Range Free Unmanned Aerial Vehicles

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project/internship titled **"Range Free Unmanned Aerial Vehicles"**, submitted by Hasan Al Banna, ID No: 171-15-8914 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 28-01-2021.

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We hereby declare that, this project has been done by us under the supervision of **Fahad Faisal , Assistant Professor, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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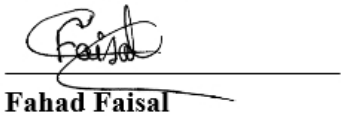

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ABSTRACT

The goal of this project is design a drone that can carry a payload from one place to another.Obiously it reduces our time & cost.Quadcopter/Hexacopter or Drone is a type of Unmanned Aerial vehicle (UAV), used in many applications to monitor and collect data in the region where manned flight is difficult or a dangerous situation.We just need to change it whole architecture and redesign it on various purpose.This paper describe drone use for delivery purpose.It consists of onboard sensors,flight controller and front camera which helps it to navigate Autonomously.And nowdays we don't need to use remote control transmitter and rc receiver.Control it with ground controller software from computer and connect with one computer to many drone.Also Our User and Controller person both see live video streaming from drone by web application.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Drone is a type of machine that can fly, and can be guarded by a remote system or can autonomously fly with the help of software.It initially were used in the defense sector. It helps to gather the information about the remote area,weapons supply etc.Nowdays drones are used for various purposes in addition to military purposes like oil pipeline monitoring,vital organ delivery, humanitarian aid and disaster relief, conservation, disease control,infrastructure development.Technology and development in robotics sector have made inexpensive and light weight drones with many sensors and actuators.

1.2 Motivations

Present days,Manufacturing industries, one of the biggest challenges is to deliver the products on time to increase the profit.Customers are far off places from the manufacturer's location to deliver the product.Slow/Delay delivery services are severe as you sell a low-quality product and it leads to customer dissatisfaction.If you a shopkeeper than you will lose your valuable customer. Delivery plays a major role in manufacturing industries in society.Here,this delivery problem, i can use currently emerging drone technology. The big advantage of using a drone in transportation or delivery purposes or medicine delivery, you can save a life also it reduces time and cost.Finding that idea,i can build a new design drone that can deliver payload autonomously and safely on our users hand from stay a long distance.

1.3 Objectives

As we see our present life,Commercial deliveries increases within cities, companies face a fundamental limitation in surface area capacity.But here is the solve,Deliver by drone aims to overcome that limitation all above city streets. It reduces our time.We use it on various purposes like as deliver medicine,products or even military components.It is help full for our societies people.Also it uses on dangerous area or flooded area where human can't delivery food or other relief's things during flooded season.

CHAPTER 2
BACKGROUND

2.1 Introduction

In this chapter, i discuss related works of my project, background information, some scope of the problems and challenges.It is help full for my project to solve some of problems. In this section, i discuss to identify the scope of the problems and my project challenges.

2.2 Related Works

In the past 2013-2015 years, the Amazon Prime Air service started by Amazon.com and its founder Jeff Bezos December 2013 declared an announcement. They were planning the rapid delivery of lightweight commercial products using UAVs.

In July 2014 it was revealed Amazon was tested 8th and 9th drone prototypes.Amazon delivery drone could carry a 5 lb (2.3 kg) package.

August 2014, google revealed it's one of programme "Google X" known as "Project Wing" announced a goal to produce drones that can deliver products sold via e-commerce.

In the same year month of septembar,The company named FedEx was tested integration of drone delivery.They used their previous logistics model.

February 2015, Ali Baba and Shanghai YTO Express started delivery drone service. Ali Baba delivered their tea to 450 customers around select customer's area in China.

In March 2016, Flirtey got their first fully autonomous drone delivery service in the United State.They also got drone delivery license.

Present 2020, UPS and Matternet started a medical delivery trial in Raleigh.It is located in North Carolina. The Wingcopter carried out a 2-week trial for delivering personal protective equipment.It deliver COVID-19 testing kits to the Isle of Mull, Scotland.

The related work of started drone delivery services has been extensively reviewed by "Drone delivery Wikipedia" at section Experiments, 3.1.1-3.1.2 .[4]

2.3 Scope of the problem

For every step of my task, there is so much problem i faced. Once i start a new job then it is not possible to define problems, but making this project, i can understand that Hardware model section is the most challenging works for working.Cause i designed 7 types of model but all those failed because of drone frame is too much weight.The motors can't produce high value of thrust for fly in the sky.

Also Drone programming part is similar difficulties for me to gain knowledge about new kind of function,new kind of software i used here.

2.4 Challenges

There are several challenges to complete my project.First i need to choose my drone frame.It will be Quad-copter or Hexa-copter or both. Then what brush-less motor i choose? I choose one type brush-less motor but are they produce enough thrust to carry a 2/3 kg payload.Then what will be the total weight?

What kind of gripping mechanism i selected?Are they gripe the payload hardly?While my drone fly in the sky,if the gripping mechanism not work?Will my drone avoid obstacles like wire,bird or wall?

It is a very challenging hard task i have never faced in my life.There are also many challenges i faced to do coding part of my drone.Also What kind of programming language i used in my project? What kind of ground controller is better for my drone?

There is so many challenges i faces but at last i say that my task is difficult, but it can be successfully completed.

CHAPTER 3

PROTOTYPE DESIGN EXPLANATION

3.1 Hardware Specification and explanation

3.1.1 Drone Mechanism: The drone mechanism consists of following components.

- Drone Frame
- Propellers
- Brush-less Motors
- ESC
- Gripping Mechanism
- Servo Motors

3.1.2 Raspberry Pi: The Raspberry Pi is also called as the mini-computer on a single chip.It's very useful mini computer for Programmer.Various generations of Raspberry Pi's have been released. The models of the RPi contains the broadband system on chip Broadcom BCM2711 SoC with a 1.5 GHz 64-bit quad-core ARM Cortex-A72 processor.It has the ability to interact with the outside world and has been used in a wide array of real life project like as my project.

3.1.3 Transmitter and Receiver:It's an autonomous drone that's why I need telemetry device to communication drone with ground controller. Telemetry is a device that can stream data two-ways, which can both send data about the flight down to a ground station (in our case, the Mission Planner) and send command up to the autopilot. The telemetry modules are the actual radio devices that transmit and receive the data.

