CONTROL OF WELDING ROBOT USING DRONE WITH AUTOPILOT

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CONTROL OF WELDING ROBOT USING DRONE WITH AUTOPILOT

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DECLARATION

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LIST OF SYMBOLS

V	Voltmeter
m	meter
CO_2	Carbon dioxide

LIST OF ABBREVIATIONS

APM	Ardupilot Mega
CAD	Computer-aided design
CCW	Counter clock-wise
CW	Clock-wise
ESC	Electronic speed controller
GCS	Ground control station
GMAW	Gas metal arc welding
GPS	Global Positioning System
MP	Mission Planner
MIG	Metal inert gas
NC	Normally close
NO	Normally open
PC	Personal computer
RC	Radio controller
RTL	Return to launch
UAV	Unmanned aerial vehicles
USM	Universiti Sains Malaysia

ABSTRAK

Pada masa ini, teknologi dron atau kenderaan tanpa pemandu (UAV) semakin berkembang dari hari ke hari. Teknologi ini digunakan dalam banyak sektor seperti pertanian, perkhidmatan awam, pengawasan udara, media, penghantaran dan lain-lain. Dalam industri robotik moden, dron boleh menjadi pendekatan terbaik untuk menggantikan lengan robot terutamanya dalam industri kimpalan MIG. Penggunaan teknologi dron dapat mengurangkan masalah had panjang kimpalan kerana ia tidak memerlukan platform seperti landasan kereta api untuk bergerak dan melakukan proses kimpalan. Hal ini dapat mengurangkan kos pembinaan landasan kereta api dan kos pekerja. Oleh sebab itu, satu kajian dilakukan untuk mengkaji kebolehanan penggabungan teknologi dron dan kimpalan dalam industri kimpalan robotik serta kaedah muncung kimpalan untuk beroperasi secara auto menggunakan geganti. Dalam penyelidikan ini, jenis dron yg digunakan adalah hexa iaitu enam bilah kipas dan dron ini akan terbang secara automatik dari satu titik ke satu titik meggunakan laluan yang dihasilkan dalam "Mission Planner". Semasa ia terbang, ia akan membawa muncung kimpalan yang telah dipasang bersamanya untuk melakukan proses kimpalan. Geganti digunakan sebagai pencetus kepada muncung kimpalan untuk beroperasi ataupun tidak beroperasi semasa penerbangan dron dalam "Mission Planner". Berdasarkan keputusan yang diperolehi, dron tidak dapat melakukan kimpalan berjarak 1m dari tanah kerana pusingan angin di bawah dron. Selain itu, dron tidak boleh bergerak ke setiap titik dengan tepat dan ini akan menjejaskan laluan kimpalan kerana resolusi GPS adalah besar. Untuk kajian seterusnya, dron bolehlah dicadangkan menggunakan teknologi seperti optitrack sebagai alat navigasi selain GPS kerana ia membantu dron untuk bergerak dari satu titik ke satu titik yang lain dengan tepat.

ABSTRACT

Drone or unmanned aerial vehicles (UAV) technology nowadays constantly evolving from day to day. This technology has widely used in many sectors such as agriculture, public services, aerial surveillance, media, delivery and others. In modern robotic industry, drone can be the best approach to replace robotic arm especially in MIG welding industry. Using drone technology, it can reduce the problem in term of limit length for welding as it doesn't need a platform such as railways to move and perform the welding process. This can reduce the cost in building the railways and labour cost. Thus, the feasibility of combining technologies (drone and welding) in robotic welding industry and the integration of welding gun operate autonomously using relay are studied. In this research, the type of the drone use is hexa which is six propellers and this drone will fly autonomously from one point to another point using path generated in Mission Planner software. During the flight, the drone will carry the welding gun which was installed on it to perform welding process. A relay is used to trigger the welding gun to operate or not during the flight through Mission Planner. The result obtained shows that the drone cannot perform welding 1m above the ground because of the circulation of wind under the drone. Moreover, the drone cannot move to each points precisely and this affect the welding path as the resolution of GPS is big. For future work, the drone is suggested to use technology such as optitrack for non-GPS navigation as this help the drone to move from one point to another point precisely.

CHAPTER 1

INTRODUCTION

1.1 Overview

Welding is a technology that provides the fastest, strongest and most economical method of joining metal [1]. The common welding process use is metal inert gas (MIG). MIG welding process also known as gas metal arc welding (GMAW) is an arc welding process that use consumable bare metal wire by flooding the arc with inert gas such as argon and helium for aluminium welding and active gas such as CO_2 (carbon dioxide) for steel welding as a protection from contaminants with atmospheric gases (oxygen, nitrogen and hydrogen) which can cause fusion defects, porosity and weld metal embrittlement. This shielding gas is feeds through the gun straight to the welding pool. Figure 1.1 shows the welding principle.

