MULTI-ROTOR ARM EXTENSION

PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY IN

Electronics and Communication Engineering

REPORT SUBMITTED

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DECLARATION

It is hereby declared that the work reported in the B.Tech Project Report entitled **Multi-rotor Arm Extension** submitted at **Jaypee University of Information Technology, Waknaghat, India** is an authentic record of our work carried out under the supervision of Dr. Vikas Baghel. This work has not been submitted elsewhere for any other degree or diploma.

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This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

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Head of the Department/Project Coordinator

ACKNOWLEDGEMENT

Special thanks to our mentor Dr.Vikas Baghel for giving an opportunity to do a great in a lifetime project. The process has led to the acquisition of a lot of new knowledge, which has been very satisfying.

Secondly, I would like to thank my family and friends who helped me complete this work in the limited time.

Harshit Singh 201002

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Meaning
UAV	Unarmed Aerial Vehicle
RC	Remote controller
LIPO	Lithium polymer battery
I/O	Input and output
S1	Screw one
S2	Screw two
G1	Gear (1)
G2	Gear (2)
TR	Threaded Rod

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ABSTRACT

Drones, also called unmanned aerial vehicles (UAVs), are flying machines that don't require a human pilot inboard. They can be controlled remotely by people on the ground or programmed to fly autonomously. These versatile vehicles have numerous applications, including in agriculture. One idea is to equip them with telescopic arms. These can extend and retract, offering flexibility in various tasks such as crop monitoring or spraying. And to control these arms, they have been integrating a wireless remote controller. This innovation will allow farmers to efficiently perform tasks from a distance, making farming operations more convenient and effective. This controller allows operators to manipulate the arm's movements from a distance, providing greater flexibility and convenience in executing farming tasks. This technological advancement facilitates not only increased productivity but also reduces labor work. Promising enhanced yields and minimize environmental impact. Robotics and agriculture heralds a new era of development and up gradation in farming. By making the power of drones equipped with telescopic arms, farmers can enhance productivity, decrease operational costs, and make informed decisions regarding their crops.

CHAPTER 1 - INTRODUCTION

1.1 Unmanned Aerial Vehicle (UAV)

Unmanned aerial vehicles (UAVs) are combat aircraft that can operate in a remote or autonomous manner. They are outfitted with sensors, electronic transmitters, offensive ordnance, and target designators to engage or disrupt enemy targets. Unmanned Aerial Vehicles (UAVs) are more efficient and have a longer range and endurance than manned aircraft because they do not require crew, life-support systems, or strict design safety requirements.

Since making its operational debut in 1995, the MQ-1 Predator, a reconnaissance UAV used by the U.S. Air Force, has been a major player in the development of tactical UAVs. After World War II, target drones and remotely piloted vehicles gave way to modern unmanned aerial vehicles (UAVs), which were essential weapons systems in the early 1980s. Other armed forces, including the US military, were influenced by the Israeli Defense Forces' innovative use of small, covert drones equipped with cameras and target designators.

When it was made in 1994, the MQ-1 predator showcased advancements in unmanned aerial vehicle technology. This piston- powered aircraft, boasting a length of 26 feet 8 inches (8 meters) and a wingspan of 41 feet 8 inches (12.5 meters), marked a moment in the evolution of aerial surveillance and reconnaissance systems, Its introduction revolutionized military operations, offering enhanced capabilities for surveillance, target acquisition have since made it a cornerstone of modern military operations, underscoring its enduring impact on the landscape of aerial warfare.

In the 21st century, Unmanned Aerial Vehicles have become more and more connected to military operations, with a focus on improving endurance, range, stealth capabilities, and also autonomous functions. UAVs have been also expanding into commercial use also like media, disaster response and more. These operations have evolved to provide safety , privacy and security concerns with authorities worldwide providing rules and guidelines for UAV operators.

1.1.1 PURPOSE OF UAVS

Unmanned aerial vehicles, or UAVs, are becoming more and more common in military operations, disaster relief efforts, and remote area exploration. The necessity for effective task execution in a variety of scenarios has increased the significance of multi-UAV systems in mission planning. The fundamental idea is that, despite potential individual limitations, a group of UAVs can effectively tackle difficult problems (Ducatelle et al., 2009). When compared to single-UAV systems, multi-UAV systems exhibit increased speed, efficiency, and reliability. With single-UAV systems, it can be difficult to plan the best routes for long missions, but new technology has greatly improved UAV mission efficiency. Even with this advancement, UAVs still have to deal with issues like sudden changes in their surroundings, gathering data, and allocating resources while on missions. Multi-UAV path planning improves adaptability while lowering the possibility of mission failure.

