WEAPON MOUNTED DRONE

FINAL YEAR PROJECT UG 2020

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ABSTRACT

This report presents a method for development of a Quadcopter with a Weapon Mounting Assembly. The project is a better solution not only for monitoring but also for engaging targets and disrupting enemy formations. Its unique characteristics like high operational speed, more stability and target acquisition will allow our troops to surprise the enemy beforehand. The proposed Quadcopter would be capable of the vertical take-off and landing feature like a rotary wing aircraft and the four propellers design provides more stability and high maneuvering capability during the target engaging process. The thesis focuses on the development of a Quadcopter with a Weapon Mounting Mechanism which is to be used in the challenge. There are two main goals with the thesis. The first goal was to create a computer model of a Quadcopter with a Weapon Mounting Mechanism to be used in a simulation software called SolidWorks. The second goal was to use the results from the simulation to build a real Quadcopter with a Weapon Mounting Mechanism which can be used in the field. The Quadcopter construction was based on own designs and all fabrication of parts for the Weapon Mounting Mechanism was done using SolidWorks and 3D printers.

ENDORSEMENT OF CORRECTNESS AND APPROVAL

It is affirmed that data presented in this thesis "**WEAPON MOUNTED DRONE**" carried out by 1) Capt Muhammad Shafqat 2) Capt Attique Janjua 3) Capt Syed Muhammad Hamza 4) Capt Valeed Ajmal 5) Capt Syed Muhammad Qasim Shah under the direction of Maj Ajlaan is in complete satisfaction of our level of Bachelor of Telecommunication Engineering, is right and endorsed. Percentage of plagiarism found in document as per software Turnitin available on LMS NUST comes out to be

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DECLARATION

We hereby declare that no content and variety of work bestowed during this thesis has been submitted in support of another award of qualification or degree either during this course or anyplace else.

This proposition is devoted in thanks to **ALLAH ALMIGHTY**, our Creator, who has blessed us with wisdom, knowledge and understanding, then to our parents for their direction and their endless support. I would also like to thank our faculty for their guidance and supervision. Without their help and supervision this project would not have been made possible.

ACKNOWLEDGEMENT

The accomplishment of this project would not have been possible without the contribution of different people; the names of which cannot be reckoned with. Their assistances are sincerely respected and thankfully recognized. We would like to thank following:

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- Maj Ajlaan for his support and guidance during the entire project.
- We acknowledge our sincere indebtedness and gratitude to our parents for their love, dream and sacrifice throughout our lives. We are thankful for their sacrifice, patience, and understanding that were inevitable to make this work possible. Their sacrifice had inspired us from the day we learned how to read and write until what we have become now.
- Lastly, we would like to thank any person who contributed to our final year project directly or indirectly. We would like to acknowledge their comments and suggestions, which were crucial for the successful completion of this study.

Table of Contents

ABSTRACT ii

ENDORSEMENT OF CORRECTNESS AND APPROVAL iii

DECLARATION iv

DEDICATION vi

ACKNOWLEDGEMENT vii

ABBREVIATIONS x

Chapter 1 1
1.1 Introduction 1
1.2 Goal and Purpose 2
1.3 Problem Statement 2
1.4 Thesis Limitations 2
1.5 Prospective Application Areas 2
1.6 Scope and Objectives 3
1.7 Specifications 3
1.8 Deliverables 3
Chapter 2 4
2.1 Literature review 4
2.2 Related Work 4
2.3 Conclusions from Related Work 5
2.4 Theory and Background 5
2.4.1 Multi-copters 6
2.4.2 Frame Design 7
2.4.3 Other Parts 7
Chapter 3 11
3.1 Detailed Design 11
3.1.1 Software & Simulation 11

3.1.2 Weapon Mounting and Firing Mechanism 11
3.1.3 Controlling Components 13

Chapter 4 15
4.1 Analyses and Testing 15
4.1.1 Method 15
4.1.2 Choosing the Frame 15
4.1.3 Layout of the Circuit 16
4.1.4 Integration of Modules 18
4.1.5 Test Outcomes 19
Chapter 5 21
5.1 Problem Statement Answers 21
5.2 Recommendations and future work 23
5.3 Safety and Rules 24
5.4 Conclusion 25
References 27
Appendix A 28
Appendix B 30

ABBREVIATIONS

1. **3D** Three Dimensional
2. **AC** Alternating Current
3. **ADC** Analog to Digital Converter
4. **DC** Direct Current
5. **ESC** Electronic Speed Controller
6. **GPS** Global Positioning System
7. **GUI** Graphical User Interface
8. **LiPo** Lithium-ion Polymer
9. **RADAR** Radio Detection And Ranging
10. **RPM** Revolutions Per Minute
11. **UAV** Unmanned Aerial Vehicle
12. **RoHS** Restriction of Hazardous Substances

Chapter 1

1.1 Introduction

The use of drones is steadily increasing, and they incorporate many different areas of technology. A study made by Single European Sky ATM Research (SEASAR), which is project run by the European Commission, predict that before 2021 there will be more than 5 million drones in circulation just for leisure and daily essential detours, then on top of that there is also military, government and commercially used drones. Expected mission types for drones are different types of surveying and light load movement [5]. For a drone to be able to interact with the real world and have the capability to engage in a battlefield it needs to be fitted with some external weapon. This thesis focuses on constructing a drone that can carry a weapon by integrating a control system for a Firing module with an on-board microcontroller. The main theme is to create a multi-copter with the capability to search for, pick up and target any hostile target in the battlefield. It will consist of a multi-rotor copter (hereafter referred to as a "quad-copter") that will be capable of stable flight with manual radio control. While there are many flight controllers, we will use a prefabricated N3 DJI Flight Controller used for multirotor and will add more efficiency and power to our quad copter. More specifically, our goal is to implement an Arduino microcontroller as to program the quadcopter and the weapon to synchronize and hit the target with accuracy and precision. The purpose of this report is to familiarize you with the benefits of this project after induction in the Pakistan Army.

1.2 Goal and Purpose

The first goal of this is to create a computer model of a drone with a Weapon Mounting module attached to be used in a simulation program. The lessons learned from the simulations are to be used to aid in the development of the real drone. The second goal, which in part will be based on the results from the first goal, is to design and choose the mechanically related parts for the drone as well as constructing a lightweight, sturdy, gripping Weapon Mounting module to be placed under the drone and integrating it with the remote controls using Radio signals and microcontroller. The purpose of the project is to give Pakistan Army ascendency over our enemies in the field of weapons and technology.

