MAJOR PROJECT REPORT

ON

GARUDA: A DRONE WITH HAND

Submitted in partial fulfillment of the requirements

For the award of the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted By

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JULY- 2021.

CERTIFICATE

I/We hereby certify that the work that is being presented in the project report entitled **Garuda: A Drone with Hand** to the partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology in Electronics & Communication Engineering from Dr. Akhilesh Das Gupta Institute of Technology & Management**, New Delhi. This is an authentic record of our own work carried out during a period from March 2021 to July 2021 under the guidance of **Ms. Swati Juenja, Assistant Professor in ECE department.**

The matter presented in this project has not been submitted by us for the award of any other degree elsewhere.

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge. He /She/They are permitted to appear in the Major Project External Examination.

(Ms. Swati Juneja)	**Prof. (Dr.) Rajiv Sharma**
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The B. Tech Major Project Viva-Voce Examination of **Hardik Gossain, Bhumika, Diksha Tuli (Enrollment No: 20415602817, 35115602817, 35215602817),** has been held on **15 JULY, 2021.**

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ABSTRACT

Today, technology is developing in the same direction in line with rapidly increasing human needs. The work done to meet these needs makes life easier every day, and these studies are concentrated in robotic arm studies. Robot arms work with an outside user or by performing predetermined commands. Nowadays, the most developed field of robot arms in every field is the industry and medicine sector. The design of the aerial UAV presented in the report includes a 5 DoF lightweight arm with a sensorized passive joint which can measure the contact force to regulate the force applied with the sensor on the structure. The aerial platform has been designed with tilted propellers to be fully actuated, achieving independent attitude and position control. It also mounts a "docking gear" to establish full contact with the infrastructure during the inspection, minimizing the measurement errors derived from the motion of the aerial platform and allowing full contact with the surface regardless of its condition .

In this report we have discussed the methodology used to make our project "Garuda". We have also explained the tools and how they are used in this project. The system design is also explained. The project includes an Aerial Manipulator with a Robotic Arm and we have named our Project as "GARUDA". The project consists of a Quadrotor, Laser Range Sensors and Monocular camera to determine the exact coordinates of the far away object. The monocular camera used in the project provides magnified images by using Image Processing Technology. The Laser Range finder sensor records the measurement vector. It also determines the distance of the drone from the object. Image Processing is done via Raspberry Pi and Computer vision. The report also presents the modelling and control of the Aerial Manipulator .

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CHAPTER - 1

INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

Technology has become a solution to many persistent problems. Though it has always been a challenge to apply these solutions in times of risky situations that is those places where human intervention might prove to be a life risk. Robotics platform is nowadays always looked upon as a promising solution for saving human lives after successful attempts at saving lives at various events.

Robotics solutions that are well adapted to local conditions of unstructured and unknown environments can greatly improve safety and security of personnel as well as work efficiency, productivity and flexibility

Unmanned Aerial Vehicles (UAV) are being widely used today for applications such as mapping, inspection, exploration and photography. An important observation regarding most applications of aerial robots is that they do not involve any kind of contact with the environment. This phenomenon can be attributed to several challenges. Traditional robotic manipulators whose base links are fixed to the ground (earth) are able to efficiently dissipate external and inertial forces encountered during manipulation. The reaction forces necessary for balancing external as well as inertial forces acting on the manipulator are available immediately owing to the fixed contact relationship of the base link with the infinitely dissipative ground. However, this is not the case for aerial manipulators as multirotor vehicle dynamics are relatively sensitive and "slow" because of inherent aerodynamic forces as well as inertia. Therefore, the task of maintaining the desired vehicle attitude against these external contact forces becomes a challenge. Since multirotors are unstable in general, compensator design and stability for closed-loop contact dynamics must be addressed. Along with performing control during contact, the transition between the free-flight regime and the contact regime can present some complications. Physical properties of the UAV platform such as payload, limits on thrust and inertia lead to intricate design challenges.

Researchers have employed a variety of approaches in design and control methodologies in aerial manipulation applications. Previous research touches on topics such as kinematics for workspace and dexterity, full-body control, lightweight design, accurate end - effector position control, interaction control, etc.

The work in developed a novel parallel manipulator with a large workspace and current based torque control to employ impedance control schemes. The work is designed as a lightweight 5-DoF aerial manipulator for pick and place applications. It has a smart self folding mechanism to minimize space occupation and static CoG imbalance. A special differential mechanism to cancel attitude disturbances was also designed. The research presented in used delta-kinematics for designing a fast and precise aerial manipulator for contact-based inspection. The sophisticated delta structure possesses compliance allowing for slight tracking errors. The researchers demonstrated the design and operation of a unique superstructure manipulator that has the ability to perch on a vertical surface through impact. It is lightweight and possesses unilateral compliance for perch and release operations.

The authors developed a 7-DoF aerial manipulator for heavy payloads. Hence, it used a backstepping-based controller for the multi-rotor, which considers full coupled dynamics and the rapidly shifting CoG. An admittance based manipulator controller is outlined in the paper. The contribution presented a multi-objective full-body controller for the system described in. The fast dynamics of the parallel manipulator ensured efficient kinematic tracking

Furthermore, the work addressed the problem of interaction in order to track desired contact force using hybrid control for the manipulator, using an impedance-based controller for position and a PI controller for regulating normal force. The authors presented the design and control of a parallel aerial manipulator for industrial inspection. The approach considered the environment as a compliant contact and used the Hunt - Crossley interaction model. This work modelled the NDT (Non-Destructive Testing) inspection task as a force regulation problem and designed a lightweight 3-DoF RRR manipulator with sufficient dexterity. A planar model of the dynamics during contact was developed, along with a passivity-based PD controller while preserving the nonlinearity of the model. Keeping in mind actuation limits and stability requirements, a simulation of the closed-loop dynamics is presented with a smooth free flight to contact transition scheme.

This project is designed keeping in mind the extreme conditions that the aerial manipulator may have to face. The robotic arm is designed to work in 5-Dof plane. The project is programmed to work in two ways that is either automatically or manually.

1.2 Basic Terms of the Project

1.2.1 Components and Material Selection

Firstly, Thermal resistance of the frame of the UAV and that of the aerial manipulator needs to be considered as many disasters leads to major fire breakage. Thus, choosing a material which can withstand heat of fire which can range from 2000 degree celsius to 2500 degree celsius. There have been researches that determine the best suited fibre or material for handling extreme temperature even in space that is it can withstand temperature of 4000 degree celsius.

Secondly, It is important that the fibre used is flexible and light. This is because while dealing in critical situations a slight damage to the body might lead to failure of the whole system and the fact that the drone has to carry the weight of the sensors and robotic arm will add on to the total weight. Thermoplastic polyurethane (TPU) is a class of plastics which exhibits maximum flexibility and it absorbs the vibrations that will result in more stable actions. Other strong materials include nylon fibre and reinforced nylon which can absorb impacts and protect both the propellers as well as the impacted object.

Lastly, the sensors used should be precisely chosen as the live images used are not only used for taking action but also for reporting purposes. The data collected will enable us to make more stable versions of the system.

1.2.2 Aerial Manipulator

Take off and landing are a critical part of a UAV with a manipulator as the arm folds and wraps itself. While landing maneuvers there have been instances of failures while using a 3-DOF system considerably, due to less flexibility in motion.

After careful study of robotic arm it can be clearly stated that, a 6-DOF arm is more efficient than a 3-DOF system in performing various operations in a disaster site. Whereas a 3-DOF system can be deployed in case any aid is to be supplied and dropped aerially.

Fig 1.1: Drone used for the project

1.2.3 5-DOF Manipulator Trajectory Planning

After studying and conducting various surveys it was interpreted that for combating SAR operations a 5-DOF system might be sufficient. For this a robotic arm which is designed to look like a human hand with upper arm, forearm and hand or the gripper. The drone together with the arm determines the position and motion of the manipulator. The gripper (hand) of the manipulator is called end - effectors since the end effect is studied at this point. The grasping that is the opening & closing or a movement can be a mechanical mechanism. The movement is generally governed by a microprocessor.

