# Faculty of Electronic and Computer Engineering and Technology

## DEVELOPMENT OF THE DRONE-BASED MEASUREMENT AND ANALYSIS FOR CONSTRUCTION APPLICATION

**MUHAMMAD SYAHMI BIN ISMAIL**

**Bachelor of Electronics Engineering Technology with Honours**

**2024**

# DEVELOPMENT OF THE DRONE-BASED MEASUREMENT AND ANALYSIS FOR CONSTRUCTION APPLICATION

**MUHAMMAD SYAHMI BIN ISMAIL**

**A project report submitted**
**in partial fulfillment of the requirements for the degree of**
**Bachelor of Electronics Engineering Technology with Honours**

**Faculty of Electrical and Electronic Engineering Technology**



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2024**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**
FAKULTI TEKNOLOGI KEJUTERAAN ELEKTRIK DAN ELEKTRONIK

**BORANG PENGESAHAN STATUS LAPORAN**
**PROJEK SARJANA MUDA II**

Tajuk Projek : Development of The Drone-Based Measurement And Analysis For Construction Application

Sesi Pengajian : 1-2023/2024

Saya Muhammad Syahmi Bin Ismail mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

| | | |
|---|---|---|
| ☐ | **SULIT*** | (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972) |
| ☐ | **TERHAD*** | (Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan) |
| ✓ | **TIDAK TERHAD** | |

Disahkan oleh:

(TANDATANGAN PENULIS)

Alamat Tetap: R13, Lot 2125,
Lorong sepakat 3,
Kg Padang Balang,
51000, Kuala Lumpur

Dr. Haslinah binti Mohd Nasir
Ketua Program Ijazah Sarjana Muda
Teknologi Kejuruteraan Elektronik
Fakulti Teknologi dan Kejuruteraan Elektronik dan Komputer (FTKEK)
Universiti Teknikal Malaysia Melaka (UTeM)
Jalan Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

(COP DAN TANDATANGAN PENYELIA)

Tarikh: 20/2/2024

Tarikh: 20/2/2024

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

**DECLARATION**

I declare that this project report entitled "Development of The Drone-Based Measurement And Analysis For Construction Application" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Student Name : MUHAMMAD SYAHMI BIN ISMAIL

Date : 20/2/2024

**APPROVAL**

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours

Signature :

Supervisor Name : DR. HASLINAH BINTI MOHD NASIR

Date : 21/2/2024

Signature :

Co-Supervisor :

Name (if any)

Date :

## DEDICATION

I am honored to dedicate my final year project to all of you who have supported me and believed in me throughout my academic journey. Your encouragement and guidance have been invaluable to me, and I am forever grateful for your love and support.

To my family, thank you for always being there for me and for your endless love and patience. Your sacrifices and belief in me have allowed me to pursue my dreams and I am so grateful for everything you have done for me.

To my friends, thank you for being my support system and for always being there to listen and offer your help and advice. Your friendship means the world to me and I am so lucky to have such amazing people in my life.

To my supervisor and mentors, thank you for your guidance and expertise. Your wisdom and guidance have been instrumental in my growth and development as a student and I am forever grateful for your support and encouragement.

This project would not have been possible without all of you, and I am deeply grateful for your love and support. Thank you for everything.

Sincerely, Muhammad Syahmi Bin Ismail

# ABSTRACT

This Project outlines a comprehensive methodology for utilizing drones in building measurement, covering software and hardware components, data analysis techniques, and user guidance. It details the process of implementing Tello SDK commands in the PyCharm IDE using basic Python code to generate the drone's real-time camera feed and controllable windows. The scope of the project is divided into data acquisition, data processing, and data analysis, with the drone's camera serving as the primary sensor for data collection. The document also discusses the methods and techniques used for measurement, emphasizing precision, accuracy, and error analysis. Additionally, it provides a flowchart for the measurement of the building and an interface for displaying measurement values. The results and discussions section presents findings related to the accuracy and precision of height and movement measurements, highlighting the potential of drone-based measurement systems for construction applications.

# *ABSTRAK*

Projek ini merangkumi metodologi menyeluruh untuk menggunakan dron dalam pengukuran bangunan, merangkumi komponen perisian dan perkakasan, teknik analisis data, dan panduan pengguna. Ia merincikan proses pelaksanaan arahan Tello SDK dalam PyCharm IDE menggunakan kod Python asas untuk menghasilkan pemantauan kamera secara langsung dan tetingkap yang boleh dikawal oleh dron. Skop projek ini dibahagikan kepada pengumpulan data, pemprosesan data, dan analisis data, dengan kamera dron berperanan sebagai sensor utama untuk pengumpulan data. Dokumen ini juga membincangkan kaedah dan teknik yang digunakan untuk pengukuran, menekankan kejituan, ketepatan, dan analisis ralat. Tambahan pula, ia menyediakan carta aliran untuk pengukuran bangunan dan antara muka untuk paparan nilai pengukuran. Bahagian hasil dan perbincangan menyajikan dapatan berkaitan ketepatan dan kejituan pengukuran ketinggian dan pergerakan, menekankan potensi sistem pengukuran berasaskan dron untuk aplikasi pembinaan..

## ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Dr. Haslinah Binti Mohd Nasir for their precious guidance, words of wisdom and patient throughout this project.

I am also indebted to Universiti Teknikal Malaysia Melaka (UTeM) and my father for the financial support which enables me to accomplish the project. Not forgetting my fellow colleague, Muhd Azim for the willingness of sharing his thoughts and ideas regarding the project.

My highest appreciation goes to my parents, and family members for their love and prayer during the period of my study.

Finally, I would like to thank all the staffs at the faculty, fellow colleagues, and classmates, as well as other individuals who are not listed here for being co-operative and helpful.

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

The sector of construction is embracing new technologies to increase the efficiency, precision, and security of building projects. These complex technologies are being integrated to expedite project execution. Alongside the emphasis on speed, monitoring methods are also being modernized [1]. Because of the higher population increase in the current situation and the increasing need for housing, house accumulation is one of the top goals in the global construction trend. This involves minimizing the sector of construction must use current construction techniques in order to achieve the desired supply in a reasonable amount of time [2].

The structure made using traditional methods measuring tools have a rich historical background. These tools have served as fundamental instruments for builders and engineers to ensure accuracy and precision in their construction projects. In the past, builders relied on tools such as measuring tapes, spirit levels, plumb bobs, and angle finders to assess and verify crucial building dimensions. These tools allowed them to align structures, maintain verticality, and ensure the proper positioning of building elements. While conventional construction building measuring tools have played a significant role in ensuring accuracy and precision, they do have some limitations when compared to the integration of digital measuring devices. One downside of relying solely on tools like measuring tapes and spirit levels is the potential for human error. Manual measurements can be subject to inaccuracies due to factors such as human perception, limited visibility, or misalignment during readings.

By utilizing drones for measurements, the potential for human error is significantly reduced. The controllable flight and data capture capabilities of drones eliminate the need for manual measurements, reducing the risk of inaccuracies caused by human perception or misalignment. Additionally, drones can access hard-to-reach areas and capture data in real-time, providing instant feedback and allowing for immediate adjustments to be made if necessary. Furthermore, drones streamline the data collection and analysis process. The captured data can be processed using specialized software, which enables accurate measurements and generates detailed reports. This digital integration enhances efficiency, as measurements can be conducted swiftly and with greater accuracy. Based on real-time data, project managers and stakeholders may create wise decisions, leading to improved project timelines and overall productivity.

Drones have overcome the limitations of conventional measuring tools by offering a more efficient and accurate solution. With their aerial capabilities and advanced imaging technologies, drones provide comprehensive data collection, reduce human error, and enable real-time analysis. Integrating drones into the construction industry's measuring processes has revolutionized project execution, contributing to faster timelines and improved overall performance.

## 1.2 Problem Statement

In traditional or conventional construction, several tools are commonly used for measurement purposes. These include measuring tapes, spirit levels, plumb bobs, and angle finders. While these tools have served the industry for many years, they have limitations compared to modern measurement tools. Traditional tools require manual handling and can be prone to human error, leading to inaccuracies in measurements. They also rely on physical contact with the structure, which may not be feasible or accurate in certain scenarios. Furthermore, traditional measurement tools often lack the ability to provide real-time data and analysis, hindering efficient decision-making during construction processes. To overcome these limitations, modern measurement tools such as laser levels, electronic distance meters, and total stations offer enhanced accuracy, speed, and data integration capabilities. These tools enable faster and more precise measurements, facilitate data analysis and visualization, and contribute to improved construction efficiency and quality.