3.1.4 Flight Controller/Pix-hawk: There are many kind of flight controller board outside in the market. But in my project i use Pix-hawk hardware system.It's easy to configure sensors and low cost.PX4 autopilot is an open-source autopilot system. It helps to build an inexpensive autonomous aircraft.

There are many sensors in the drone which are necessary for fly autonomously. Initial sensors like an accelerometer help the drone remain in flight to control motor speeds or surface deflections to steer the drone. Navigation sensors like a GPS module use for a specific specific waypoint or path routing to measuring the drone's location. Also,

magnetic sensors help the drone to fly along specific navigation to find out east, south, north, and west to the earth.

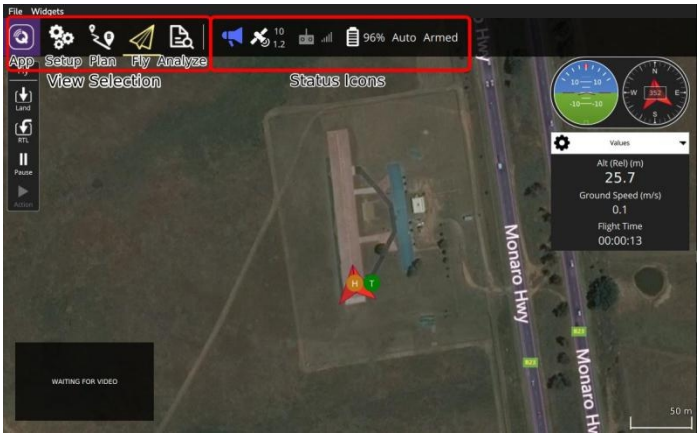
3.2 Software Specification and explanation

3.2.1 Programming Languages: The core Language I used here Python.It's easy to learn and implement although it's different for drone programming.

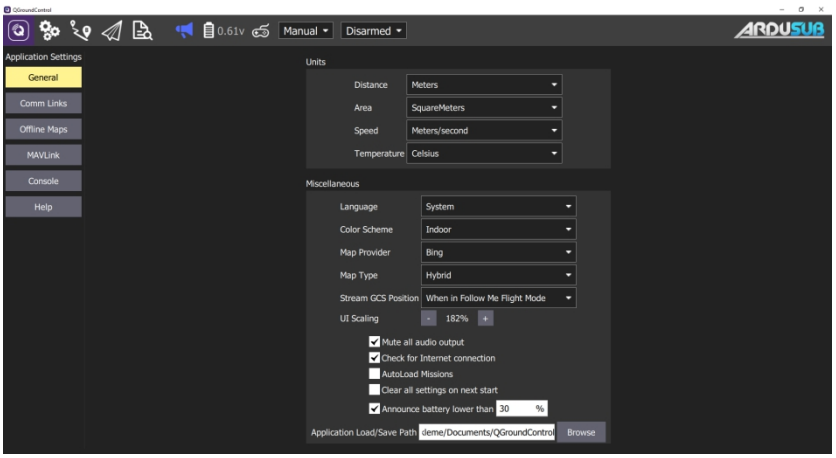
3.2.2 Open CV: It's a highly optimized library having the programming functions for the real time applications of the computer vision.The various algorithms in this platform are can be used for the face recognition, human computer interaction, mobile robotics etc.It supports the areas like the artificial neural networks and deep learning.Also implement in different languages such as java,python,C++ etc.

3.2.3 Raspberry Pi OS (Raspbian): Raspberry Pi is a Debian-based operating system for Raspberry Pi hardware and software.Raspberry Pi hardware is the most important component for drone cause it control the whole system of a drone include pixhawk autopilot.

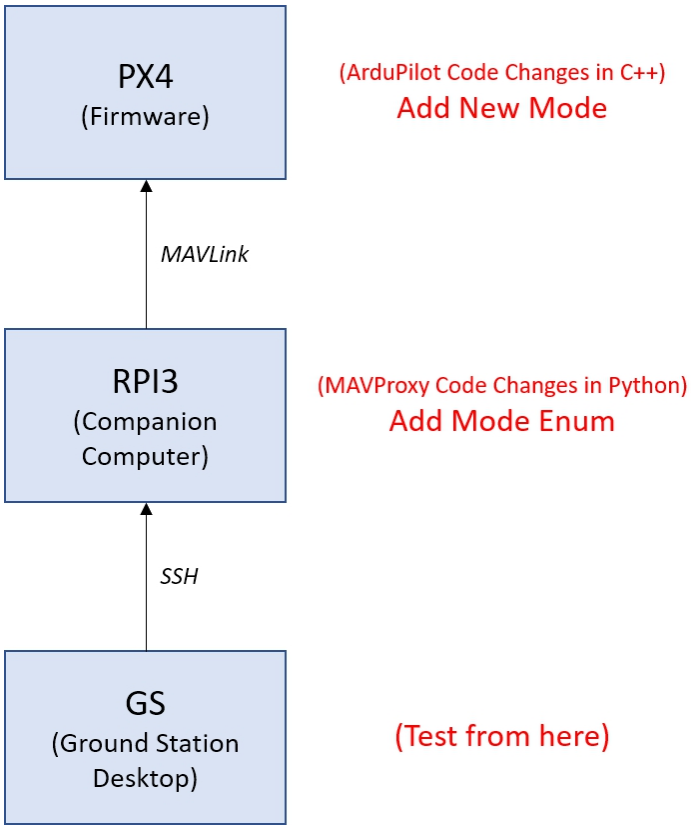
3.2.4 Ground Control Station: In my project i control my drone use my laptop and a software.It's called Qgroundcontroller. ArduPilot is an open source, unmanned vehicle Autopilot Software Suite capable of controlling autonomous drone.The ArduPilot software suite consists of navigation software running on the vehicle.



Fig(1). show the Ground-control set up



Fig(2).Ground control settings



Fig(3).Connection diagram of GC, Raspberry pi and Pix-hawk.

3.2.5 Mavproxy protocol and MavLink: First,Mavproxy and Mavlink are written in python.Mavproxy use for Ground control station uav system.Micro Air Vehicle Link (MAVLink) is a lightweight protocol to communicate with drone.It's easy to

configure.Both Ground control station and one-board raspberry pi needs it to control over network.Mavlink protocol also use for communicating raspberry pi with flight controller Pixhawk.Mavlink has some besic command that sent from ground station to raspberry pi then it load a script or it's destination command where it go pix-hawk.