The aim of trajectory planning is to describe the requisite motion of the manipulator at a time sequence of end effectors location and derivatives of these locations, which are generated by "interpolating" or "approximating" the desired path by a polynomial function this is generally programmed using MATLAB .The space curve that the manipulator hand moves along from an initial to final location is called path. These time base sequence locations, obtained from the trajectory planning serve as reference input or "control set points" to the manipulator's control system, in turn assures that the manipulator executes the planned trajectories.

1.2.4 Robotic Arm.

A robotic arm is a type of mechanical arm usually programmable with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain. The terminus of the kinematic chain of the manipulator is called the end effector and it is analogous to the human hand. However, the term "robotic hand" as a synonym of the robotic arm is often proscribed.

1.3 Literature Overview

For many decades Robotic arm have been used for Assembly, Dispensing, Inspection & Testing, Pick and place, Performing complex surgeries, etc. Aerial search and rescue (SAR) operations are always preferred in disaster zones. Earlier practices included sending large planes to the zones which was not an efficient method because it needs to be landed in the area of disasters. After world war 2 introduction of small planes and helicopters allowed the process to be more convenient and more efficient. However, while combating search and rescue operations many rescuers lose their lives because of flying at low altitudes. During the last decade many adventure activities in greenland, which is prone to avalanche increased exponentially. After the first usage of UAV in Greenland in the SAR operation in a snow avalanche near a snow activity site, there was no turning back, as it turned out to be the most efficient method of all.

In India, the National Disaster Management Authority (NDMA), an apex body for disaster management, used drones for the first time during the Uttarakhand floods in 2013, and subsequently during the Kerala floods in 2018. The UAVs have been serving military operations as well by dropping the munitions which are predefined or by firing through manned instructions. Besides battlefield operations, UAVs have been extensively used in the US military research for information-warfare and security purposes.

Due to the considerable bulk of applications for aerial vehicles, it is quite difficult to perform an accurate taxonomy of UAVs since there exist many devices in the market with different dimensions, mechanical configuration, actuators and so on. Classifying the UAVs from their high manoeuvrability and low endurance toward their low manoeuvrability and high endurance yields:

1. rotary wings UAVs (RW-UAVs), like multirotors (e.g., quadcopters, hexacopters), small-scale helicopter-based UAVs (HUAVs), coaxial helicopters and ducted fan UAVs;
2. convertibles UAVs, characterized by interchangeable designs, like tilting rotors or cruise-flight-enable ducted fans UAVs, tail sitters UAVs and so on;
3. bio-inspired UAVs, taking inspiration from the flight of the insects and are mainly concerning flapping wing devices;
4. fixed-wing UAVs, like acrobatic flyers, Delta-wings and electric gliders;
5. lighter-than-air UAVs (LtA-UAVs) like autonomous blimps.

Among the above-listed devices, the vertical take-off and landing (VToL) UAVs do not need a runway to both detach and land from/to the ground. Compared to standard aircrafts, multirotors UAVs are low-cost devices and easily maneuverable. They can perform hovering in a precise way, but the endurance is not their best peculiarity. The first issue is that conventional VToL devices, such as multirotors UAVs with parallel axis, are underactuated and this establishes several problems in stabilizing the vehicle and tracking the desired trajectories. The most widely used controller takes into account hierarchical architecture highlighting a time-scale separation between the linear (slow time-scale) and angular (fast time-scale) dynamics. Moreover, it is possible to show that the position and the yaw angle of the VToL UAV are flat outputs. Hence, it is possible to find a set of inputs to track any trajectory in the Cartesian space with a desired heading angle of the UAV. This solves the underactuation problem since tracking of the flat outputs (slow time-scale part of the system) generates the references for the low-level attitude controller (fast time-scale part of the system). Other worthy approaches rely upon backstepping , impedance and optical flow techniques.

The second issue is that the aerodynamic model of UAVs is very complicated and several assumptions are made during its derivation. This leads to robust control designs that are worthy of interest within UAMs (see Section IV-B). Most of them implement an integral action to resist against external disturbances and cope with unknown and time-varying parameters (e.g., the battery level). Recently, adaptive controls have been employed to counteract such disturbances. A nonlinear force observer is introduced to estimate disturbances applied to a quadrotor. A sliding mode observer is instead employed to impose more robustness on the closed-loop system. Since passivity-based controllers do not rely on the exact compensation of the considered model, they are expected to be more robust to parameter uncertainties.

1.4 Motivation

There has been numerous amount of disasters over the globe in which human effectiveness has been questioned and not been useful to a certain extent. One of the main reason is because the situation demands of Robotics solutions that are well adapted to local conditions of unstructured and unknown environments and can greatly improve safety and security of personnel as well as work efficiency, productivity and flexibility. In our project we have introduced one such application in which a robotic arm is equipped with a quadrotor and The robotic arm is responsible for carrying out various tasks, precisely in zones where there is a risk to put a human into.

The system is designed in order to deal with extreme conditions where it is nearly impossible for a human to reach. Robotics arms can be brought to use in the situations of high risk and can prove to be a remarkable solution in saving the no. of lives lost. It consists of a Drone equipped with a robotic arm .The main reason for this project is to deal with problems which are associated with high altitudes and it's either very dangerous or impossible for a human to reach and rectify. So, Alongside an arm the drone is mounted with a camera (Monocular) to perform advanced image processing that could assist the concerned person with the task.

The Robotic Arm can be operated in two modes i.e Automatic where on a click of a button the arm could perform tasks like pick and place of objects while the other mode would contain manual operations of the arm. There will be a specially designed glove that the operator could wear and the arm would replicate the movement of a human arm making it easier for the person to perform the task.

CHAPTER – 2

METHODOLOGY ADOPTED

2.1 Tools used for the Drone

2.1.1 Brushless Motors

The motors of your drone are what propellers are connected to which cause them to spin around and generate thrust to enable your drone to fly.

A brushless motor consists of two main sections:

- Rotor - the part that rotates and has the magnets mounted in a radial pattern
- Stator - the part that does not rotate, and has electromagnet

  The brushless motor used in this project is of 2800 kVolts. Brushless DC Electric motors are used in the making of the project.

2.1.2 Camera (possibly monocular)

The camera used in our drone is a Monocular Camera. A monocular is a modified refracting telescope used to magnify the images of distant objects by passing light through a series of lenses and usually also prisms. Most modern monocular use prisms instead of relay lenses to ensure an erect image, resulting in a lightweight, compact telescope. The typical volume and weight of a monocular are less than half of a pair of binoculars having similar optical properties, making a monocular easier to carry and also proportionally less expensive. This is due to the fact that binoculars are essentially two sets of monoculars packed together — one for each eye. Monoculars only produce one 2-dimensional image, while binoculars produce two parallaxed images (binocular vision) to allow stereopsis and depth perception.

Monoculars are ideally suited to those with vision in only one eye, or where compactness and low weight are important. Monoculars are also sometimes preferred where difficulties occur using both eyes through binoculars because of significant eye variation or poor vision in one eye.

A monocular with a straight optical path is relatively long; prisms are normally used to fold the optical path to make an instrument which is much shorter (see the entry on binoculars for details).

Visually impaired people may use monoculars to see objects at distances at which people with normal vision do not have difficulty, e.g., to read text on a chalkboard or projection screen. Applications for viewing more distant objects include natural history, hunting, marine and military. Compact monoculars are also used in art galleries and museums to obtain a closer view of exhibits.

A monocular camera is a common type of vision sensor used in automated driving applications one of which is drone. When the camera is mounted on the drone the camera can detect objects, lane boundaries and can track objects through a scene.

2.1.3 Electronic Speed Control

An electronic speed control (ESC) is an electronic circuit that controls and regulates the speed of an electric motors which is brushless motors in case of our project. A signal from the flight controllers causes the ESC to raise or lower the voltage to the motor as required and thus changes the speed of the propeller. It may also provide reversing of the motor and dynamic braking. Miniature electronic speed controls are used in electrically powered radio controlled models. Full-size electric vehicles also have systems to control the speed of their drive motors. Electronic Speed Controllers (ESC) are an essential component of modern quadcopters (and all multirotors), offering high power, high frequency, high resolution 3-phase AC power to a motor in an extremely compact miniature package. These craft depend entirely on the variable speed of the motors driving the propellers. Fine speed control over a wide range in motor/prop speed gives all of the control necessary for a quadcopter (and all multirotors) to fly.