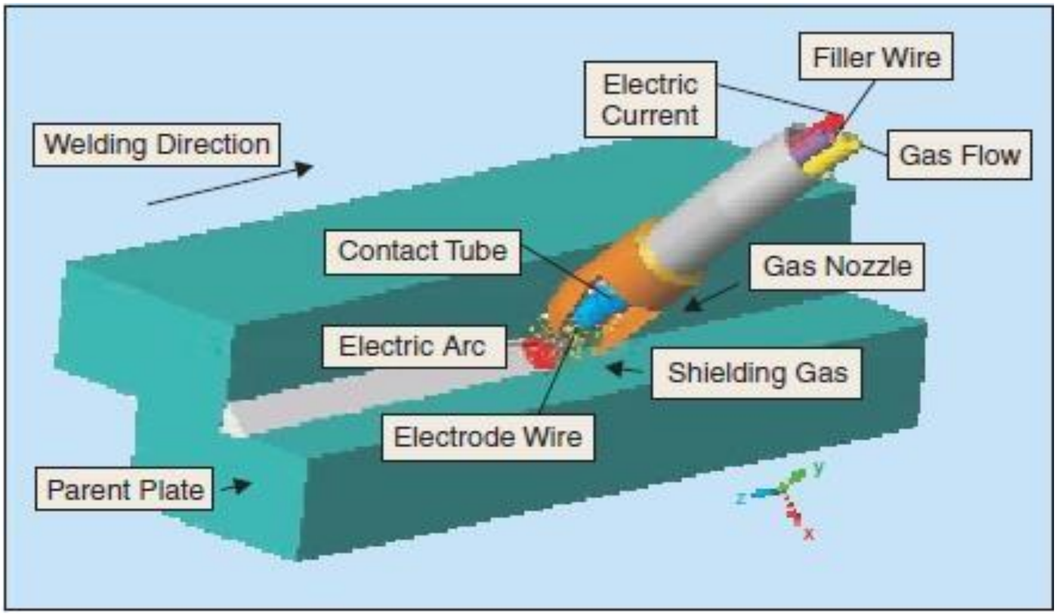


Figure 1.1 MIG welding process principle [2]

Nowadays, MIG welding process is widely use in industrial robotic welding around the world. In fact, many products require welding operations in their assembly processes as the automobile industry is the most common industry uses robotic welding in their assembly line. Robotic welding is mainly concerned with the use of mechanized programmable tools, known as robots, which completely automating a welding process by both performing the weld and handling the part [1].

In addition, the robotic welding systems bring other advantages such as improved productivity, safety, weld quality, flexibility and workspace utilization and reduced labour cost [3]. There are many robotics welding that are designed and marketed nowadays which are KUKA KR 6-2, FANUC F-200iB robot, Panasonic Perform Arc robot, MOTOMAN VA1400 robotic arm, CLOOS QIROX welding robots and The Daihen FD-V6 robot.

1.2 Problem statement

Generally, welding process such as MIG currently vital in modern robotic industry especially in the automotive industry as it brings good quality of welding, improve cycle time, increase efficiency and reduce health problem of the welders. However, there is a problem to robotic welding industry when the welding distance is high as the industry currently uses robot arm to perform the welding operation. Thus, there will be limit in term of welding length. Although there are railways to ease the movement of the robotic welding from one spot to another, there still a limit to the robotic welding when it need to perform welding operation for a long distance which require a long railways. So, these will increase the budget of the welding operation due to the requirement of long railway.

Drone which is more formally known as unmanned aerial vehicles (UAV) is the best approach to replace the robot arm in modern robotic industry that can reduce the welding length problem. The drone technology is constantly evolving as new innovation and big investment are bringing more advanced drones to the market every few months [4]. A drone is defined as powered, aerial vehicle that does not carry a human operators which use aerodynamic forces to provide vehicle lift. It can be piloted remotely or fly autonomously with the help of autopilot system that was installed inside it. Moreover, it can be recoverable and can carry a payload within certain limit of weight.

For this project, both technologies that are drone and welding will be combined. A MIG welding gun will be installed on the drone which enable joining the two base materials by controlling the flying path of the drone. In order to control the autopilot of the drone to fly autonomously, Mission Planner (MP) will generate the flight path based on Solid Works: 3D computer-aided design (CAD) model.

1.3 Research objective

The project carries out with few objectives that are listed below:

1. To study the feasibility of combining technologies (drone and welding) in robotic welding industry
2. To integrate welding gun autonomously on drone using relay which control the flow of the current
3. To control flying path of the drone for performing welding process using MP based on model design in Solid Works

1.4 Scope of study

This project is more focussing on improvement of robotic welding industry by utilizing drone technology instead of robot arm which involves fabrication, programming and experimentation to obtain the results. This project will be using the understanding in autonomous drone system, MIG welding operations and Solid Works.

For autonomous drone system, the flying path is generated in MP based on model design in Solid Works. The drone will move in a straight line which the welding process take place as the model created in Solid Works was in a rectangular shape. In MP, the drone will travel from one point to another point by scaling up the distance for each point from 2cm to 7m as the resolution of the GPS is big. For the welding operation, a relay is used to trigger the welding gun to perform the process. The power to activate the relay is obtained from the flight controller Ardupilot Mega (APM) which is 5 volts (V) which magnetised and turn the normally open (NO) switch to become normally close (NC). This step is then applied in MP which used to control the welding gun to operate autonomously.

