained through the investigation and testing of flight change modes, balance systems, autonomous modes, quadcopter rate point mode, and failsafe system.

5.1. The results of the Flight Mode Change investigation
The results of the investigation were there is an increasing in the time of changing the mode from stabilizing to auto when the distance is further away. At a distance of 20 meters, changing the flight mode takes an average of 0.7 seconds, at a distance of 8 meters it takes an average of 1.5 seconds, at a distance of 15 meters it takes an average of 2.02 seconds, at a distance of 25 meters it takes an average time of 3.66 seconds, at a distance of 50 meters it takes an average time of 8.22 seconds, but often failure modes are changed.
5.2. Flight Investigation Data Autonomous Mode

Autonomous flight test results data are obtained after the repeated autonomous flight by changing the number of waypoints (WP) so that the mileage increases and calculates flight time until all waypoints are achieve, the autonomous mode test results are obtained. Figure 3 shows a graph of the autonomous mode test data. And showing an increase in quadcopter travel time, the farther the mileage at the same speed, the longer the travel time will be. Comparison of the time between testing and calculation shows the farther the distance, the greater the deviation or comparison obtained. Autonomous aviation investigation is repeated and performed 5 times per test by giving a different mileage of 127 meters, 218 meters, 296 meters, 356 meters, and 450 meters. The number of WPs is different and the speed is the same, then the test travel time is obtained, which is then compared to the travel time of the test results so that the intersection of the quadcopter travel time in autonomous mode can be obtained.

5.3. The results of the Balance Investigation of Tensile Disorders

Quadcopter balance investigation of the applied tensile force is the result of investigation from the state of a floating quadcopter in a loiter mode and is given a tensile force or given a disturbance to the balance, so that the obtained test data is in the form of a balancing time performed by a quadcopter when given interference on a particular side. A quadcopter is given interference or style when flying in heating mode. A disturbance is given on 6 sides, namely left, top, right, bottom, front, and back, with the angle of each side, which is then calculated for the time of balancing the quadcopter when experiencing interference until the condition stabilizes again. The graph in Figure 4 shows the average length of time a quadcopter balances based on the side of the interference provided and obtained the fastest time of disturbance on the lower side.

5.4. The Results of Quadcopter Speed Point Investigation

The results of the investigation of the quadcopter rate point obtained in the form of the value of the distance deviation traveled by the quadcopter. By comparing the rate path made in the WP and the actual path, it is obtained a deviation from the distance of the quadcopter rate point. The investigation was carried out with 5 different routes with different distances but the same number of waypoints (WP), each route was tested 5 times for testing. Figure 5 is a depiction graph of the data obtained showing the test results of quadcopter speed points, where testing is done by giving the same...
number of waypoint as many as 5 pieces, the same height is 30 meters, and the distance between different WPs with the aim to determine the influence of inter distance WP. Figure 5 shows the comparison of the test values of quadcopter rate points with different distances between WPs. The farther the distance between WPs, the more deviation and the greater the total deviation but does not affect the average deviation per one junction that is below the 20 meter value.

5.5. The results of the Flight Mode Change investigation
The results of the Failsafe System investigation of Failure Conditions, data obtained two data with different failsafe conditions, namely the failsafe system in which the battery voltage is below the minimum limit and the failsafe system in the signal state of the RC transmitter that is not detected.

Table 1. Results from the investigation of the voltage failure failsafe system

| No | Minimum Parameter Voltage | Voltages Actually | Buzzer | WP Notifications | Action |
|----|--------------------------|-------------------|-------|-----------------|--------|
| 1  | 14,8                     | 16,01             | No    | No              | No     |
| 2  | 14,8                     | 15,7              | No    | No              | No     |
| 3  | 14,8                     | 15,6              | No    | No              | No     |
| 4  | 14,8                     | 15,4              | No    | No              | No     |
| 5  | 14,8                     | 14,8              | No    | No              | No     |
| 6  | 14,8                     | 14,7              | Yes   | Yes             | RTL    |
| 7  | 14,8                     | 14,5              | Yes   | Yes             | RTL    |
| 8  | 14,8                     | 14,2              | Yes   | Yes             | RTL    |
| 9  | 14,8                     | 13,8              | Yes   | Yes             | RTL    |
| 10 | 14,8                     | 12,8              | Yes   | Yes             | RTL    |

Data from the investigation of the failsafe system with voltage failure conditions obtained in the form of a value from the minimum parameter voltage that is regulated, with the actual voltage conditions, indicated by the buzzer sound and notification on the mission planner and the action taken, namely RTL mode (Return To Launch mode). Table 1 is the result of investigation the voltage failure failsafe system.

From the results of the second failsafe system investigation that is in the condition of the RC transmitter or remote control, the signal is lost to the receiver that is on the quadcopter. Table 2 is the result of the failsafe system testing the signal failure of the obtained RC transmitter.

Table 2. Results of testing the failsafe RC signal failure system

| No | Distance (meters) | Signal RC Transmitter | Buzzer | Notifications | Action |
|----|-------------------|-----------------------|--------|---------------|--------|
| 1  | 20                | Yes                   | No     | No            | No     |
| 2  | 20                | Yes                   | No     | No            | No     |
| 3  | 40                | Yes                   | No     | No            | No     |
| 4  | 40                | Yes                   | No     | No            | No     |
| 5  | 40                | Yes                   | No     | No            | No     |
| 6  | 60                | No                    | Yes    | Yes           | RTL    |
| 7  | 60                | No                    | Yes    | Yes           | RTL    |
| 8  | 50                | No                    | Yes    | Yes           | RTL    |
| 9  | 50                | Yes                   | No     | No            | No     |
| 10 | 50                | No                    | Yes    | Yes           | RTL    |

6. Conclusions
The results of the investigation of UAV flight parameters for the implementation of the FWN in order to measure and monitor weather changes, found several conclusions obtained where it is possible to use UAVs or quadcopter to be used as FWNs, and the results issues are as follows:

There is an increase in the time of changing the mode from stabilizing to auto when the distance is further away. Comparison of the time between testing and calculation shows the farther the distance, the greater the deviation or comparison obtained. A disturbance is given on 6 sides, namely left, top, right, bottom, front, and back, with the angle of each side, which is then calculated for the time of
balancing the quadcopter when experiencing interference until the condition stabilizes again. The farther the distance between WPs, the more deviation and the greater the total deviation, but does not affect the average deviation per one junction that is below the 20-meter value. The failsafe system can function properly when the condition is lacking in voltage and the loss of the signal from the RC transmitter so that the possibility of loss or damage to the quadcopter can be minimized.

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