Drones present an innovative and efficient solution for replacing conventional measurement tools in construction projects. Drones equipped with cameras and specialized sensors can capture aerial images and collect data from various perspectives, providing valuable information for measurement and analysis. With the ability to fly and navigate through construction sites, drones can quickly capture accurate measurements of land, structures, and other elements. The captured data can be processed using computer vision algorithms and integrated with Building Information Modeling (BIM) systems, allowing for real-time visualization and analysis. Drone technology offers the advantages of speed, accuracy, and remote accessibility, enabling construction professionals to make informed decisions, detect potential issues, and monitor progress more effectively. By utilizing drones for measurement purposes, construction projects can benefit from improved efficiency, reduced costs, and enhanced safety.

## 1.3 Project Objective

The aims of this project are:

a) To design the algorithm for drone-based measurement using computer vision technique for data retrieval.

b) To develop Personal Computer (PC) of user interface for construction measurement.

c) To analyze the accuracy and precision of the drone-based measurement.

## 1.4 Scope of Project


Figure 1.1 Scope of the project

Figure 1.1 shows the scope of this project which divided into three

Data Acquisition:

The drone is equipped with a camera that captures images or videos of the designated area in civil construction. The camera serves as the primary sensor for data collection to make the measurement.

Data Processing:

The captured images from the drone camera are processed using software tools, such as PyCharm. The software provides a development environment for coding and implementing the necessary algorithms for image processing and analysis.



Data Analysis:

The processed images undergo further analysis using computer vision techniques. Algorithms and methods are applied to extract relevant information and measurements from the visual data. This analysis may involve object detection, feature extraction, or image classification to identify specific elements or objects of interest to measure the accuracy and the precision of the system.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter discusses the important information and details which are found by several studies and research from related previous study. The market size for building engineering has, to some extent, increased with the fast expansion of China's market economy. Additionally, it makes people's lives and jobs more convenient. As a result, tougher construction quality criteria for building engineering have been proposed. The essential component of building engineering construction, civil engineering construction technology, directly influences the building engineering construction quality.



## 2.2 The importance of construction technology

People's economic status and living standards are improving in the new circumstances. Natural civil engineering construction technology has received increasing attention as people today seek to improve their quality of life. As is common knowledge, there are many different types of civil engineering, and because of this complexity, a lot of civil engineering construction technologies will be used during the building process. Whatever specifics are present, they will have a direct impact on how well civil engineering is built. According to the current state of construction, there are still numerous issues with civil engineering construction technologies [1]. As a result, the construction companies should come up with reasonable solutions to the issues that arise during the building of civil engineering and ensure that this sector of the construction industry develops quickly. Technology is the creation, modification, application, and knowledge of tools, machines, techniques, crafts, systems, and organizational methods to solve problems, enhance preexisting solutions to problems, achieve goals, or carry out particular functions [2].

## 2.3 Construction Activities

The planning stage of a construction project and the needs of numerous stakeholders, including technological, structural, time, spatial, financial, environmental, legislative, and safety factors, influence the feasibility and optimal design of the construction site. However, the integration of site-related activities into the planning and scheduling of construction projects has been neglected in practice, as confirmed by a study conducted in 1999. Construction companies often fail to consider site-related tasks in their project documents for planning and scheduling. This may be due to a lack of suitable tools or a reluctance to study drawings and perform quantity take-offs for comparison with the Bill of Quantities. Additionally, attempts to account for site-related activities, such as on-site facilities, scaffolding, and equipment, through documents like site layouts, often fall short as they are not regularly updated to reflect the evolving nature of construction sites [1].

“Heavy-duty self-propelled vehicles specifically created for carrying out construction-related tasks are referred to as "Construction Equipment" (CE) or "Heavy Equipment." Its use is crucial to the effective completion of civil projects, making it a significant capital investment for the building sector. Equipment specifically used for moving earth is referred to as CE and includes excavators, dump trucks, loaders, compaction rollers, graders, scrapers, etc. Excavating, hauling, spreading, and compacting are the four essential steps of those earthworks [3].

Beside of that, the lack of productivity is a global issue, and during the past 30 years or so, attempts have been undertaken to investigate strategies to boost production on building sites. a survey of the variables that can reduce productivity on the job site, as well as the most recent results in productivity research. Pre-construction activities, construction-related activities, managerial and leadership challenges, motivational and organizational aspects are some of the activities [4]. Although there has been progress in creating methods and tools to increase productivity on the job, more has to be done to invest in technology and innovation. Pre-construction factors such as "the experience of the selected site and project managers," "design errors," "buildability of the design," "project planning," "communication," "leadership style," and "procurement method" are considered to be the most important ones affecting site productivity.

### 2.3.1 Conventional approach of civil engineering construction technology



Figure 2.1 Surveying tool station

There are much more civil construction tools that commonly used until today which are one of the figure above surveying tool station. A surveying tool station is a sophisticated surveying tool which combines the capabilities of an electronic distance measuring (EDM) tool with those of a theodolite and data collector. Surveyors can use it to measure angles distances, and elevations with high precision and store the data digitally. Among these tools, the tape measure holds a prominent position. Its versatility and portability make it an indispensable companion for construction professionals, allowing them to obtain precise measurements of distances, lengths, and dimensions. Whether it's for material ordering, layout planning, or ensuring proper fit and alignment of components, the tape measure is an invaluable tool [5]. Another valuable tool is the concrete moisture meter, which measures the moisture content within concrete structures. By assessing moisture levels, this tool helps prevent potential issues such as premature drying, cracking, or delamination of concrete. It ensures that the concrete meets the required standards for strength and durability, enabling construction professionals to make informed decisions about the curing process and the appropriate time for subsequent construction activities.

The ground-penetrating radar (GPR) system is another indispensable tool in civil construction. It employs radar pulses to create subsurface images, allowing professionals to detect and visualize hidden features, such as utilities, pipes, and buried structures. By providing a non-destructive means of subsurface investigation, the GPR system enhances safety, minimizes the risk of damage, and aids in accurate planning and excavation.

Lastly, the dumpy level, also known as an automatic level, is widely used in construction for establishing accurate horizontal planes. It is particularly valuable in tasks such as leveling ground surfaces, setting benchmark heights, and transferring levels across different points [6]. With its ease of use and reliable performance, the dumpy level ensures precise measurements, enabling construction professionals to achieve consistent and accurate results.

### 2.3.2 Modern approach of civil engineering construction technology

Modern construction techniques are predominantly centered around the suitable emphasis on output. They engage individuals from the construction sector and methodologies to pursue progress in terms of schedule adherence and construction efficiency. Automation and robotics have improved productivity, job quality, safety, the working environment, and the efficiency of construction time, labour costs, and site conditions. Construction standards and quality When a unique task is consistently performed, productivity in individual exercise robots has been successfully achieved [7].

Thanks to advancements in ICT, site-related data can now be constantly shared and updated among selected construction participants. The concept of an intelligent or smart construction site represents a modern approach to considering construction activities and site layout. An intelligent construction site can be understood on three levels: (i) robotization and industrial automation of construction processes, (ii) communication technologies facilitating communication between construction participants and elements, and (iii) the application of smart technologies in construction. While there is no precise definition of an intelligent site, research indicates that it incorporates hardware (sensors, labels, smartphones, tablets, wearable devices with built-in chips), software (Bluetooth, Wi-Fi, GPS), and communication technologies (computational, analytical, storage, visualization, artificial intelligence, Internet of Things, virtual reality/augmented reality, and cloud computing) with embedded intelligence and advanced digital applications related to construction and sites. These elements enable capturing and analyzing technological, structural, temporal, spatial, environmental, and safety aspects of the design and building feasibility, which mutually synergize for optimal outcomes.

The goal of virtual reality (VR) simulation is to create immersive settings that allow users to gain novel insights into how the real world functions. Depending on how many users can access virtual things from their local area and how much a space is created artificially or is based on the real world. Virtual reality (VR) aims to replace a user's experience of the real world with a 3D fake environment created by a computer. Furthermore, it is not necessary to base this virtual 3D world on a genuine one. In order to provide consumers a sense of a "real" sensation, VR therefore implies an effort to create a virtual environment (VE) with visual and immersive aids [8].

### 2.3.3 The used of drones

Drones, commonly referred to as unmanned aerial vehicles (UAVs), have gained popularity recently for a variety of applications, including civil engineering tasks. These tasks include mapping, surveying, and inspection, among others. Drones have been utilised to investigate challenging areas of a construction site and to capture randomly overhead pictures of the area. Drones are just now being used systematically to increase building process productivity [9]. Drones offer several advantages over traditional civil engineering tools, such as improved efficiency, cost-effectiveness, and accessibility to hard-to-reach areas.



Drones have emerged as a significant tool in this regard. While drones may not directly participate in the execution of construction tasks, they play a crucial role in expediting project and helping better measuring system. By enabling faster calculations measurement system, drones facilitate quicker decision-making, ultimately reducing project timelines. The utilization of drones in the field of construction management has seen a significant increase in recent years. Drones have become a prominent trend in the construction industry, and their usage is expected to continue rising in the next decade. Drones are anticipated to play an important role in the development of futuristic structures.

