**Unmanned Aerial System Control using Gyroscope in Mobile Devices**

*Other title options: Android-based Motion Sensor Operated Unmanned Aerial Vehicle, LIPAD: Low-cost Implementation of Android Motion Sensor-operated Drone*

A Research Paper

Presented to:

**Engr. Julius Jr. V. Olandria**

Adviser in ECE 170 - System Design/Capstone Project 1

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Necesito, Michael John T.

Orcullo, Carl Jev F.

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# Abstract

Keywords: *Drone, UAV Control, Android controller, Motion Sensor*

# Chapter 1

## 1.1 Background of the Study

With the emergence of advanced technology, people have become creative as to which technological advancement should be done next. People eventually went to improve some aspects of technology. For instance, the creation of aerial vehicles such as airplanes and helicopters opened a new idea for inventors to create a more systematic aerial vehicle that can be controlled from afar and will not require pilots. Thus, the idea of unmanned aerial vehicles comes to place.

Drones are also called Unmanned Aerial Vehicles (UAV) or Unmanned Aerial Systems (UAS) and, as their name implies, are aircrafts that can fly without the aid of a pilot and passengers. Instead, drones are controlled either by controlling them remotely via radio waves or using a predetermined route programmed within the UAV themselves [Kardasz et al., 2016].

Drones were originally used for enemy spying during WWI. They're little radio-controlled planes that may be used to capture photographs. Their usage has now spread to civilian hobbyists and is rapidly growing into several fields like in agriculture [Stehr, 2015]. In a wide number of fields, drone technology offers great benefits and prospects. Drones help in surveying, humanitarian assistance, disaster risk management, research, and transportation, among other things [Ayamga, 2021].

In the recent years, drone industry rises at a rapid pace with sales in consumer drones exceeding $1.25 billion in the US alone back in 2020 [SeedScientific, 2019]. In fact, the same statistics report also presented the worth of the agricultural, consumer, industrial, governmental, and military drones all reached billions of dollars in 2020.

Manual control on drones typically uses a controller with two rods that allows to control the throttle and rudder control of the drone. However, recent innovations on drone control now involves several options such as using brain signals to control a drone connected through WiFi controlling a drone through Google glass [Hassanalian & Abdelkefi, 2017].

Another innovation on drone control system is presented by [Masoud et al., 2016] and is a smartphone-based drone controller connected to the drone via Bluetooth. Bluetooth, according to [Bray & Sturman, 2001], is defined as a low cost, low power, short range radio technology whose original purpose was to replace wired cables in connecting devices. In 2010, Bluetooth 4.0 was released—also called Bluetooth Low Energy (BLE). As defined by [Townsend et al., 2014], BLE supports a hub-and-spoke model of connectivity. That is, one device being a central hub—or simply the “Central”—while other devices connected to it are dubbed “Peripherals”.

As such, this study focuses on presenting an innovation on modern-day control of drones. To be specific, this study will make a drone connected to an Android device via a Bluetooth module, and is controlled by the user using the Android device’s microelectromechanical systems (MEMS) gyroscope and accelerometer.

## 1.2 Statement of the Problem

The main underlying issue of the project is connecting an Android phone to a drone equipped with a Bluetooth module. Specifically, the problem that the researchers will try to solve mainly revolves in transmitting an Android phone’s real-time gyroscope and accelerometer data to a drone, allowing it to hover based on the data it received.

## 1.3 Objectives

The researchers aim:

### 1.3.1 General Objective(s):

1. To develop a drone that can be controlled using an Android phone’s real-time gyroscope and accelerometer data.

### 1.3.2 Specific Objective(s):

1. To create an X-frame drone equipped with a Bluetooth module.
2. To connect the Android device to the drone.
3. To get the Android device’s gyroscope and accelerometer data.
4. To transmit the data to the drone.
5. To move the drone based on the data transmitted.

## 1.4 Significance of the Study

The study will benefit the following:

1. **Drone Enthusiasts** - This innovation in drone control will make the drone enthusiasts explore new possibilities. Having a switch of controls from the typical joystick controller will revolutionize future drone controls.
2. **Mobile Phone Companies** - Phone companies can include this type of drone control system to their devices.
3. **Mobile Application Developers** - The application can provide information to the app developers on how to utilize the sensors built in the mobile device itself, especially the gyroscope.
4. **Technological Advancements** - The change in drone control can be a progress in technology especially in drone controls.
5. **Future Researchers** - Future scholars can utilize the information acquired in this study as a reference in their own research, and it can be improved.