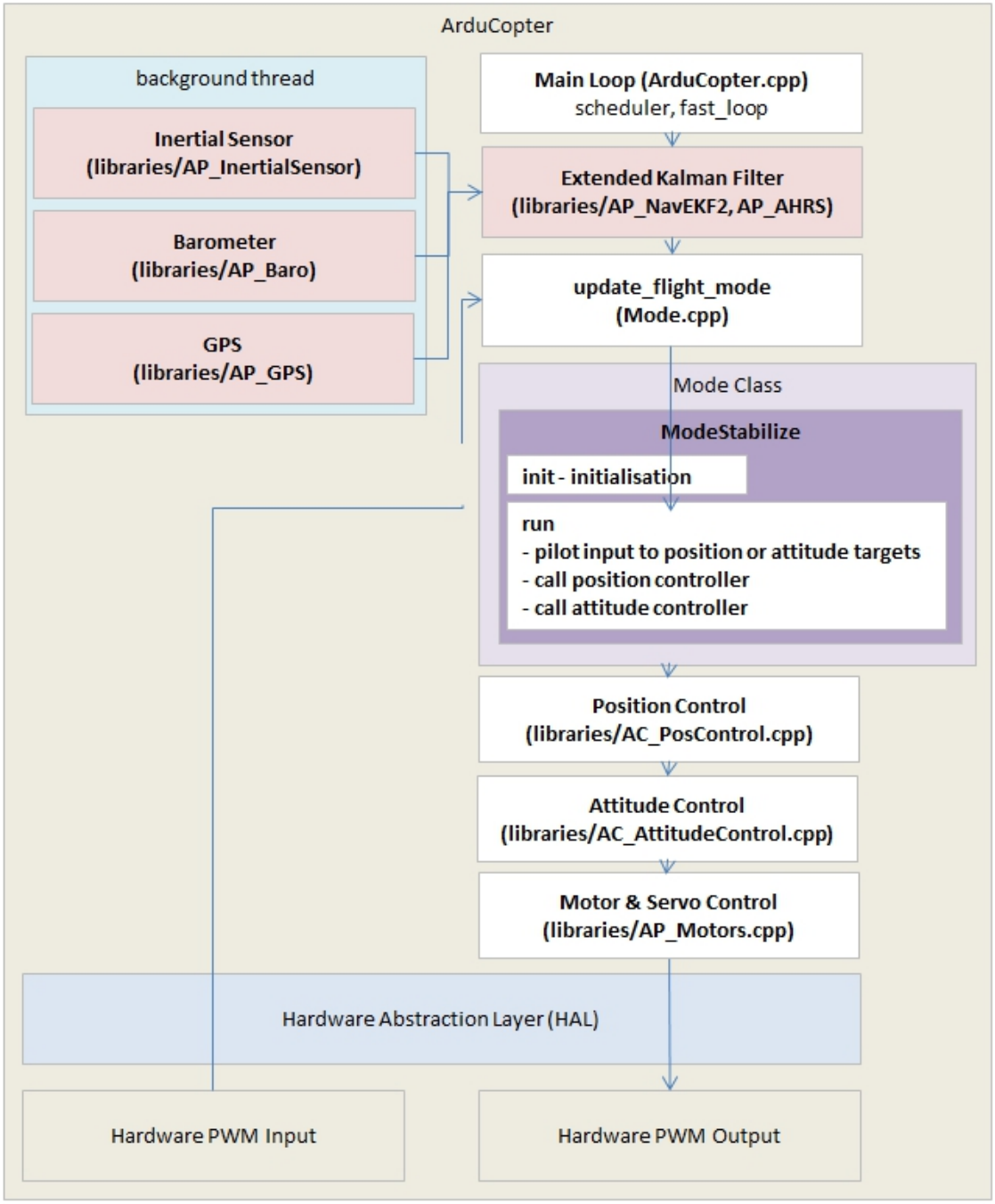
The mavproxy message guideline has been extensively reviewed by "Mavlink.io" website at section "Mavlink common message set"[7]

Byte Index	Content	Value	Explanation
0	Packet start sign	v1.0: 0xFE (v0.9: 0x55)	Indicates the start of a new packet.
1	Payload length	0 - 255	Indicates length of the following payload.
2	Packet sequence	0 - 255	Each component counts up his send sequence. Allows to detect packet loss
3	System ID	1 - 255	ID of the SENDING system. Allows to differentiate different MAVs on the same network.
4	Component ID	0 - 255	ID of the SENDING component. Allows to differentiate different components of the same system, e.g. the IMU and the autopilot.
5	Message ID	0 - 255	ID of the message - the id defines what the payload "means" and how it should be correctly decoded.
6 to (n+6)	Data	(0 - 255) bytes	Data of the message, depends on the message id.
(n+7) to (n+8)	Checksum (low byte, high byte)	ITU X.25/SAE AS-4 hash, **excluding packet start sign, so bytes 1..(n+6)** Note: The checksum also includes MAVLINK_CRC_EXTRA (Number computed from message fields. Protects the packet from decoding a different version of the same packet but with different variables).	

Fig(4).Mavlink message format

3.2.6 ArduPilot: ArduPilot is an open source software.It use for controlling unmanned vehicle autonomous.It has different type unmanned vehicle set up options such as multi-copter,helicopters,boats,unmanned submarine.It is written in C++, Python.