Quadcopter ESCs usually can use a faster update rate compared to the standard 50 Hz signal used in most other RC applications. A variety of ESC protocols beyond PWM are utilized for modern-day multirotors, including, Oneshot42, Oneshot125, Multishot, and DShot. DShot is a digital protocol that offers certain advantages over classical analog control, such as higher resolution, CRC checksums, and lack of oscillator drift (removing the need for calibration). Modern day ESC protocols can communicate at speeds of 37.5 kHz or greater, with a DSHOT2400 frame only taking 6.5 μs.

2.1.4 Power distribution board

SmartAP PDB (Power Distribution Board) is a board which allows transferring the power from the battery to ESCs / Motors and generate power supply for the flight controller and other peripherals with different voltage levels. Also, PDB provides the functionality for battery voltage / current measurements.

PDB's essentially distribute the power from the battery to the drone esc. But the technology has improved so much in recent days that PDB's also distribute power to some other peripherals such as FPV Video Transmitters, FPV Cameras and the Quadcopter Flight Controller itself. Some modern FC's have integrated PDB's, are limited by space and can only accommodate so much that they do not do a very good job at filtering the voltage spikes from the insane current draws from our quads. Power Distribution Board are still preferred as they reduce the stress on the Flight Controllers and usually are better filtered from electrical noise.

2.1.5 Power Supply

In this project we have used Lithium polymer batteries which are often called as Lipo batteries of 11.1V till 12.6 Volts.

The Lipo battery is useful in Drone and to power, your portable DIY projects, these actively work for a longer time. Nowadays these Lipo battery is used in drone because of its lightweight, and high power delivering capacity in a compact size.

A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated as LiPo, LIP, Li-poly, lithium-poly and others), is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte. High conductivity semisolid (gel) polymers form this electrolyte. These batteries provide higher specific energy than other lithium battery types and are used in applications where weight is a critical feature, such as mobile devices, radio-controlled aircraft and some electric vehicles.

2.1.6 Flight Controller

The drone flight controller is the brains behind the multi-rotor and is used to perform a series of calculations that stabilize its flight and operations. It's function is similar to the CPU in your home computer; although, it's used to control the rotational speeds of each motor as well as communicate with other components. It accomplishes flight control by receiving and subsequently processing commands from the radio transmitter a pilot holds. The Flight controller consists of the following components.

2.1.7 Gyroscope

Gyroscope sensor is a device that can measure and maintain the orientation and angular velocity of an object. These can measure the tilt and lateral orientation of the object whereas accelerometer can only measure the linear motion. Gyroscope sensors are also called as Angular Rate Sensor or Angular Velocity Sensors. These measures the rate of rotation and helps to keep the drone in an balanced condition. Gyroscope is basically used to provide stability or maintain a reference direction.

2.1.8 Accelerometer

An accelerometer is a tool that measures proper acceleration. Proper acceleration is the acceleration (the rate of change of velocity) of a body in its own instantaneous rest frame; this is different from coordinate acceleration which is acceleration in a fixed coordinate system. For example, an accelerometer at rest on the surface of the Earth will measure an acceleration due to Earth's gravity, straight upwards (by definition) of $g \approx 9.81\ m/s^2$. By contrast, accelerometers in free fall (falling toward the center of the Earth at a rate of about $9.81\ m/s^2$) will measure zero.

Accelerometers have many uses in industry and science. Highly sensitive accelerometers are used in inertial navigation systems for aircraft and missiles. Vibration in rotating machines is monitored by accelerometers. They are used in tablet computers and digital cameras so that images on screens are always displayed upright. In unmanned aerial vehicles, accelerometers help to stabilise flight.

When two or more accelerometers are coordinated with one another, they can measure differences in proper acceleration, particularly gravity, over their separation in space—that is, the gradient of the gravitational field. Gravity gradiometry is useful because absolute gravity is a weak effect and depends on the local density of the Earth, which is quite variable.

Single- and multi-axis accelerometers can detect both the magnitude and the direction of the proper acceleration, as a vector quantity, and can be used to sense orientation (because the direction of weight changes), coordinate acceleration, vibration, shock, and falling in a resistive medium (a case in which the proper acceleration changes, increasing from zero). Micro machined micro electromechanical systems (MEMS) accelerometers are increasingly present in portable electronic devices and video-game controllers, to detect changes in the positions of these devices. It provides the acceleration force which the drone uses to move in all the direction.

2.1.9 Magnetometer

A magnetometer is a device that measures magnetic field or magnetic dipole moment. Some magnetometers measure the direction, strength, or relative change of a magnetic field at a particular location. A compass is one such device, one that measures the direction of an ambient magnetic field, in this case, the Earth's magnetic field. Other magnetometers measure the magnetic dipole moment of a magnetic material such as a ferromagnet, for example by recording the effect of this magnetic dipole on the induced current in a coil.

The first magnetometer capable of measuring the absolute magnetic intensity at a point in space was invented by Carl Friedrich Gauss in 1833 and notable developments in the 19th century included the Hall effect, which is still widely used.

Magnetometers are widely used for measuring the Earth's magnetic field, in geophysical surveys, to detect magnetic anomalies of various types, and to determine the dipole moment of magnetic materials. In an aircraft's attitude and heading reference system, they are commonly used as a heading reference. Magnetometers are also used by the military in magnetic mines to detect submarines. Consequently, some countries, such as the United States, Canada and Australia, classify the more sensitive magnetometers as military technology, and control their distribution.

Magnetometers can be used as metal detectors: they can detect only magnetic (ferrous) metals, but can detect such metals at a much larger depth than conventional metal detectors; they are capable of detecting large objects, such as cars, at tens of metres, while a metal detector's range is rarely more than 2 metres. In recent years, magnetometers have been miniaturized to the extent that they can be incorporated in integrated circuits at very low cost and are finding increasing use as miniaturized compasses (MEMS magnetic field sensor).

2.1.10 GPS

The Global Positioning System (GPS) originally Navstar GPS, is a satellite-based radio navigation system owned by the United States government and operated by the United States Space Force. It is one of the global navigation satellite systems (GNSS) that provides geolocation and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. Obstacles such as mountains and buildings block the relatively weak GPS signals. The GPS does not require the user to transmit any data, and it operates independently of any telephonic or internet reception, though these technologies can enhance the usefulness of the GPS positioning information. The GPS provides critical positioning capabilities to military, civil, and commercial users around the world. The United States government created the system, maintains it and makes it freely accessible to anyone with a GPS receiver.

Raspberry Pi GPS Module is built with CP2102 as USB to UART Bridge chip, which is stable and faster. There is also an L80-39 GPS chip inside the chip. The L80-39 is with 66 search channels and 22 simultaneous tracking channels, which can help communicate satellite with UART or USB.

The use of GPS in the project is for the navigation. So, GPS is used to determine the position of the drone. It also measures the relative positioning and speed of the vehicle.

2.2 Tools used for Robotic arm

The Robotic Arm of the project is made by the Project owners with the help of servo motors and other components as mentioned below. The tools used for the Robotic arm are as follows:

Fig 2.1 : Robotic Arm used in the project

2.2.1 Flex sensors

A flex sensor or bend sensor is a sensor that measures the amount of deflection or bending of the robotic arm. Usually, the sensor is stuck to the surface and resistance of sensor element is varied by bending the surface. Since the resistance is directly proportional to the amount of bend it is used as a goniometer, and often called a flexible potentiometer. Flex sensor is used in wide areas of research from computer interfaces, rehabilitation, security systems and even music interfaces. It is also famous among students and Hobbyists.