In fact, the global year-over-year growth of drone usage in construction has reached an impressive 239%, surpassing the growth rates in other commercial sectors [1].

### 2.3.4 Types of drones used in the construction industry

The construction industry has shown a significant increase of almost 240% in drone usage, making it one of the popular trends. Drones provide valuable help in construction activities due to their aviation benefits and capabilities. Commercial drones are widely preferred in the construction industry, despite the availability of various drone options in the market. Drones can be grouped into different categories, such as those for photography, mapping, military purposes, and surveillance [10]. However, the most useful way to classify drones is based on their aerial platform. There are four main types of drones, which are fixed wing, multi rotor, single rotor, and fixed wing hybrid VTOL drones. Multi-rotor drones are the most popular type of drones used for both recreational and professional purposes, such as aerial mapping. They are typically used for tasks like aerial photography, video recording, and surveying. Multi-rotor drones can be classified based on the number of rotors they have, such as tricopters (3 rotors), quadcopters (4 rotors), hexacopters (6 rotors), and octocopters (8 rotors) [11]. Figure 3.1 shows different types of drone

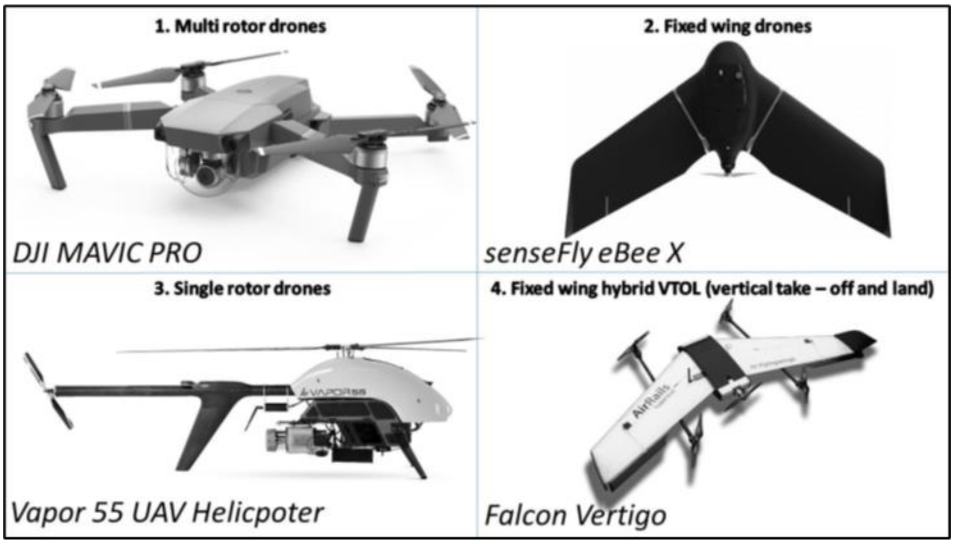



Figure 2.2 Different types of drone

Multi-rotor drones have some drawbacks, such as limited endurance and speed. This makes them unsuitable for large-scale aerial mapping tasks like pipelines, roads, power lines, and highways. Despite advancements in drone technology, multi-rotor drones still require a lot of energy to stay airborne. Depending on the weight of the drone and camera, they can typically only stay in the air for an average of 20-30 minutes or less. Fixed wing drones are more energy efficient than multi-rotor drones because they only require energy to move forward, not to stay airborne. This makes them ideal for topographic mapping of large areas and covering longer distances. However, their main drawback is their inability to stay in one place, which limits their ability to create detailed aerial maps of structures. Another disadvantage is that they require a runway or catapult launcher for takeoff and landing, depending on their size [12].

## 2.4 Previous Research

### 2.4.1 The comparison of modern construction and conventional construction

Modular construction offers numerous advantages over traditional construction methods and proves to be more cost-effective, time-saving, and resource-efficient. The significant advantages of modular construction technology can be observed in terms of construction duration, work quality, and safety which shown in Table 2.1.

Table 2.1 Comparison Between Modern vs Conventional Construction

| Modern Construction | Aspects | Conventional Construction |
|---|---|---|
| Modern construction methods utilize advanced techniques and technologies such as prefabrication, modular construction, and 3D printing. These methods allow for faster construction, improved quality control, and reduced labor requirements [13] | Construction Methods | Conventional construction involves on-site assembly of building components, relying heavily on manual labor and traditional construction techniques. |
| Drones can capture aerial images and create highly accurate topographic maps of construction sites. This eliminates the need for manual surveying, measurements, saving time and resources. The data collected by drones can be used for site analysis, earthwork | Construction Monitoring and Data Analytics | Tape measures are commonly used for linear measurements, such as determining the length or width of building elements. They require physical contact with the object being measured and are prone to human errors and inaccuracies. |

| | | |
|---|---|---|
| calculations, and infrastructure planning [14]. | | |
| Modern construction utilizes digital scheduling tools and software, such as project management systems and construction planning software, to optimize project schedules and manage timelines efficiently [15]. | Project Scheduling and Time Management | Conventional construction often relies on manual scheduling methods, which may be more prone to errors and may not account for dynamic changes in the project timeline. |

### 2.4.2 Comparison between current technology of modern construction

The construction industry is experiencing a rapid transformation driven by advancements in technology, leading to the emergence of modern construction practices. Current technology in modern construction encompasses a wide range of innovative solutions, including Building Information Modeling (BIM), robotics, 3D printing, virtual reality, and Internet of Things (IoT) applications. These technologies are revolutionizing the methods used in building design, construction, and operation, offering improved efficiency, sustainability, and cost-effectiveness. In today current technology of modern construction are shown in Table 2.2.



Table 2.2 Current Technology of Modern Construction

| Author | Approach | Findings |
|---|---|---|
| J. K. Pancho [16] | Using Ultrasonic Distance Measuring Device | To analyze the use of ultrasonic technology for measuring distance by building an |

| | | |
|---|---|---|
| | | ultrasonic distance measuring equipment |
| J. Jasmari [17] | Smartphone Distance Measurement Application | To utilize the global positioning systems (GPS) and digital cameras that have been made possible by advances in smartphone technology. |
| J. A. S. D. Fonseca, A. Baptista, M. J. Martins, and J. P. N. Torres [18] | Laser-based Distance Measuring Methods | The three basic methods of measurement are triangulation, telemetry and interferometry which make a distance measurement system. |

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

This chapter presented the methods of this project, which were carried out throughout the entire project. It was one of the key parts in preparing the outcome. The methods of execution and techniques chosen for this project were described in order to accomplish the goals. One approach used in this chapter, which had been used previously, was to collect the measurement of a building. This method employed one computer software and one hardware tool, the drone itself. The data was then used for analysis, specifically taking the measurement of a building from the perspective of error, precision, and accuracy.

## 3.2 Flowchart

In Figure 3.1, the flowchart showed the detailed steps from turning on the computer, turning on the drone, and lastly, getting connected to the drone.