1.3 Problem Statement

- Why is it important to create a weapon mounted multi-copter, to provide a foundation and force multiplier for the Pakistan Army?
- What is important to consider when constructing a multi-copter with a Weapon Mounting module, and how does the module affect the multi-copters performance?

1.4 Thesis Limitations

The thesis is focused on building and choosing parts for a drone with a controllable Weapon Mounting module and since the market for drones and drone parts is quite big it means there are many configurations available. Parts for the Weapon mounting Mechanism however are rarely tailored to a specific drone and therefore the project naturally puts more construction focus on the Weapon Mounting mechanism. The fabrication of parts for this module will make use of Three-Dimensional (3D) printers and the Computer-Aided Design (CAD) software SolidWorks and strive to produce prototypes at the low cost of Aluminum filament. There will be no design or production of electronic parts which means that as far as possible prefabricated parts will be used, that includes motors, motor controllers, PCB boards, flight control computers, etc. The flight control of the drone will be handled by a PX4 compatible flight controller and will therefore not be developed independently.

1.5 Prospective Application Areas

1. Defense and military applications to localize fire support etc.
2. Police and paramilitary forces, to enable precise and quick response.
3. In buildings to pinpoint potential break-ins.
4. This project will add a new offensive surveillance system.

1.6 Scope and Objectives

The scope of this project was to achieve the following objectives,

1. Planning a remote technique to engage the enemy
2. Understanding the behavior of environments
3. Designing an algorithm for calculating the time delay of the firing mechanism
4. Implementing the live feed from the drone on a Smart Tablet

Following are the goals we achieved with the project

1. Efficiently automating the firing Mechanism
2. Modular design, we can add Brushless Motors and ESCs and other drone parts for the flight of the drone
3. Recoil Mechanism absorbs the recoil of the weapon effectively

1.7 Specifications

1. Aluminum frame
2. Recoil Mechanism
3. Weapon Mounting assembly
4. Android device for live feed
5. Camera

1.8 Deliverables

1. Aluminum Frame
2. Camera live feed with Android device
3. Automatic weapon firing Mechanism

Chapter 2

2.1 Literature review

By mounting a weapon on a drone which is also capable of surveillance is responsible for detecting a target, based upon its video live feed, and displaying the results in a GUI over an Android device. Following are the functions performed by the drone.

1. Lock the target where the enemy is located
2. Engage the target using the remote controls
3. Evaluate time delays between the signals received from multiple sensors
4. Display on GUI android device

2.2 Related Work

In the report Avian-inspired grasping for quadrotor micro UAVs [1] researchers at Pennsylvania University focus their efforts on a quick pickup of an object by imitating the behavior of an eagle grasping its prey. Drones are not energy efficient and by having a quick pick up resources can be used elsewhere like giving the drone a longer reach. A high level of integration is needed between manipulator and navigation system for the solution to work.

Object manipulation from a drone in flight using a manipulator require kinematic and dynamic models as well as a navigation system that can tolerate reaction forces from the external environment. In the paper Aerial Manipulation Using a Quadrotor with a Two DOF Robotic Arm [2] the authors take the arm into consideration when creating the mathematical model instead of regarding it as a disturbance to the PID controller.

ROS is very useful when controlling a robot and in the paper on 3D Simulators for Multirobot Systems in ROS: MORSE or Gazebo? [3] several alternatives for simulation to go with it are presented. Most simulators use C++ programming language except for MORSE which is Python based. The most supported and used simulator is Gazebo which is maintained by Open Source Robotics Foundation which also maintain ROS. The results from the study showed that MORSE could simulate at a higher real time factor than Gazebo under heavy load. Both simulators are open source and free to use.

There is a lot to take into consideration when constructing a multi-copter and in the paper Design and Prototyping High Endurance Multi-Rotor [4] design and analysis is thoroughly looked at in spite the disadvantages of multi-rotor air crafts such as reliance on heavy batteries and the need for constant propulsion.

2.3 Conclusions from related work

Attributes that need to be defined that are related both to the Firing and Weapon mounting mechanism are being manipulated and are as following:

1. Circumstances: Depending on under what circumstances the Weapon will fire, it can require higher levels of integration of the control system for the manipulator. If the weapon is firing under a controlled, uniform, situation it requires a less complex control system meaning it can be more robust and have a bigger chance of success.
2. Size: The size of the object matters and affects the size of the mechanism, and in what way the mechanism needs to absorb the recoil of the weapon. The shape of the module that will hold the weapon is therefore affected directly by the size of the drone.
3. Shape: Either a generic way to mount the mechanism needs to be used or a more tailored solution based on what the intended object to pick up is. If the shape is very difficult to mount the weapon and firing mechanism it might need to be less generic.
4. Surface friction: The way a weapon fires is dependent on the size and type of the weapon that will be used, if it has a greater recoil it will generate an inward force and if the friction of the weapon holding assembly is not powerful enough then the surface friction generated will need to mitigate the force of gravity in another way.
5. Control: A control system with plenty of community support while developing can be helpful during development.
6. Simulation: To be able to test a robot before it is used a simulator can save a lot of time and resources.

2.4 Theory & Background

The theory relevant to this thesis can be divided into three parts:

1. Multi-copters: Describes what the different parts are called and what relevance they hold and how they work.
2. Software & simulation: Explains what software is intended to be used mainly for simulation.

3. Weapon Mounting Assembly: Contain information about different mechanisms for absorbing the recoil and firing the weapon at the aimed target using the camera live feed and wireless firing module.

2.4.1 Multi-copters

A multi-copter, more commonly known as a drone, is a helicopter with more than two propellers. Different types are called quadcopter see in figure 2.11, hexa-copter see in figure 2.12 and octa-copter see in figure 2.13, where quad, hex, and octal stands for how many propellers the multi-copter have. More than two propellers make the multi-copter easier to control compared to a helicopter, but at the expense of the load capacity and fly time. The structure of a multi-copter can be varied to look very differently depending on what is needed, the key design feature however is to keep the propellers in a symmetric pattern. [6] The illustrations below show common quad-, hex- and octa-configuration.