Fig.1 Hexacopter drone

This is base model when the drone was first designed, it's a Hexacopter drone with 12V lithium battery and 6 motors connected with ESC (Electronics Speed Controllers) all the ESCs are connected directly to the flight controller, Fly sky CT6B receiver and transmitter has been used , the receiver is connected to the flight controller to control it wirelessly, there is also a GPS for tracking drone’s location.

1.1.2 USES OF UAVS

- Drones are indispensable in many domains, providing effective answers to a wide range of problems. Drones improve overall operations in waste management by streamlining duties like garbage collection and landfill monitoring. Applications for road safety include road network surveillance, accident investigation, and risk assessment.
- Drones are useful for traffic monitoring because they can extract online and offline traffic parameters, which improves traffic control systems. UAV technology is useful for managing roadway infrastructure, particularly when it comes to identifying pavement deterioration and inspecting bridges.
- Drones are a quick and effective way to identify stress, schedule treatments, monitor plant growth, and scout crops in agriculture. In environmental applications, vast areas are mapped and observed for management, protection, and research in areas that are impossible for humans to access.
- Drones play a crucial role in disaster relief efforts by speeding up the delivery of supplies to impacted areas and minimizing reaction times during natural catastrophes. They map both natural and artificial forests, which is useful information for managing and analyzing the health of trees.
- Drones inspect hard-to-reach areas in ports and maritime environments, providing information on environmental health and safety, traffic control, and port surveillance. Drone applications are beneficial for monitoring fish populations, water quality, and vessel traffic in coastal areas and waterways.
- Drones fitted with LiDAR technology greatly increase surveying and aerial mapping by producing accurate 3D models. Drones aid in the development of metro maps and in-depth surveys and mapping. Drones of an industrial grade help in mining by mapping the terrain, assisting with asset inspection, and surveying. This increases operational efficiency. Cheaper prices for civil engineering projects. Drones are used in real estate applications to take overhead photos and movies that provide potential purchasers a different viewpoint.

Fig.2 3D model of the drone

This drone's 3D design has been performed on Solidworks. This model shows a Multirotor drone with the following features:

Frame- The frame is made to hold the motors, propellers and electronic components.

Motors and propellers - The drone features multiple motors and propellers, placed to ensure balanced lift and stability during flight.

Electronic components- This model includes a compartment for housing electronic components such as the flight controller, battery and camera.

1.1.3 TYPES OF UAVS

They are designed for specific purposes and applications. Here are some common types:

1. **Fixed- Wing drones -** These drones resemble airplanes and are designed for longer flight durations and greater distances. They are efficient for tasks such as aerial mapping, surveillance, and reconnaissance.
2. **Multirotor UAVs -** These drones have multiple rotors (typically four, six , or eight) and are highly maneuverable. They are commonly used for tasks such as aerial photography, videographer, and inspections due to their stability and hovering capabilities.
3. **Payload- specific UAVs-** Some drones are designed for payload works only such as LiDAR sensors for mapping, thermal cameras for search and also for rescue purposes.
4. **Bio- Inspired UAVs-** Designed to mimic characteristics of birds, insects, or other animals,

these drones are developed for specialized applications like environmental monitoring, search and rescue, and agriculture.

5. **Nano UAVs –** Also known as micro drones, these are very small drones typically used for indoor applications, close- range reconnaissance, or tasks where maneuverability in tight spaces is crucial.
6. **Hybrid UAVs –** They combine features of both fixed-wing and Multirotor drones. They can take off and land vertically like Multirotors but transition to fixed-wing flight for efficient long-range operations. This versatility makes them ideal for applications such as surveillance, mapping and cargo delivery.
7. **Solar-Powered UAVs-** These UAVs are equipped with solar panels on their wings to harness solar energy for onboard systems. They are used for long duration missions such as environmental monitoring, atmospheric research, and telecommunications.

CHAPTER 2 - REVIEW OF LITERATURE

2.1.1 LITERATURE REVIEW

1. L Bogdan, E Toma - Applied Mechanics and Materials, 2014 - Trans Tech Publications The focus of the paper is on the integration of telescopic modules into the robotic arm structure, as it examines a robotic arm driven by a monomial telescopic planetary gear.