CHAPTER 2

LITERATURE REVIEW

2.1 Autonomous system in drone

Autonomous system formally known as autopilot system basically allows a drone to safely perform a flight mission without using remote controller. It includes a user interface to prepare a flight route and analysis, assign the flight mission and control its execution in flight by relying on Global Positioning System (GPS). It also require sensors and control systems in order to perform complex sequence of operations in different types of system.

Moreover, the drone also capable to avoid collisions, capture data and store valuable information by creating commands, wait to review and then choose the follow up actions which done by user or operator [5]. Nowadays, autonomous system for UAV such as drones are growing rapidly. The application of this system is vast and span the commercial, consumer, research and public sectors. It is widely used in agriculture, public services, aerial surveillance, media, delivery and others.

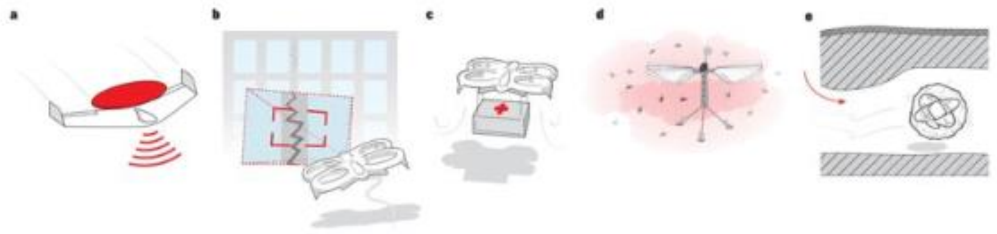
2.1.1 Agriculture

UAV can assist farmers in a number of ways [6]. Their ability to cover large distances makes them suitable for monitoring conditions such as irrigation or frost, or crops and livestock. For example to check for diseases. They can be used as part of a precision agriculture system, through both surveillance capabilities and the ability to apply pesticides or fertilisers in targeted areas. It is feasible that UAV could also plant and harvest crops or be used in pollination with more extensive development. UAV can replace more laborious methods of farming as well as provide improved levels of monitoring, making them an instrument of agricultural modernisation.

They can also be cost effective for farmers as decisions can be made based on better information, and cultivation can be more finely tuned [6]. They can also be much cheaper than alternatives such as manned helicopters. UAV have great potential for use in agriculture not only for their versatile capabilities but also because they are less of a privacy and safety risk in rural settings. To perform their functions they would fly at relatively low levels, avoiding the risk of colliding with other air traffic. Operating over large farms also mitigates the risk of causing injury should they fall from the sky or fly too low, and rural areas pose less of a concern of a UAV intruding on neighbours' privacy. Agricultural UAV would only need to be flown above land owned by the operator, reducing legal and privacy-related contentions.

2.1.2 Public Services

UAV can be useful in assisting with emergency services type undertakings such as search and rescue as shown in Figure 2.1.



a, Fixed-wing drones with a long flight time could provide bird's-eye-view images and a communication network for rescuers on the ground. **b,** Rotorcrafts with hovering capabilities could inspect structures for cracks and leaks; and **c,** transport medical supplies from nearby hospitals. **d,** Swarms of dispensable drones with flapping wings could enter buildings to search for chemical hazards. **e,** Multi-modal caged robots could fly and roll into complex structures to safely search for signs of life.

Figure 2.1 Autonomous drone in rescue situations [7]

A UAV' ability to reach inaccessible or dangerous locations, fitted with equipment such as video and infrared cameras which make them useful for tasks such as locating stranded victims of a natural disaster or missing hill-walkers [6]. They can similarly be used to assist police for locating crime suspects and for border control monitoring. Small UAV may also reach narrow or awkward locations which helicopters would be prevented from approaching. UAV have an advantage over manned helicopters for locating people in dangerous areas because there is no risk to an on board crew. For example, UAV can be used in monitoring and fighting forest fires, or can fly in dangerous weather conditions without posing an additional risk to human life.

2.1.3 Aerial Surveillance

UAV have recently been used by estate agents to create marketing videos of high-end properties and by environmentalists to find whaling vessels [6]. There has been interest expressed in using UAV for monitoring oil and gas pipelines – the first commercial UAV flight in US airspace which took place in September 2013 was carried out by oil and gas group ConocoPhillips. UAV can also be used for purposes as various as mapping, patrolling game reserves, and monitoring piracy prone areas. Although UAV offer great potential in the field of aerial surveillance, there are also considerable privacy concerns associated with this.

2.1.4 Media

UAV can be used to record footage that a cameraman would not be able to [6]. For example, they can film both a close up of an object and then fly back for a long-range view or they can track and follow a moving object such as a running animal. The BBC's Global Video Unit has recently acquired a UAV and they said that it will transform their delivery method for television and online news. Across the media sector, UAV are already in use for filming sports events, such as skiing, mountain biking and surfing which are difficult to capture from the ground. They have been used to make Hollywood films, including Skyfall, The Hunger Games and Iron Man 3.

