Monitoring system on towercopter using ELM (Extreme Learning Machine) method

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Abstract. Towercopter has experienced rapid development in recent years. Towercopter is a tool with one brushless motor and one propeller that is installed between two support poles. Towercopter requires balance to be able to move during takeoff or hovering. In this final project, a study will be developed using three brushless motors. Towercopter is a singlecopter prototype that specifically moves vertically. The load disturbance test on the system causes the towercopter to become unstable while working towards the setpoint. It needs to be controlled so that it is stable. So to solve these problems a prototype is made. Towercopter in this final project is a prototype designed using three brushless motors and 3 propellers which are mounted on two support poles, namely stainless axles. Using two sharp irradi sensors to detect height and slope. The purpose of this final project is to produce an altitude control on a towercopter using the ELM (Extreme Learning Machine) method.

1. Introduction

Looking at the geographical position of Indonesia which is located at the end of the movement of three world plates, namely Eurasia, Indo-Australia, and Pacific, making Indonesia a cataclysm-prone country [1]. The impact caused by the cataclysm is detrimental to the surrounding community. Besides the loss of material, the evacuation process, victim's search, and disaster management process frequently also take a long time due to the condition of the disaster is difficult to access [1].

In the process, evacuation and monitoring of cataclysm locations can be carried out through land and Air. Whereas through the air, usually use the assistance of helicopters to comb the location of the disaster (I Gede Andika, 2018). A Helicopter one of a kind of Unmanned Aerial Vehicle (UAV) which is an unmanned aircraft that does not require a human operator, can fly independently, or be driven remotely and can carry cargo [2].

However, in fact, in the field some problems are natural disturbance in the area is bigger like wind and also because the burden itself when the helicopter dropped the goods or raise the goods using a rope with the help of the pilot so that the stability in the helicopter bad. To improve stability, a height controller is required to increase the stability of the helicopter when carrying the load.
The previous research was conducted by Chintia Putri Unarya under the title "Vertical motion arrangement System Planning in Towercopter using Labview-based control PID" [3]. In this study the method still has drawbacks in terms of the time it takes to get the PID parameter and still use the ultrasonic sensor HC-SRO4 which causes the sensor to still be less precise and tends to be unstable so that the resulting response is less good.

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Rifqi Nabila Zufar also conducts a study under the title "Design-build of altitude position control system on Proportional-based Integral Towecopter using Artificial Neural Network Tuning" In this study also still uses the ultrasonic sensors HC-SR04 that the sensory readings are still less precise and can be developed using the PID-ANN method to reduce existing oscillation. In both studies, it still uses 1 input and 1 output.

Therefore, the purpose of this research is to create a design-build towercopter with 4 inputs and 3 outputs. Equipped with 2 IR sharp sensors that can add sensor precision in the data readings and 2 load cell sensors to add interference test to the system of load, and 3 brushless motors as Actuators. This study using the ELM method is expected to be able to repair two previous methods. Therefore, a study titled "Design-Build of altitude position control system on Towercopeter using ELM (Extreme Learning Machine) method".

2. Methodology
2.1. System Design
Flowchart System is a working step of the system, namely system initialization first by making sure all hardware is connected and can work well. After the initialization of the system is to determine the set point for the height of the towercopter. After that Towercopter will work towards SetPoint. Then the altitude on the towercopter will be read by the sharp IP sensor. Afterward plus a test of interference by adding the sensor load cell and slope detected by the IR sharp sensor. Some of these inputs are controlled by the ELM process to deliver the output to send commands to the brushless motor to move the propeller to the set point on the Towertreecopter. If the system has not reached the setpoint then the system returns to the ELM process. When the system has reached a set point then the data will be monitored by Android and to display the chart set point.
Figure 1. System Design.
2.2. Towercopter Design
The following is a hardware design design that will be used in this final project.

![Figure 2. Towercopter Hardware Design.](image)

The mechanical design of the tool in this final project has been illustrated in the hardware design which is equipped with three drivers and four sensors so that the system can run as intended.

2.3. ELM Model Design
From Figure 3 can be explained that this final task uses 4 inputs and 3 outputs. The ELM itself is an artificial neural network that uses one hidden layer. There are 4 inputs symbolized by x1, x2, X3, and X4 that display both the altitude and weight values by both sensors. The Output is a speed of 3 brushless motors symbolized by T1, T2, T3. The ELM structure above consists of Matrik H, Matrik Beta, and Tansig used for the activation function. The ELM method was applied to adjust the propeller height of the towercopter to balance.

![Figure 3. ELM Model Design](image)
2.4. Android App Design

Based on figure 4 the function of this android is the control start and stop on towercopter. And to display the setpoint graph on the system. Setpoint control and also for monitoring sensor data namely height, load weight, and slope. Based on figure 15 the data is obtained from the tool, namely when inputting setpoint 50 will display the graph and data as in the android image below.

