

## **MultiWii Based Quadcopter by Using Arduino Controller**

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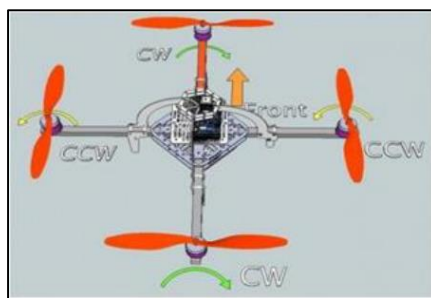
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**Abstract:** A quadcopter is a type of unmanned aircraft that can take off and land vertically and is controlled by radio equipment and self-programming devices. Quadcopters are equipped with four motors that use variable thrust to control the aircraft's lift and allow for PID control of its roll, pitch, yaw, and thrust. In this study, the design and development of a quadcopter drone were examined. The main components of a quadcopter include a flight controller using an Arduino controller with integrated accelerometers and gyroscope sensors, brushless DC motors with propellers, a transceiver module, and other parts. The transceiver module of the two joysticks successfully transmitted the control signal to the flight controller. The brushless DC motors on the quadcopter rotated at various speeds to carry out various motions that are controlled by the joysticks. The integrated accelerometer and gyroscope module of the flight controller successfully measured accelerations and angular rates. Meanwhile, the MultiWii software displayed the current throttle angle, pitch angle, yaw angle, and roll angle of the quadcopter. Thus, a quadcopter can be implemented using the software and hardware components that were chosen. However, there is an incompatibility between MultiWii open-source software with the hardware chosen for this project since there is a lack of safety-critical applications. This study allows people to increase their understanding of the structure of unmanned aerial vehicles and how to develop a quadcopter that can receive the control signal from the transmitter and perform a stable flight.

**Keywords:** Drone, Quadcopter, Arduino Controller

### **1. Introduction**

An aircraft that is lifted with four propellers and powered by a motor on the end of each is called a quadcopter [1]. There are two types of configuration for the quadcopter with four propellers to be flown which are X-configuration and + configuration. As compared to the + configuration which is more acrobatic, an X-configuration quadrotor is said to be more stable [2]. Two of the motors spin counters clockwise, while the other two spin in the other direction as shown in Figure 1.



**Figure 1: Quadcopter motor configuration** [3]

The implementation of the flight controller in the drone may lead the efficient moving swiftly. Therefore, the flight controller enables the operator to use simple controls like roll, pitch and yaw. The flight controller needs a lot of input signals from accelerometers and gyroscope sensors to measure acceleration and rotation.

A drone could be developed with a purpose appropriate for a person in their field [4]. It is significant to understand the software development and hardware development of the quadcopter. It allows people to investigate further improvements in this technology. The objectives of this project are to design the circuit of the transceiver system of the quadcopter by using an Arduino controller, to integrate the MultiWii software-based flight controller on the quadcopter frame, and to test and evaluate the control system and flight performance of the quadcopter.

MultiWii software provides information on calibration and identification to control a multirotor remote-controlled model. The quadcopter's flight controller and its transmitter are developed using Arduino Nano microcontroller board. The microcontrollers are programmed to allow the antenna and circuit board inside the quadcopter to receive signals from the transmitter and turn on the quadrotors using electronic speed controllers (ESCs). The microcontroller is supplied with a LiPo battery for the quadcopter while an alkaline battery for the transmitter [5].

There are some scopes for this project. Quadcopter needs to consider the limited flight time approximate 25 minutes due to the energy its battery will consume for four propellers. The transceiver module in the quadcopter has limited transmitting power and a limited communication distance that can be reached which is 1km range in open space.

A quadcopter is a type of unmanned aerial vehicle that is powered by four motors and can take off and land vertically. To build a quadcopter, use an Arduino microcontroller as the flight controller, which is the central processing unit that controls all of the other components. The quadcopter's motors are responsible for providing lift and controlling the movement of the vehicle. These are typically brushless DC motors with propellers attached. Electronic Speed Controllers, or ESCs, are used to regulate the speed of the motors and ensure that they are running at the desired speed.