2. A Ogawa, T Fujioka, H Nabae… - 2020 IEEE/SICE …, 2020 - ieeexplore.ieee.orgThe authors discuss the drawbacks of traditional telescopic structures and suggest a linear mechanism for controlled expansion and contraction that uses a slide screw.

3. V Gomez, M Hernando, E Aguado, D Bajo, C Rossi - Soft Robotics, 2023 - liebertpub.com. The article presents the ROBOMINERS project, which aims to improve the safety and efficiency of mining robots. In order to achieve reconfigurability during operation, it focuses on the development and kinematic modeling of a soft, telescopic, continuum arm integrated into a modular robot.

4. W Myeong, SSong, H Myung -2018 15th International …, 2018 ieeexplore.ieee.org. A unique rotating arm wall-climbing drone is suggested for use on different kinds of surfaces. The application of wall-climbing robots in various tasks, such as structural health monitoring and maintenance, is highlighted in the paper .

5. S Brischetto, A Ciano, CG Ferro - Curved and Layered Structures, 2016 - degruyter.com. An innovative Unmanned Aerial Vehicle (UAV) with multiple rotors and a variable configuration is presented in this paper. The main structure offers simple and quick configuration changes by combining a universal plate and a circular ring to form a rail guide for arms.For drone teleoperation tasks, especially obstacle avoidance, teleoperators rely on both haptic and visual feedback. The study addresses the drawbacks of large haptic interfaces.

6. A novel all-purpose drone design featuring movable arms and a variable number of rotors is suggested. The paper presents a comparative analysis of various rotor configurations, including Dodecacopter and Octocopter, analyzing how well they perform in terms of trajectory with varying arm lengths.

7. R Szabo, RS Ricman - 2022 International Symposium on …, 2022

ieeexplore.ieee.org.

The paper presents a terrestrial drone that consists of a robotic arm and rover combination. Using a radio remote controller, the system is made to reach difficult-to-reach places like radioactive fields or small spaces.

8. W Thomas, P Wegrowski, J Limerick… - … and Computing (IETC …, 2022 - ieeexplore.ieee.org.The design and analysis of a robotic arm for UAVs requiring little actuation is the main focus. As part of a sophisticated grasping system, the foldable arm mechanism tries to reduce weight and has a case to hold the arm during flight.

9. P Wegrowski, W Thomas, J Lemrick… - … and Computing (IETC), 2022 - ieeexplore.ieee.org.The design of a robotic arm prototype for a quadcopter with a modular folding mechanism is analyzed in this paper. By extending from the drone's body, the foldable arm reduces air resistance and makes object retrieval or sampling easier.

2.1.2 MOTIVATION AND PROBLEM STATEMENT

The use of drones in agriculture is expanding rapidly along with the global population. Drones are being used for a wide range of purposes, including photography, military use, surveillance, and agriculture.

Drones are used for a lot of work these days due to the overwhelming demand for work. Numerous pieces of equipment, including a robotic arm, spraying system, camera, and many more, are attached to the drones. Because sometimes there isn't enough room on the drone to accommodate additional useful equipment if we want to upgrade the equipment. The rapid increase of drones has crowded the development of regularity frameworks. Such as airspace management, privacy concerns, and safety regulations are critical.

Owing to the overwhelming demand for drones and the limited space available for equipment, it will attach a telescopic on the drone's lower side, which will extend and retract with the transmitter, allowing the user to add more necessary parts by creating more room. For instance, a small pesticide sprayer can be installed in the arms , which will extend and cover a larger diameter, enabling us to spray more pesticide in a shorter amount of time.

The drone's weight plays a critical role in its ability to fly. To ensure that it flies smoothly and evenly, by attaching the extendable arms to the propeller it will allow us to monitor the use of arms wirelessly, Multirotor arm extension will help providing more room for new parts which will help upgrade the drone for the greater level. These arms enable drones to interact with environment in their ways that other drones cannot, for example gripping, and performing delicate operations. These arms can also be used in medical stuff like sending supplies to the medical departments in short amount of time.

2.1.3 METHODOLOGY

A telescopic arm will be attached to the drone, and to control its extraction and compression, a nut bolt on the arm's base will be installed. The arm will be controlled via the drone's transmitter, which will be set up to operate on a separate channel. The mechanism for the arm will consist of two cuboid-shaped rods that are attached to each other with a long, light-weight screw. The arm will be able to be extracted and compressed using a motor and gears, and at the end of the arm is a hole where different pieces of equipment can be attached.