## 1.5 Scope and Delimitation

### 1.5.1 Scope

The Android device used is Oppo A92 and the range for the drone controlled is between 2-3 meters away from the user.

### 1.5.2 Delimitation

The paper will not discuss thoroughly the specifics of gyroscopes, Bluetooth LE, and the hardware used to build the robot.

## 1.6 Definition of Terms

The following are the terms mostly used in the study:

**Unmanned Aerial Vehicle (UAV)** - also known as drone, is an aircraft that does not require an onboard pilot [Li et al., 2019].

**Micro-Electro-Mechanical Sensors (MEMS) -** Sensors made on a tiny scale and measure a change in electrical signal in consequence of any forms of mechanical motion [Nagpal, 2016].

**Gyroscope -** A sensor that monitors, and reports, the amount of rotation the device is currently at along the said device’s x, y, and z axes [Nagpal, 2016].

**Accelerometer -** Accelerometers, in mobile phones, are used to detect the orientation of the phone [Gsmarena, 2022]. [Nagpal, 2016] added that accelerometers, as its name implies, determine the acceleration of a device along its x, y, and z axes, including the change of velocity and the static gravity applied on the device itself.

**Bluetooth -** Bluetooth is defined as a low cost, low power, short range radio technology whose original purpose was to replace wired cables in connecting devices [Bray et al., 2001].

# Chapter 2

**Related Literatures and Studies**

## 2.1 Drones

### 2.1.1 Definition

By general definition, a drone is defined by any vehicle—air, land, or sea—without any human crew aboard it. Moreover, [Chamayou, 2015] further described that these vehicles are controlled either remotely or automatically. In the former, drones are manually controlled by human operators from a distance while the latter describe drones that are controlled by robotics means.

The main drone types are enumerated as fixed-wing systems and multirotor systems by [Custers, 2016]. Fixed-wing systems, by definition, are drones with fixed static wings. Multirotor systems, on the other hand, use propellers to generate lift. [Custers, 2016] also defines a tertiary drone type, “other systems”, and is generally used to label drones that do not fall into either system, or a hybrid of both systems.

In [Kardasz, 2016], drones are composed of two major systems—its movement system and its control system. The former major system is expanded into its frame, propellers and engine, and the drone’s power. Generally, a drone’s frames should be light and are based on the number of that drone’s propeller and engines. The same article categorized drones, specifically multirotor drones, into its possible frame constructions with propellers at the end of each arm [Kardasz, 2016].

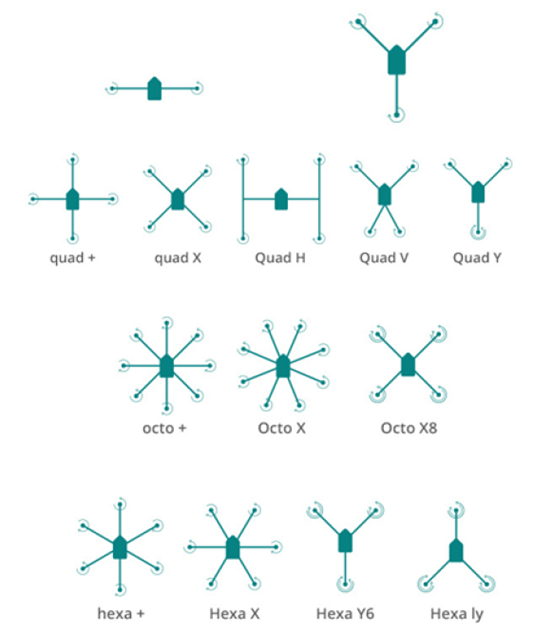


Figure 2.1 Drones as Categorized by its Frame Construction

In quadcopter drones, two of its propellers rotate clockwise while the remaining two propellers rotate counterclockwise. This results in the drone hovering from its position [Custers, 2016].

### 2.1.2 Functions and Applications

Drones can be fitted with a variety of payloads as long as the drone is capable of handling the attachment's weight and size. Cameras and microphones are the most popular payloads on drones [Custers, 2016].

[Kardasz, 2016] also attempted to classify drones according to their intended use: civil drones and military drones. [Irizarry, 2012] added a new type of drone that focuses on commercial applications: commercial drone.

## 2.2 Android Sensors

Android documentation described motion sensors to be useful in monitoring device movement. The movement could either be a motion in relative to the device’s frame of reference or in relative to the world’s frame of reference. An example of the former case could be a game where the user controls their character by moving the device while an example of the latter case could be the device sensing movement with the user inside the car [Android Developers, 2022].