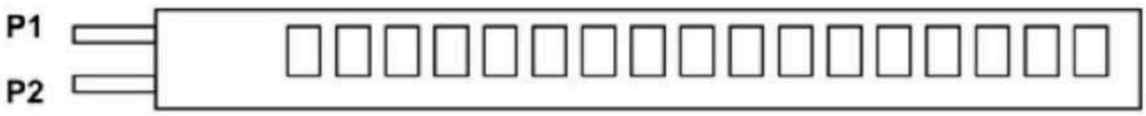

Fig 2.2 : Flex Sensor

2.2.2 Servo Motors

Servo; Detects the operation error of a mechanism, provides feedback and corrects faults. The servo motor can have alternating current (AC), direct current (DC) or stepper motors. In addition to these, there are drive and control circuits. Servo motors are the kinds of motors that can fulfill the commands we want. They can operate steadily even at very small or very large speeds. In these motors, the large moment can be obtained from the small size. Servo motors are used in control systems such as fast operation, excessive axis movement, condition control and so on. Servo motors are the last control element of a mechanism. They are highly sensitive and servo motors are used in conjunction with electronic or programmable circuits. These engines are divided into AC and DC. When the AC servo motors are brushless type motors, the servo motors brush. Servo motors has mostly three cables. These are a red cable for power, black for grounding and yellow cables for control (data, data). One of the servomotors used in the production phase of the project is shown below.

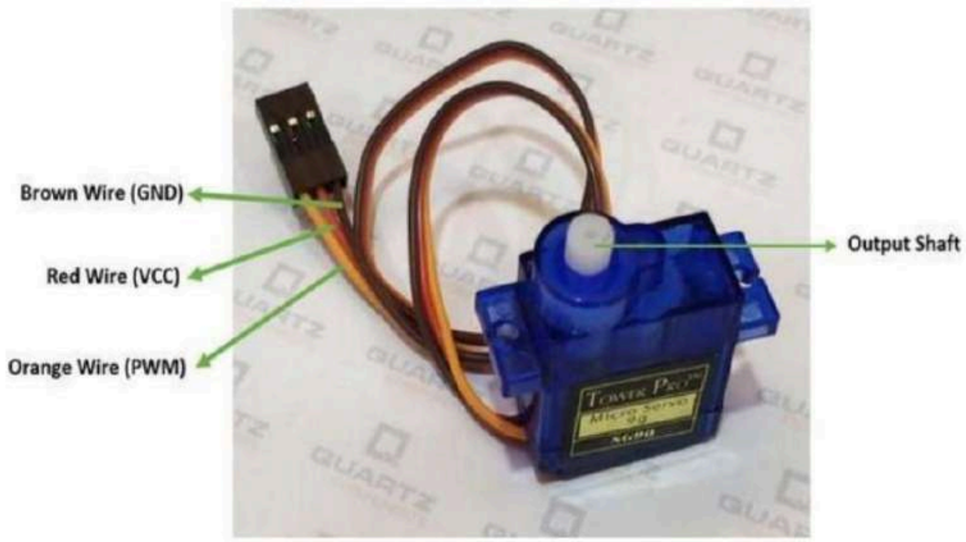

Fig 2.3: Servo Motor

Servo Motors are mounted in every joint of a Robotic welding arm actuating movement and adding dexterity.

2.2.3 Linear Potentiometers

A linear potentiometer is a type of position sensor. They are used to measure displacement along a single axis, either up and down or left and right. They are used to change the direction of the robotic arm in accordance to the linear motion of human hands.

Linear potentiometers are often rod actuated and connected to an internal slider or wiper carrier. The rod will be connected to a device or object which requires measurement. The linear potentiometer proportionally divides an applied regulated voltage over its operational range and provides a proportional voltage output relevant to the position of the wiper.

Linear potentiometers are a contacting type of sensor which means that the moving parts make contact with each other during use. This makes them sufficiently robust to be used within a variety of applications whilst remaining relatively inexpensive. They are able to function in wide temperature ranges and offer long life, high accuracy and repeatability. There are many advantages to using a linear potentiometer for applications, these include:

- Long life

- Wide operating temperature range
- Improved linearity
- Laser trimming of the track
- Typically lower cost (than non-contacting alternatives)

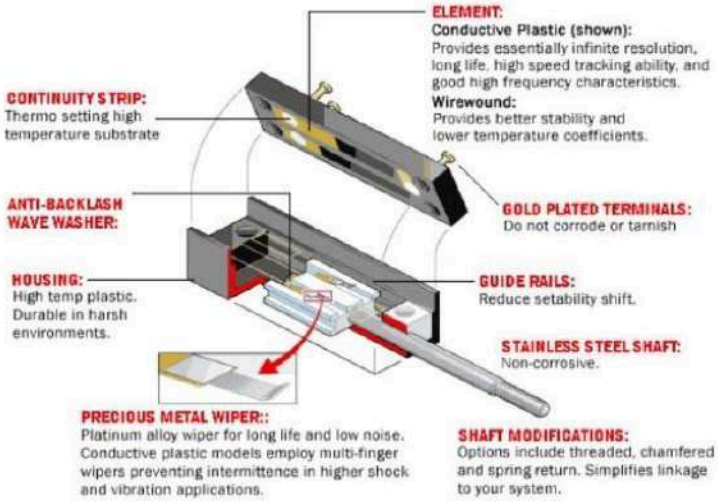

Fig 2.4: Linear Potentiometer

2.3 Arduino

Arduino is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices. Its hardware products are licensed under a CC-BY-SA license, while software is licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially from the official website or through authorized distributors.

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards ('shields') or breadboards (for prototyping) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs. The microcontrollers can be programmed using the C and C++ programming languages, using a standard API which is also known as the "Arduino language". In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) and a command line tool (arduino-cli) developed in Go.

The Arduino project began in 2005 as a tool for students at the Interaction Design Institute Ivrea in Ivrea, Italy, aiming to provide a low-cost and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats and motion detectors.

2.4 RF Module

An RF module (short for radio-frequency module) is a (usually) small electronic device used to transmit and/or receive radio signals between two devices. In an embedded system it is often desirable to communicate with another device wirelessly. This wireless communication may be accomplished through optical communication or through radio-frequency (RF) communication. For many applications, the medium of choice is RF since it does not require line of sight. RF communications incorporate a transmitter and a receiver. They are of various types and ranges. Some can transmit up to 500 feet. RF modules are typicallyfabricated using RF CMOS technology.

RF modules are widely used in electronic design owing to the difficulty of designing radio circuitry. Good electronic radio design is notoriously complex because of the sensitivity of radio circuits and the accuracy of components and layouts required to achieve operation on a specific frequency. In addition, reliable RF communication circuit requires careful monitoring of the manufacturing process to ensure that the RF performance is not adversely affected. Finally, radio circuits are usually subject to limits on radiated emissions, and require Conformance testing and certification by a standardization organization such as ETSI or the U.S. Federal Communications Commission (FCC). For these reasons, design engineers will often design a circuit for an application which requires radio communication and then "drop in" a pre-made radio module rather than attempt a discrete design, saving time and money on development.

RF modules are most often used in medium and low volume products for consumer applications such as garage door openers, wireless alarm or monitoring systems, industrial remote controls, smart sensor applications, and wireless home automation systems. They are sometimes used to replace older infrared communication designs as they have the advantage of not requiring line-of-sight operation.

Several carrier frequencies are commonly used in commercially available RF modules, including those in the industrial, scientific and medical (ISM) radio bands such as 433.92 MHz, 915 MHz, and 2400 MHz. These frequencies are used because of national and international regulations governing the used of radio for communication. Short Range Devices may also use frequencies available for unlicensed such as 315 MHz and 868 MHz.

RF modules may comply with a defined protocol for RF communications such as Zigbee, Bluetooth Low Energy, or Wi-Fi, or they may implement a proprietary protocol.

2.4.1 Transmitter modules

An RF transmitter module is a small PCB sub-assembly capable of transmitting a radio wave and modulating that wave to carry data. Transmitter modules are usually implemented alongside a microcontroller which will provide data to the module which can be transmitted. RF transmitters are usually subject to regulatory requirements which dictate the maximum allowable transmitter power output, harmonics, and band edge requirements.

2.4.2 Receiver modules

An RF receiver module receives the modulated RF signal, and demodulates it. There are two types of RF receiver modules: super heterodyne receivers and super regenerative receivers. Super regenerative modules are usually low cost and low power designs using a series of amplifiers to extract modulated data from a carrier wave. Super regenerative modules are generally imprecise as their frequency of operation varies considerably with temperature and power supply voltage. Super heterodyne receivers have a performance advantage over super regenerative; they offer increased accuracy and stability over a large voltage and temperature range. This stability comes from a fixed crystal design which in the past tended to mean a comparatively more expensive product. However, advances in receiver chip design now mean that currently there is little price difference between super heterodyne and super regenerative receiver modules.