The specification of ardupilot has been extensively reviewed by Shobhan Singh "An Approach to Semi-Autonomous Indoor Drone System" at section 6.1, page 19-22.[3]

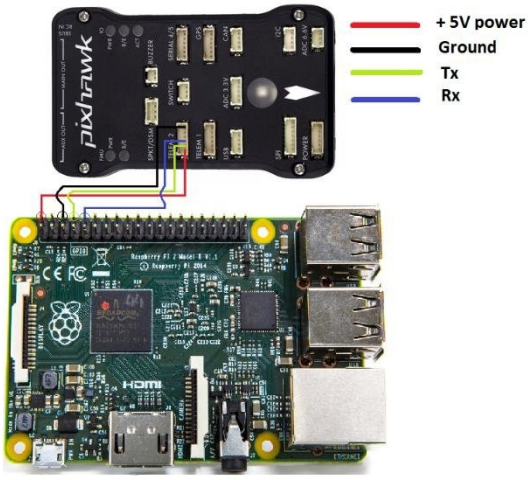


Fig(5).show the architecture of ardu-pilot.[3]

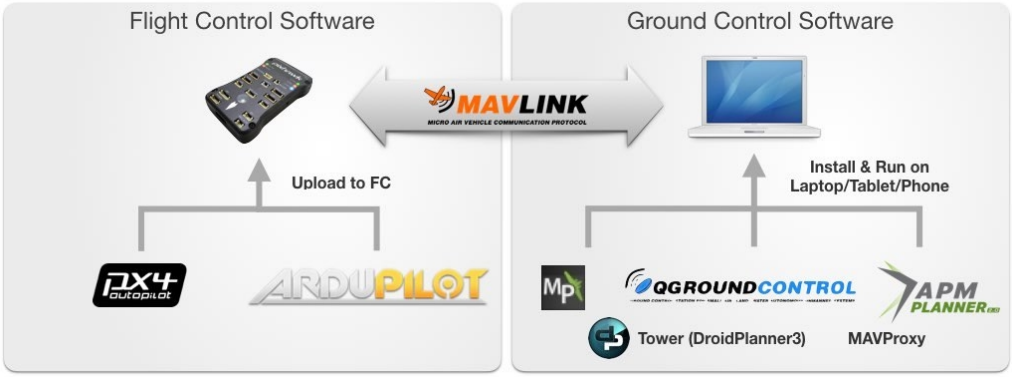
3.3 How it works?

In this section i explain how to configure Raspberry Pi (RPi) and communicate it with flight controller pix-hawk using the MAVLink protocol.For image recognition simply can't be done by the flight controller due to the memory requirements for saving images.

In my project,their are three main components and these components are Raspberry pi called brain of a drone,Pix-hawk called heart of a drone and Mavlink is help to communication between raspberry and pix-hawk .There is two telemetry port ,telematry1 port used for device and other one port connect to the Raspberry Pi Ground, TX and RX pins as shown in the Figure(6) below. The Raspberry Pi can be powered by connecting the red V+ cable to the +5V pin or from USB in



Fig(6).Raspberry pi and Pixhawk wire set up.



Fig(7).MavLink communication.

CHAPTER 4

SIMULATION AND TESTING

4.1 Simulation of Scripts

Here i control drone without RC transmitter/controller.So i need to do code for controlling drone and a ground station apps.In this section i describe the coding part of the drone.

For drone programming language ,i use python.Python is easy to learn and easy to implement.Python has many open source project and library. Drone-kit is one of the community driven project and it is open source project.It allows developers to create an app that run onboard companion computer.

It communicate with ardupilot flight controller using low latency link.It also be used for ground station apps and communicating with vehicles over a higher latency RF-link.Drone-kit communicate with vehicles using Mav-link Protocol.Here two python scripts were written to control drone when it is flying. One is execute_mission.py scripts that can locate specific location and find path to delivery the product and the other one is land.py that help to return drone to home.

Also Mavlink protocol has some command to control drone using Laptop or android device.There are two type of internet protocol use to communicate with network and vehicles .Those are TCP and UDP protocol.It helps to connect a remote ip address and control it from anywhere and the connection command is:

mavproxy.py --master=udpout:10.10.1.1:14550

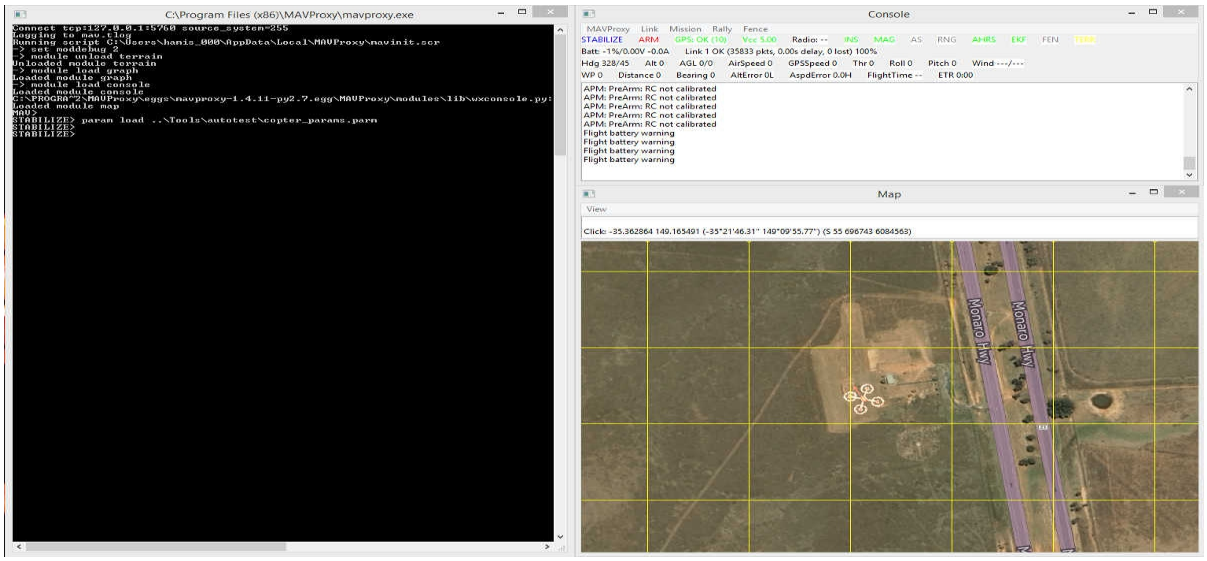
mavproxy.py --master=tcpout:10.10.1.1:14550.

mavproxy.py --master=/dev/ttyAMA0 --baudrate 57600 --aircraft MyCopter .