[Nagpal, 2016] explored Android sensors where he described sensors as “a device that measures a particular kind of quality”. Most sensors installed in Android devices are Micro Electro Mechanical Sensors (MEMS). Specified in the same book, motion sensors measure force that could potentially create any form of motion in the device’s x, y, and z axes. Table 2.1 summarizes Android motion sensors with their type, value, underlying sensors, description, usage, and power consumption.

## 2.3 Bluetooth 4.0

The rise of Bluetooth revolutionized the way people interact with technology around them [Bray & Sturman, 2001]. Bluetooth Low Energy—or simply Bluetooth 4.0—has been designed by the Bluetooth Special Interest Group (SIG) and was optimized for a low cost, low power, and low complexity radio standard [Townsend, 2014]. This enabled BLE to be a solution for efficiently controlling and monitoring applications it is connected to, making it play a vital part in the emerging concept of Internet of Things (IoT) [Gomez et al., 2012; Bulić et al., 2019].

Bluetooth Low Energy has a similar protocol stack to the classic Bluetooth and is presented in Figure 2.2 and is further defined in [Bray & Sturman, 2001]. Furthermore, a BLE device can transmit data in a line-of-sight range (approximately 30 meters), although a more common operating range is within 2 to 5 meters [Townsend, 2014].

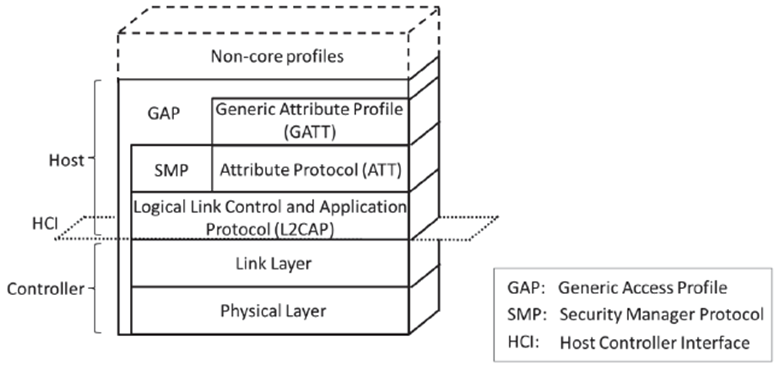


Figure 2.2 BLE Protocol Stack

In fact, several studies [Masoud et al., 2016; Alemark & Berkvist, 2014; Kumar et al., 2019] implemented Bluetooth Low Energy to communicate with their drones, as it was efficient and has a low cost compared to other means.