The telescopic arm that is integrated into the drone is an advanced mechanism that is intended to increase the drone's capabilities for a variety of tasks that need precise manipulation and control. Its central component is a finely designed nut bolt mechanism that is positioned at the base of the arm to provide stability and facilitate easy rotation and extension/retraction movements. This mechanism provides operators with precise control over the arm's movements, independent of the drone's flight functions. It interfaces seamlessly with the transmitter of the drone through a dedicated channel.

The arm itself is painstakingly made from strong, lightweight materials, usually carbon fiber or aluminum, to achieve the ideal ratio of weight efficiency to durability. Two cuboid-shaped rods that are intricately connected to one another make up its structure, which provides a strong foundation for the arm's functions. Its operation is centered around a long, thin screw that passes through the rod assembly's center. This screw powers the arm's ability to extend and retract, working in tandem with a precisely designed motor and gears.

2.1.4 COMPONENTS FIGURES

Fig.3 – Threaded rod

Fig.4 – Micro Gear Box Motor

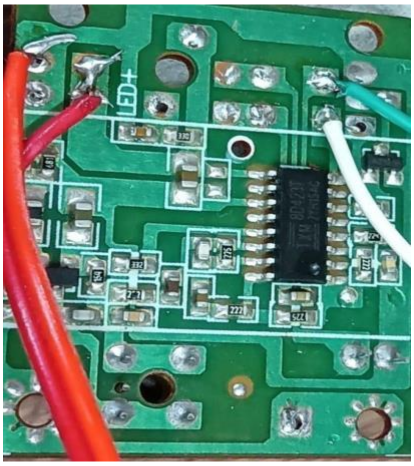

Fig.5&6- R/C car transmitter and receiver of 20 MHz frequency

Fig. 7 Lithium Polymer Battery Pack (Lipo) of 14.8V Battery

2.1.5 TABLE OF COMPONENTS

TABLE: 1

Serial No.	Components
1	Light weight rod
2	Motor (12v)
3	Receiver
4	Transmitter
5	Battery

The arm operates without the need of any physical connections. One device is called the receiver which is connected to the motor that helps in moving the arm. The other device, known as the R/C transmitter which allows remote control of the receiver enabling wireless operation of the arm. The motor of 12V is connected to the receiver where power is given to the 12V Lithium polymer battery.

CHAPTER 3 - SIMULATION RESULT

3.1.1 Brief of the project

In this project, an extendable arm was designed using software named Solidworks. Various lengths and widths were taken for the two arms nestled within the main (base) arm, to make smooth movement without having any difficulties. Grippers were made inside the arms to maintain a consistent distance during extension and retraction processes. The final prototype is shown in page 21, where a threaded rod is attached to the screw at the front arm to help it extend and retract. Also an overview of the design and simulation conducted in Solidworks is presented in detail in the figure on the next page. The motor which has been used in this project, it has an RPM of 100 rotations per minute, and it is directly connected to the rod which has a thickness of 4mm and has a length of 15cm (0.15m) both are connected to the base of the arm.

These extendable arms are intended for making into a spraying system mounted on a drone. Their purpose is to enhance the efficiency of the pesticide distribution by covering a larger radius in a shorter time span.. This innovation is expected to significantly reduce both time and workload. Right now only a prototype of a single arm has been developed thus far, capable of extending up to 10 cm in length.

This mechanism provides users with smooth control over the arm's movements, independent of the drone's flight functions. The motor used has an RPM of 100 rotations per minute, and it is directly connected to the rod which is connected to the base of the arm. The threaded rod has a length of 15cm and has thickness of 4mm. The motor interfaces seamlessly with the receiver connected to the transmitter of the drone through a dedicated channel of 24Mhz.