2.1.5 Delivery

The recent announcement that Amazon was testing UAV for parcel deliveries was met with fervid media coverage and comment [6]. Several other companies have similarly been experimenting with using UAV for delivery. Among others, Domino's has tested them for pizza delivery and a dry cleaners have delivered fresh laundry by UAV. At a music festival in South Africa in 2013, crowd members were able to order beer through a smartphone app which was then delivered to their location in the crowd by UAV, greeted by "a crowd of 5,000 cheers".

This application of UAV is one which most captures the imagination but is however problematic for logistical reasons. To have numerous delivery vehicles flying in the sky would necessitate advanced systems to ensure that they did not crash into other airborne objects or cause damage or injury by falling to the ground. It is not inconceivable that such solutions can be found but most agree that Amazon's suggestion of a four or five year deadline for delivery UAV is highly unlikely. Nevertheless, UAV are being used to transport items in some contexts. It has been suggested that although they are currently unsuitable for dense, inhabited areas such as cities, delivery by UAV can be more immediately suitable for use in rural, poorly supplied regions. Airware, a UAV development company, the Massachusetts Institute of Technology and the Bill and Melinda Gates Foundation are working on a pilot project to deliver medicines and vaccines by UAV to remote regions of Africa later this year.

There have been some suggestions for the systematic adoption of UAV for deliveries. AirHighway is a US group of UAV engineers and entrepreneurs which is proposing the creation of aerial 'highways' – dedicated airspace corridors – for use by fully automated UAV as shown in Figure 2.2.

Figure 2.2 Airspace highways [6]

They propose that these would navigate by sensors which are able to replace their own batteries and identify and deliver packages using identification tags. While delivery by UAV may one day revolutionise shipping, the need for extremely high safety standards, infrastructure investment and meticulous integration planning mean that this is unlikely in the near future.

2.1.6 Other uses

UAV can come in almost any conceivable size and design, and accordingly there is a wide scope for how they can be applied by entrepreneurial developers [6]. Some other uses of UAV which have been suggested include for advertising and flying solar power farms. UAV can make useful research tools. For example, NASA has used them for taking measurements such as the air temperature, humidity and pressure of hurricanes. Beyond the commercial and research sectors, there is also interest in UAV from private hobbyists. The versatile capabilities of UAV mean that they can be designed for numerous different purposes and this is likely to lead to a substantial business market.

2.2 Drone configuration and components

There are several components that are important to build a drone which are frame, motors, electronic speed controller (ESC), propellers, batteries, landing gear, flight controller, radio controller (RC) and receiver, telemetry and ground station.

2.2.1 Frame

All the components will be carry on this platform as it need to be lightweight and study. Stiffness, material and arms are the common factors to be considered while choosing a frame [8]. When a frame is stiff, it enable the flight to be smoother because of the minimal bending and warping. A frame also need to be strong and capable to fly through some resistance mid-air to avoid damage during long flight sessions.

Moreover, the common material use for a frame is carbon fiber because it has physical characteristics suited for flight in the higher altitudes and also make a drone a lot agiler through it light weight structure.

Lastly, the arms determine the stability of the flight. It should not be flex so easily as it prone to vibrate.

2.2.2 Motors

A drone should use brushless motors instead of brushes motors because the total power use by the motor is being turned into rotational force and less power is being lost as heat in term of efficiency [9]. It also last longer as no brushes to wear out.

Motors should be capable to hover in midair at about half throttle which means it can produce 50% more thrust that the drone as it help to stabilize itself even in windy conditions [10]. Furthermore, Kv value of the motor or revolution per minutes that motors will attempt to spin per volt applied depend on the pole count. The higher the pole count, the lower the value of Kv as it require more voltage during the flight but produce greater torque. When the value of Kv is low, it is best to use small blades or propellers with these motors.

Lastly, the movement of the motors different for each type of copter. The rotations will be different as shown in Figure 2.3 to ensure higher stability of the motors and effectiveness of the device.