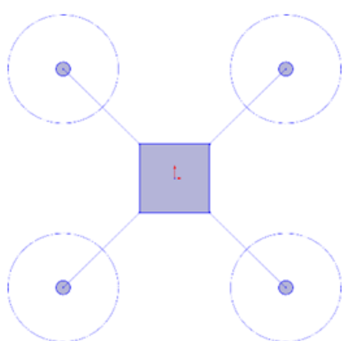


Figure 2.11: Quadcopter

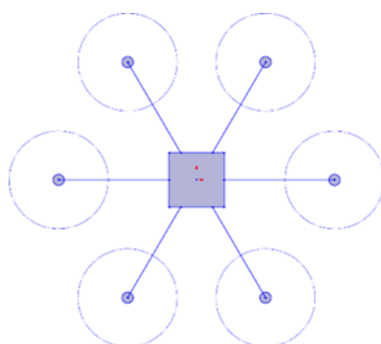


Figure 2.12: Hexa-copter

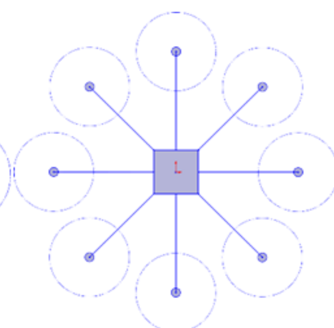


Figure 2.13: Octocopter

The propeller on a helicopter uses a pitch mechanism while a multi-copter has a fixed pitch. This means that a helicopter can keep a constant speed on the propeller while using the pitch mechanism to move, the multi-copter need to change the rotation speed on some rotors to be able to move. By increasing and decreasing the speed on the motors the multi-copter can create different movements, up, down, forward, backward, pitch, roll and yaw. Changing the speed up and down requires more energy than changing the pitch mechanism in a helicopter. We have selected a quadcopter design which will be the base of this project and effect all the corresponding steps.

2.4.2 Frame Design

The frame is basically the body of the multi-copter. Shape and material can vary depending on size and design. A larger frame often has more arms than a small frame and a large frame is often built in carbon fiber or aluminum or both combined while a small one often is in plastic. The motor axes create a circle and the diameter of this circle is used to specify the size of the multi-copter. The size is usually measured in millimeters. This size determines the maximum size of the propellers and by adding longer arms larger propellers can be used.

2.4.3 Other Parts

1. **Propellers**

   a. **Size & pitch**: Propellers are normally named after their size and pitch by referring to a four-digit number. The two first digits describe the radius and the two last digits describe the pitch, both measured in inches. The pitch is the distance a propeller would move in one revolution if it were moving through a solid like a screw.

   b. **Material**: Commonly used material for propellers is carbon fiber, plastic, or wood. Carbon fiber is more expensive than plastic and wood but has the advantages such as less vibration, lighter and stronger.

   c. **Number of blades**: The blades on the propeller can vary and the most common are two, three or four blades. By increasing number of blades, the characteristics are changed, more blades result in a higher thrust while the efficiency is decreased.

2. **Motors**

   The most common motor used on a multi-copter is brushless Direct Current (DC) motor, this due to a high efficiency, small size and low cost. Some important parameters are the following:

   a. **Size**: The name of a motor for multi-copters often contains a four-digit number. This number specifies the size of the motor in millimeters. An example is the Sunnysky X4110S 460KV, where 4110 is the number specifying the size. 41 is the diameter of the stator while 10 is the height, so this motor has a stator which is 41 mm wide and 10 mm high.

b. **KV**: When choosing to motor the KV value is important. This is a value that describes the motors rotation relative to the voltage supplied, the Revolutions Per Minute (RPM) per Volt (RPM/Volt). For example, when powering the previously mentioned Sunnysky X4110S 460KV with 22.2V, it would rotate:

$KV * V = RPM \Rightarrow 460 * 22.2 = 10212\ RPM$

If looking at the Arris X2205 2300KV which has a higher KV value, this would rotate:

$KV * V = RPM \Rightarrow 2300 * 16 = 36800\ RPM$

The value describes the speed of the motor without a load, when adding a propeller, the speed will decrease depending on the propeller specifications. A motor with low KV is often able to generate more torque than one with a high KV and is therefore more suited drive a larger propeller. Low KV combined with high torque gives a slower but heavy-lifting multi-copter while a motor with high KV would be better for a low weight racing drone due to the speed.

c. **Thrust to weight ratio**: This is a useful guideline when building a multi-copter. It says that the thrust of all the motors together should be at least twice the weight of the drone. This guideline is used to

$$\frac{\text{Thrust}}{\text{Weight}} = \text{Thrust-to-weight ratio}$$

ensure that the motors always have enough thrust to handle, e.g. situations where it needs to make rapid movements or strong winds. It is calculated by the following formula:

d. **Thrust**: The following two tables, figure 2.14 and figure 2.15, show the specification of the previous two mentioned motors. This tables are provided by the manufacturer. The thrust depends on which propeller and what voltage is provided. As seen in the tables, the

Sunnysky X4110S 460KV have a maximum thrust of 2520 gram while the Arris X2205 2300KV has a maximum thrust of 1010 grams. The total thrust is calculated by multiplying the thrust with the number of motors. For example, if a hexacopter was provided with the Sunnysky X4110S 460KV it would give a maximum total thrust of:

$$\underline{\mathbf{6 * 2.52 = 15.12kg}}$$

Propeller	Voltage (V)	Current(A)	Power (W)	Thrust(G)	Speed (RPM)
T5040-3	12	5	60	280	13513
		10	120	480	17857
		15	180	630	20408
		16.3	193	660	20833
	16	5	80	330	14705
		10	158	555	19230
		15	238	730	22222
		20	320	880	24390
		24.4	400	1010	26315

Figure 2.14: Arris X2205 2300KV

Prop (inch)	Volts (V)	Amps (A)	Thrust(g)	RPM (RPM/Min)	Watts (W)	Efficiency (g/W)
APC1238	22.2	1	320	3215	22.2	14.41441441
		2	500	3990	44.4	11.26126126
		3	650	4475	66.6	9.75975976
		4	820	4842	88.8	9.234234234
		5	940	5160	111	8.468468468
		6	1050	5400	133.2	7.882882883
		7	1140	5700	155.4	7.335907336
		8	1260	5900	177.6	7.094594595
		9	1380	6111	199.8	6.906906907
		10	1490	6282	222	6.711711712
		12	1670	6635	266.4	6.268768769
		15	1910	7000	333	5.735735736
		18	2100	7290	399.6	5.255255255
		21	2320	7600	466.2	4.976404976
		24.6	2520	7900	546.12	4.614370468

Figure 2.15: Sunnysky X4110S 460KV

3. Electronic Speed Controllers (ESCs)

An ESC is an electrical circuit that is used to control the speed on the motor. This is done using a Pulse-Width Modulation (PWM) signal which the flight controller circuit sends to the ESC. Based on the PWM signal the ESC transform the power from a DC battery to a three phase Alternating Current (AC) like signal which control the speed of the motor.