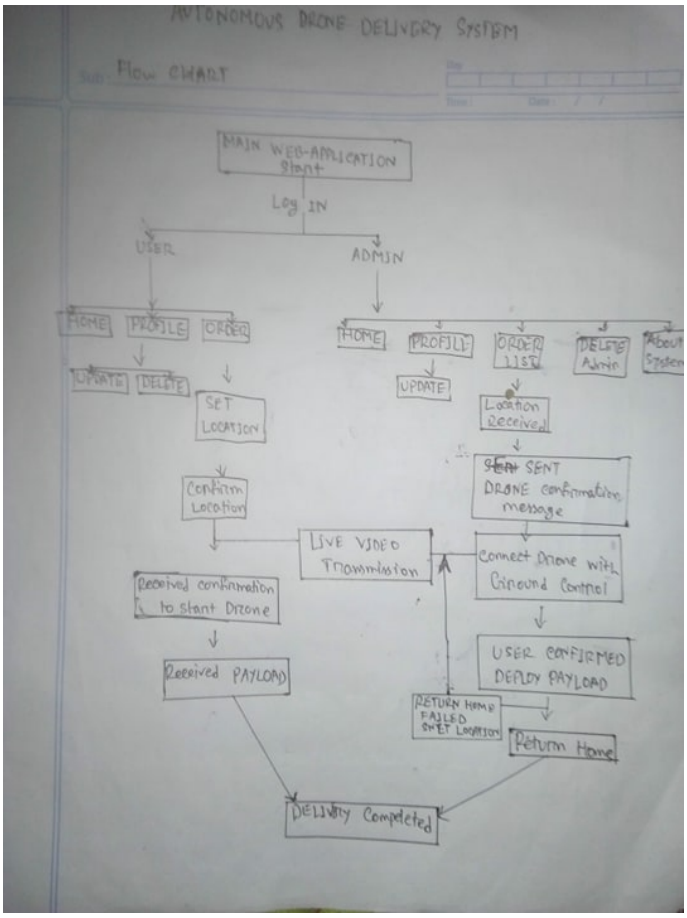
The mavlink's command guideline has been extensively reviewed by "Mavproxy" website at section "Over Network"[5]

Mavproxy has some default command to control drone in different mode.Like as Guided mode,RITL mode,Land etc.Fig(8) show the simulation of drone.

Fig(8). show the pix-hawk ardupilot simulation of drone.



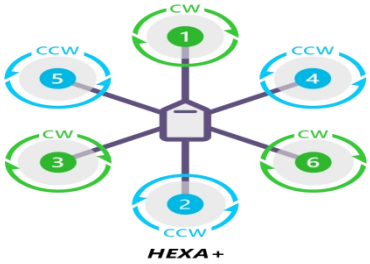
Fig(9). show the simulation of drone.



Fig(10). Flow chart of drone program.

4.2 Hardware Testing

In this section,i explain the hardware part of my drone.Actually it's a Hexa-copter.It has six axis and use six brush-less motor.The hardware of six motor set up are three motor rotate clockwise and the other three motor rotate anti-clockwise.Fig(11).show the rotation of motor.



Fig(11).Motor rotation set up[5]

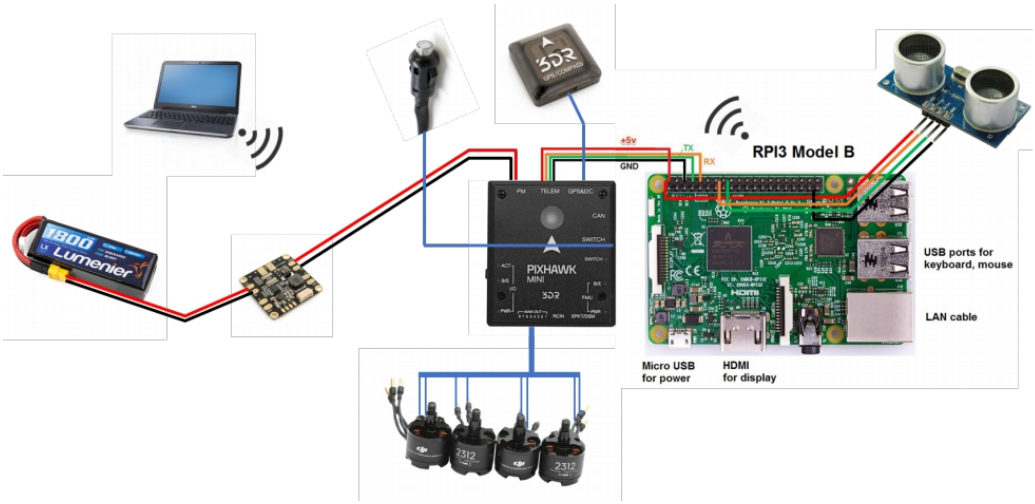
The analysis of the motor rotation set up has been extensively reviewed by Shobhan Singh "An Approach to Semi-Autonomous Indoor Drone System" at page 9-11.[5]

Each and every motor produce 400-670 gm thrust.so the total thrust calculation is 6*(400-670)gm = 2400-4020gm.So the total weight of the drone will be 3000gm or 3kg.But my drone frame, 3S Lipo battery and other components total weight is 1700gm or 1.7kg.

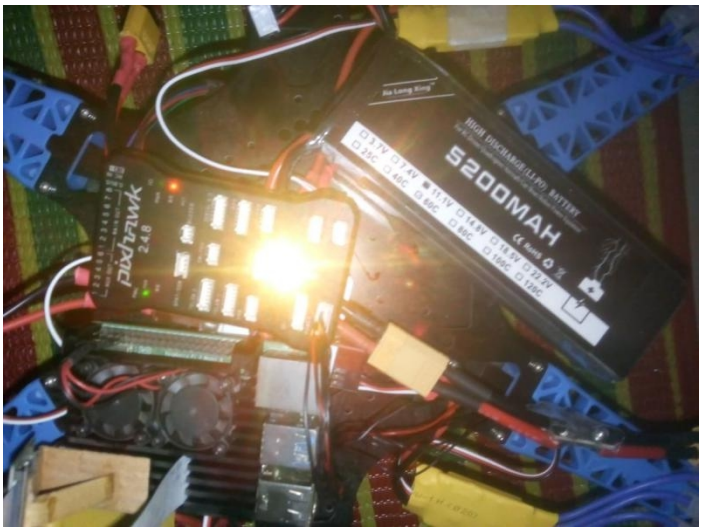
The payload size of the drone is(total weight - component weight)=(3000-1700)gm = 1300gm or 1.3 kg.So my drone can carry 1kg-1.4kg payload to deliver specific location in 3/4km.The range is limited to control drone in 3km because of limited power supply.And the drone fly time is 21 min.