2 .5 Open CV

OpenCV (Open Source Computer Vision Library) is a library of programming functions mainly aimed at real-time computer vision. Originally developed by Intel, it was later supported by Willow Garage then It seez (which was later acquired by Intel). The library is cross-platform and free for use under the open- source Apache 2 License. Starting with2011, Open CV features GPU acceleration for real-time operations.

2.6 Working

The working of the system consists of two stages:

Firstly, The multirotor (for this project a quadrotor has been used) is responsible to gather the data from the site from the visual and range sensors mounted on the drone itself.

Three important modules mounted on a mobile platform are: (1) range sensor (2DLiDAR), (2) moving machine (servo), and (3) optical camera. We get two types of data froma multi-sensor system. The LiDAR sensor can only scan a horizontal azimuth. The visual sensors plots the coordinates in 2-D plane thus plotting the 3-D map of the location.

2.6.1 Image processing

Simple CV libraries have allowed to enhance or process the image called image processing. Which required locating the coordinates of an object and control the robotic arm for pick and place pre-specified object operations.

2.6.2 Working and Algorithm of Robotic arm

After the image processing is done the robotic arm is then deployed to work either manually or automatically according to the situation.

- **Manual deployment of the Robotic arm**

The manual deployment is done using flex sensors .The drone is deployed at the site of action and a person wearing flex sensors move the hand and the robotic arm moves in the same manner.

Fig 2.5 : Manual Deployment of Robotic arm using Flex sensors.

- **Automatic deployment**

In this, the robotic arm is programmed to perform various tasks i.e. on the click of the button the actions are performed by the arm.

Kinematics in robotics is the science of motion investigation. Robot arm links can be rotated or offset according to the reference coordinate frame. Angular and linear displacements between limbs are called joint coordinates and are defined by limb variables. In order to determine the amount of rotation and displacement according to the reference coordinate system of the endpoint, the matrices A which represent the amounts of each limb rotation and displacement are multiplied in turn. If the coordinates of the end point are given, limb variables can be obtained by going backward. These operations are called forward and inverse kinematics.

The Arm developed for the work is a 5 DOF (Degree of freedom) robotic arm including the wrist and gripper movement at the end- effector. It is made to work in two different modes, i.e., Autonomous and Manual mode. While working with manual mode, we are supposed to give the input to the robotic Arm in the form of angles and hence the servo motors of the arm move as per the given input. PID (Proportional Integral Derivative) algorithm is also applied for the smooth movement of the robotic Arm. Tracking the movement of the Arm is also an important task even if the Arm is manually controlled. To do so we have applied Forward Kinematic Algorithm

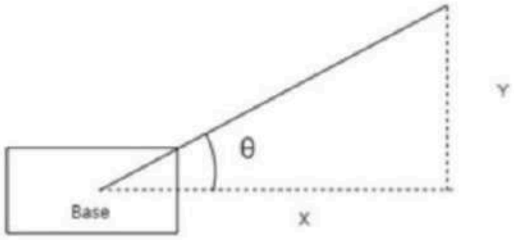

Fig 2.6 : Top View

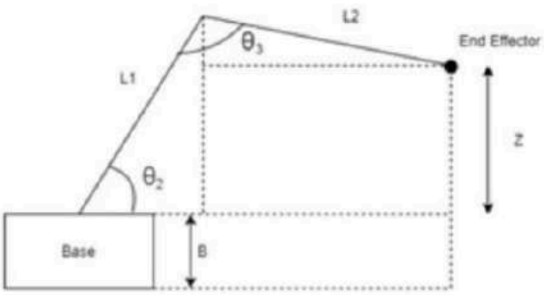

Fig 2.7 : Bottom View

As told earlier, if we are known with angles θ_1, θ_2, θ_3, the end effector's position could be found. We are known with the angles, Arm Lengths L_1 and L_2 and also the base height B, the coordinate position of the end effector could be found using the following equations:

$Z = L_1 \text{ Sin } \theta_1 - L_2 \text{ Sin } (\theta_3 + \theta_2) + B$

$X = [\ L_1 \text{ Cos } \theta_2 - L_2 \text{ Cos } (\theta_3 + \theta_2)] * \text{Cos } \theta_1$

$Y = [\ L_1 \text{ Cos } \theta_2 - L_2 \text{ Cos } (\theta_3 + \theta_2)] * \text{Sin } \theta_1$

The above equations were used for the calculation of the coordinates in 3D space from given angles. For making the Arm autonomous, we must give the coordinates to the Arm, and it is supposed to calculate the angles to reach the given position. To perform such a function, we will use an algorithm known as Inverse Kinematics Algorithm.

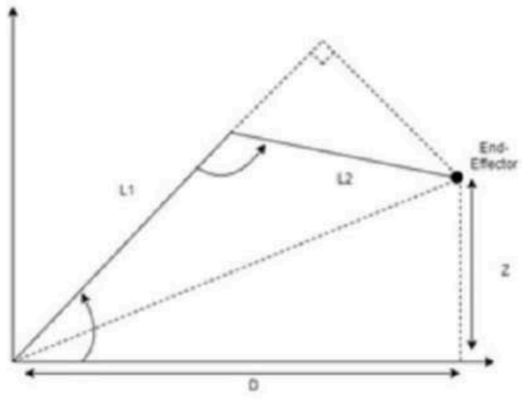

Fig 2.8 : Inverse Kinematics

Here we are given the 3D coordinates of the point where the end - effector is supposed to traverse autonomously. We have the arm lengths L1 and L2.

Here we are given the 3D coordinates of the point where the end - effector is supposed to traverse autonomously. We have the arm lengths L_1 and L_2.

$$D = \sqrt{X^2 + Y^2}$$

$$\Theta_1 = \cos^{-1}\left(\frac{L_1^2 + L_2^2 - (Z^2 + D^2)}{2\, L_1 L_2}\right)$$

$$\Theta_2 = \tan^{-1}\left(\frac{L_2 \sin\Theta_1}{L_1 + L_2 \cos\Theta_1}\right)$$

$$\Theta_3 = \tan^{-1}\frac{Y}{X}$$

Hence as we got the angle, the robotic Arm could place itself to the desired coordinates.

After placing the end - effector to the desired coordinates does not solve the problem, the orientation of the gripper also matters for picking or placing any object. We have used a rotational matrix that can calculate the rotation required to place the gripper in the correct orientation. To know the rotation of the end - effector frame with respect to the base frame, a rotation matrix could be used. The rotation matrix of any degree can be calculated by multiplying individual rotations between consecutive frames together.

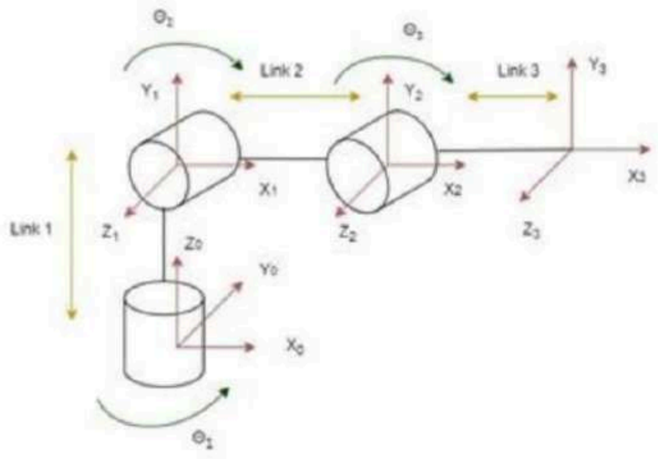

Fig 2.9 : Rotational Kinematics

So, rotation of base concerning end effector is given by rot_0^3

$rot_0^3 = (rot_0^1)\,(rot_1^2)\,(rot_2^3)$

Whererot_0^1 ,$rot_1^2 and rot_2^3$ can be calculated by:

$$rot_0^1 = \begin{bmatrix} \cos\Theta_1 & 0 & \sin\Theta_1 \\ \sin\Theta_1 & 0 & -\cos\Theta_1 \\ 0 & 0 & 0 \end{bmatrix}$$

$$rot_1^2 = \begin{bmatrix} \cos\Theta_2 & -\sin\Theta_2 & 0 \\ \sin\Theta_2 & \cos\Theta_2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$rot_2^3 = \begin{bmatrix} \cos\Theta_3 & -\sin\Theta_3 & 0 \\ \sin\Theta_3 & \cos\Theta_3 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