4. Batteries

One of the most used batteries for multi-copters is the Lithium-ion Polymer (LiPo) battery. Two important parameters when describing batteries are the capacity, measured in ampere hours (Ah), and voltage, measured in volts (V). The nominal voltage of a single LiPo cell is 3.7 V, and when fully charged it can reach up to 4.2 V. LiPo batteries are often described with an S-number, like 1S, 2S, 3S etc. This refer to how many cells connected in series are in the battery. For example, a 2S is equal to 2 3.7 = 7.2V while a 6S is equal to 6 3.7 = 22.2V. Easy to remember is that in a battery connected in series increase the voltage whereas a battery connected in parallel increase the capacity. We are using 2200mAH (LiPo) Battery for this setup.

Chapter 3

3.1 Detailed Design

The project is divided into two major parts, the hardware, and the software. The hardware consists of Aluminum Frame of the quadcopter and the Weapon Mounting Assembly. The software part consists of SolidWorks which is used to design the structure and test the functioning of the drone. A camera is also mounted to determine and display live feed on a GUI.

3.1.1 Software & Simulation

The software uses several programs for both 2D and 3D designs. SOLIDWORKS is used to develop mechatronics systems from beginning to end. We will use the software for planning, visual ideation, modeling, feasibility assessment, prototyping, and project management. The software is mostly used for design and building of mechanical and software elements. It can be used for device management, analytics, data automation, and cloud services. The overall design was made on SolidWorks and looks like this:

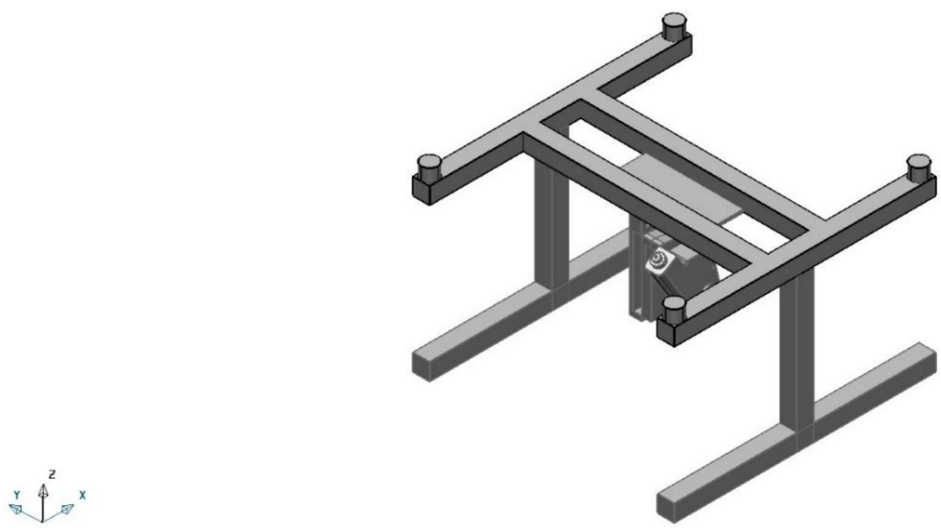


Figure 3.1: Aluminum Frame Structure layout

3.1.2 Weapon Mounting and Firing Mechanism

In this thesis these three types of mechanisms for creating motion that can be used for firing a weapon countering Recoil of the weapon, have been considered:

1. **Firing Mechanism**: Worm gears are gears where one of the gears have a screw-like thread which drives another gear, often resulting in a movement

change of 90◦. The movement transferred when the worm slides on the gear resulting in higher friction then a regular gear pair.[7]

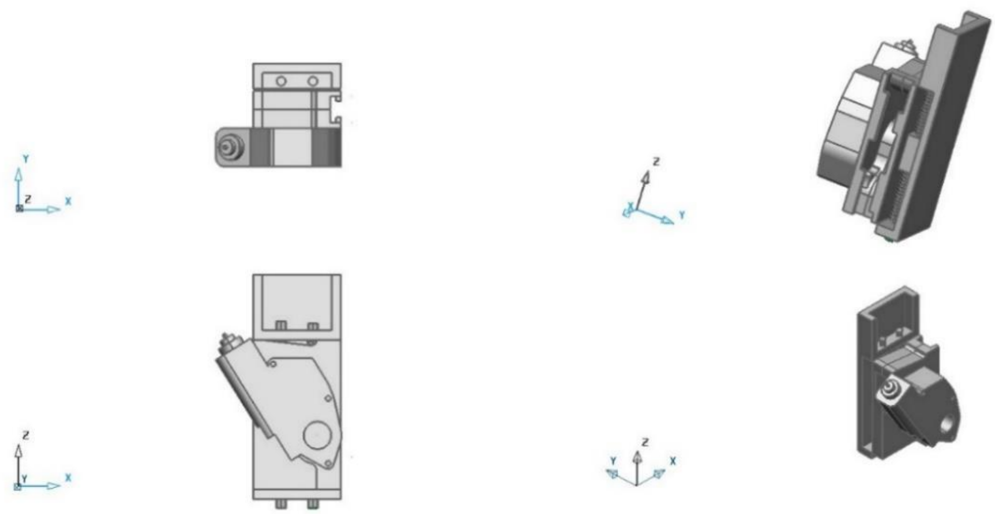
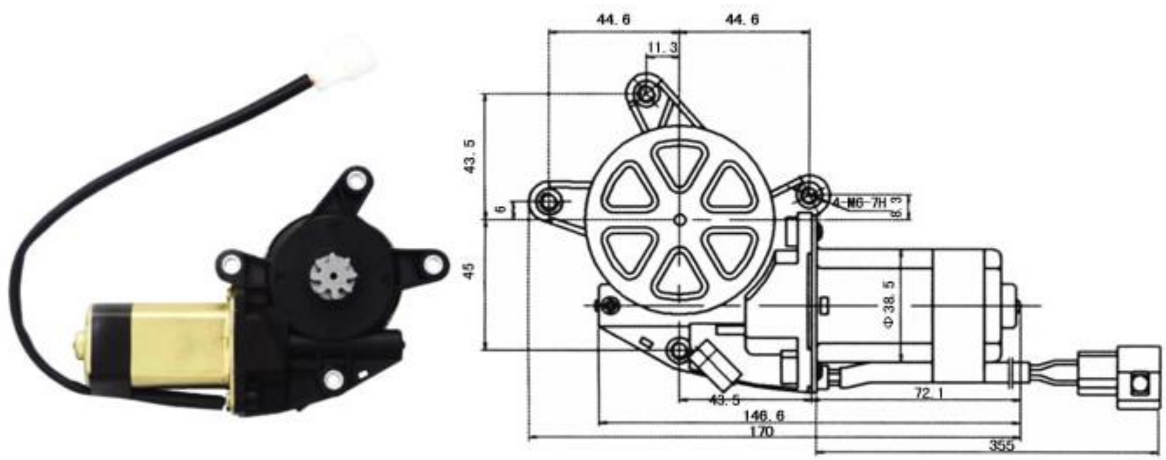