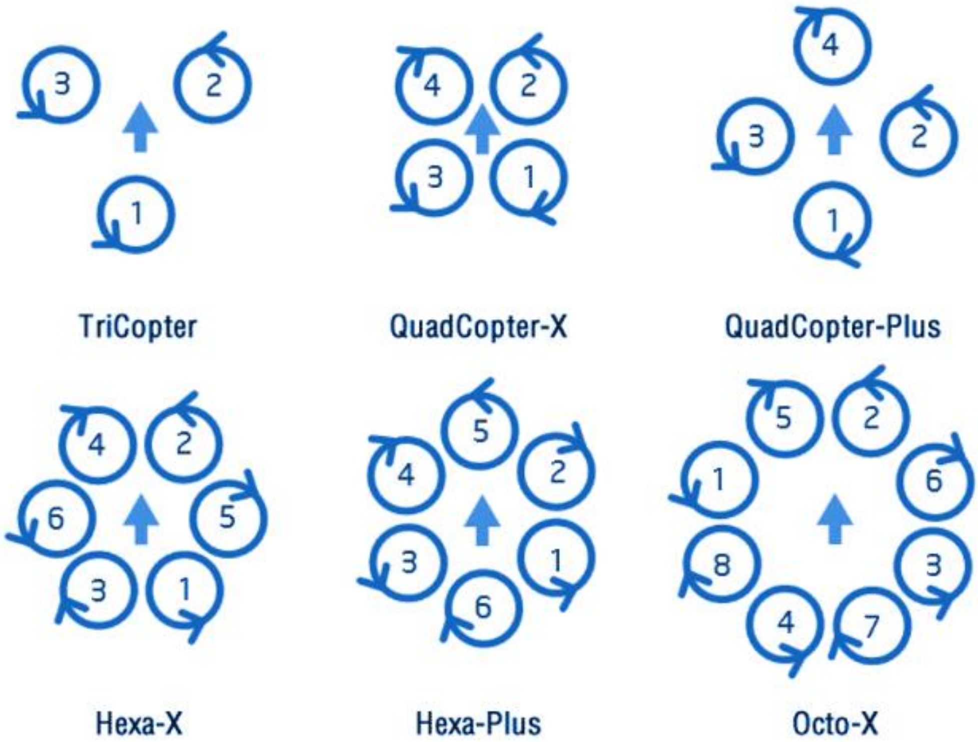


Figure 2.3 Movement of the motors [10]

2.2.3 Electronic speed controller (ESC)

ESC is a little device that control the speed of the brushless motors which supplies certain amount of amperage to the motors. The amperage depend on motors and propeller and the selection of ESC based on thrust data table that should be provided with any multi-rotor motors [11].

ESC will has servo connector that connects to the flight controller. 95% of the time this will be a 3 wire connector, the middle wire (usually Red) will be the power output (5V) the white wire (sometimes orange) is the signal wire. The black wire (sometimes brown) is the ground connector. However in some cases when using OPTO ESC's, there might only have two connectors, the signal and ground wires with a space in the middle.

The next connector issue to consider is that of the battery connector. Obviously, ESCs need to be powered, and therefore they need to be connected to your battery in some way. ESCs can therefore come with pre-soldered battery connectors soldered onto the power cables of the ESC (the red and black cables). These connectors are usually one of the following: deans/T-plug, XT60, EC3 or EC5 as these are the classic battery connectors.

2.2.4 Propellers

There are two vital factors to choose propellers which are diameter and pitch [10]. Propellers with larger diameters produce more thrust and thus can alter the thrust to weight ratio of the motor and for smaller diameter, the opposite happens which it generate less thrust.

Pitch is defined as the distance covered in one rotation of the propeller. The lower the pitch, the higher is the thrust generated. This also means that the flights will be free from turbulence as the motors will be able to carry heavier weights and also have long flight times. Since the drones are mostly intended for hovering in mid-air, lower pitch propellers will work well with the motors. However, for mini-drones with acrobatic movements, larger pitch propellers is suitable for them.

2.2.5 Batteries

Good in choosing batteries will give the best flight time and performance within the maximum take-off weight of the drone [12]. Basically, by using a discharge rate (C rating) that is too low, it can result in battery being damaged and the drone under-performing the battery cannot release current fast enough to power the motors properly. Since higher C rating batteries are heavier, if the battery that are used has a C rating that is too high, the drone will carry extra weight around which ultimately reducing the flight time.

In order to know what the total current draw of the drone system is, it can be calculated based on this simple formula [12]:

Max continuous Amp draw (A) = Battery capacity (Ah) x Discharge rate (C)

The above value uses to check whether the battery is suitable for the motors based on data thrust table which explain the maximum current draw from it. The battery voltage, or cell count is another important decision that need to be considered. Higher voltage batteries allow motors to produce more power. However, the higher voltage batteries are heavier since they contain more cells. Make sure that motors or ESCs and other electronics are able to support the voltage of the batteries. Some motors will only support a specific cell count or a specific range of voltages which might make the decision easier.

2.2.6 Landing gear

Landing gear is an important part when landing the drone because it significantly reduces the shock when the drone lands on a solid ground. It also help the drone to stabilize itself on the ground before fly. Landing gear is install at each of the arms as the shape and size of it can be made in various ways.

2.2.7 Flight controller

The flight controller is the brains of the drone. The flight controller reads all of the sensor data and calculates the best commands to send to the drone in order for it to fly [13]. In a flight controller, there are processor, accelerometer and gyroscope, compass (magnetometer), barometer and data logging.

The processor is the central unit that runs the autopilot firmware and performs all the calculations. Moreover, the accelerometer measures acceleration forces, and the gyro measures rotational forces. By combining these measurements the flight controller is able to calculate the drone current attitude (angle it is flying at) and perform necessary corrections.