2.7 Block Diagram representation of the system

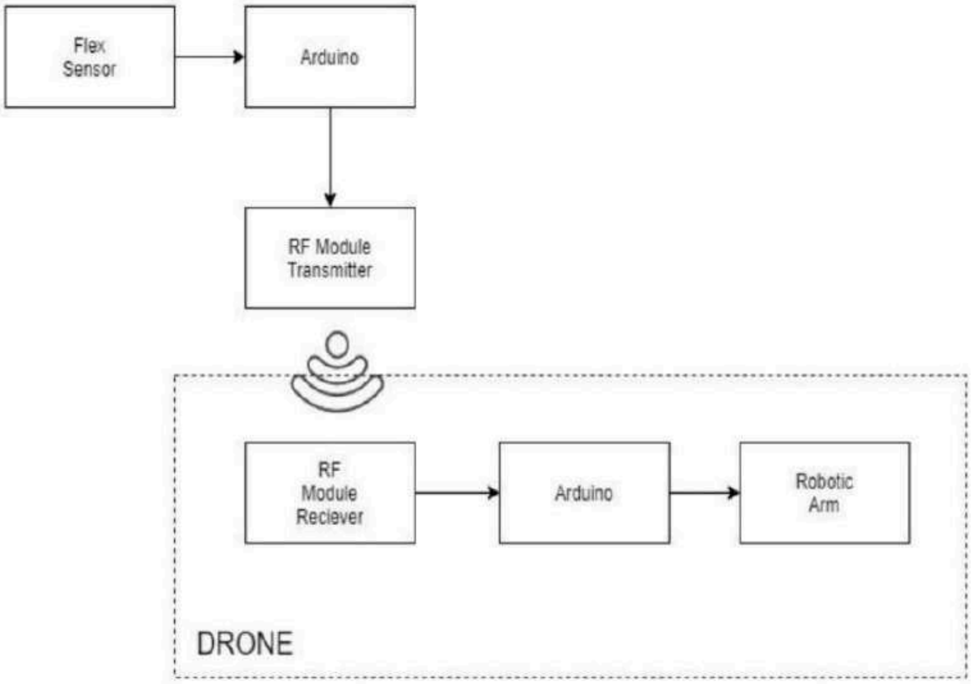

Fig 2.10 : Block Diagram Of the Project

2.8 Block Diagram representation of Image Processing

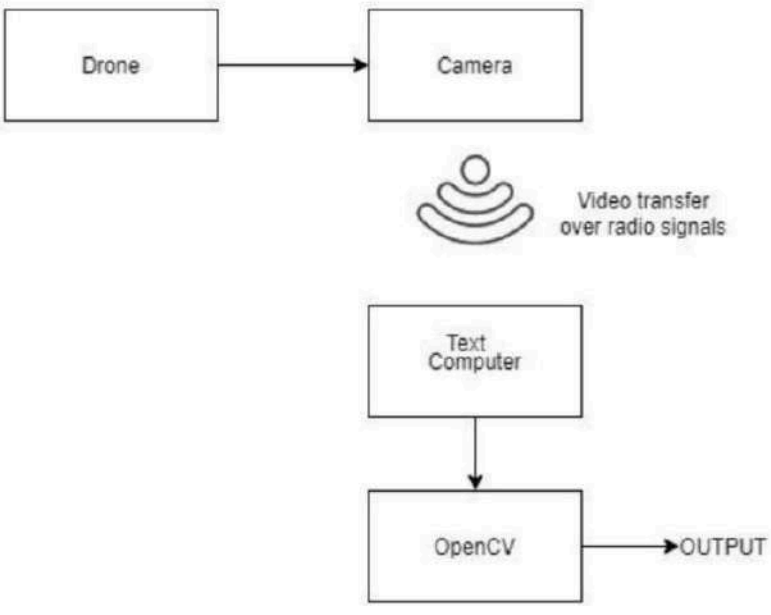

Fig 2.11 : Block Diagram representing Image Processing

CHAPTER – 3

DESIGNING AND RESULT ANALYSIS

3.1 Control Flow of the system

The control flow of the system can be broadly classified into three sections which are sensing, the Robotic Arm performs processing and the final action.

3.1.1 Sensing

The sensing of the outlying objects is performed by the triangulation of the images captured from the camera and the coordinates located by the range sensors of the 2-D plane

The laser rangefinder works on the Time of flight principle, that is the Time taken by the narrow laser beam emitting pulses from a source to reach the object and reflect back. Thus, laser pulses will only determine any of the two axes. While the images processed from the camera will allow us to plot the coordinate of the third axis.

The amalgamation of both the visual sensors and the distance sensor allows us to find the exact coordinates of the object. To increase the efficiency, we have attached an Infrared sensor to the gripper to analyze whether the position is correct or not before the gripper closes. The camera and the distance sensor are placed on the top of the drone while the Arm is fixed under the drone. We have measured the distance manually and normalized our calculation, taking the drone's base as the origin for performing all the tasks.

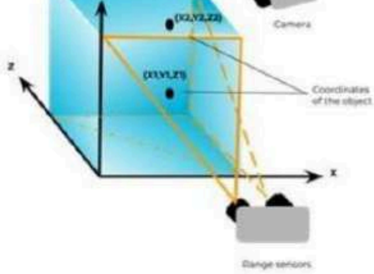

Fig. 3.1. Range sensors and the visual sensor together plotting the coordinates of the object

3.1.2 Image processing

For image processing, we have used Raspberry-Pi 4 as the control unit and OpenCV along with python libraries like imutils and NumPy to detect the object. The Algorithm of identification of images and quantification is programmed in the Raspberry pi board. For experimental purposes, we have kept the object of a particular colour for making our work easier.

3.1.3 Working of Aerial Manipulator

The coordinates taken from image processing and distance sensor are then given to the controller for controlling the Robotic Arm. Inverse Kinematics Algorithm takes in coordinates as input and gives out the servo angle to rotate to reach the required position. After reaching if the IR sensor detects an object, the gripper closes and picks up the object.

All the above-discussed functions are integrated on a quadcopter. We have used a medium-sized quadcopter with 1800Kv motors that can easily lift a payload of around 1.5 kg. For now, we have kept the UAV manual which will be controlled using a radio transmitter. For the controller, STM32 based flight controller is used, which we have interfaced with raspberry pi for giving commands to the Arm directly from the transmitter.