Figure 3.2: Layout of the Firing Mechanism

a. Layout, Working and Specifications of a Power Window Motor



SPECIFICATION

Voltage Rating (V)	No Load		Load Rating			Locked Torque (Kgf. cm)	Locked Current (A)
	Speed (r.p.m)	Current (A)	Torque (Kgf. cm)	Speed (r.p.m)	Current (A)		
12	85±25	≤3	30	70±20	≤7	85±25	≤20

Figure 3.3: Window Motor Specifications

2. **Counter Recoil Mechanism**: An Aluminum plate with metal rods hold the complete weapon assembly. By fastening both together the springs take on

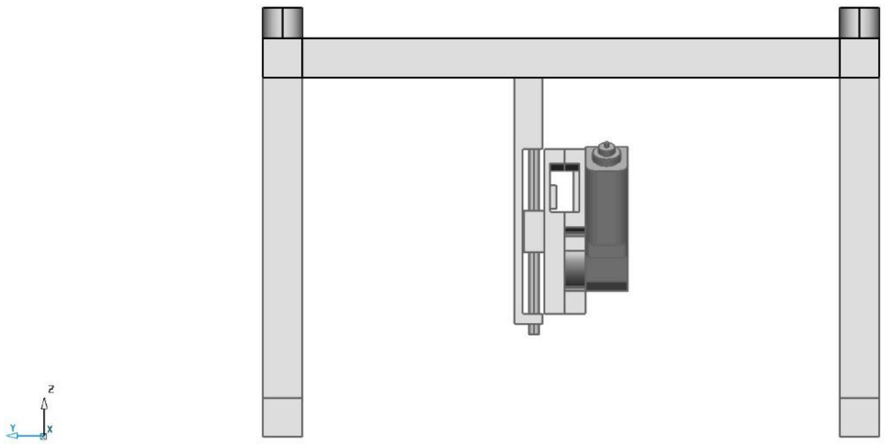


Figure 3.4: Recoil Mechanism

the force of the recoil generated by the weapon while firing and keeping the other parts unaffected.

3. **Live Video Streaming**: Live feed is directly transmitted to the Android device for target acquisition and monitoring of the drone.

3.1.3 Controlling Components

1. **Arduino Boards**

An Arduino board is a simple easy to use programmable device designed to connect to sensors, relays, motors etc. It is inexpensive and most boards are based on the AVR family 8-bit microcontroller. To easily program an Arduino board the Integrated Development Environment (IDE) has been developed and is open source just like the hardware designs for all the boards.

An Arduino board is pretty much just a carrier board for the microcontroller meaning what every characteristic the microcontroller has defines the board. As an example of what relevant features a micro controller can have the following:

a. In-system programming by on-chip boot program.

b. 6 PWM channels (Explained further in the Servo chapter)

c. 23 programmable Input/ Output (I/O) lines.

d. Six- or eight-channel 10-bit Analog to Digital Converter (ADC).

e. Two-wire serial interface (Compatible with I2C)

2. Servo motors

A servo motor is a motor designed to have its rotation angle, speed, and acceleration controlled. The term servo does not imply what type of motor is being controlled, just that is has position feedback. Basically, the motor controller receives a feedback signal indicating the position of the motor shaft and redetermines how to alter the next control signal to be sent to the motor.

3. Live Feed Camera

A camera is mounted using the servo motors which hold the camera just over the weapon for the aiming and target acquisition purpose. The servo motor is used to automate the camera and rotate it in the forward direction while taking the flight and in the downward direction to take aim while firing at the target. It has two PCB layouts and a battery which are used to make it functional:

a. **Two circuit Boards and a camera of a JJRC drone**: These two will be interconnected and given a Power source, using a LiPo Battery. The circuit board shown on the right has a Wifi Repeater that trasmits the Live feed from the camera over to a Smart Phone or Tablet using a JJRC software comercially availabe.

Figure 3.5: Camera Modules

4. RC Reciever and Transmitter

Radio Reciever and Transmitter are used for the wireless control of the Trigger Mechanism and the movement of the camera.

Chapter 4

4.1 Assembly and Testing

4.1.1 Method

1. Phase one - Before: Phase one is when the planning of the project and gathering of a theoretical base takes place. Some examples of activities during the phase is researching other similar projects, formulating a specification of requirements, defining project limitations, setting up a time plan, familiarizing with new software etc. After phase one a rough plan of execution is finished and ready to be used for phase two.
2. Phase two - During: The second phase contain the basis for the project methodology and focus on implementing and testing the theoretical ideas from phase one into practice. The methodology content is structured around three main steps, step one is the simulation part where a digital 3D model is created, which is used for simulation in SolidWorks. The second step is the creation and assembly of hardware by using the results from the simulations. Mechanical design iterations are made using SolidWorks design and additive manufacturing, other parts need to be purchased, e.g. motors and electronics. The end of the second phase contain integration of the drone and the Weapon Mounting Module finally.
3. Phase three - After: Under the third phase the work completed during phase two is evaluated and analyzed, the final report is finalized containing conclusions, results along with thought, discussions, and future improvements from the authors.