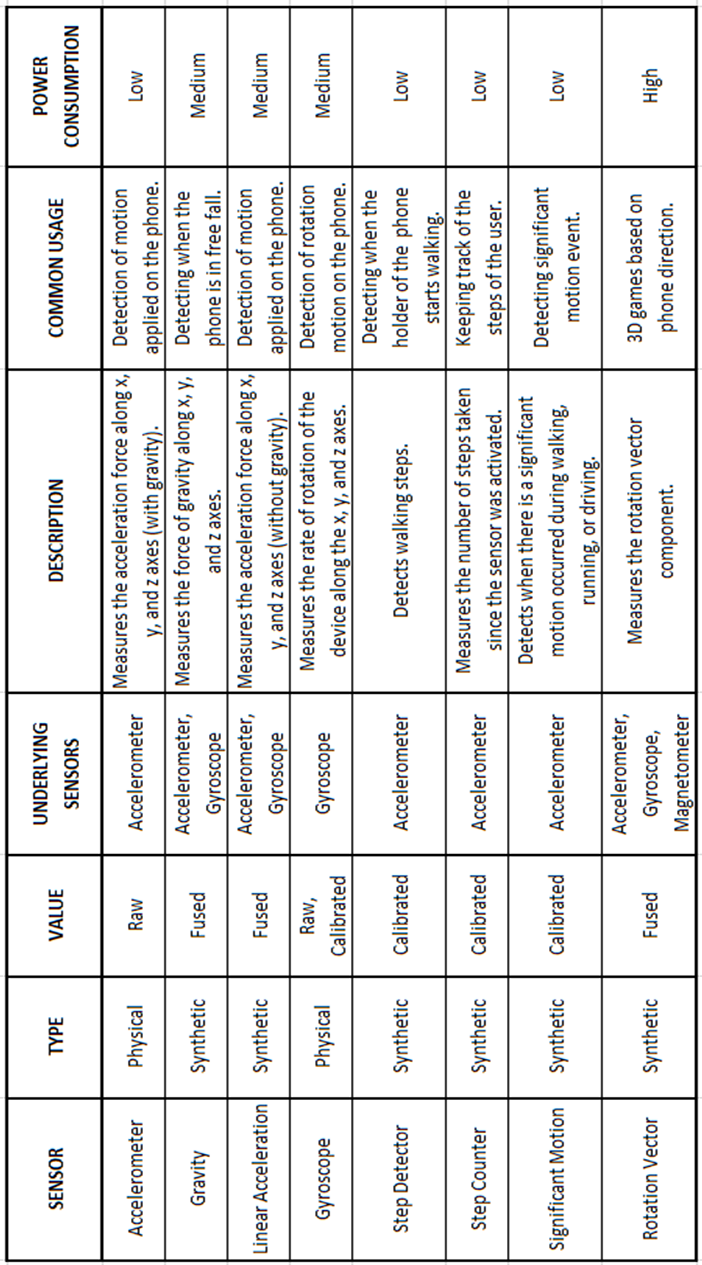


Table 2.1 Summary of Android Motion Sensors

# Chapter 3

## Methodology

## 3.1 Materials

The following are the materials that will be used for this study, both hardware and software.

### 3.1.1 Hardware

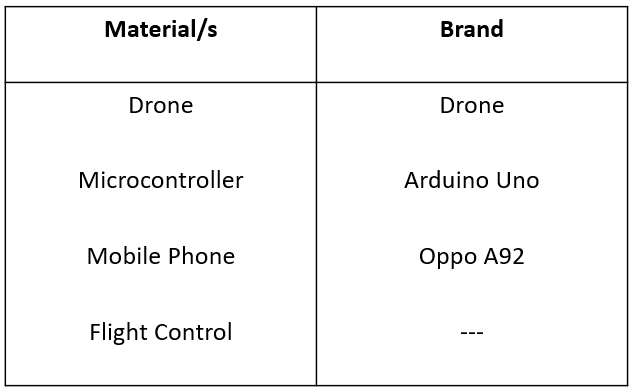


Figure 3.1 Hardware Materials

### 3.1.2 Software

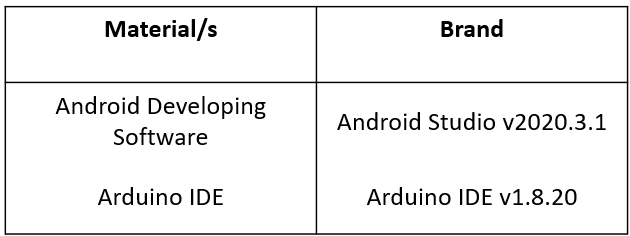
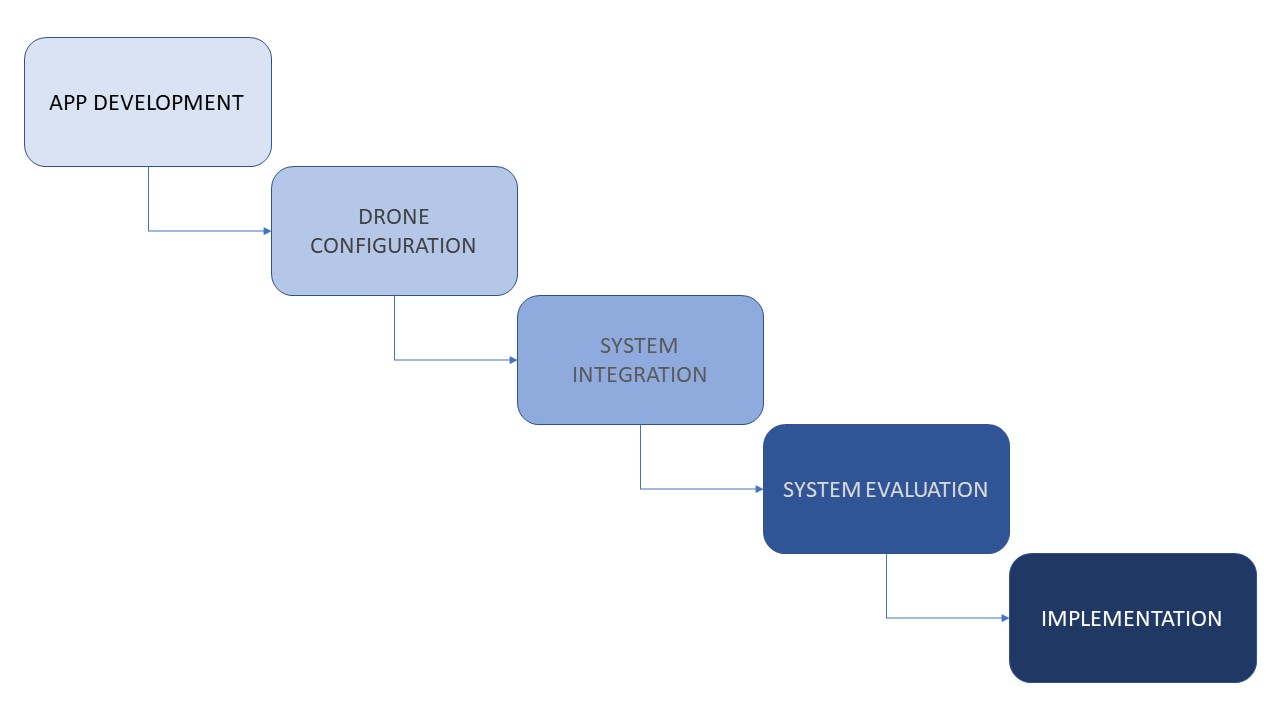