3.2 Algorithm to determine the coordinates of the 2-D plane

```
import cv2 # Import the OpenCV library

import numpy as np # Import Numpy library


def main():

  """

  Main method of the program.

  """
```

```
# Create a VideoCapture object
    cap = cv2.VideoCapture(0)

    # Create the background subtractor object
    # Use the last 700 video frames to build the background
back_sub = cv2.createBackgroundSubtractorMOG2(history=700,
varThreshold=25,detectShadows=True)

    # Create kernel for morphological operation
    # You can tweak the dimensions of the kernel
    # e.g. instead of 20,20 you can try 30,30.
    kernel = np.ones((20,20),np.uint8)

while(True):

# Capture frame-by-frame
        # This method returns True/False as well
        # as the video frame.
        ret, frame = cap.read()

        # Use every frame to calculate the foreground mask and update
        # the background
```

```
fg_mask = back_sub.apply(frame)


    # Close dark gaps in foreground object using closing
fg_mask = cv2.morphologyEx(fg_mask, cv2.MORPH_CLOSE, kernel)


# Remove salt and pepper noise with a median filter
fg_mask = cv2.medianBlur(fg_mask, 5)


    # Threshold the image to make it either black or white
    _, fg_mask = cv2.threshold(fg_mask,127,255,cv2.THRESH_BINARY)


    # Find the index of the largest contour and draw bounding box
fg_mask_bb = fg_mask
    contours, hierarchy =
cv2.findContours(fg_mask_bb,cv2.RETR_TREE,cv2.CHAIN_APPROX_SIMPLE)[-2:]
    areas = [cv2.contourArea(c) for c in contours]


    # If there are no countours
    if len(areas) < 1:


      # Display the resulting frame
      cv2.imshow('frame',frame)
```

```
        # If "q" is pressed on the keyboard,
        # exit this loop
if cv2.waitKey(1) & 0xFF == ord('q'):
          break

        # Go to the top of the while loop
        continue

      else:
        # Find the largest moving object in the image
max_index = np.argmax(areas)

      # Draw the bounding box
cnt = contours[max_index]
x,y,w,h = cv2.boundingRect(cnt)
      cv2.rectangle(frame,(x,y),(x+w,y+h),(0,255,0),3)

      # Draw circle in the center of the bounding box
      x2 = x + int(w/2)
      y2 = y + int(h/2)
      cv2.circle(frame,(x2,y2),4,(0,255,0),-1)

      # Print the centroid coordinates (we'll use the center of the
```

```
    # bounding box) on the image
text = "x: " + str(x2) + ", y: " + str(y2)
    cv2.putText(frame, text, (x2 - 10, y2 - 10),
      cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 255, 0), 2)

    # Display the resulting frame
cv2.imshow('frame',frame)

    # If "q" is pressed on the keyboard,
    # exit this loop
    if cv2.waitKey(1) & 0xFF == ord('q'):
      break

  # Close down the video stream
cap.release()
  cv2.destroyAllWindows()
```

3.3 Depth Perception Algorithm

```
#include<wire.h>

#include<LIDARLite.h>

LIDARLitelidarLite;

int cal_cnt=0;

void setup()

{

Serial.begin(9600);

lidarLite.begin(0,true);

lidarLite.configure(0);

}

void loop()

{

int dist;

if (cal_cnt == 0)

{

Distance=lidarLite.distance();

}

else

{

Distance=lidarLite.distance(false);
```

```
}

cal_cnt++;

Cal_cnt = cal_cnt % 100;

Serial.print(Distance);

Serial.println(" cm");

delay(10);

}
```

CHAPTER – 4

ADVANTAGES AND APPLICATIONS

4.1 Advantages

The proposed project has the following advantages:

1. Maintaining a Safe Environment

   UAVs can be used for a variety of tasks that help promote a safer environment. With their remote monitoring capabilities, drones can monitor situations, report potential dangers, and warn people of unsafe conditions, helping create and maintain a safe environment. For example, camera-equipped drones can evaluate traffic patterns which help drivers avoid high-risk areas.

   Additionally, aerial drones are ideal for military missions that are too dangerous for humans to venture upon. By obtaining real-time data on aspects such as area surveillance and monitoring public safety, they enable the operators to inspect suspicious items and situations without posing a threat to their security or welfare.

2. Affordable Cost-Saving Technology

   Because the drone technology is continuously getting refined, the cost of purchasing a drone isn't as high as it used to be. This caused their popularity to increase exponentially among the public, you can even find used drones for sale nowadays. This means that the drones are no longer exclusively available for the military, law enforcement, or the elite only.

   UAVs can also provide numerous cost-saving opportunities in various areas; they can directly replace several manned operations, saving on the cost of labor. Additionally, they can save energy and operating costs because a single drone can accomplish tasks that would typically require multiple vehicles to complete. They're also cheaper to purchase, maintain, and fuel than the regular airplanes.

3. Quality Imaging and Live Streaming

Drones can take high-quality aerial videos and photographs and collect vast amounts of high-resolution data. These data can be used to create accurate 3D maps and detailed 3D models which have many critical uses. For instance, 3D mapping of disaster areas can enable rescue teams to be better equipped before entering hazardous situations.

Due to their ability to capture high-quality images and videos, drones are commonly used for live streaming momentous events and important occasions in the entertainment industry as well as political and global events. They can also be used to cover personal events and capture significant milestones.

4. Easily Controllable

The new advanced drone-control technology allows for easy operation by users with relatively minimal experience who are using drones for basic simple tasks. This, combined with the relatively low cost of most models, has contributed to the increased popularity and accessibility of UAVs among a wide range of users.

Aerial drones have a greater range of movement than the traditional manned aircraft; they're able to fly lower and in more directions, allowing them to navigate hard-to-access areas with ease. They can also stay in the air for longer, doing repetitive tasks with precision under testing conditions.

5. Quality of Aerial Imaging

AERIAL PHOTOGRAPHY With their high-resolution cameras furnished with top-notch sensors, UAVs can take excellent Aerial Photographs, aerial videos and accumulate large volumes of accurate data. The data obtained is transformed into detailed 3D Maps and 3D Models for a complete analysis. 3D Mapping is particularly relevant to disclose cracks, damages, or other hazardous elements in disaster areas. Drones, when paired along with high - resolution images or 4K video abilities, is well-known for live streaming significant events such as entertainment, personal, political, and global affairs.

6. Easy Controllable or Deployable

The regular advancement in drone-control technology allows operators to quickly deploy and operate drones even with a relatively minimal technical background. With an extensive range of low-cost drones available for several purposes, drones are open to a broad spectrum of operators. Unmanned aerial vehicles (UAVs) have a more comprehensive range of movement, fly lower in all directions, and can navigate effortlessly when contrasted to a crewed aircraft.

7. Security

Another advantage that weighs out the pros and cons of a drone is the security centered around them. With relevant permissions and licenses, drone operators can utilize an Unmanned Aircraft System (UAS) to render safety and surveillance to private organizations, potential venues, and other expenses. Drones can also accumulate reliable information from natural catastrophes to support safety and recovery efforts.

Fig 4.1 : Drone helping a person

8. Minimizes obvious Danger and Health Risks

With the support of a Drone, numerous dangers like elevation, wind, weather, and radiation that were earlier suffered by crew members have been replaced with more viable and safer alternatives. Drones facilitate straightforward and secure inspections of towering and complicated constructions like oil and gas refineries, flare stacks, and pipelines.

9. In- depth and detail data Inplace

Many drone models are launched into the market with obstacle avoidance capacities. They can operate quite close to constructions, and this encourages them to seize precise data. They capture high-resolution images or 4K videos that explicitly reveal cracks, damages, displaced wires, and additional defects that we cannot detect through our naked eye. UAVs allow obtaining complete data without endangering inspection crew members of the company.

10. Reach Hazardous Area

UAVs make obtaining efficient data from hard-to-reach locations a cakewalk for industry professionals. It is the most suitable alternative to overcome limitations of traditional methods regarding worker's safety, especially in hazardous situations like radiation monitoring, inspecting high-voltage lines. Drones also allow a more cost-effective approach toward inspections of these locations.

Fig 4.2 : Spraying sanitizer in times of pandemic

11. Flexibility for Quick Instructions

Since Drones come with varied specifications, several can provide high or low altitude Inspections. The versatility of these characteristics empowers clients to customize the tools with ease for their projects. Drones are suitable for both regular and emergency scenarios, the Construction Industry abides by these advantages, especially building developers for Rooftop Inspections. Drones can carry out multiple roles, such as capturing high-quality photos, videos, thermal images, etc. This data is then transmitted and processed immediately, as opposed to the time-consuming conventional method.

12. Multi-rotor drones are easy control and maneuver
13. They have the ability to hover
14. They can take off and land vertically
15. And are very stable
16. Remote surveillance may allow the concerned departments to take actions faster and more efficiently.
17. Faster actions will result in lesser casualties.
18. Precision

UAVs appropriate GPS (the Global Positioning System) in their software, which is why they can be programmed and guided precisely to specific locations. For example, in Precision Agriculture, a Drone Aircraft is employed to perform many farming obligations like pesticide spraying, identification of weeds, monitoring crop health, crop damage, crop assessment, field soil analysis, Irrigation Monitoring etc. This feature of precision through the GPS conserves time and expenses for farmers.