4.1.2 Choosing the Frame

To be able to start simulations and to design a Weapon Mounting module a decision on what frame configuration to use must be taken. Quadcopters require fewer motors, ESCs and propellers but are vulnerable if any of those parts fail during flight. A six, or more, rotor copter has a bigger chance of staying in the air if a propeller or any part driving a propeller fail but keeping in view the budget constraints we will go for the quadcopter. A good control system can potentially compensate for the loss of thrust by increasing the speed on the other working propellers but depending on what thrust to weight ratio the copter has it might not be enough. A quadcopter however cannot simply be downgraded to a tri-copter since the steering works differently. The final frame choice was based on future potential, a higher chance of handling motor failure and costs. The quadcopter cannot handle motor failure, but since this a prototype and it needs to be cost effective, we will go with this choice. The material choice for our custom-made frame of the drone will be of Aluminum.

4.1.3 Layout of the Circuit

The window motor is connected to the LiPo battery which is connected to the relay that works in such a way that when the Radio Signal is transmitted using the Channel 1. The Trigger of the pistol will be pressed, as the motor starts to rotate, since the relay passes a signal through it, whose input is given on the Pin 9 of the Arduino. The Servo motor is attached to the circuit to function the movement of the camera, it will move 90 degrees clockwise as the Receiver receives a signal at Channel two, connected to the Pin 9 of Arduino.

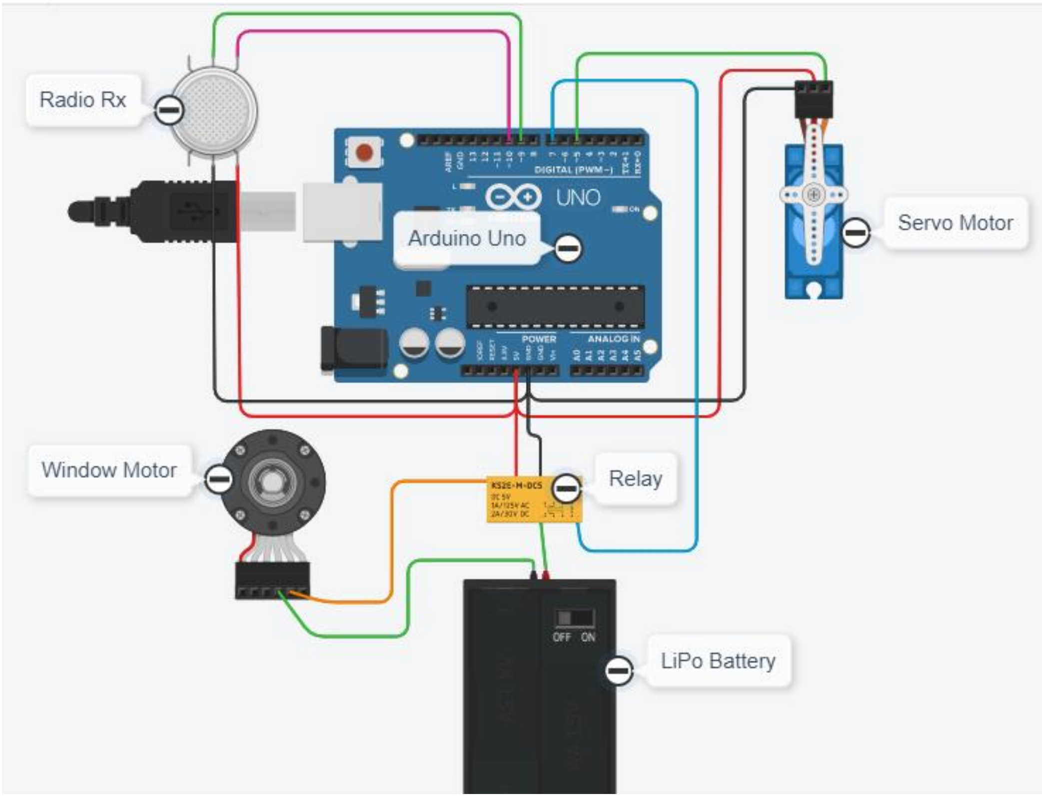


Figure 4.1: Circuit Layout

The following code was used and uploaded to Arduino uno. It clearly states the functions explained above in the circuit layout in the code format.[8]

sketch_jul06a | Arduino 1.8.12

File Edit Sketch Tools Help

sketch_jul06a §

```
/*---------
 * WEAPON MOUNTED DRONE MCS
 ----------*/

#include <Servo.h>

Servo servo;
int angle=0;

int ch1=0;
int ch2=0;
int fire_cmd=10;
int rotation_cmd=9;
int fire=7;
int camera=5;


void setup() {

  servo.attach(camera);
  pinMode(fire_cmd,INPUT);
  pinMode(fire,OUTPUT);
  Serial.begin(9600);
  digitalWrite(fire,HIGH);

}

void loop() {
```

```
void loop() {
 fireCode();
 cameraRotation();

}

void cameraRotation(){

  ch2 = pulseIn (rotation_cmd,HIGH);
  angle=map(ch2,800,2000,0,90);
  servo.write(angle);
  delay(5);
  Serial.println(angle);


}

void fireCode(){

  ch1 = pulseIn (fire_cmd,HIGH);  //Read and store channel 1
  if(ch1<1100){
    digitalWrite(fire,LOW);
  }

  else if(ch1==0){

    digitalWrite(fire,HIGH);


   }


 Serial.println (ch1);

}
```

Figure 4.2: Excerpt of the Arduino Uno Code

4.1.4 Integration of the Modules

Integrating the drone and the Weapon Mounting assembly together is the most important part of the project. The stability of the drone while firing of the weapon need to be integrated and tested accordingly. When it is all set up, the quadcopter can be controlled both via a Radio Transmitter or a Wi-Fi signal

Transmitter. The quadcopter can then be loaded with the weapon. It requires a stable flight and a recoilless fire hence making the integration successful both for the quadcopter and the Weapon mounting module. To control the Weapon Firing module a window motor is used that is more durable and lightweight and presses the trigger smoothly.