Compass or magnetometer use to measure the magnetic force, just like a compass. This sensor is important for multi rotor drones because the accelerometer and gyroscope sensors are not enough to let the flight controller know what direction the drone is facing. Compass sensors are very sensitive to magnetic interference. Things such as wires, motors and ESC's can all cause magnetic interference, so that is the reason of an additional compass sensor mounted on the GPS module as the GPS module is usually mounted far away from all the other equipment.

For barometer, it measure the aircrafts altitude. These pressure sensors are so sensitive that they can detect the change in air pressure when your drone moves a few centimetres. Lastly, data logging stores a log of all the things the autopilot is doing just like a black box on an aircraft. This is particularly useful if something is not working properly as the logs can be used to find and identify the problem.

2.2.8 Radio controller (RC) and receiver

RC is an electronic device that uses radio signals to transmit commands wirelessly via a set radio frequency over to the receiver [14]. It is remotely controlled and connected to an aircraft or multirotor. In other words, it is the device that translates pilot's commands into movement of the multirotor. In some radios, there is an option to connect an external transmitter module. This makes it possible to use a different frequency (for instance, 900MHz in a 2.4GHz radio)

RC transmits commands via channels. Each channel is an individual action being sent to the aircraft. Throttle, Yaw, Pitch and Roll are the four main inputs required to control the drone. Each of them uses one channel, so there is minimum of four channels required. Every switch, slider or knob on the transmitter uses one channel to send the information through to the receiver.

Moreover, there are 2 common modes use to fly the drone. The mode determines drone movement assigned to a certain stick movement. There are 4 transmitter modes with Mode 2 being the most popular and is usually set as the default mode on most radios as shown in Figure 2.4.

RC commonly use the following frequencies: 27MHz, 72MHz, 433MHz, 900MHz, 1.3GHz and 2.4GHz. For long range flight, 433MHz, 900MHz and 1.3GHz are typically used. 27MHz and 72MHz are older frequencies which were being used for many years in RC. Equipment operating on those frequencies used crystals to bind RC with a receiver.

For receiver, it is capable of receiving commands from the RC and then interprets the signal via the flight controller where those commands are converted into specific actions controlling the aircraft. Receiver can have the following features which are telemetry (sending data back to transmitter), redundancy function (two receivers connected together and if one loses connection, second one takes over), easy removable antennas (more convenient with connectors if antenna is to be replaced) and possibility of firmware upgrades (for bug fixes).

Lastly, RC will only communicate with a receiver if the two are bind. If binding process fail, the receiver cannot interpret the signals transmit via RC and the flight test cannot be done because of this problem.

Figure 2.4 Mode set in RC [14]

2.2.9 Telemetry and ground control station (GCS)

Telemetry is use to send and receive data between the drone and GCS [13]. It also allow pilot to monitor important information about the drone such as track of the drone, external thing around the drone and real time key components of the drone such as battery levels. Telemetry comes in pair which one of them is connected to the GCS and the other one will be connected to the flight controller. The common frequencies of the telemetry use are 433MHz and 915MHz.

GCS is typically a software application, running on a ground-based computer that communicates with the drone via wireless telemetry [15]. It displays real-time data on the UAVs performance and position and can serve as a “virtual cockpit”, showing many of the same instruments that you would have if you were flying a real plane. A GCS can also be used to control a drone in flight, uploading new mission commands and setting parameters.

2.3 Automated welding system for MIG welding

Automated welding is widely considered by industries as a tool to enhance productivity, weld quality, and in some cases lower the manufacturing costs [16]. A fixture is used in manufacturing to securely locate a part in such a way that promotes ease-of-use and ensures that important tolerances are met. Fixtures help make a process repeatable by having consistent placement of the part. There are differences between machining fixtures and welding fixtures. The biggest difference is that a welding fixture needs to hold each component that will be welded without interfering with the welding gun. Welding fixtures also need to resist high heat and sputter, permit passage of weld run off, and in some cases conduct electricity and provide grounding.

For automated welding, the fixture should strive for accessibility, repeatability, simplicity, and dependability. The fixture needs to be consistent in the placement of parts as well as the placement of the fixture in the welding robot's enclosure. In order to decrease lead time, the fixture needs to be simple to load parts so that the process to load and unload parts will be more quickly and easy. Furthermore, the most important factors to obtain good quality of welds are source of energy to create union by fusion or pressure, method for removing surface contaminants, method for protecting metal from atmospheric contamination and control of welding metallurgy. In addition, the MIG gun angles must be travelled and worked in an angle of 20 degree for the welding process besides the welding speed. When the welding speed increase, the temperature decrease in the fusion zone but it has less effect to the areas outside the fusion zone and heat affected zone [17].

Lastly, sensors are mainly used in robot welding to measure the process parameters such as location and geometry of weld pool and online control of welding process. In addition, sensors are used for inspection of defects in welding and evaluation of weld quality. For robot welding applications, an ideal sensor should measure the weld path, identify in advance seam, corners, and as small as possible. Generally all the three requirements do not exist in an ideal robot, therefore one should select a sensor suitable for the specific welding situation. Robots with seam tracking capability are equipped with Sensors that can measure geometrical parameters. Technological sensors are used to measure parameters that are mostly used for monitoring or controlling purposes. Contact sensors, like nozzle or finger, are easier to use and less expensive than non-contact sensors. However, contact type sensors cannot be used for thin lap joint. Non-contact sensors also known as through-the-arc sensors can be used for tee, U and V grooves, tee joints or lap joints over a limited thickness. Non-contact types of sensors are best suitable for welding of large workpieces with weaving when penetration control is not critical [18].