Fig 4.3 : Pros and Cons of UAV's

4.2 Applications

1. It allows the robotic arm to reach and perform operations where it is difficult for humans to intervene.
2. Allows faster response and action.
3. Assess property damage.
4. Helps take informed decisions to take actions.
5. Better visualization
6. Better understanding of event.
7. Aerial Photography
8. Disaster Management
9. Precision Agriculture
10. Search and Rescue Operations
11. Law Enforcement
12. Entertainment Purposes

13. Weather Forecasting

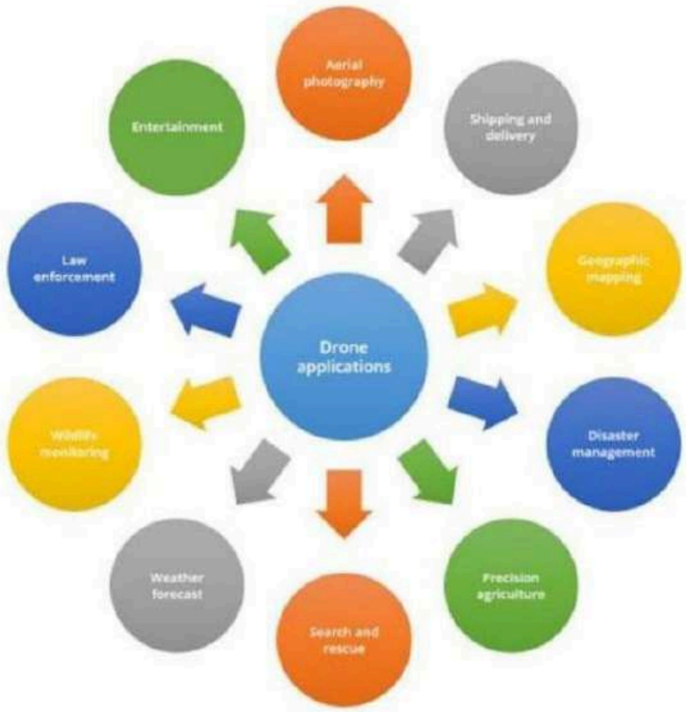

Fig 4.4 : Applications of Drones

CHAPTER – 5

CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

In conclusion, this work demonstrated the design, controller and implementation scheme for a Five degree-of-freedom aerial manipulator. One of the most important drawbacks of this work is the assumption of force regulation through pitch and 2-D position regulation alone. Such state observers are included in techniques such as torque-based control and compliant control of manipulator interaction. Additionally, the model, although intended to capture the low-level nonlinear dynamics, did not consider the effect of the manipulator inertia on the system. From a design perspective, the serial manipulator in this work provides a large workspace and sufficient dexterity. However, a parallel mechanism tends to be faster in kinematic reference tracking along the manipulated surface due to additional actuators. Another point of improvement is the overall design. The off - center weights may be reduced by mounting all motors along the vertical axis of the quadrotor and use drive mechanisms such as pulley-belts or chain sprockets.

Robotic arms, many areas are developable. Thanks to the robotic arms, many tasks are made easier and the resulting robots and a projected robot arm have been developed. In addition to this, the ability to move the robot arm is further increased, and when the camera is placed in the finger area and the sensitivity is increased, it can be used in a wide range of applications from the medical sector to the automation systems. With the robotic arms developed in this way, the risk of infecting the patient in the medical sector is minimized, while the human errors are minimized during the surgical intervention. Despite the fact that the robotic arm made in this project is of prototype quality, it has a quality that can be improved for more robotic systems. Besides these, robotic arm sector, which is open to development, will keep its importance in the future. The purpose of the project is to provide control of 4 axes moving robot arm design and mounting on with the aerial Manipulator. The necessary theoretical and practical information for this purpose has been obtained and the error level has been reduced to a minimum. For example; some pharmacy-based drug-giving necessary infrastructure has been established for the project. During the process of making and developing the project, a lot of theoretical knowledge has been transferred to the practice and it has been ensured that it is suitable for the purpose of the project.

Fig 5.1 : The Garuda

5.2 FUTURE SCOPE

This project can be used for national security purposes, Disaster Management roles, Chemical disasters where there is a risk to put human into and the drone can perform actions in place of humans. In this pandemic situation, The Garuda can also be used for sanitizing purposes at a large scale.

Since, this project is a prototype and the motion of the arm working in the 5-DoF is used to complete the task by the user. For future purposes, this project can also be used for 7-DoF which will make the project more accessible, more efficient and more to use.

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10) https://www.Design_and_Control_of_an_Aerial_Manipulator_for_Co.pdf
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APPENDIX

Algorithm to determine the coordinates of the 2-D plane

```
import cv2 # Import the OpenCV library

import numpy as np # Import Numpy library



def main():

   """

   Main method of the program.

   """



# Create a VideoCapture object

   cap = cv2.VideoCapture(0)



   # Create the background subtractor object

   # Use the last 700 video frames to build the background

back_sub = cv2.createBackgroundSubtractorMOG2(history=700,

varThreshold=25,detectShadows=True)



   # Create kernel for morphological operation

   # You can tweak the dimensions of the kernel

   # e.g. instead of 20,20 you can try 30,30.

   kernel = np.ones((20,20),np.uint8)
```

```
while(True):

# Capture frame-by-frame
    # This method returns True/False as well
    # as the video frame.
    ret, frame = cap.read()

    # Use every frame to calculate the foreground mask and update
    # the background
fg_mask = back_sub.apply(frame)

    # Close dark gaps in foreground object using closing
fg_mask = cv2.morphologyEx(fg_mask, cv2.MORPH_CLOSE, kernel)

# Remove salt and pepper noise with a median filter
fg_mask = cv2.medianBlur(fg_mask, 5)

    # Threshold the image to make it either black or white
    _, fg_mask = cv2.threshold(fg_mask,127,255,cv2.THRESH_BINARY)

    # Find the index of the largest contour and draw bounding box
fg_mask_bb = fg_mask
```

```
    contours, hierarchy =
cv2.findContours(fg_mask_bb,cv2.RETR_TREE,cv2.CHAIN_APPROX_SIMPLE)[-2:]

    areas = [cv2.contourArea(c) for c in contours]


    # If there are no countours

    if len(areas) < 1:


      # Display the resulting frame

      cv2.imshow('frame',frame)


      # If "q" is pressed on the keyboard,

      # exit this loop

if cv2.waitKey(1) & 0xFF == ord('q'):

        break


      # Go to the top of the while loop

      continue


    else:

      # Find the largest moving object in the image

max_index = np.argmax(areas)


    # Draw the bounding box
```

```
cnt = contours[max_index]
x,y,w,h = cv2.boundingRect(cnt)
    cv2.rectangle(frame,(x,y),(x+w,y+h),(0,255,0),3)

    # Draw circle in the center of the bounding box
    x2 = x + int(w/2)
    y2 = y + int(h/2)
    cv2.circle(frame,(x2,y2),4,(0,255,0),-1)

    # Print the centroid coordinates (we'll use the center of the
    # bounding box) on the image
text = "x: " + str(x2) + ", y: " + str(y2)
    cv2.putText(frame, text, (x2 - 10, y2 - 10),
      cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 255, 0), 2)

    # Display the resulting frame
cv2.imshow('frame',frame)

    # If "q" is pressed on the keyboard,
    # exit this loop
    if cv2.waitKey(1) & 0xFF == ord('q'):
      break
```

```
# Close down the video stream
cap.release()
cv2.destroyAllWindows()
```

Depth Perception Algorithm

```
#include<wire.h>
#include<LIDARLite.h>
LIDARLitelidarLite;
int cal_cnt=0;
void setup()
{
Serial.begin(9600);
lidarLite.begin(0,true);
lidarLite.configure(0);
}
void loop()
{
int dist;
if (cal_cnt == 0)
{
Distance=lidarLite.distance();
```

```
}
else
{
Distance=lidarLite.distance(false);
}
cal_cnt++;
Cal_cnt = cal_cnt % 100;
Serial.print(Distance);
Serial.println(" cm");
delay(10);
}
```

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Rajiv Sharma		
Prof.(Dr.) Rajiv Sharma Convener	Prof.(Dr.) Sanjay Sharma Director	Sh. S.N. Garg C.E.O

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