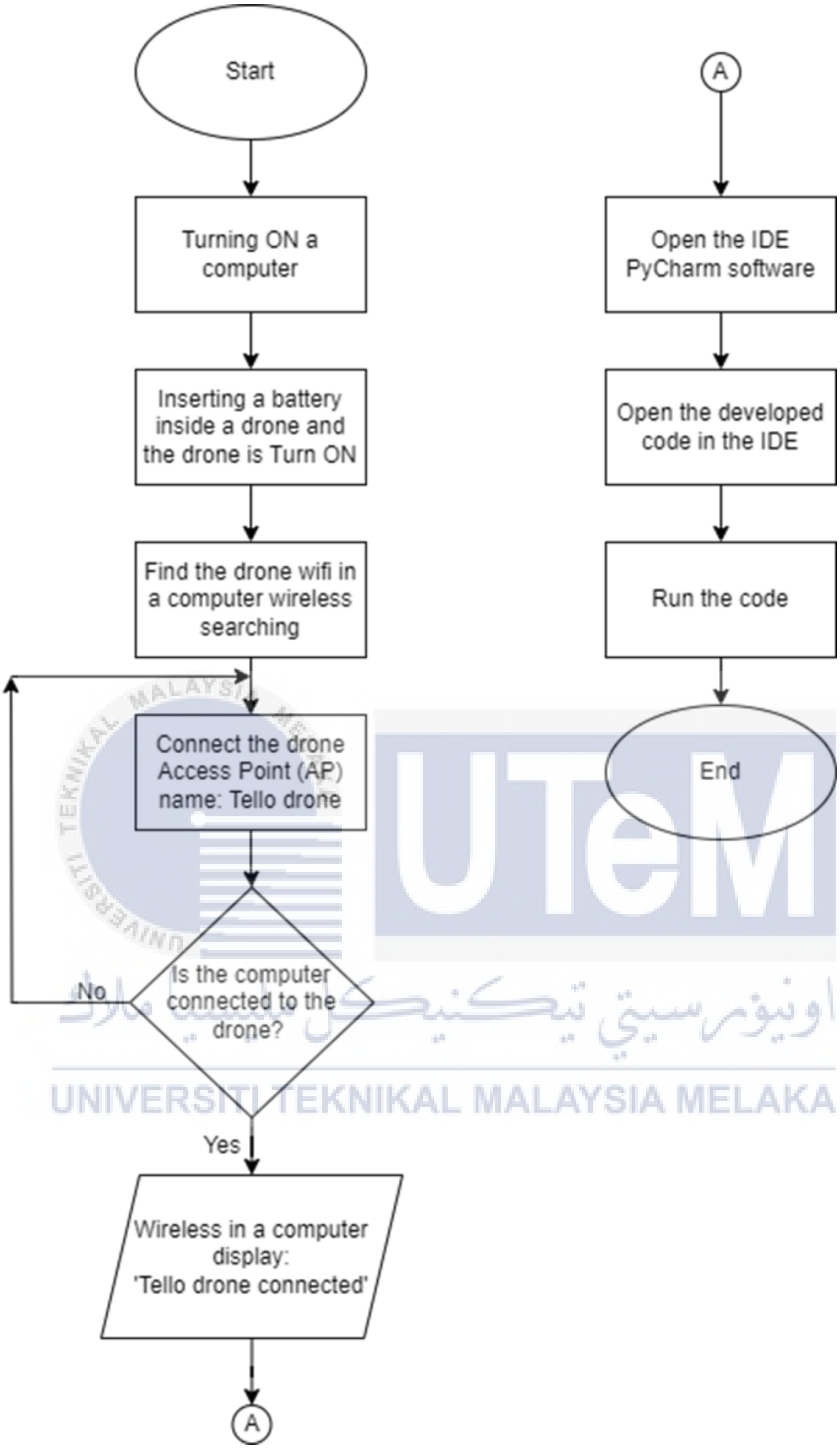



Figure 3.1 The flowchart on the basic connected to the drone

Figure 3.2 showed the flowchart of all the processes that had continued from Figure 3.1. Once the computer was connected to the drone wirelessly, the user could open the IDE PyCharm software. They opened the targeted file and clicked run. Once the code had run, the process output showed two output windows simultaneously. One output window showed the real-time camera, and the other output window showed two buttons and two textboxes, labeled textbox1 and textbox2.

The program began when the user clicked the take-off button, and then the value of height was also counted. The drone flew approximately 1 meter from the ground when it started to take off. When the user wanted to increase the height to 1.5 meters, they needed to press the 'W' key on the keyboard. Once the height displayed in the textbox reached 1.5 meters, the user needed to click the stop button. At this point, the stopwatch also stopped running in the background. If the user did not want to continue measuring the object, they could click the land button to end the program. Once the drone had completely landed on the ground, the two windows closed automatically.

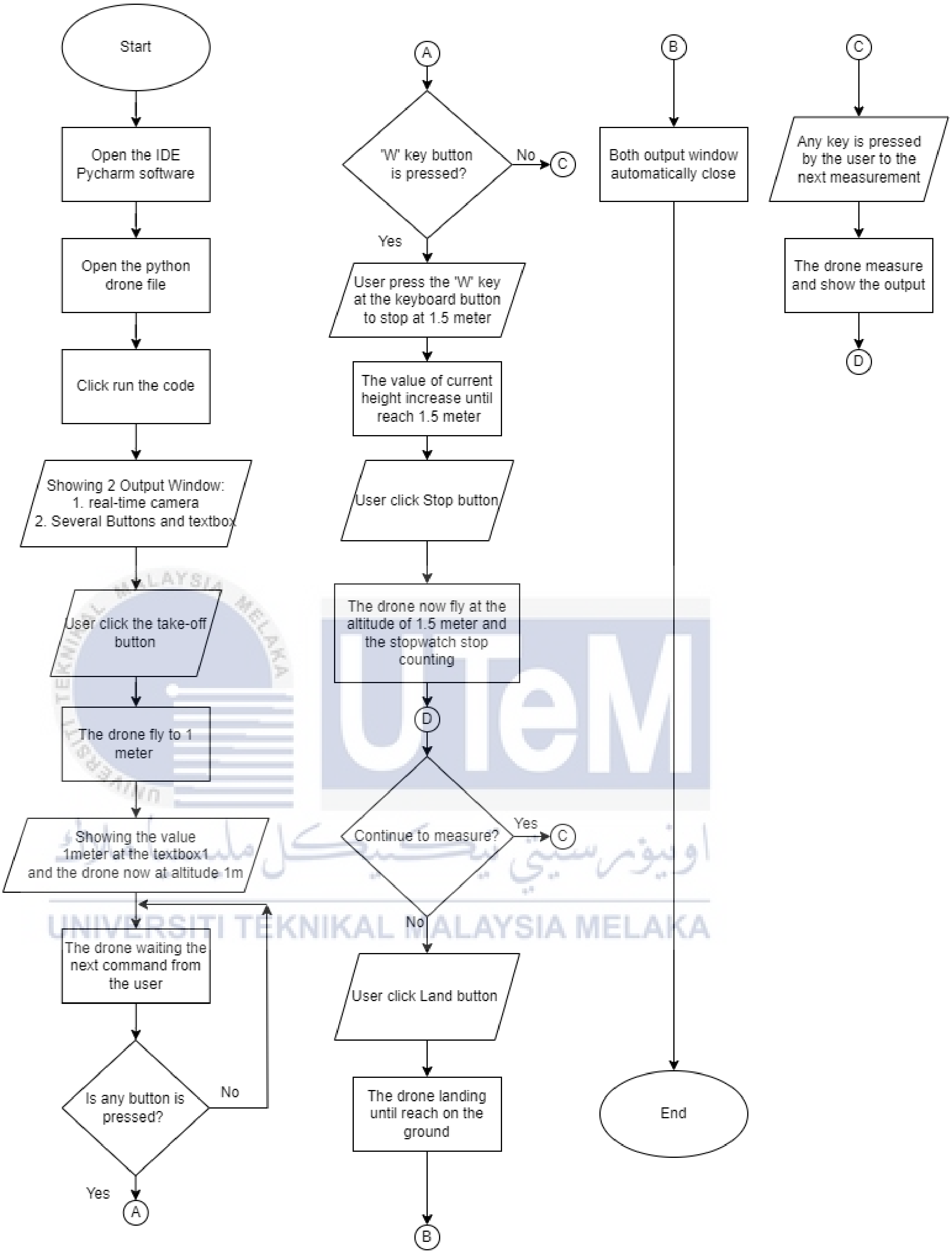



Figure 3.2 The flowchart for the measurement of the building

### 3.2.1 Drone-based measurement

One output window displayed the real-time camera feed. A line bisected the camera feed, visually indicating the sensor's height measurement limit.

The other output window presented two buttons, along with textbox1 and textbox2, which enabled drone control and function display. The buttons comprised takeoff, landing, start (for initiating measurements), and stop (for halting measurements). Textbox1 exhibited the length, width, and height values, while textbox2 displayed the stopwatch count. All processes commenced when the takeoff button was clicked, and height measurements were automatically captured and presented within textbox1. The drone obeyed commands issued via the four arrow keys on the computer, enabling forward, backward, left, and right movement. Additionally, the ‘A’ and ‘D’ keys, designated for drone yaw, facilitated directional changes without impacting measurements. The IDE PyCharm software housed meticulously coded instructions for each drone movement, ensuring seamless functionality.

## 3.3 Equipment

Software and library used in this project are:

a) PyCharm

b) OpenCV

c) PyGame

d) djitellopy

### 3.3.1 PyCharm

PyCharm is an Integrated Development Environment (IDE) used for programming in Python. It is developed by JetBrains, a company known for creating tools for software developers. PyCharm is a cross-platform IDE, meaning that it can run on Windows, macOS, and Linux. It provides code completion, error highlighting, and refactoring for Python, as well as support for web development with Django. PyCharm also includes a debugger, interactive console, and integration with version control systems such as Git.



### 3.3.2 OpenCV

Open-Source Computer Vision (OpenCV) is a free and open-source library. It was originally developed by Intel and is now maintained by the OpenCV Foundation. OpenCV is written in C++ and has interfaces for Python, C, and Java, as well as Android and iOS. OpenCV is widely used in computer vision and machine learning applications, including image and video processing, object detection and tracking, and machine learning. It has a large collection of algorithms for image and video processing, including basic image processing

### 3.3.3 PyGame

Pygame is a set of Python modules designed for writing video games. It builds on top of the Simple DirectMedia Layer (SDL), which is a low-level multimedia library for handling various aspects of multimedia, including graphics, sound, and user input. Pygame provides a higher-level interface and tools specifically geared towards game development. In this project used input from the keyboard inside the PyGame window to read the data what user are giving the command to the drone.