3.1.2 Solidworks Simulation

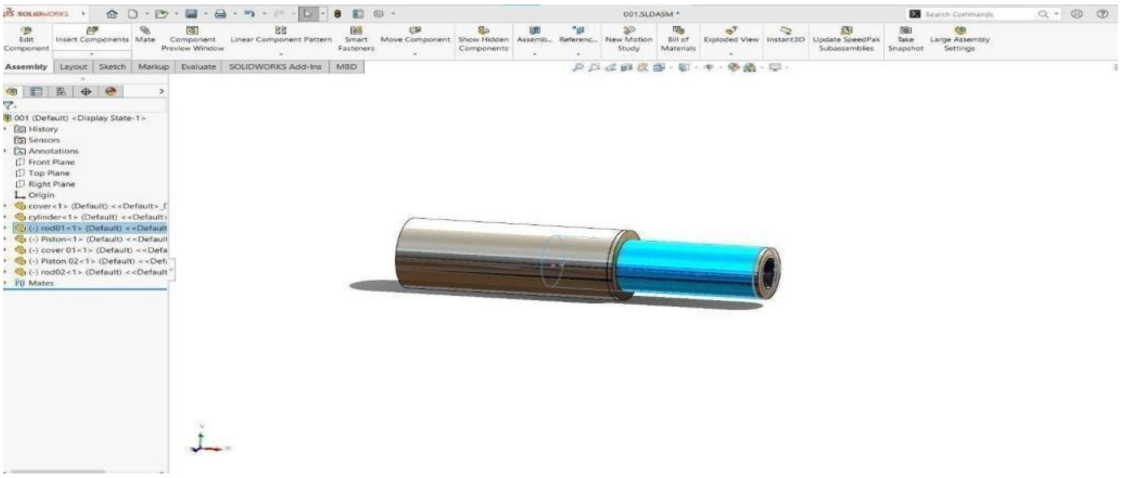

Fig. 8 Solidworks simulation of the telescopic arm in its compressed state

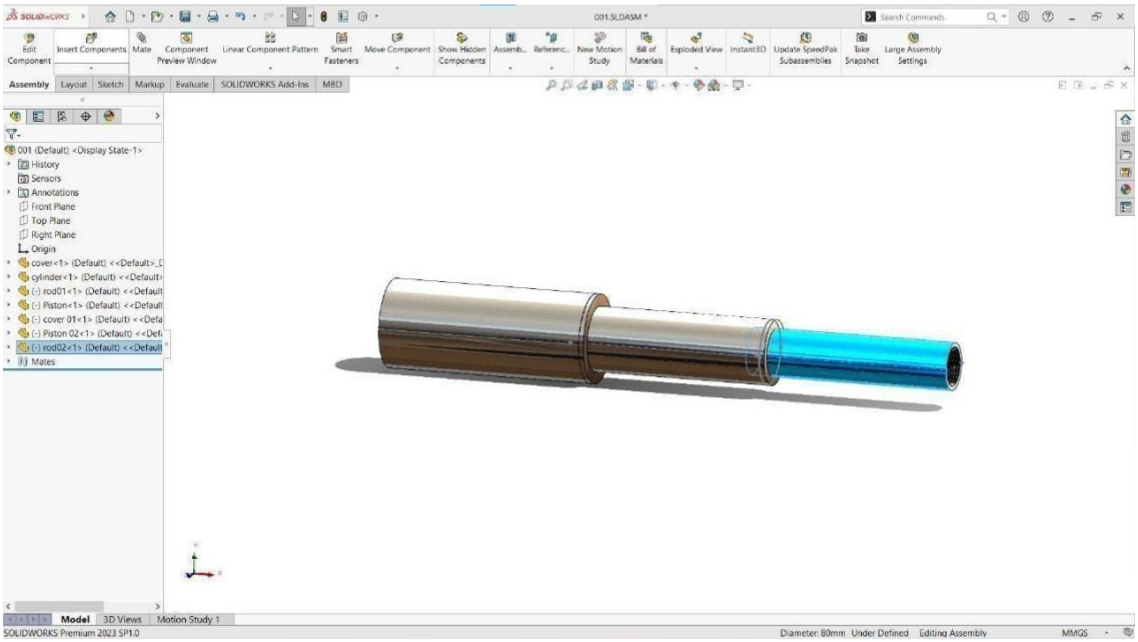

Fig.9 Solidworks simulation of the telescopic arm in its expanded state

Each part of the arm is designed with interlocking features to make sure it has secured contraction and retraction. The design shows a three-arm segment extension mechanism. In this figure, a third arm was attached within the second arm, designed to extend only after the second arm's expansion. The length of this inner arm is limited up to 5cm of length to minimize weight.Highstrength and lightweight materials are chosen to minimize weight while maximizing the durability.Each arm designed has a different dimension and width to make it suitable to extend and retract.