4.1.5 Test Outcomes

The following three tests were conducted, and the result of each test flight was studied, and improvements were done after each test.

1. Weapon Mounting and Firing: A controlled pressure is required to press a trigger; hence a gear worm is designed that rotates with the gears of the automatic window motor. The weapon is clamped inside a grip, that is specifically made for the pistol. It is the image of the pistol engraved in an aluminum slab as per the design in two parts. These parts are then clamped together on the pistol and bolted with nuts to give extra grip. the motor is connected to a 2200mAH battery which is connected to a relay and a Radio Receiver.

   Test Outcomes:

   - When the signal is sent through the Radio Rx and Tx towards the relay the motor gear starts to rotate, and the trigger is pressed smoothly
   - Initially the friction of the worm gear was set very low, this was noticed during testing and friction was increased.

2. Recoil Mechanism: The weapon Firing assembly is held using nuts and bolts which are perfectly attached to a plate that extends downwards from the center of the drone frame. While firing of the weapon this part absorbs the recoil of the weapon.

   Test Outcomes:

   - When the round was fired the springs attached to the plate to counter the recoil of the pistol were very affective and the quadcopter frame, maintained stability up to a remarkable level.

- The springs absorbed the jerk and due to their elasticity brought the weapon back to its original position.

3. **Camera Assembly:**

The servo motor connected to the circuit diagram as shown previously is used to rotate the camera at 90 degrees angle. It is also giving live feed to a Smart Tablet through Wi-Fi repeater.

Test Outcomes**:**

- The camera gave a swift and continuous live feed to the JJRC application installed in the Smart Tablet. Its range is not as effective as the Radio signal Repeater, as it works using a Wi-Fi module. The video streamed was live and is an added feature enhancing the capability of the drone.

Chapter 5

5.1 Problem statement answers

The focus from the beginning has been on designing a Weapon Mounting module for a quadcopter. The idea from the start was to design according to a battlefield scenario designed specifically for Pakistan Army. The scenario was to be able to locate and eliminate any hostile target as a supporting means to the infantry. Looking at what different drones that were possible to buy on the market that had a flight ready mechanism; it was noticed that they could not handle much payload. So the decision was made to design and build a custom one instead. Building a custom quadcopter allowed for heavier payload, more powerful hardware and the freedom to design a more complex automatic Firing Mechanism. With that in mind when starting the simulations the Recoil mechanism was successfully tested. Almost half the project was spent understanding how the simulation and control software worked and the model was then created with accurate and precise calculations. Now we can answer the questions stated in the beginning of the thesis.

Why is it important to create a weapon mounted multi-copter, to provide a foundation and force multiplier for the Pakistan Army?

Drones are taking over the tasks previously performed by the soldiers as we have moved into the age of insurgency and Terrorism. The drone strikes are often controversial as they allow the attacking nation to remain literally above the fray. So that the soldiers of that army are not at risk. Drones also seem to blur the boundaries between warfare on the one hand and counterterrorism and law enforcement on the other.

The insurgents plotting terror attacks all over the world need to be talked and that there was no other feasible way of thwarting these plans, other than embracing the new technology of drones and multi copters. These have a stable flight and very less chances of detection, due to their low flight and minimum detection signature.

This armies all over the world are benefiting from the extraordinary utility of armed drones - or unmanned aerial vehicles (UAVs) in the battlefield. To cope up with this revolution taking over the world, we also need to take a step forward and develop our own fleet of drones/ multi-copters in order to counter the threat that we might face in the near future.

What is important to consider when constructing a multi-copter with a Weapon Mounting module, and how does the module affect the multi-copters performance?

1. Power & thrust: Unless the gripping module is very simple, like a rope with a hook or something similar, the weight and size will increase on the multicopter. That in turn will increase the power consumption. If the Weapon mounting module is electrically powered that will also increase the power consumption. It is for that reason we first specify what type of weapon needs to be mounted and then increase the thrust capacity and batteries to cope with the new added weight and power consumption. The time when a multicopter uses the most power is, not unsurprisingly, when it is flying. It is therefore important to not spend too much time in the air while targeting an object.
2. Sensor blockage: Depending on the size and what sensors the multicopter uses there is a risk of the target object blocking those sensors. A dangerous scenario would be if the multicopter was to use a laser sensor for height sensing and the object blocks that sensor making the multicopter rise indefinitely.
3. Landing: There is a big chance that a Weapon mounting module will be placed on the underside of the multicopter. No matter how the module is attached; by a winched magnet or a string, the multicopter still has to be able to land with the module attached. It is therefore important to take the ability to land into consideration when designing the Weapon Mounting module.
4. Stability: There can be risks while firing objects connected to stability both in the air and on the ground while taking of. If the weapon is heavy or is attached to the main frame of the drone non symmetrically it can affect the center of gravity on the drone. The flight controller might be unable to compensate and making the drone drift, spin or wobble. It is therefore important to get a stable centred grip on the intended target, or to have an advanced enough navigation system to handle such changes.
5. Delays, disturbances and unreliability: A feature that helped in both early and later stages of the project in order to monitor the behaviour of the quadcopter, which includes delays and disturbances which make it more difficult to when navigating and hovering. Because of that factor of unreliability a decision was taken to simply

fire use a wire attached to the trigger, in order to fire. This is of course not the most generic way to fire and was undertaken in order to find out if the window motor had the power to press the trigger.

6. Mass,weight and inertia: Not having correct mass and inertia values during simulation can be a source of bad disturbances. Having exact values is mostly useful in later simulations when more reliable data is needed. Correct values are required in order to calculate the exact payload a drone can carry.
7. Parts and control: Another very helpful attribute to focus on is with the intent to move on to real world tests by having a control system for the drone to be a success in reality. The specifications of the motors, propellors and ESCs depend on the Overall weight of the drone.
8. Mixing simulation and reality: Mixing simulations and real world tests so that one is not caught up in solving issues that might not be as important in reality as they seem in a simulator.
9. Reliable models: One issue, which might be overlooked is the importance of good modelling software. If the physics engine is provided with a faulty or overly complex model the calculations might not only be wrong but there might also be a high number of unwanted calculations being done. Initially, for the sake of being able to use .dae files, the program SketchUp was used for modelling and the quality of the 3D files were quite low. Many unwanted surfaces and collisions made the simulator unable to use the files sometimes, and then we shifetd to SolidWorks for better results.