### 3.3.4 Djitellopy

Djitellopy is a Python library that provides a simple and easy-to-use interface for programming and controlling the Ryze Tello drone. Djitellopy acts as a wrapper around the official Tello SDK (Software Development Kit), abstracting the complexity of the communication protocols and providing a more straightforward interface for controlling the drone through Python scripts.

Table 3.1 Software and library used for tello drone

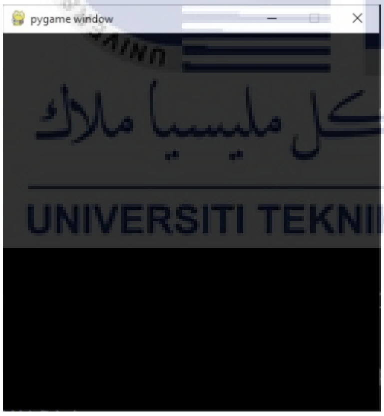
| Software | PyCharm | OpenCV |
|---|---|---|
| | Can fit with python language  | It is a library used in PyCharm IDE. cv2 module is the main module in OpenCV that provides developers with an easy-to-use interface for working with image and video  |
| | PyGame | Djitellopy |
| | Combination of Pygame and a drone control library, such as Djitellopy, to create a graphical user interface (GUI) for interacting with the Tello drone.  | Djitellopy acts as a wrapper around the official Tello SDK (Software Development Kit). Providing a more straightforward interface for controlling the drone through Python scripts.  |

Table 3.2 Hardware used and specifications

| Hardware (Drone) | Aircraft | Flight Performance |
|---|---|---|
| | Weight: Approximately 80 g (Propellers and Battery Included)<br>Dimensions: 98×92.5×41 mm<br>Propeller: 3 inches<br>Built-in Functions: Range Finder, Barometer, LED, Vision System, 2.4 GHz 802.11n Wi-Fi, 720p Live View<br>Port: Micro USB Charging Port | Max Flight Distance: 100m<br>Max Speed: 8m/s<br>Max Flight Time: 13min<br>Max Flight Height: 30m |
| | Battery | Camera |
| | Detachable Battery: 1.1Ah/3.8V | Photo: 5MP (2592x1936)<br>FOV: 82.6°<br>Video: HD720P30<br>Format: JPG(Photo); MP4(Video)<br>EIS: Yes |
| Personal Computer (PC) | Keyboard, Mouse and monitor | |

## 3.4 Data Analysis

Data analysis was the process of scrutinizing, cleansing, transforming, and modeling data to extract information, make judgments, and guide decision-making. It entailed employing various techniques and methods to uncover patterns, correlations, and trends hidden within the data. This crucial step facilitated the extraction of meaningful insights and informed decisions based on the existing data. The analysis results were then interpreted to draw conclusions, make predictions, or inform decision-making processes.

In the context of drone-based measurements, data analysis techniques found application in processing and analyzing captured images or video frames. For instance, computer vision algorithms aided in object detection, boundary and feature identification, and relevant information extraction from the visual data. This often involved techniques like image segmentation, feature extraction, and object recognition.

As a first step, the researcher sought libraries online based on the Tello SDK commands. These commands were then implemented in the PyCharm IDE using basic Python code that the drone could understand. The all figures below illustrates the initial process for generating the drone's real-time camera feed and controllable windows.

Figure 3.3 displayed the initialization code responsible for drone startup. This integral process included library imports, establishing a connection between the drone and its library. Upon successful connection, the drone initiated a stream camera with a w*h screen size and printed the battery percentage.

```
from djitellopy import tello
import KeyPressModule as kp
from time import sleep
import time
import cv2
import numpy as np


kp.init()
me = tello.Tello()
me.connect()
me.streamon()
w, h = 360, 240
print(me.get_battery())
```

Figure 3.3 Basic code for initializing the drone

Figure 3.4 then showcased the code enabling drone control via the computer keyboard.

```
def getKeyboardInput():
    lr, fb, ud, yv = 0, 0, 0, 0
    speed = 100

    if kp.getKey("LEFT"): lr = -speed
    elif kp.getKey("RIGHT"): lr = speed

    if kp.getKey("UP"): fb = speed
    elif kp.getKey("DOWN"): fb = -speed

    x = me.get_height()
    if kp.getKey("w"):
        ud = speed
        print(x)

    x = me.get_height()
    if kp.getKey("s"):
        ud = -speed
        print(x)

    if kp.getKey("a"): yv = -speed
    elif kp.getKey("d"): yv = speed

    if kp.getKey("q"):
        me.land()
    elif kp.getKey("e"):
        me.takeoff()

    return [lr, fb, ud, yv]
```

Figure 3.4 The keyboard input control code

Figure 3.5 presented the output generated upon code execution, revealing two distinct windows: the output window and the Pygame window.



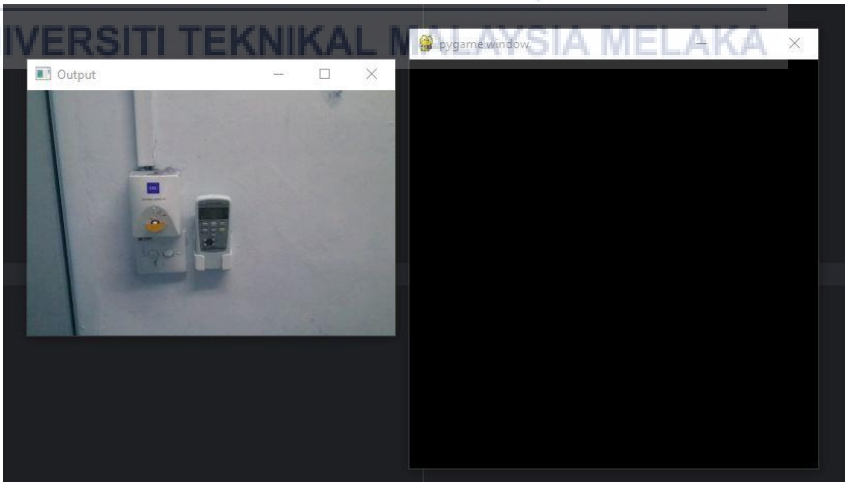



Figure 3.5 Output and Pygame window for the drone

Next, the second step is to take the measurement of the drone height and also the measurement horizontal axis for movement of the drone. The Figure 3.6 shows the process of measuring height door house.

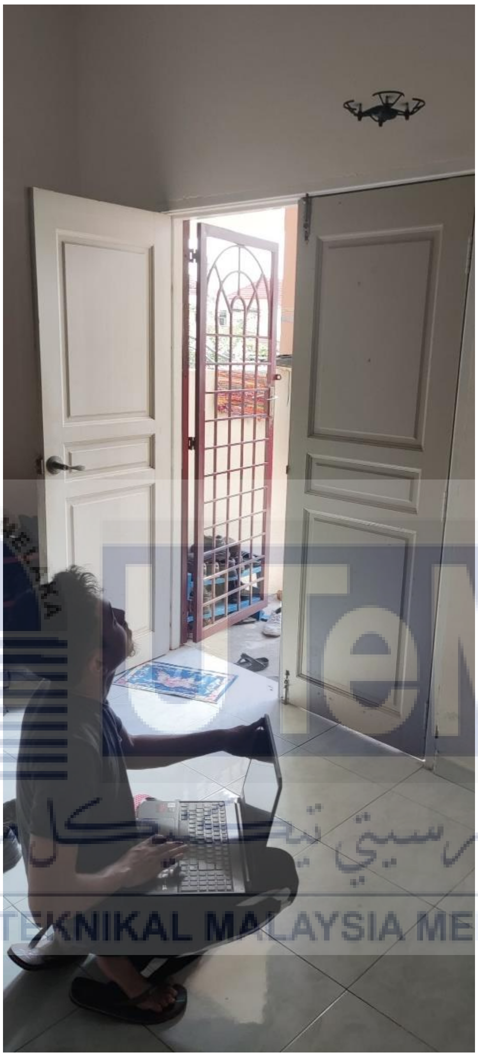




Figure 3.6Measuring the door house

The Figure 3.7 shows the height of the pillar was taken.

Figure 3.7Measuring height of the pillar



All the measurement will be using the equation of the accuracy, precision, and average. All of these need to be taken to assess the degree of correctness or precision of a measurement or prediction. These formula are:

Accuracy (%)= $\frac{(Observed\ value - Theoritical\ value\ )}{(Theoritical\ value)} \times 100\%$ (2)

Precision:

Absolute deviation, $|d_i| = individual\ value - average\ value$ (3)

Average absolute deviation, $|d_{avg}|$

$$= \frac{|d_1|+|d_2|+|d_3|+\cdots|d_n|}{\text{n}} \tag{4}$$

Average:

$$\text{Average} = \frac{(Sum\ of\ all\ observations\ )}{(Total\ number\ of\ observations)} \tag{5}$$

## 3.5 User Guide

In the Figure 3.8, user need to open the IDE PyCharm software. After that, the user need to open the code and also connect to the drone through wifi.