CHAPTER 3

METHODOLOGY

3.1 Introduction

This study includes two major parts which are the setup for drone and setup for welding operation. Both of them run autonomously using MP software. MP generate the flying path for the drone and is used to control the operation of welding gun by monitoring the welding gun to turn on or off using relay.

3.2 Setup for drone (before test flight)

For pre-flight setup, the drone need to be setup properly to avoid any problem during the test. Make sure all the nuts, screws and washers are properly tighten, ESCs, motors and propellers are matched correctly depend on the direction of rotation of the propellers which are clock-wise (CW) or counter clock-wise (CCW) as shown in Figure 3.1.

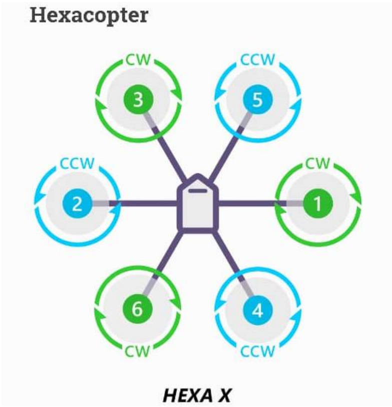


Figure 3.1 Direction of rotation of the propellers

Next, the receiver which is FUTABA R7008SB is chosen to be bind with the RC. The binding process is important as the receiver will receive signal from the RC and then translate it into command for flight control. Calibration of ESCs are done to guide and set limit for high and low throttle power from RC to ensure the drone fly at the suitable speed in addition to check the direction of rotation of the motors. If the motors rotate in wrong direction, the connection of the ESCs need to be checked and then re-calibrate them again. If the direction of rotation of motors are true, ESCs cables will be connected to output pins at APM board and 5 inputs pins from APM's board will be connected to the receiver as shown in Figure 3.2.

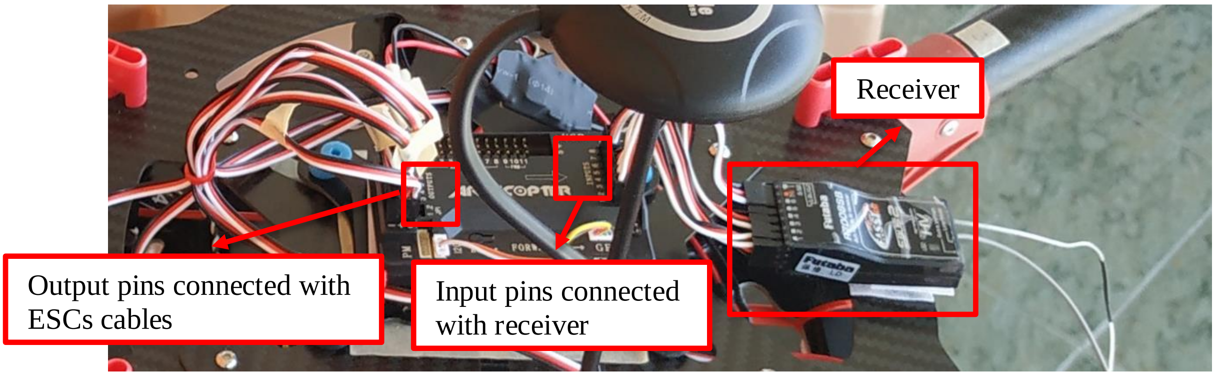


Figure 3.2 Connection on APM’s board

Lastly, the APM flight controller will be connected with MP to control the behaviour of the copter by installing firmware, downloading all information and parameters, choosing frame type, calibrating compass, accelerometer and radio, setting flight modes and lastly configure the failsafe before the drone ready to go for a flight test. The overall setup are illustrated in the flow chart as shown in Figure 3.3.