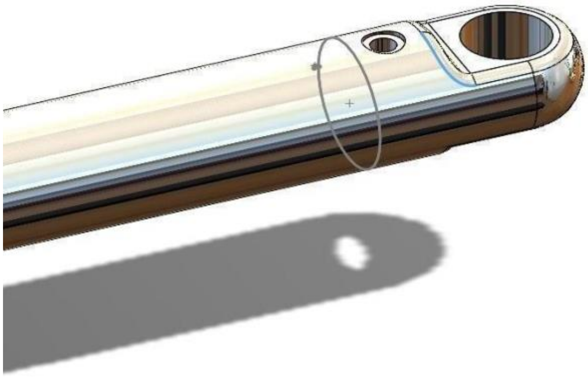

Fig. 10 Hook

The design shown in figure 10 shows the hook attached to the end of the drone's extended arm.This component is essential to attach spraying pumps or carry additional equipment like delivery services. The hook is strategically placed to maintain the balance for the drone. It can only carry light weight materials. Solidworks also includes tests ensuring the hook's longevity.It's a powerful CAD software, to make sure precision and functionality. It also minimizes aerodynamic problems for the drone. Furthermore, the hook's shape and dimensions are designed to securely hold various payloads without giving problems to drone's movements.

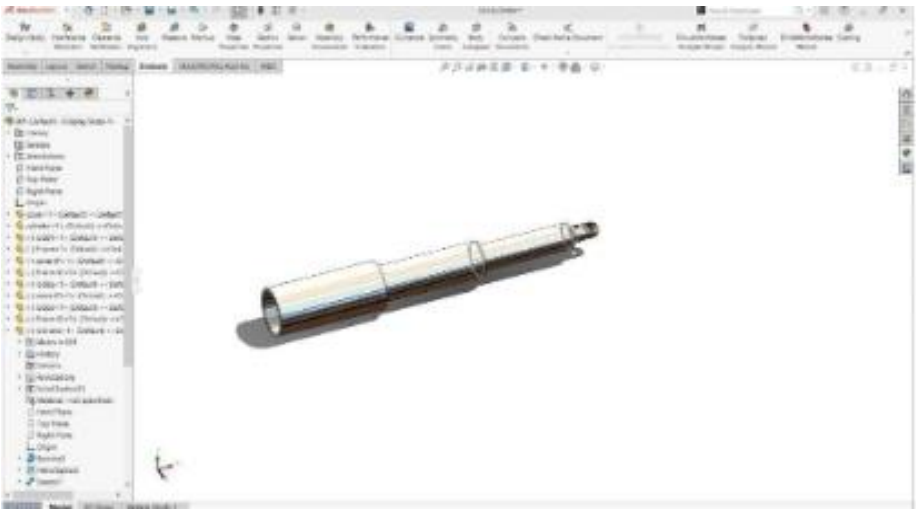

Fig. 11 Sideview of the arm

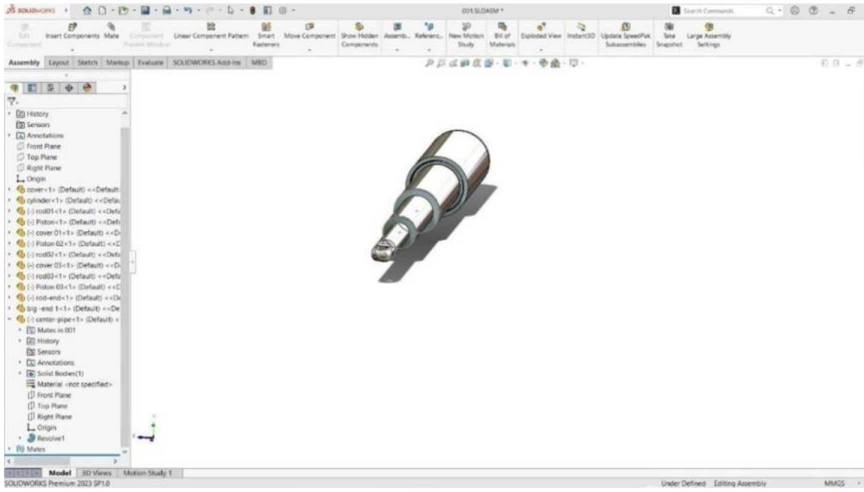

Fig. 12 Front view of the arm

Final design of the arm performed on the software the grappling hook is attached at the base of the arm, a total of three arms are used in this simulation. A gripper part is made inside the arms so that it won't fall out of the arms while extending.