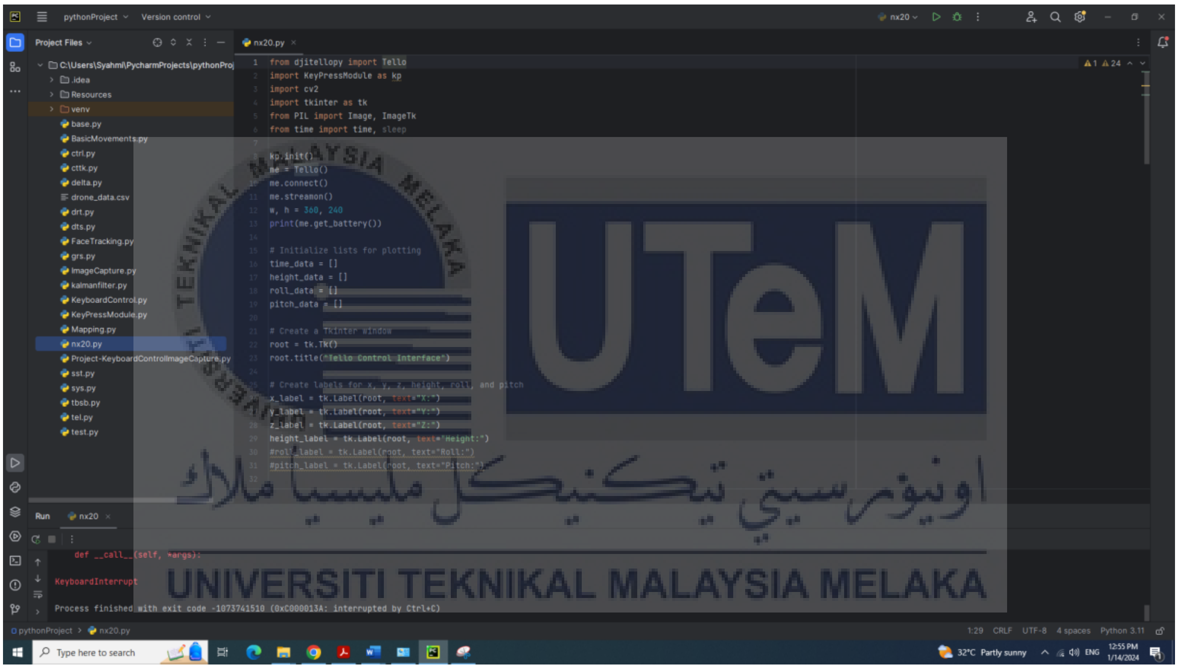


Figure 3.8 Open IDE PyCharm software

Figure 3.9 shows the indications button for user to control the drone.

```
if kp.getKey("LEFT"): lr = -speed
elif kp.getKey("RIGHT"): lr = speed

if kp.getKey("UP"): fb = speed
elif kp.getKey("DOWN"): fb = -speed

x = me.get_height()
if kp.getKey("w"):
    ud = speed
    print(x)

x = me.get_height()
if kp.getKey("s"):
    ud = -speed
    print(x)

if kp.getKey("a"): yv = -speed
elif kp.getKey("d"): yv = speed

if kp.getKey("q"):
    me.land()
elif kp.getKey("e"):
    me.takeoff()
```

Figure 3.9 Indications button provided in the code

Figure 3.10 shows the reading height for user

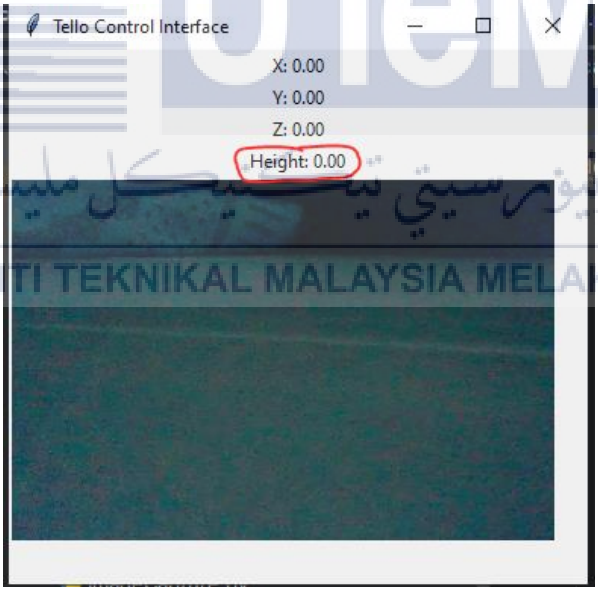



Figure 3.10 Reading for the height

## 3.6 Summary

The document provides a detailed methodology for utilizing a drone in building measurement, covering aspects such as software and hardware components, data analysis techniques, and user guidance. It offers a structured approach to the project, addressing technical aspects of drone operation, measurement procedures, and data analysis, while also providing user-friendly guidance for conducting the measurements.

# CHAPTER 4

# RESULTS AND DISCUSSIONS

## 4.1 Introduction

This chapter provides the findings and analysis on the Development Of The Drone-Based Measurement and Analysis for Construction Application. The results consist of Personal Computer (PC).

## 4.2 Result and Analysis

### 4.2.1 Personal Computer (PC) applications interface

When the program is running the output window shows both Pygame and Tello Control Interface as shown in Figure 4.1.



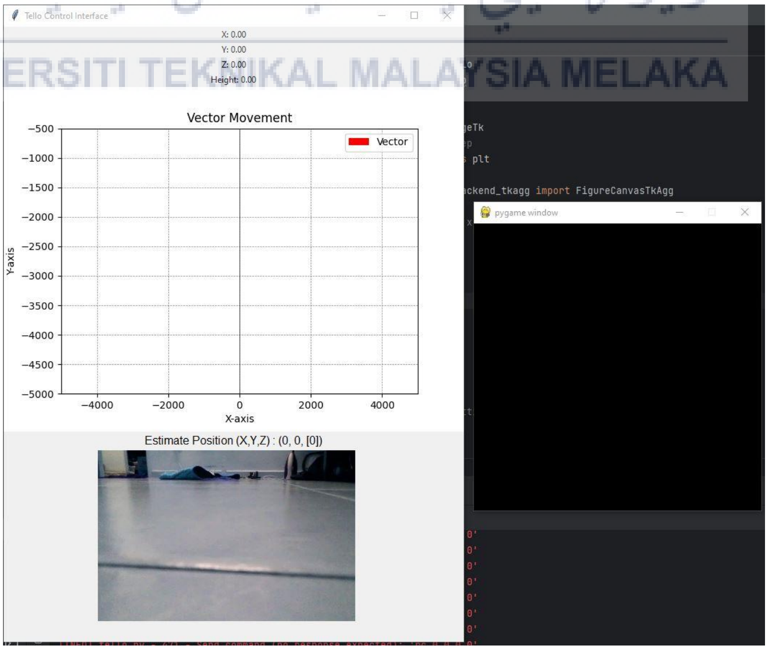



Figure 4.1 Both windows appear after run the program

The drone is placed on the floor where the researcher stand and take the height measurement from the floor to the same level of the lamp wall by take-off the drone as in Figure 4.2.

Figure 4.2 Drone take the measurement height

In the Figure 4.3 shows the result when the drone is same level as the lamp wall. The reading shows that the height 190.00 which in cm. The Vector Movement graph shows nothing same as the value of (X,Y,Z) in the camera live-feed because of the first take-off.




Figure 4.3 The interface and the value from the measurement

Next, the reading movement of the drone to the right is taken as shown in Figure 4.4. The coordinate value shows that the value inside the parenthesis is acts like the (x,y). The thing is, the x value is set for the movement move to right or left while the y value is set for the movement move forward and backward.

In the code, the researcher set the fix value for the speed of the drone. The value of the speed is set to 15 cm/s. The reading is taken for fully pressed the right arrow key and hold it for 10 seconds. The value in theories will get 150cm distance but this value shows 1.26 or same like in cm is126 cm. This testing shows that the movement error have a little an error.




Figure 4.4 The reading of the moving drone

When taking the measurement in term of accuracy need to consider the ability and the reliability of this project. The calculation of the accuracy of the movement was shown in the table 4.1.

Table 4.1 The movement accuracy of the drone

| Term | Definition | Formula | Results |
|---|---|---|---|
| Accuracy | How close a measurement or result is to the true value. | $\text{Accuracy}(\%) = \frac{(126-150)}{(150)} \times 100\%$<br>= -16% | The value shows that the accuracy is less than 16% from the theoretical value |

In the Figure 4.5 shows that another testing for taking the reading the height of the door house. The actual height of the door is 200cm.