To power the quadcopter and its components, it requires lithium polymer battery, or LiPo battery. Radio transmitter and receiver components are used to send control signals from the operator to the quadcopter and receive feedback from the quadcopter's sensors. Quadcopters are equipped with sensors that help them sense their orientation and movement. These typically include accelerometers, gyroscopes, and magnetometers. The quadcopter's frame is the structure that holds all of the other components together and provides a mount for the motors and other parts.

Propellers are used to provide thrust and help the quadcopter maintain stability in flight. Quadcopters typically use two pairs of propellers, with one pair spinning in a clockwise direction and the other spinning counterclockwise. This allows the quadcopter to cancel out the torque produced by the motors and stay stable in the air. The use of the power distribution board on the quadcopter kit frame allows all the positive and negative wires of 4 ESCs to connect in parallel with 1 Lipo battery. In

addition to the core components mentioned above, some quadcopters may also include additional optional components such as a GPS module, a camera, or additional sensors.

The specification of the components used in this study shown in below list:

- Dual-axis XY joystick
- A2212-6T 2200KV brushless motor
- 5045 propellers with clockwise and court clockwise
- Electronic Speed Controllers (ESCs)
- 3S 60C 3000mAh LiPo rechargeable battery
- Arduino Nano
- GY521 MPU6050 module
- HC12 transceiver module
- Power Distribution Board with the quadcopter frame

## 2. Methods

To build a quadcopter using an Arduino microcontroller, need to gather the necessary components including the microcontroller itself, four brushless DC motors with propellers, electronic speed controllers (ESCs) for each motor, a lithium polymer (LiPo) battery, a radio transmitter and receiver, sensors such as accelerometers, gyroscopes, and magnetometers, a frame to hold all of the components, and propellers.

The first step in building the quadcopter is to assemble the frame. This involves connecting the various pieces of the frame and mounting the motors to it. Next, connect the electronics, including the Arduino microcontroller, the ESCs, and the sensors, using wires. Make sure to follow the instructions for specific components to ensure that they are connected correctly.

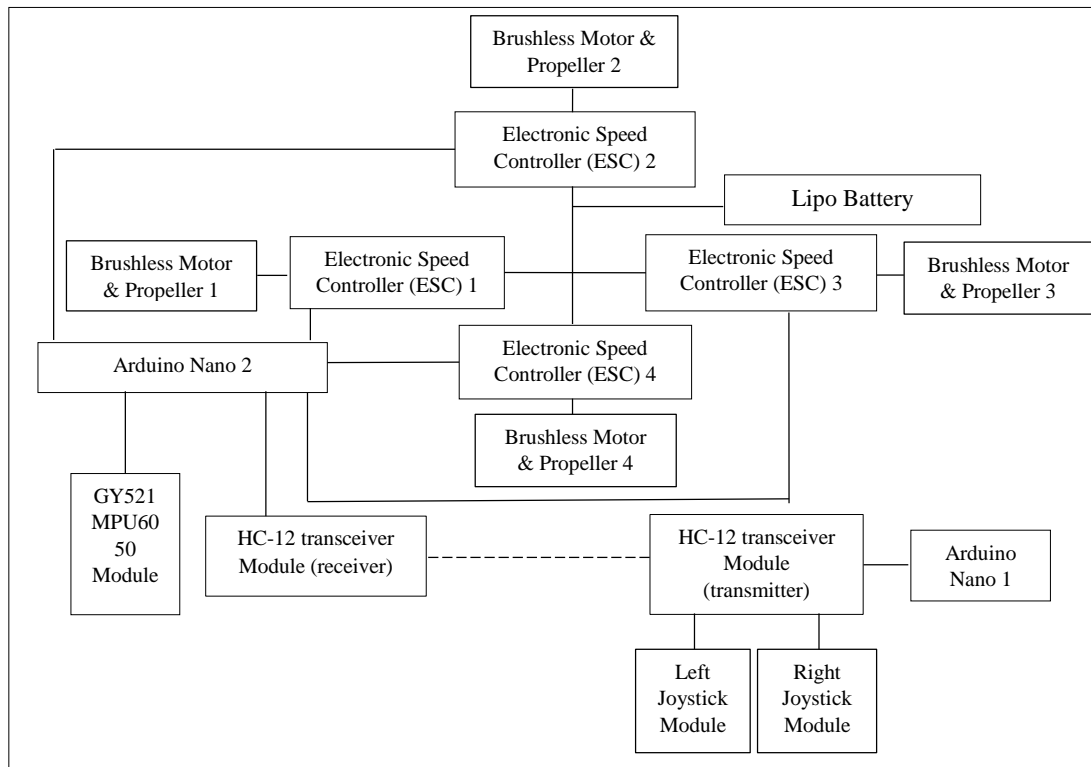
Once the electronics are in place, install the propellers by attaching them to the motors according to the instructions for quadcopter. Some quadcopters use different-sized propellers on opposite pairs of motors, so be sure to match the correct propeller with the correct motor. Install the battery and radio transmitter onto the quadcopter, following the instructions for these components.