3.1.3 - BLOCK DIAGRAM

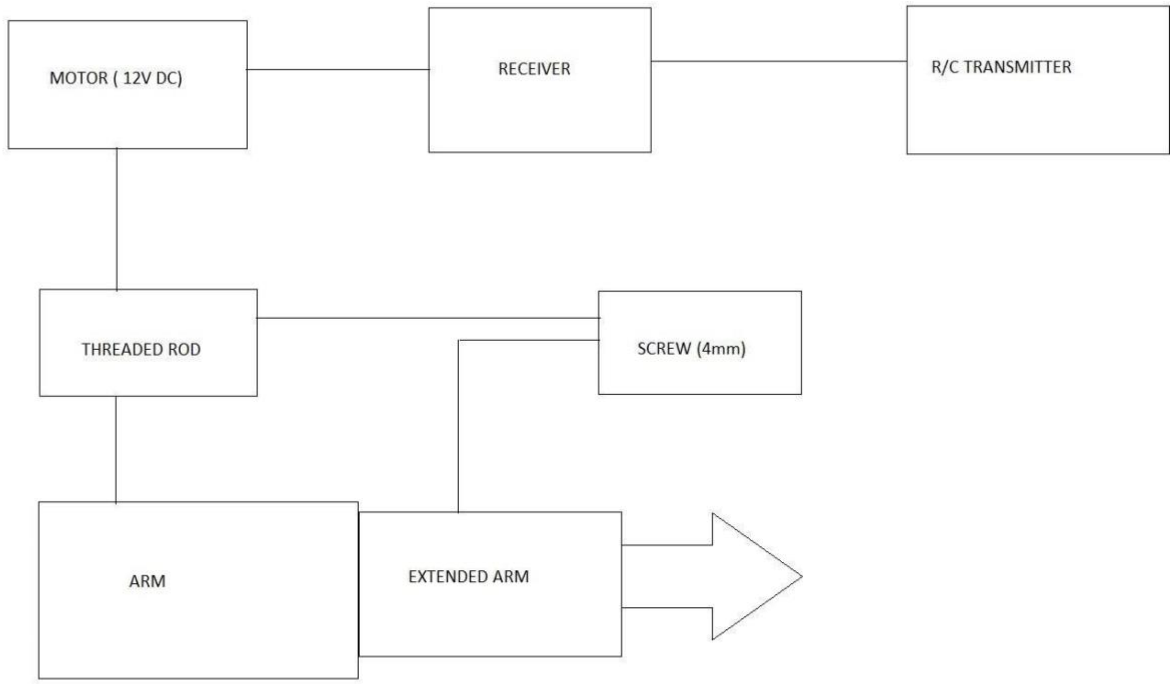

Fig. 13 Block diagram of the Arm System

3.1.4 FINAL ARM MODEL

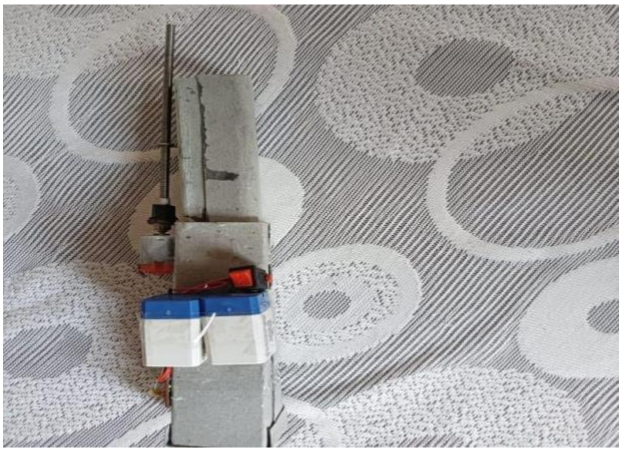

Fig.14 Upper view of the ARM

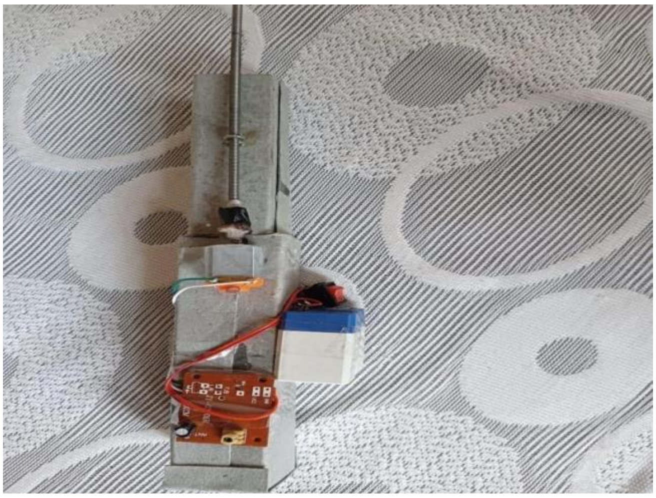

Fig. 15 Vertical view of the ARM

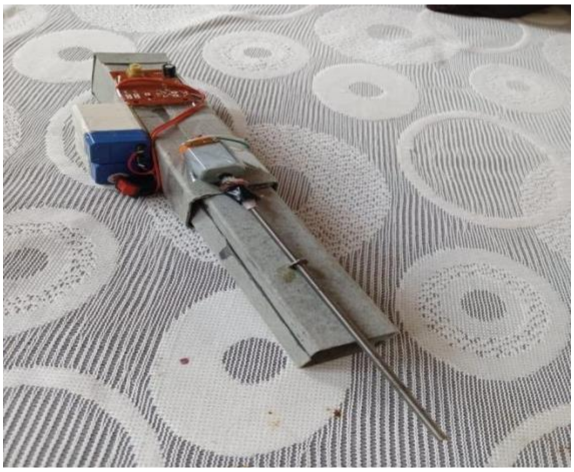

Fig.16 -Final view of the prototype arm

This is the final prototype which has been made, it consists of two batteries of 4V each (total 8V). The base arm has a length of 15cm in a cuboid shape and has width of 3.5cm. Whereas the second arm which has been inserted inside the base arm with a screw has the length if 20cm and has the width of 2.9cm. This arm can extend up to 7 to 10 cm in length providing extra coverage for spraying at crops. It also has a switch button to on/ off the battery whenever required. The arms have been made of cardboard sheets to prevent heavy weight on the motor as well as the threaded rod. It is controlled wirelessly with the help of R/C transmitter and receiver of both having the same frequency of 24 MHz This arm has been designed for our drone to enhance the drone’s functional capabilities. The primary objective of this Multirotor arm extension is to improve drone’s efficiency in tasks such as surveillance, data collection, and environmental monitoring.

3.1.5 ADVANTAGES

Advantages of the Multirotor arm extension are as follows: -

- Light weight arms are used in this prototype.
- Can be used to attach extra equipments.
- It will cover more area when it is extracted for spraying.
- Increased separation between propellers reduces vibrations transmitted to the drone's body and sensitive onboard sensors, improving data accuracy and component lifespan.
- The extendable arm facilitates the spraying of pesticides over a larger area compared to traditional methods.
- Longer arms makes the drone more resistant to external disturbances like wind, resulting in improved stability.
- It also provides more opportunities to place electrical components like sensors and cameras, optimizing the performance.
- Integrating the extendable arm on the drone improves its overall stability during flight. By distributing weight more evenly and providing additional support.

CONCLUSION