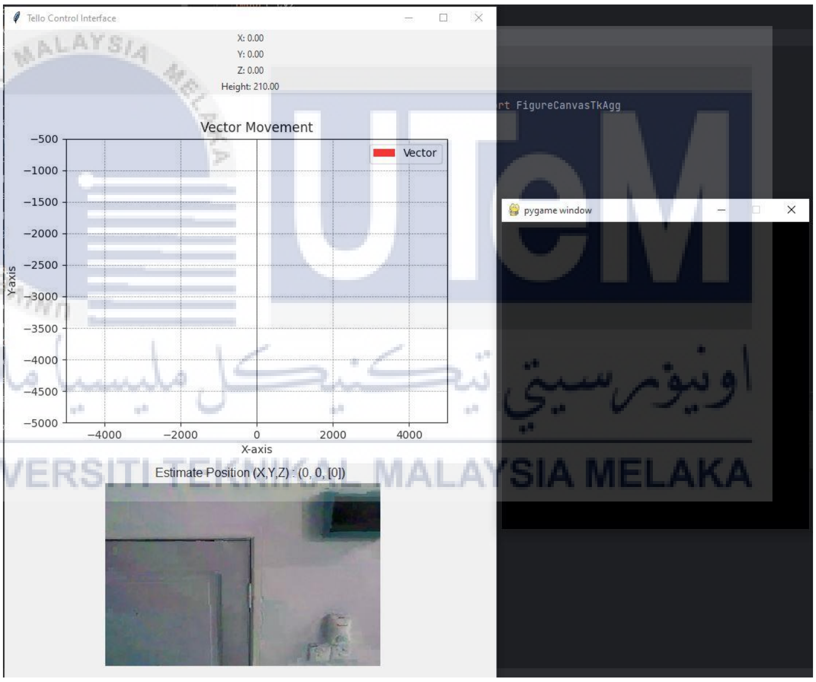




Figure 4.5 The value of the first height of the door

The drone was flying two times for check the accuracy and also precision. The first data is taken in the Figure 4.5 while the second data is taken in Figure 4.6.

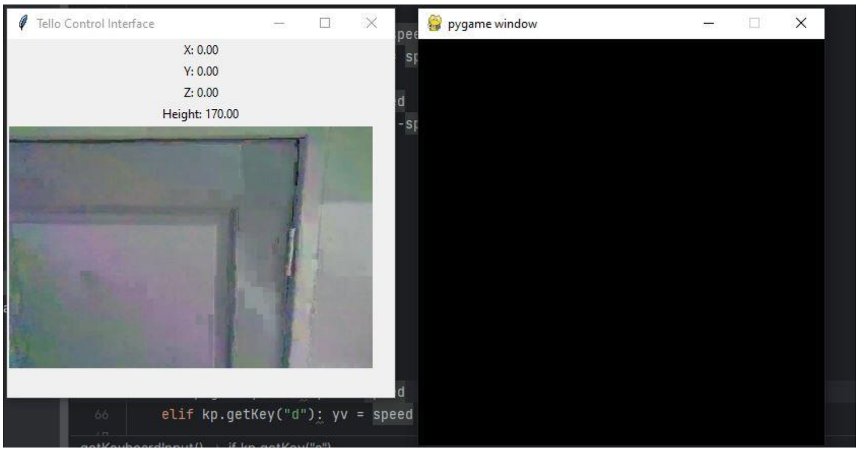



Figure 4.6 The value of the second height of the door

For find the precision, the researcher need to find the average of the measurement. By using the formula:

Average:

$$\text{Average} = \frac{(Sum\ of\ all\ observations\ )}{(Total\ number\ of\ observations)}$$



Average:

$$\text{Average} = \frac{(210+170\ )}{(2)}$$

= 190cm

| Term | Definition | Formula | Results |
| --- | --- | --- | --- |
| Accuracy (Test 1) | How close a measurement or result is to the true value. | $\text{Accuracy}(\%) = \frac{(210-200\ )}{(200)} \times 100\%$<br>= 5% | The value shows that the accuracy is more than 5% from the theoretical value |
| Accuracy (Test 2) | How close a measurement or result is to the true value. | $\text{Accuracy}(\%) = \frac{(170-200\ )}{(200)} \times 100\%$<br>= -15% | The value shows that the accuracy is less than 15% from the theoretical value |
| Precision (Test 1) | How close a set of measurements or | Absolute deviation, $\lvert d_i \rvert = 210 - 190$ | The precision is more than 20 |

| | | | |
|---|---|---|---|
| | results are to each other, even if they're not exactly correct. | = 20 | |
| Precision (Test 2) | How close a set of measurements or results are to each other, even if they're not exactly correct. | Absolute deviation, $\|d_i\| = 170 - 190$<br>= -20 | The precision is less than 20 |

## 4.3 Summary

Overall, the findings underscore the potential of drone-based measurement systems for construction applications, providing insights into the accuracy and precision of height and movement measurements. The study's thorough analysis of the PC application interface, measurement procedures, and the calculation of accuracy and precision contributes to the understanding of the system's capabilities and limitations. This research lays a foundation for further advancements in drone-based measurement and analysis, with implications for enhancing construction processes through technological innovations and precise data acquisition.

## CHAPTER 5

## CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

For this project, development of the drone-based measurement and analysis for construction applications, focusing on the accuracy and precision of height and movement measurements. It provides a comprehensive overview of the project's objectives, methodology, results, and conclusions. The study emphasizes the potential of drone-based measurement systems to revolutionize construction processes through technological innovations and precise data acquisition. The findings and analysis presented in the document underscore the system's capabilities and limitations, laying the groundwork for further advancements in drone-based measurement and analysis in the construction industry.

The project's objectives include the development of a drone-based measurement algorithm using computer vision techniques, the creation of mobile applications for construction measurement, and the analysis of accuracy and precision. The document details the methodology for executing the project, encompassing the use of software and hardware components, data analysis techniques, and user guidance for conducting measurements. It also provides a structured approach to the project, addressing technical aspects of drone operation, measurement procedures, and data analysis. The thorough analysis of the PC application interface, measurement procedures, and the calculation of accuracy and precision contributes to the understanding of the system's capabilities and limitations, providing valuable insights into the potential of drone-based measurement systems for construction applications.

Furthermore, the document presents the findings and analysis of the drone-based measurement system, including the PC application interface, measurement procedures, and calculations of accuracy and precision for height and movement measurements. It also discusses the potential implications of the research for enhancing construction processes through technological innovations and precise data acquisition. The document's detailed methodology and results provide a comprehensive understanding of the project's execution and findings, highlighting the potential for future advancements in drone-based measurement and analysis in the construction industry. Overall, the document serves as a valuable resource for understanding the development and potential applications of drone-based measurement systems in the construction sector.



## 5.2 Sustainable Development Goals (SGD)

This project discusses the integration of drone-based measurement systems in the construction industry, aiming to enhance efficiency and precision in building projects. The use of advanced technologies such as drones and computer vision techniques aligns with Sustainable Development Goal 9, which focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. By leveraging drone technology for data acquisition and analysis, the construction sector can improve productivity, reduce resource consumption, and minimize environmental impact. Additionally, the emphasis on modernizing monitoring methods and increasing efficiency in construction aligns with the broader goal of sustainable urban development, as outlined in

Sustainable Development Goal 11. The document's exploration of innovative measurement and analysis techniques in construction reflects a commitment to sustainable development by promoting technological advancements that can contribute to more sustainable and resilient infrastructure and cities.

## 5.3 Future Recommendations

Based on the findings and analysis presented in the document, several future recommendations and potential areas for further work can be identified. Firstly, the integration of drone-based measurement systems in construction applications presents opportunities for future research and development. One potential area for future work is the refinement and optimization of the drone-based measurement algorithm using computer vision techniques. This could involve exploring advanced image processing and machine learning algorithms to enhance the accuracy and precision of height and movement measurements. Additionally, further research could focus on the development of mobile applications with user-friendly interfaces specifically tailored for construction measurement, aiming to streamline data collection and analysis processes. By leveraging advancements in mobile technology and user interface design, future work could enhance the accessibility and usability of drone-based measurement systems for construction professionals.

Furthermore, future recommendations could also center on the analysis of the accuracy and precision of drone-based measurements in diverse construction scenarios. This could involve conducting field studies and real-world testing to validate the performance of the drone-based measurement system across various construction environments and project types. By assessing the system's capabilities and limitations in practical settings, future work could provide valuable insights into the reliability and robustness of drone-based measurements, contributing to the refinement and validation of the technology for widespread adoption in the construction industry.