Figure 3.2 Software Materials

## 3.2 Process Model

The process model that will be used is the waterfall model. The waterfall model emphasizes the whole process of the study from the starting plans up to the implementation of the said study.

Figure 3.3 The Process Model

## 3.3 Hardware and Software System Architecture

The software system architecture alongside its hardware infrastructure is shown in Figure 3.4.

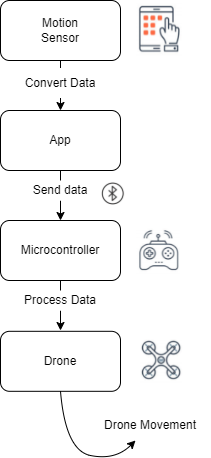


Figure 3.4 Hardware and Software System Architecture

The application created is going to collect data from the mobile device’s sensors during the implementation of the drone control. It is then processed into data that will be transferred into the application itself and will be sent via bluetooth into the Arduino Uno attached to the drone. It will then process the said data which will allow the drone to move according to the user’s choice of movement.

## 3.3 Research Procedures

The study will undergo five stages: App Development, Drone Configuration, System Integration, System Evaluation, and Implementation.

### 3.3.1 App Development

The software used to create the application is Android Studio version 2020.3.1. The codes were referenced and then modified from [sylsau, 2017] and [Pervaiz, 2018]. The mobile device used for the application is Oppo A92. The codes are as follows:

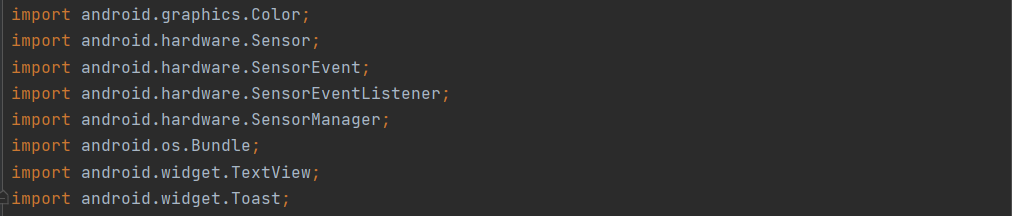
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Figure 3.5 Imports for the Application

Figure 3.5 shows the imports used in the application which are Color, Sensor, SensorEvent, SensorEventListener, SensorManager, TextView, and Toast. Color is used to temporarily determine the changes happening in the mobile device. Sensor contains the list of sensors a device has (e.g. accelerometer, gyroscope, proximity, gravity, etc.). SensorEvent is used to determine what type of sensor is going to be used by the application. SensorEventListener is used for receiving notifications from SensorManager when new sensor data is received. SensorManager lets you access the device’s sensors. TextView is a widget used for displaying texts. And Toast is used as a pop-up notification in applications, and in this case, Toast is used when your mobile device does not have a gyroscope.