With the physical components of the quadcopter assembled, then use the Arduino programming environment to write and upload code that will control the motors and sensors. This code will include instructions for taking input from the radio transmitter and using it to control the quadcopter. Finally, power on the quadcopter and use the radio transmitter to test its movement and stability, making any necessary adjustments to the code or the physical setup of the quadcopter to ensure that it is working properly.

### 2.1 System block diagram

The block diagram for the MultiWii-based quadcopter using an Arduino controller is shown in Figure 2 below. The block diagram below represents the two main parts of the quadcopter which are the transmitter that connects the microcontroller Arduino Nano 1 and the receiver that connects the microcontroller Arduino Nano 2. Every dashes line in the block diagram represents the wireless connection while the solid line represents the wire connection.

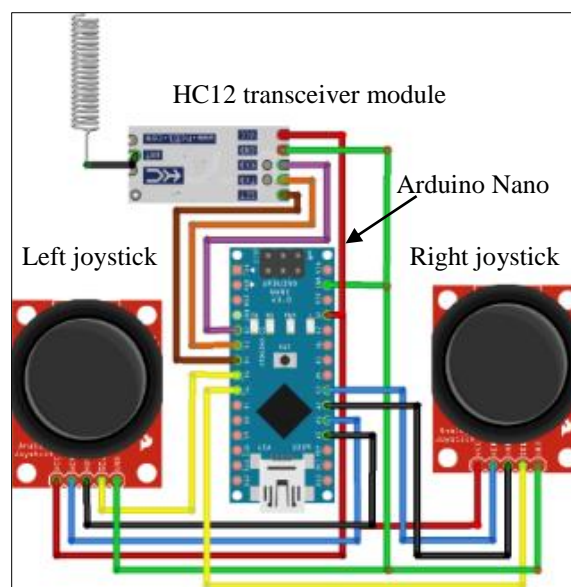
Once the transmitter and the receiver of the quadcopter are connected, PID calibration is set and the receiver starts receiving the sensor data from the quadcopter. The control of the joystick on the transmitter will send the signal to the receiver and the 4 DC motor will take the action that affects the motion and direction of the quadcopter.