5.2 Recommendations and future work

1. When simulating a drone this was extra important since the flight behaviour was affected instantly depending on what real time calculation factor was able to be achieved. The drone has been made functional using the minimal resources avalaible, it may be gradually be designed and improved to an explicit drone for more accurate and integrated fire control in the future.
2. The Wifi Transmitter and Reciever used for the camera are basic, these may be replaced with the more modern Radio Recievers, to improve range and sensitivity.

3. Any weapon may be mounted on the drone by changing the specifications of the parts of the drone, using the steps taken to design this prototype.
4. A separate camera Module may be designed which may be used to track the target, using image detecting softwares.
5. More firepower can be generated with a custom made magazine, to carry more number of rounds at a time.
6. Brushless motors and DJI Flight controllers may be used for a stable flight of the weapon mounted Drone.
7. The hardware works very well when looking at the quadcopter itself; it is strong, can lift heavy and is quite reactive. The size could be made smaller or bigger and in turn the weight could be improved. This can be done by changing the material used, we can use carbon fiber instead of Aluminum. By doing so the drone might lose some weight and size and gain more durability.

5.3 Safety and Rules

1. Economy: We ourselves funded the construction and development of the quadcopter including enough spare parts to build two whole quadcopters, this was to ensure a successful completion of the project. The estimated cost for one quadcopter including spare parts, chargers, batteries, cases for transportation etc, ended up at Rupees 1.5LAC. Costs related to travelling is not included. If a similar project were to be held at a private company the costs would be significantly higher since no personnel costs are included. The sum of Rupees 1.5LAC would only be enough for about one month's work for one engineer.
2. Environment: Different parts consist of different materials and to create an overview of what materials was used to build the quadcopter the following list helps:
    a. 3D printed parts:
        i. PLA: A biodegradable plastic that is made from starch. PLA can both be recycled and used again or composted or burned.
        ii. TPU: The TPU used in this project is an Eco-friendly TPU which is biodegradable, there are however all kinds of TPU and not all are environmentally friendly.

b. Electronics: Many different types of materials, all parts used on the quadcopter in this thesis is RoHS compliant, meaning they contain less hazardous materials and are easier to recycle.

c. Main Frame: Made from aluminum which is easy to recycle and does not harm the environment severely if the quadcopter were to crash somewhere hard to reach.

d. Batteries: The batteries are the hardest part to recycle if anything were to happen. It is also the part of the quadcopter that could render other parts as well. It is therefore important that the batteries are protected during the functioning of the quadcopter.

3. Rules / Safety: The following measures should be taken for the safety of the quadcopter:

   a. The quadcopter needs to be marked using a codename which would refer to the name of the pilot of the quadcopter and his phone number.
   b. If flying when it is dark, lights need to be used on the quadcopter.
   c. Do not fly higher than 120 meters.
   d. Do not fly closer to an airport.
   e. Do not fly over prisons, nuclear plants, or nature reserve.
   f. Only the trained individual should fly/operate the quadcopter.

5.4 Conclusion

1. The camera live feed and camera control using the rotation of 90 degrees guarantees the timely and accurate target acquisition acting as a quick reaction force multiplier for the Pakistan Military.
2. Helping in indication of the enemy in live operations helps the action to be quick and accurate.
3. The operator of the drone will be inside a bunker, safe from the enemy shelling and firing.
4. In battlefield scenario, the prototype will help in locating enemy targets faster.
5. Bomb explosions can be gladly located.
6. The firing Mechanism absorbs the recoil of the weapon, using high resistive metal springs.

7. The trigger mechanism is also very accurate and uses a window motor that rotates a worm gear and presses the trigger very effectively.

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Appendix A

Extended Title: Weapon Mounted Drone with Recoil Counter Mechanism and Live Camera Feed
Brief Description of The Project / Thesis with Salient Specs: Implementation of our knowledge encompassing Microcontroller based Electronic circuits to design and develop “Weapon Mounted Drone” to cause maximum damage to enemy without physical interference of own personnel and to create a gaming environment that has a direct influence on the battlefield.
Scope of Work Automated weapon mounting Assembly with added feature of live feed, recoil mechanism and target acquisition using Radio signals.
Academic Objectives The project will impart following skills into the syndicate: 1. Signal processing techniques 2. Java language learning 3. Digital signal processing (radio)

Application / End Goal Objectives: The aim of this method is to provide an accurate mode for tracing enemy remotely and causing maximum damage to the enemy with minimum loss of own troops. This is a passive drone and cannot be detected on radar. This will have a vast military application for detecting and localizing enemy combatants and/or surprising the enemy. Civilian applications include integration with existing security method to detect acts of theft or terrorism by surveillance to visually highlight the intruders and engage with them.
Material Resources Required: 1. Aluminum Frame 2. Automatic Window Motor 3. JJRC Camera Module 4. Recoil Counter Mechanism 5. Wires 6. LiPo Battery 7. Radio Rx and Tx 8. Arduino
No of Students Required: 5

Appendix B

<table>
<tr><th></th><th>Nov 19</th><th>Dec 19</th><th>Jan/Feb 20</th><th>Mar 20</th><th>Apr 20</th><th>May/June 20</th><th>July 20</th></tr>
<tr><td>Literature Study</td><td colspan="2">Completed</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Software Design</td><td></td><td colspan="3">Completed</td><td></td><td></td><td></td></tr>
<tr><td>Frame</td><td></td><td></td><td colspan="3">Completed</td><td></td><td></td></tr>
<tr><td>Firing Mechanism</td><td></td><td></td><td></td><td colspan="2">Completed</td><td></td><td></td></tr>
<tr><td>Integration of all parts</td><td></td><td></td><td></td><td></td><td colspan="2">Completed</td><td></td></tr>
<tr><td>Finalization</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Completed</td></tr>
<tr><td>Testing</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Completed</td></tr>
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