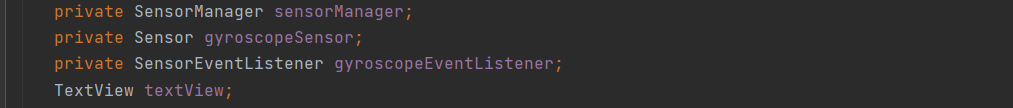


Figure 3.6 Variables

Figure 3.6 shows the variables in the application. SensorManager is named sensorManager, Sensor named gyroscopeSensor, SensorEventListener named gyroscopeEventListener, and TextView named textView.

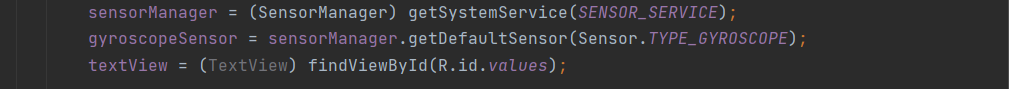


Figure 3.7 Initialization of the Variables

The code from Figure 3.7 shows the initialization of the variables in the application for them to be used in the entire coding process. You can see that the type of sensor used is a gyroscope.

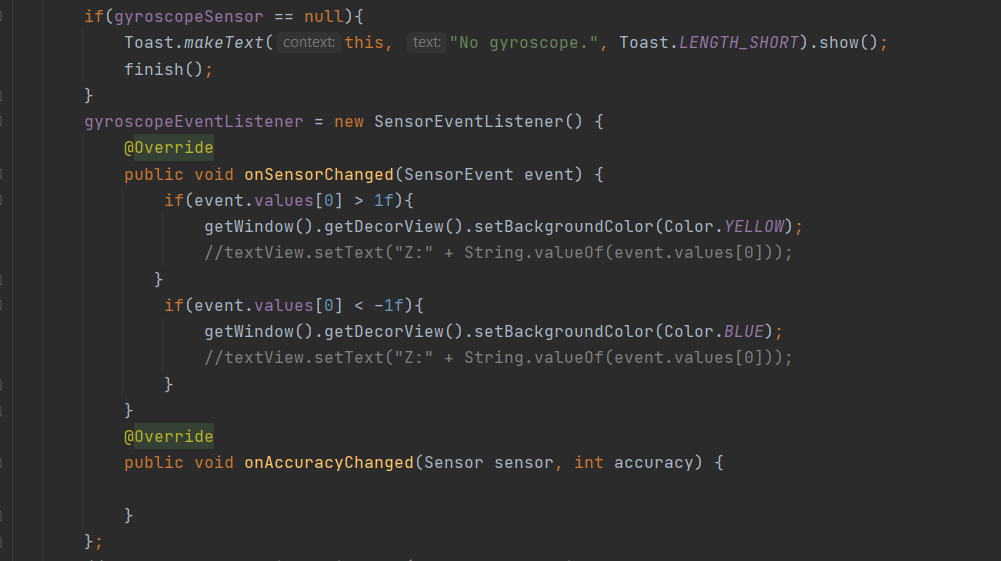


Figure 3.8 EventListener codes

Figure 3.8 shows the use of Toast widget. Once the SensorManager detects that the device does not contain a gyroscope, it will immediately flash a pop-up notification that states “No gyroscope.” and ends the application. Else, it will continue the application and for now, the application only turns to color yellow when the angle velocity along the x-axis of the phone is greater than 1f.

### 3.3.2 Drone Configuration

The drone that will be used is going to be remodeled with the addition of a bluetooth module and a microcontroller. The microcontroller that will be used is an Arduino Uno. The drone is an X-framed drone and has four brushless motors for more stable flight. The drone is equipped with two batteries, one for the drone itself and one for the Arduino Uno. The stabilization of the flight of the drone will be controlled by the flight controller.

### 3.3.3 System Integration

The process in the system integration starts with the application turning on and connecting to the bluetooth module connected to the Arduino Uno in the drone. It then sends the data of the sensors from the mobile phone to the microcontroller of the drone. The microcontroller then receives the data and performs which specific directions it must take based on the code in the microcontroller itself.

### 3.3.4 System Evaluation

The debugging of the android application as well as the codes in the microcontroller were thoroughly checked. It is then confirmed that the data gathered was from the gyroscope sensor of the android phone. Also, the said data were sent in real time into the microcontroller via the Bluetooth module, and then processed by the microcontroller to perform the code in the microcontroller which allows the drone to move based on the researcher’s movement.

### 3.3.5 Implementation

Upon the implementation of the software–that is, the application on the mobile device, and the code programmed into the drone–into the hardware, the drone managed to fly according to what was envisioned by the researchers. The drone could be operated by the connected Android device’s current orientation.

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