**Figure 2: Block diagram for first-person-view (FPV) MultiWii based quadcopter by using Arduino controller**

### 2.3 Circuit development for the transmitter

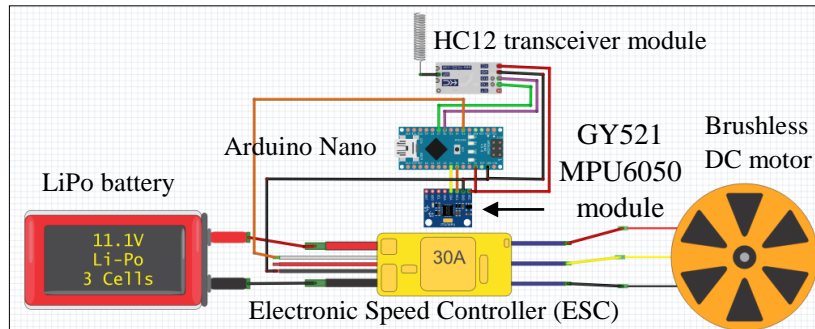
The parts that need to build a transmitter are 2 joysticks, 1 Arduino Nano and 1 HC12 transceiver module. Figure 3 below shows the wiring diagram of the transmitter. The left joystick is used to control the throttle and the yaw while the right joystick is used to control the pitch and the roll. For testing the functionality of this transmitter, it needs to prepare another HC12 transceiver module as a receiver connected to another microcontroller Arduino Nano. This receiver will be uploaded with a temporary code. Observe the data by clicking the serial monitor in Arduino IDE software.



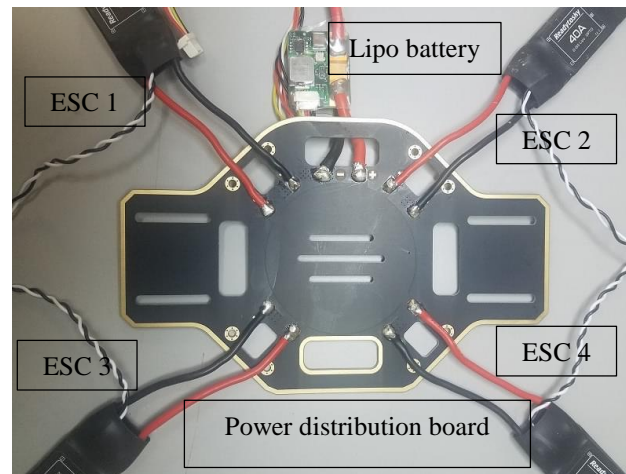
**Figure 3: Wiring diagram of the transmitter**

## 2.4 Circuit development for the receiver

The parts that need to build a receiver are 1 Arduino Nano, 1 HC12 transceiver module, GY521 MPU6050 module, 4 brushless motors, 4 electronic speed controllers (ESC), 4 propellers and 1 Lipo battery. Figure 4 below shows the wiring diagram of the receiver in the drone. Figure 4 shows only 1 electronic speed controller (ESC) with 1 brushless motor. The way to connect all 4 ESCs with 1 Lipo battery is using a quadcopter kit frame that consists of a power distribution board shown in Figure 5.



**Figure 4: Wiring diagram for the receiver in the drone**



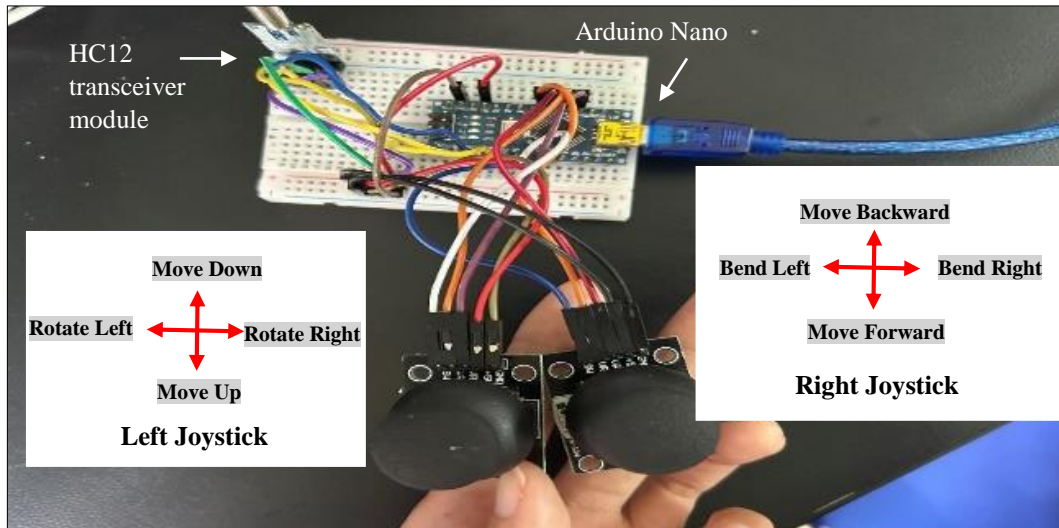
**Figure 5: Configuration of the power distribution board**