If i give more power to the drone then it will be range free because of i connect with a specific ip address through mavproxy.but the power is limited,if i give more power cell lipo battery than drone will be heavy to fly.Also it's a cause to not fly with heavy weight.Fig(12).show how to set up all components.

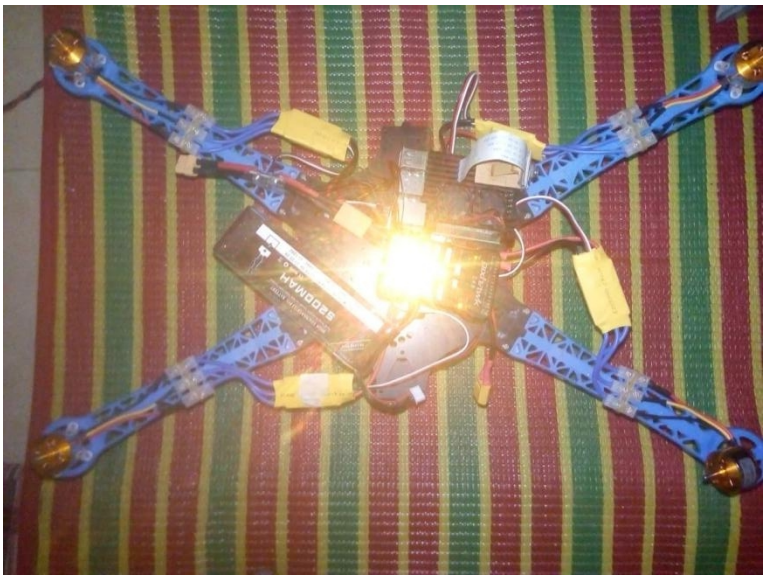
The analysis of the hardware components has been extensively reviewed by Jagadish S Jakati1, Sanyogita W.2, Akshata P.3, Sonali G.4, Namrata G.5, "AUTONOMOUS DRONE ROBOT" at section Methodology,page 2366-2367.[1]



Fig(12).Hardware architecture



Fig(13). the hardware set up



Fig(14) show the hardware set up

CHAPTER 5

THE GRIPPING MECHANISM

Designing the gripping mechanism for the delivery drone, several options are needed to be discussed and evaluated.The power of the motors and the thrust they produced is it enough to lift the packages.The power of the motors and the lift they could create needed to be evaluated.

The next steps would be how the box would be carried through the air, the delivery system as well as connecting the delivery system to the drone itself.Depends on What kind of mechanism is best for my drone.There are three kind of mechanism i found to set up gripping payload with drone.Those are

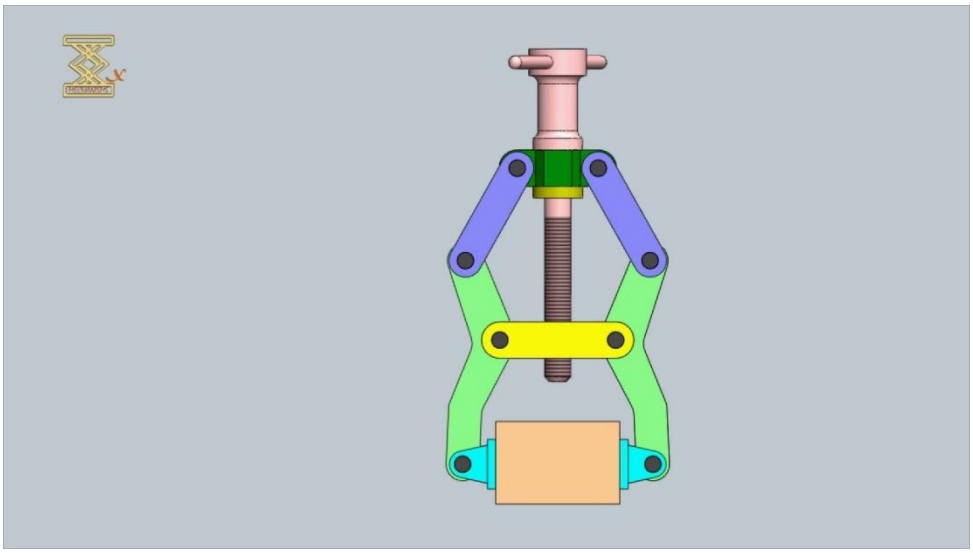
1.Clamp mechanism

2.Drone Attachment

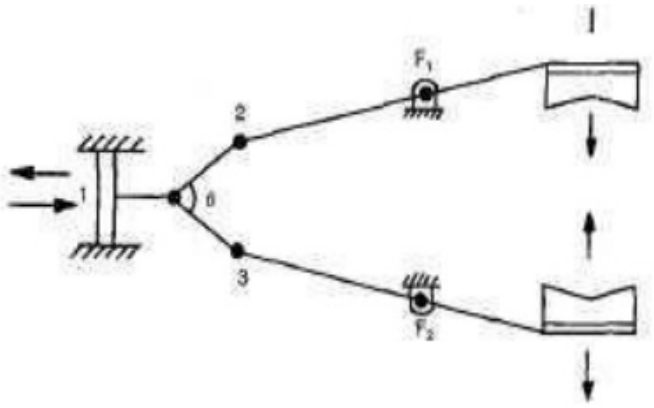
3.Long range click lifted mechanism.