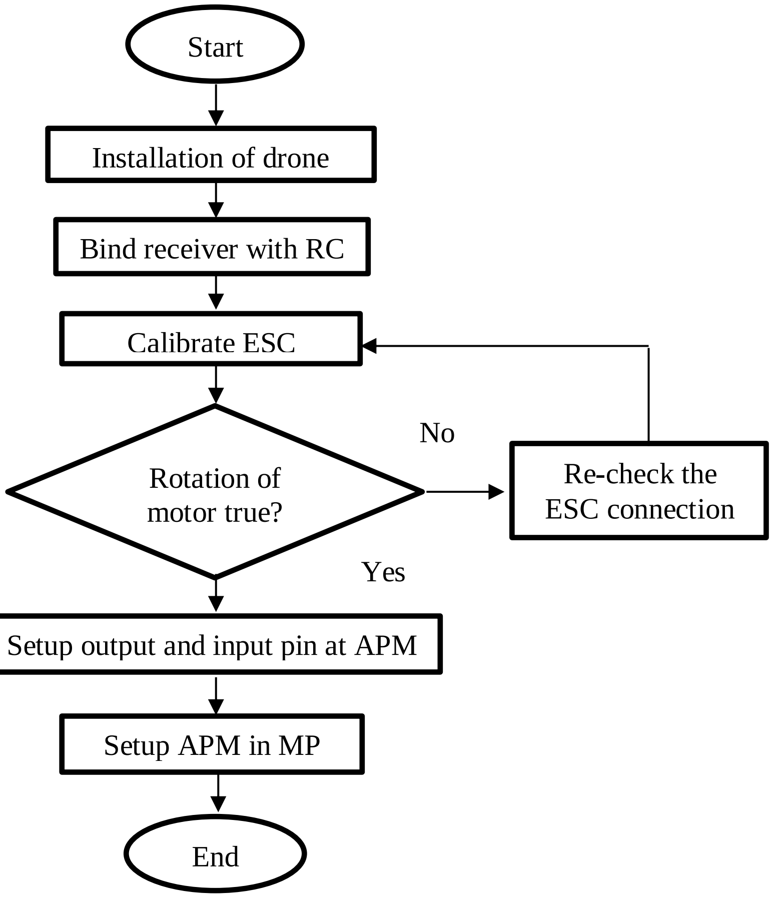


Figure 3.3 Flow chart for setup drone before test flight

3.2.1 Installation of drone

For this project, RS900 will be used as shown in Figure 3.4. It is designed for professional aerial photography and cinematography. It is user friendly, safe, stabilized and easy to fly while its integrated design makes assembly and configuration simple and fast. Retractable landing gear, vibration dampers, slightly angled arms and a minimalized gimbal mount allow for a clear 360 degree view from the camera. It also provide a patented power distribution board, built-in high-speed ESCs and motors with high efficiency propellers ensure dynamic stability and maximized power efficiency.

There are 6 propellers which three of them for CW and the other three propellers for CCW, 6 motor of Kv400 and 6 ESCs were installed to this drone. CCW mark had been mounted to the motor 1 (M1), motor 3(M3) and motor 5 (M5) positions of the center frame. The arms mark with CW had been mounted to the motor 2 (M2), motor 4 (M4) and motor 6 (M6).

There are two red's frame arms which indicate forward facing (nose) of the drone. For wiring, the power cables were connected to the positive (+) or negative (-) gold bracket which each bracket has two cables of the same colour. Red cables are positive and black cables are negative. Lastly, all the screws had been tighten using Allen keys.

Figure 3.4 Front view of RS900

3.2.2 Bind receiver with RC

A radio control system is made up of two elements, the transmitter and the receiver on the drone. Dramatically simplifying things here, drone transmitter reads stick inputs and sends them through the air to receiver in near real time. Once the receiver has this information it passes it on to drone’s flight controller which makes the drone move accordingly.

RC however simply needs to bind or pair with a receiver when it’s first setup. Most RC transmitters come with 2.4GHz, it’s the most popular frequency currently. Lower frequencies are also available for longer range such as 433MHz and 900MHz. The 2.4GHz system is the standard for radio control after new protocols were created that introduced frequency hopping technology. It basically looks for available channel automatically to avoid interfering with other pilots, allowing multiple pilots flying at the same time. The higher frequency of 2.4GHz has the advantage of smaller antenna which is much more portable. However the range is shorter than the lower frequencies. For this research, RC FUTABA T114SG is used together with FUTABA R7008SB as shown in Figure 3.5.

Figure 3.5 T14SG RC (left) and Futaba R7008SB receiver (right)

To bind RC with receiver, switch on RC only and select Model-01 on the screen to change the mode from helicopter to multirotor as shown in Figure 3.6.

Figure 3.6 Change mode from helicopter to multirotor

Next, open linkage menu, scroll down to system and press return (RTN) button make sure G is selected for higher power transmission and FASSTest-12CH for faster response time as shown in Figure 3.7. Scroll down to link and select it.

Figure 3.7 Open linkage menu and select system for RC

RC produced chime sound indicating it's trying and searching for a receiver as shown in Figure 3.8. At the same time, plug power lead for battery into the receiver. At this stage, red color for LED's receiver appeared as shown in Figure 3.9.

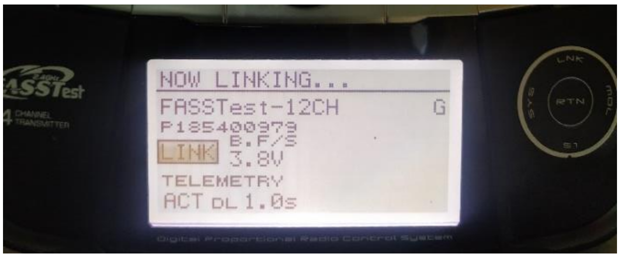


Figure 3.8 Link start to blink and RC will be produced chime sound

Figure 3.9 Red color appear for LED's receiver