## 3. Results and Discussion

The results and discussion section present data and analysis of the study. This section observed and discussed the result after the appropriate setup of the transceiver system, flight controller on the drone.

### 3.1 Transmitter system testing

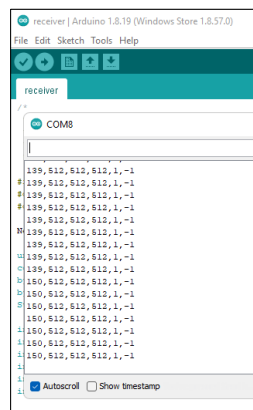
The transmitter is transmitted the control signal to the receiver once the left and right joystick on the transmitter is moved. Figure 6 clearly labelled the respective movement for each push direction of the left and right joystick in the transmitter.



**Figure 6: Joystick program mode in the transmitter**

The receiver will be received the signal from the transmitter and the data will be displayed on the Arduino IDE software by clicking the Serial Monitor of the receiver program window as shown in Figure 7. The initial reading for all the parameters throttle, yaw, pitch, and roll is 512. It shows the reading of throttle in the first column followed by yaw, pitch, and roll for each respective column. The increase or the decrease of each reading is affected by controlling in four directions of the left or right joystick which are pushed up, down, left or right.

The first column is the reading of throttle which represent moving down when the reading decreases and moving up when the reading increases. The second column is the reading of yaw, representing rotate left when the reading decreases and rotate right when the reading increases. The third column is the reading of pitch which represent moving backwards when the reading decreases and moving forward when the reading increases. The fourth column is the reading of roll which represent a bend left when the reading decreases and a bend right when the reading increases.



**Figure 7: Serial Monitor of the receiver program window displayed on Arduino IDE software**

### 3.2 Flight controller implementation

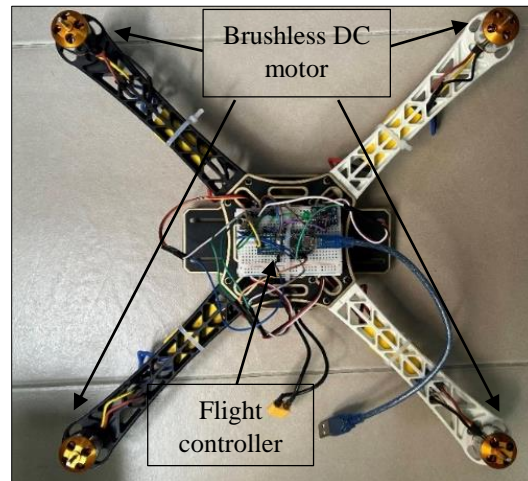
The main components of the flight controller consist of Arduino Nano, magnetometers GY521 MPU6050 module and HC12 transceiver module. These three components provide the function of the flight controller to stabilize the quadcopter during flight [6]. The flight controller is implemented on the small breadboard and placed above the quadcopter frame. The completed circuit of the flight controller where the signal wire from four Electronic Speed Controllers (ESCs) is connected to the Arduino Nano. This connection allows the flight controller receives signals from the transmitter and sends the control



signal to the ESCs, which then instructs the ESCs to make precise adjustments to the motor rotational speeds and stabilise the craft [7].