Understanding the synergy between the transmitter, receiver and motor has been instrumental in comprehending how the entire system operates without any problem. With this knowledge in hand, it is possible to develop a robust arm mechanism that can be wirelessly controlled by a receiver. Additionally, the functionality of the motor coupled with a threaded rod and screw mechanism, which will play a crucial role in extending and compressing the arm.

This wireless control capability not only enhances the usability of the system but also promises to streamline operations significantly. By eliminating the need for manual intervention, our wireless arm mechanism ensures ease of use, saves time, and promotes efficiency in carrying out various tasks. This advancement represents a significant step forward in leveraging technology to optimize workflow processes and achieve desired outcomes with greater effectiveness.

Additionally, it will have the capability to transport moderate weights over short distances swiftly, facilitating the transportation of spraying pumps. Moreover, by extending the arm, it will prevent issues of damaging the components while spraying pesticides, because it can spray some water at the electrical components which can damage the drone completely, so by extending the arms we will be able to reduce that problem.

FUTURE WORK

In the future, our focus will extend to integrating a grabbing system into the drone's design. This system will be specifically engineered to handle light-weighted objects for delivery purposes.

1. **Delivery Assistance:** The grabbing system will enable the drone to carry small parcels or payloads, expanding its utility for delivery services.

2. **Enhanced Stability:** By bearing the weight of the drone, the grabbing system will contribute to maximum stability during flight, enhancing overall performance and maneuverability.

3. **Innovative Design:** Exploring the possibility of designing the grabbing system with a 3D printer. This approach allows for customizing the design to meet specific requirements and optimizing functionality. With these advancements, the goal is to make them more versatile in various applications, including delivery services.

4. **Continuous Innovation:-** The research will continue to explore new opportunities for enhancing the Multirotor extension arm and also the grabbing system at the end of this arm. This ensures that the delivery solutions will grow with the changing needs of the industry, medical and normal deliveries and the society.

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