The analysis of the gripping mechanism has been extensively reviewed by Muhammad H. Abdelraziq,Joe Reed "AUTONOMOUS DELIVERY DRONE" at section "TheMechanical System Design" page 25-32.[2]

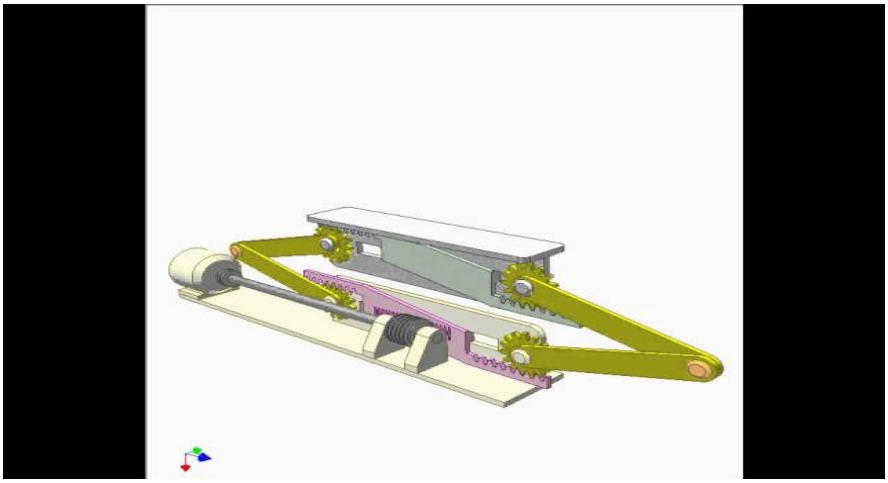
But in my case, my mechanism is combination of two stage.It has two stage.First one stage is uses for Long range click lifted mechanism and Second is two side clamping mechanism.First one is use for lifted the packet and second holding mechanism is the largest design challenge of the project. The design uses two clamps to hold a package.They can move forward and back-award using servo motor and gears and the all mechanism is 3d printed out.Attaching the clamping mechanism to the drone is a crucial part to frame design i have ever faced cause i failed to 3d print out three times and each of the time i failed and comes up different causes and gathered failed experienced.



Fig(15).show the Clamp mechanism



Fig(16) .show the drone attachment mechanism drawing.



Fig(17). show the Click lifted mechanism

The analysis of the Lifting mechanism as been extensively reviewed by thang010146 at YouTube.[6]

5.1 Gripping Mechanism Control System

In the beginners design plan, a Servo Motor SG90 motor was to be used to drive the gripping mechanism. it is a relatively small, cheap and light-weight servo motor.Further, the motor SG90 Servo Motor driver can interface directly with 3.3V and 5V logic circuits (Arduino or RPI3)but here the servo motor driver was wired and connected to raspberry pi port.

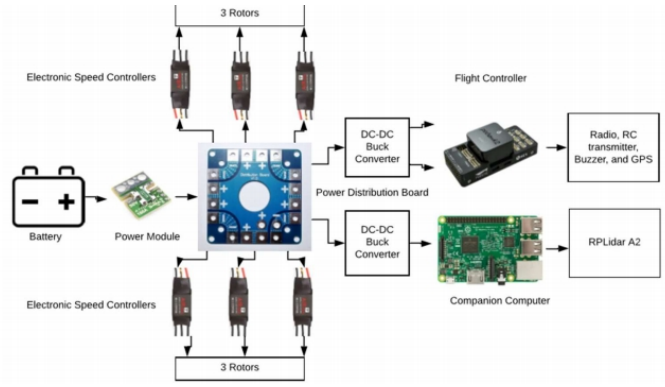
CHAPTER 6

POWER DISTRIBUTION

While testing the circuit board power distribution system, several critical problem i faced. First as, is Li-po battery give enough power to produce motors thrust to take off drone from ground? Second is , are all circuits and board can get proper distribution of power?

The first issue was resolved by increasing Li-po battery cell and mAH.Second issue resolved by useing the power distribution module and adding isolation and capacitors to prevent voltage spikes or drops. Power was supplied to the pix-hawk through two different ports (Power 1 and Power 2) as shown in Figure() . The Power 1 port is the main power port that feeds the Pix-hawk.Second one connect with ESC power distribution board.Power 1 is supplied with 5V and 4A (20W) from a dc-dc board converter while power 2 port is fed for 5V and 3A (15W) from the same converter. After enabling the second auxiliary power port on the flight controller, the flight controller and all mandatory hardware connected to it remained working even at 100% throttle and were not affected by any decrease in the battery voltage.Also i add another power source for raspberry pi connection.

Since the issue of the power module was discovered at a late stage in the implementation phase, there was no time to replace it with a new one. Consequently, to temporarily fix the power module, a tiny Zener diode was soldered to the power module board to enable correct voltage and current reading. The power module was tested, and it is working properly as intended.Fig(18). show the power distribution circuit.



Fig(18):power distribution set up.

CHAPTER 7

FAILSAFE MECHANISMS

Mission Planner & Pix-hawk is come out with a multiplicity of failsafe features that would ease vehicle recovery and prevent wandering if vehicle control is lost.The failsafe mechanisms that were configured and enabled are: Radio Failsafe, Battery Failsafe, Crash Check etc.

7.1 Radio Failsafe

Radio Failsafe is triggered when communication between the pilot's ground control telemetry transmitter and the flight controller's receiver is lost.. This can happen if the pilot turns off the ground control data transmitter or the RC transmitter loses power.When the radio failsafe is triggered while the drone is armed and flying, the drone will switch to RTL mode.If drone can't find location then it will fly back to home location and land.Otherwise, if the radio failsafe is pressed when the drone is armed but has landed or has not taken off yet, it will force the drone to disarm quickly.

7.2 Battery Failsafe

This failsafe mechanism is triggered once the battery voltage drops below a selected value or the remaining capacity is below a minimum allowed value. Once triggered, a warning message will be displayed in red in the ground station control and a loud alarm will be played. If the pilot does not respond for 30 seconds, the drone will immediately land at safe location.

7.3 Crash Check

The Ardupilot developers recently added failsafe feature to their Ardupilot system and it triggered if the following conditions are true for 2 seconds:

- Drone is armed
- The vehicle has not landed the distance flight controller can sent message to gsc.
- The vehicle is not changing position.
- The actual lean angle of the drone is more than the maximum allowed lean angle.

Once triggered, the motors will disarm quickly.

The analysis of the fail safe mechanism has been extensively reviewed by Muhammad H.Abdelraziq,Joe Reed "Autonomous delivery drone".page 42.[2]

CHAPTER 8

BUDGET AND OVERALL COST

The overall cost of the project shown in below table (1).The main electrical parts flight controller, the raspberry pi, the telemetry radio, and the 3DR GPS module cost around $841 which is 37% of the whole assigned budget. Other common electrical components like the RC receiver, the micro memory card for the raspberry pi, and the I2C isolation board for the power distribution system and this cost approximately $225. The overall cost of the prototype was $1120.00- $1554.55.