### 3.3 Quadcopter frame implementation

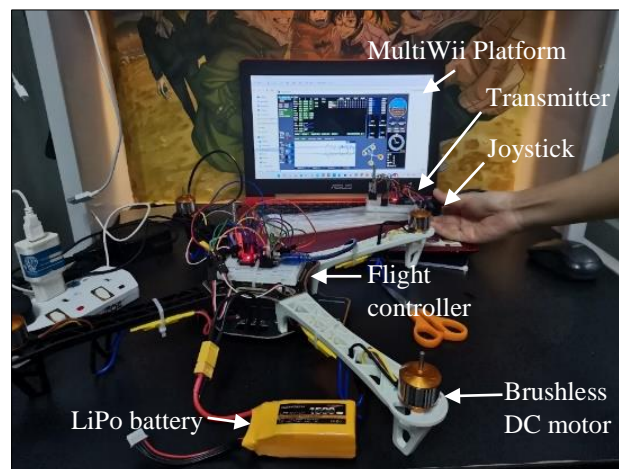
The ESCs are connected with brushless DC motors using the bullet connector [8]. All signal wires of ESCs were connected to the flight controller that was placed on above the quadcopter frame. The LiPo battery was connected to the power distribution board of the quadcopter to deliver the power to four ESCs. X-configuration quadrotor is said to be more stable [2]. Figure 8 shows the overview of the flight controller, ESCs and brushless DC motor in the quadcopter.



**Figure 8: Overview of the quadcopter**

### 3.4 Flight controller testing and PID calibration

By using MultiWii software, it started to read the flight controller and shows the visualization of the drone's position. The combination of accelerometers and gyroscopes sensor inside the flight controller sensed the balancing and levelling condition and the output of the sensor is shown in the MultiWii platform. Therefore, each position parameter such as roll, and yaw is sent back to the PC to represent the condition of the quadcopter from time to time. Figure 9 shows all brushless DC motors spin after move the left joystick towards the "Move Up" direction for about 3 seconds. Move the left joystick to the "Move Down" direction to stop the motors.



**Figure 9: Spin of brushless DC motors after the joystick is moved**

The calibration of the accelerometer sensor was done by clicking the CALIB\_ACC button and transferred to the Arduino Nano by clicking the WRITE button. Figure 10 shows the proportional, integral and derivative (PID) value for each position parameter after the calibration of the accelerometer.

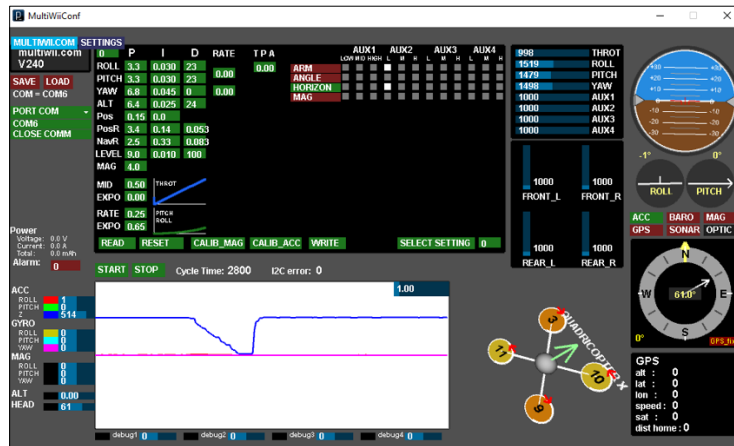


Figure 10: PID calibration for the accelerometer sensor

The PID value as a control option that was transferred to the flight controller may create the most efficient regulation of the current measured motion parameter such as pitch, yaw and roll every time the joysticks control the movement of the quadcopter.