Moreover, future research and development efforts could focus on addressing the global issue of productivity in the construction sector. The document highlights the significance of boosting production on building sites and the potential impact of technology and innovation in addressing productivity challenges. Therefore, future work could explore innovative strategies, tools, and technologies to increase efficiency, precision, and security in building projects. This could involve investigating the integration of advanced technologies, such as drones, artificial intelligence, and automation, to optimize construction processes and mitigate productivity constraints. Additionally, future research could delve into the identification and mitigation of factors that affect site productivity, such as pre-construction activities, construction-related activities, managerial and leadership challenges, and organizational aspects, aiming to develop comprehensive solutions for enhancing productivity in the construction industry.

## REFERENCES


[1] J. Wang, Z. Xie, B. Zhang, L. Tian, and L. Xu, "On the innovation and development of civil engineering construction technology," *Smart Construction Research*, vol. 2, no. 2, Jul. 2018, doi: 10.18063/scr.v2i2.476.

[2] M. J. Skibniewski and E. K. Zavadskas, "Technology development in construction: A continuum from distant past into the future," *Journal of Civil Engineering and Management*, vol. 19, no. 1. pp. 136–147, Feb. 01, 2013. doi: 10.3846/13923730.2012.756060.

[3] I. Naskoudakis and K. Petroutsatou, "A Thematic Review of Main Researches on Construction Equipment over the Recent Years," in *Procedia Engineering*, Elsevier Ltd, 2016, pp. 206–213. doi: 10.1016/j.proeng.2016.11.611.

[4] S. G. Naoum, "Factors influencing labor productivity on construction sites," *International Journal of Productivity and Performance Management*, vol. 65, no. 3, pp. 401–421, Mar. 2016, doi: 10.1108/ijppm-03-2015-0045.

[5] "23 Surveying Instruments And Their Uses - Civiconcepts." https://civiconcepts.com/blog/surveying-instruments (accessed May 30, 2023).

[6] I. M. Elhassan and A. S. Ali, "Comparative study of accuracy in distance measurement using: Optical and digital levels," *Journal of King Saud University - Engineering Sciences*, vol. 23, no. 1, pp. 15–19, Jan. 2011, doi: 10.1016/j.jksues.2010.10.001.

[7] P. Ajugiya, "COMPARISON OF MODERN AND CONVENTIONAL CONSTRUCTION TECHNIQUES FOR NEXT GENERATION: A REVIEW E-Proceedings of National Conference on Emerging Trends in Engineering Comparison of Modern and Conventional Construction Techniques for Next Generation: A Review," 2016. [Online]. Available: https://www.researchgate.net/publication/313791962

[8] M. Spisakova, P. Mesaros, P. Kaleja, and T. Mandicak, "Virtual Reality as a Tool for Increasing Safety of Construction Sites," in *ICETA 2020 - 18th IEEE International Conference on Emerging eLearning Technologies and Applications, Proceedings*, Institute of Electrical and Electronics Engineers Inc., Nov. 2020, pp. 652–657. doi: 10.1109/ICETA51985.2020.9379202.

[9] S. George, J. Wang, M. Bala, T. Eiszler, P. Pillai, and M. Satyanarayanan, “Towards drone-sourced live video analytics for the construction industry,” in *HotMobile 2019 - Proceedings of the 20th International Workshop on Mobile Computing Systems and Applications*, Association for Computing Machinery, Inc, Feb. 2019, pp. 3–8. doi: 10.1145/3301293.3302365.

[10] M. Sönmez *et al.*, “Unmanned Aerial Vehicles – Classification, Types of Composite Materials Used in Their Structure and Applications,” Leather and Footwear Research Institute (INCDTP-ICPI), Nov. 2022, pp. 77–82. doi: 10.24264/icams-2022.i.11.

[11] B. Vergouw, H. Nagel, G. Bondt, and B. H. M. Custers, “Drone Technology: Types, Payloads, Applications, Frequency Spectrum Issues and Future Developments,” 2016.

[12] M. Tkáč and P. Mésároš, “Utilizing drone technology in the civil engineering,” *Selected Scientific Papers - Journal of Civil Engineering*, vol. 14, no. 1, pp. 27–37, Dec. 2019, doi: 10.1515/sspjce-2019-0003.

[13] M. S. Yasser, S. Nassar, and Y. Sahib Nassar, “Comparing the use of modern and traditional building design systems in construction projects.” [Online]. Available: www.techniumscience.com

[14] P. (Amir E. ) Piroozfar, H. Altan, and O. Popovic-Larsen, “Design for sustainability: A comparative study of a customized modern method of construction versus conventional methods of construction,” *Architectural Engineering and Design Management*, vol. 8, no. 1, pp. 55–75, 2012, doi: 10.1080/17452007.2012.650935.

[15] J. Endzelis and M. Daukšys, “Comparison between modular building technology and traditional construction,” *Journal of Sustainable Architecture and Civil Engineering*, vol. 23, no. 2, Dec. 2018, doi: 10.5755/j01.sace.23.2.21579.

[16] J. K. Pancho, “Ultrasonic Distance Measuring Device Study”, doi: 10.13140/RG.2.2.22528.17928/2.

[17] J. Jasmari, “Smartphone Distance Measurement Application Using Image Processing Methods,” in *IOP Conference Series: Earth and Environmental Science*, Institute of Physics, 2022. doi: 10.1088/1755-1315/1064/1/012010.

[18] J. A. S. D. Fonseca, A. Baptista, M. J. Martins, and J. P. N. Torres, “Distance Measurement Systems Using Lasers and Their Applications,” *Applied Physics Research*, vol. 9, no. 4, p. 33, Jul. 2017, doi: 10.5539/apr.v9n4p33.

# APPENDICES

## Appendix A Gantt Chart PSM 1

| PROJECT PLANNING PSM 1 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Activity | March | | April | | | | May | | | | June | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| PSM 1 | PSM 1 General Briefing | | | | | | Mid Term Break | | | | | | | | | |
| **Proposed Project:** | | | | | | | | | | | | | | | | |
| Decide Project Title | | ■ | | | | | | | | | | | | | | |
| Meeting with supervisor | | | ■ | | | | | ■ | | | ■ | | ■ | | | |
| Identify objective, problem statement & scope of the project | | | ■ | ■ | | | | | | | | | | | | |
| **Research of Software:** | | | | | | | | | | | | | | | | |
| Finding related past research | | | | | ■ | ■ | | ■ | ■ | ■ | | | | | | |
| Finding software to use | | | | | ■ | ■ | | | | | | | | | | |
| Identify software to use | | | | | ■ | ■ | | | | | | | | | | |
| **Selection of Software:** | | | | | | | | | | | | | | | | |
| Finalized software used | | | | | | | | ■ | ■ | | | | | | | |
| Installing selected software | | | | | | | | ■ | ■ | | | | | | | |
| Run simulation for preliminary result | | | | | | | | | | ■ | ■ | ■ | | | | |
| **Project Deliverable (PSM 1):** | | | | | | | | | | | | | | | | |
| Completing report untill chapter 4 | | | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| Prepare slide presentation | | | | | | | | | | | | ■ | ■ | ■ | | |
| Submission PSM 1 report | | | | | | | | | | | | | ■ | | | |

# Appendix B Gantt Chart PSM 2

| Project Activity | Oct | | | | Nov | | | | Dec | | | | Jan | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 18 |
| PSM 2 | | PSM 2 General Briefing | | | | | | | Mid Term Break | | | | | | | | | |
| Developing The Drone-Based Measurement: | | | | | | | | | | | | | | | | | | |
| ➢ Coding for input controlling the drone | | | | | | | | | | | | | | | | | | |
| ➢ Troubleshooting and add on more features | | | | | | | | | | | | | | | | | | |
| Developing The Interface: | | | | | | | | | | | | | | | | | | |
| ➢ Add more function to the screen | | | | | | | | | | | | | | | | | | |
| ➢ Generate the graph movement of the drone | | | | | | | | | | | | | | | | | | |
| Generate the Output result: | | | | | | | | | | | | | | | | | | |
| ➢ Testing the program | | | | | | | | | | | | | | | | | | |
| ➢ Troubleshooting any error | | | | | | | | | | | | | | | | | | |
| Making the analysis | | | | | | | | | | | | | | | | | | |
| ➢ Record and capture the process of the measurement | | | | | | | | | | | | | | | | | | |
| ➢ Use other method to get the data of the measurement | | | | | | | | | | | | | | | | | | |
| ➢ Using variety of python libraries for getting the data | | | | | | | | | | | | | | | | | | |
| Project deliverable (PSM 2): | | | | | | | | | | | | | | | | | | |
| ➢ Completing report | | | | | | | | | | | | | | | | | | |
| ➢ Turnitin report | | | | | | | | | | | | | | | | | | |
| ➢ Completing execution summary and poster | | | | | | | | | | | | | | | | | | |
| ➢ Submission PSM 2 report | | | | | | | | | | | | | | | | | | |