![Android Application Loading Page](image1)

**Figure 4.** Android Application Loading Page.

![Android Application Menu Page](image2)

**Figure 5.** Android Application Menu Page.
3. Result and Discussion

3.1. Towercopter Design Result

The following is the design for the placement of hardware on the mechanics shown in the image below.

![Figure 6. Towercopter design result.](image)

The mechanical design in this final project uses two 8mm diameter stainless axles with 80cm length and 93cm 5mm acrylic cutting as the main frame. In making this mechanical hardware, it requires aluminum to put 3 brushless motors and 2 load cell sensors. Two linear bearings are attached to each stainless axle to drive the towercopter. On aluminum, a connecting road is installed to connect the load cell 1 sensor and the load cell 2 sensor on this mechanical hardware. In this tool, four sensors are installed, namely 2 ir sharp sensors and 2 load cell sensors. Ir sharp sensors are used to detect the height and slope of the towercopter. Which of the sensors is able to detect up to 80 cm while for this tool the maximum is up to 70 cm. The load cell sensor functions to detect the load to be tested for interference with the towercopter. In this mechanical design, there are actuators, namely 3 brushless motors that will be connected to the propeller.

3.2. Ir Sensor Sharp Testing

At this final task use 2 Ir sharp sensors that serve to detect altitude on the towercopter and tilt. At the test this time using a ruler workpiece that is. In this sensor test, the observed value is output distance that reads by the sensor with a distance range of 10 cm – 42 cm.

![Figure 7. Ir sensor sharp Test.](image)
Table 1. Ir sensor sharp testing data

| Testing | Ruler(cm) | Ir sensor Sharp(cm) | Error (%) |
|---------|-----------|---------------------|-----------|
| 1       | 10.00     | 10.07               | 0.7 %     |
| 2       | 17.00     | 17.35               | 2.05 %    |
| 3       | 20.00     | 20.48               | 2.4 %     |
| 4       | 21.00     | 21.56               | 2.6 %     |
| 5       | 23.00     | 23.64               | 2.7 %     |
| 6       | 26.00     | 26.42               | 1.61 %    |
| 7       | 30.00     | 30.47               | 1.56 %    |
| 8       | 33.00     | 33.59               | 1.78 %    |
| 9       | 39.00     | 39.02               | 0.05 %    |
| 10      | 42.00     | 42.09               | 0.21 %    |

Error average = 1.5 %

The reading error of the sharp ir sensor is quite small, namely 1.56%. This test shows that the sensor has a good distance reading capability with very low error. Of the 10 tests, it shows that the sensor has a good distance reading capability with a very low error.

3.3. Sensor Load Cell Testing

This test is done by spilling oil (diesel fuel) on the water in the aquarium. Oil will be spilled on the surface of the water with a certain thickness then ADC data will be recorded. Figure 18 shows the TEMT6000 sensor testing to retrieve ADC data from the light intensity emitted by the LED. The following Table 4.5 is the result of ADC data from the taking made on the TEMT6000 sensor.

Figure 8. Sensor Load Cell Test.
Table 2. Sensor load cell testing data

| Testing | Load (gr) | Sensor load cell (gr) | Error (%) |
|---------|-----------|-----------------------|-----------|
| 1       | 50.00     | 51.67                 | 3.34 %    |
| 2       | 100.00    | 100.50                | 0.5 %     |
| 3       | 150.00    | 149.00                | 0.66 %    |
| 4       | 200.00    | 199.00                | 0.5 %     |
| 5       | 250.00    | 246.33                | 1.46 %    |
| 6       | 300.00    | 296.00                | 1.33 %    |
| 7       | 350.00    | 345.00                | 1.42 %    |
| 8       | 400.00    | 394.50                | 1.37 %    |
| 9       | 450.00    | 440.33                | 2.14 %    |
| 10      | 500.00    | 488.16                | 2.36 %    |

Error average = 1.5 %

This study used 2 load cell sensors to detect the weight that would be in the problem test on the towercopter. Picture 9 is a series of load cell sensors, HX711 modules, and STM. In table 2 is a test load cell sensor using a workpiece weighing 50-500 grams. Out of the 10 tests showed that the sensor had a good load-reading capability with a very low error of 1.5%.

3.4. ELM testing

Extreme Learning Machine (ELM) applied to arrange the speed of the motor which then being used to arrange the speed of motor 1, 2, and 3 when the burden is placed in the middle, in the right corner or in the left corner. The test has done to know about the accuracy of the method, then to compare datasheet result and training result to know about the errors. The error during the test of ELM can be counted using the formula as follow:

\[
(3.1)
\]

Table 3. No-load testing
Table 3 is the test without burden, by comparing the original data: data from the tool and training data so that from that test can be gotten the data or the average error M1 0,1122%, M2 0,1104%, M3 0,2413%.

4. Conclusion
The conclusion is that towercopter can be controlled via android to display setpoint graphs, control start and stop, and display data from sensors. The ELM test was successful, namely when testing with a load of 100 grams, a low error was obtained with an average error of the three motors, namely 0,1122%, M2 0,1104%, M3 0,2413%.
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