Components	Amount
Raspberry pi , Aluminum Heat Sink	$ 67.60
Pixhawk , Vibrator absorve frame	$ 200.00
Brushless Motors	$ 55.00
3dr Gps module	$ 65.83
Telemetry Device	$ 74.65
Drone Fame	$ 70.00
Gripping Mechanism	$ 195.00
Servo Motor SG90	$ 7.00
Propeller	$ 12.00
Power distribution modules	$ 16.00
Esc	$ 53.19
Esc power distribution board	$ 6.69
3s Li-po Battery	$ 73.69
HD Action Camera	$ 245.60
Nuts, Screws, Glue, Duct Tape, etc.	$ 47.83
MicroSD Card	$ 25.69
Clamping Shaft Collar	$ 21.17
T-shape Connector male, female	$ 9.00
Xt-60 Connector male,female	$ 11.17
The Cube with Standard Carrier Board	$ 225.00
Total	$ 1490.24

Table 1: Total estimate cost of my project

CONCLUSION

After ordering all necessary components on online and writing all the Python scripts, the assembly and the testing of the drone took one month.A lot of time was spend on troubleshooting issues and learning necessary skills needed to complete the prototype.After the assembly stage, the final prototype included a robust sensor package integrated into the flight controller, GPS, anti-vibration rubber bane , power isolation boards to protect the sensitive costly electric circuit board and other components, and a new kin of gripping mechanism.

This prototype can perform autonomous missions with the gripping mechanism attached to the drone's bottom.The delivery drone prototype has passed several rigorous tests to ensure safety, however, the more i test ,more safe data i collect.Delivery drone can't harm to our environment. It's nature friendly and there are no greenhouse effect comes out of it. This is only true if the drone is used for small packages in small areas like University campuses or small residential areas, small city. Finally, this prototype delivery drone can be easily modified into a multipurpose drone for different kind of job.

APPENDIX

I have faced so many problems to complete my project and that first was methodology selection. This project was so hard for me because only some works done before with different ways but it's not open source,it is done by private company.I have to collect data from different online platforms, manipulate them to train my model for image processing.
I made a new gripping mechanism that get a better strong rate successfully. Successfully my gripping mechanism model gets the best classification result from other company model.My development task was very difficult and i successfully overcomed it.

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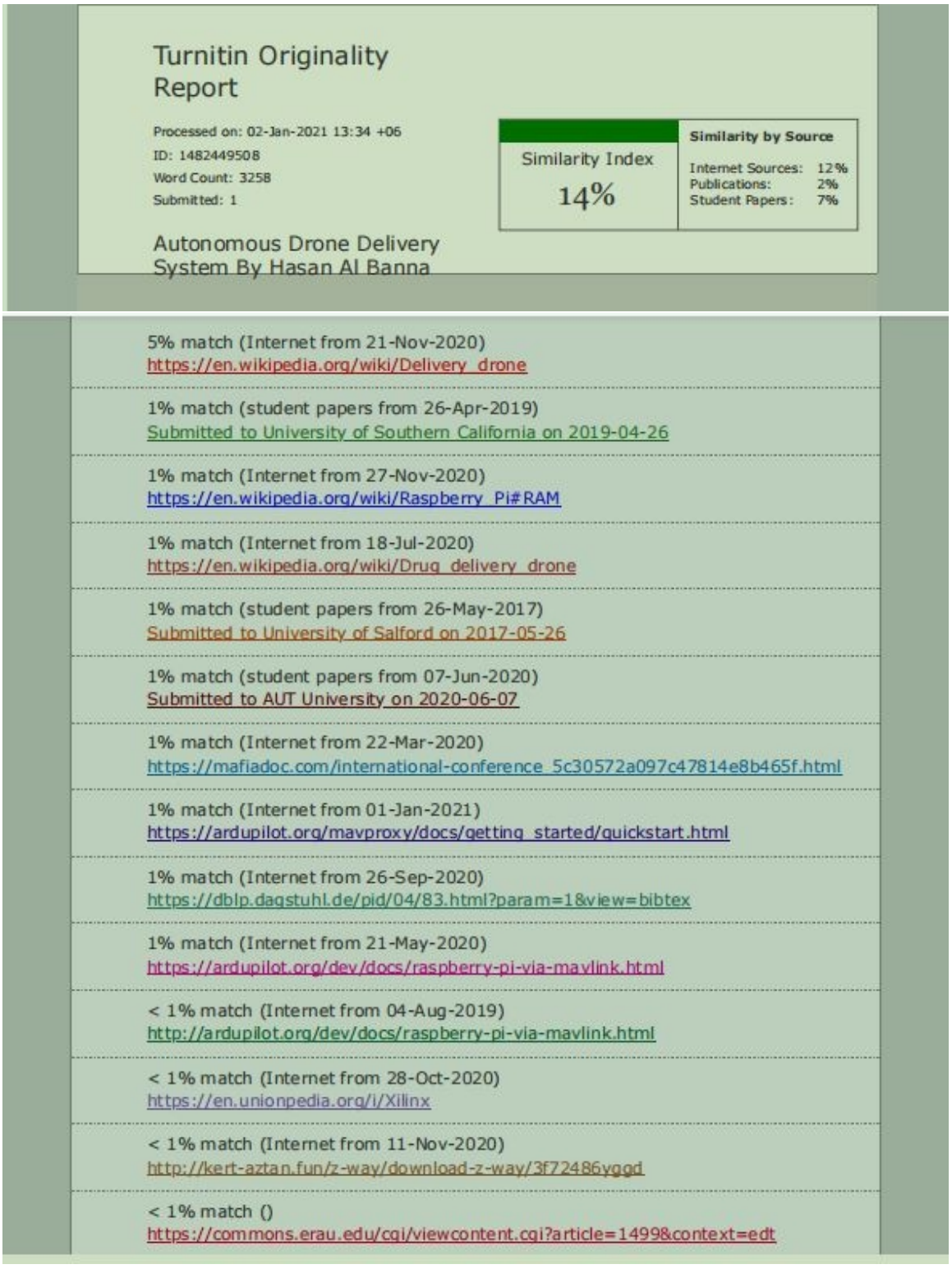

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