Each brushless DC motor spin at a different speed based on the joystick moves as shown in Figure 11.

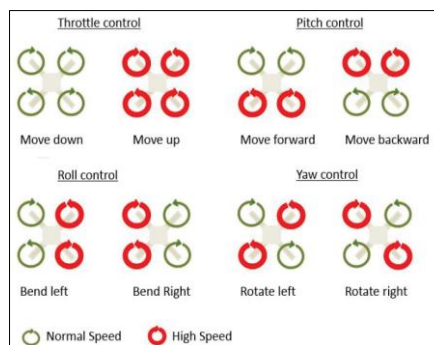


Figure 11: Propeller speeds and resulting quadrotor motion

Four brushless DC motors spin at high speed to create lift force once the left joystick moves to the “Move Up” direction. Either two of the brushless DC motors spin at high speed may control pitch, roll and yaw. To complete the motions of throttle, pitch, roll and yaw commands must be matched onto brushless DC motor speeds or propeller speeds.

#### 4. Conclusion

As a conclusion, this project is investigated the implementation of a quadcopter. An unmanned quadcopter required a transmitter on the ground and a receiver on the flight controller that was placed on the main body of the quadcopter. The transceiver module successfully transmitter able transmits the control signal to the receiver. The brushless DC motors are successfully spin at different speeds to perform a different motion that controls by the joysticks. The flight controller's integrated accelerometer and gyroscope sensors successfully detect accelerations and angular rates. Thus, the software and the hardware parts selected can be used to implement a quadcopter. Unfortunately, the quadcopter lack safety-critical application while using MultiWii open-source software.



However, the quadcopter may proceed for further improvement by replacing other better autopilot systems and integrating other sensors to perform advanced applications. A better open source autopilot system and hardware such as Pixhawk flight controller and DJI series flight controller. It is highly recommended to use image processing data to optimize the drone's trajectory and identify the precise location.

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### References

- [1] M. Masoud, Y. Jaradat, M. Farhoud, and A. Almdallaleh, "On Implementing a Low Cost Quadcopter Drone with Smartphone Control," no. May, 2016.
- [2] S. Gupte, P. I. T. Mohandas, and J. M. Conrad, "A survey of quadrotor unmanned aerial vehicles," *Conf. Proc. - IEEE SOUTHEASTCON*, 2012, doi: 10.1109/SECon.2012.6196930.
- [3] A. Jadhav, A. Khapre, J. Khadase, and R. S. Nipanikar, "Quadcopter for Traffic Surveillance," *GRD J. Eng. /*, vol. 1, 2016, Accessed: Apr. 20, 2022. [Online]. Available: [www.grdjournals.com](http://www.grdjournals.com).
- [4] Y. Li and C. Liu, "Applications of multirotor drone technologies in construction management," *Int. J. Constr. Manag.*, vol. 19, no. 5, pp. 401–412, 2019, doi: 10.1080/15623599.2018.1452101.
- [5] A. Ghosh, H. Roy, and S. Dhar, "Arduino quadcopter," *Proc. - 2018 4th IEEE Int. Conf. Res. Comput. Intell. Commun. Networks, ICRCICN 2018*, no. April 2021, pp. 280–283, 2018, doi: 10.1109/ICRCICN.2018.8718695.
- [6] I. Journal, "IRJET- GSM BASED AGRICULTURAL MONITORING SYSTEM USING DRONE GSM BASED AGRICULTURAL MONITORING SYSTEM USING DRONE."
- [7] S. Agarwal, A. Mohan, and K. Kumar, "DESIGN AND FABRICATION OF TWINROTOR," pp. 369–377, 2013.
- [8] A. Ajay, J. Amal Prakash, S. Gokul, S. Aji, and P. R. Prabhu, "Origami Based Cargo Drone," *J. Electron. Des. Eng.*, vol. 5, no. 3, pp. 1–8.