International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

Resizable Drone Designs: for Maneuvering Through Paths of Varying Dimensions

Varun Prakash. R, Kirubakaran. G, Dinesh Kumar. D, Vignesh Nainar. A

Abstract*: An unmanned aerial vehicle, commonly known as a drone, is an aircraft without a human pilot aboard. Essentially, a drone is a flying robot that can be remotely controlled or fly autonomously through software-controlled flight plans in their embedded systems, Flying robots are increasingly adopted in search and rescue missions because of their capability to quickly collect and stream information from remote and dangerous areas. Their maneuverability and hovering capabilities allow them to navigate through complex structures, inspect damaged buildings, and even explore underground tunnels and caves. Since their size is fixed, maneuvering over the compact areas and tunnels of variable size becomes an issue. To overcome this issue, we propose a model of quadrotor design which has the capability to change its size. The arm length of the quadrotor is changed dynamically so that it can fly in areas of variable sizes that would be hard to reach with the quadrotor of fixed arm length. On the other hand, our model is cost-effective, since the arm of the drone is designed with PVC (Polyvinyl Chloride). Using this model, drones will be able to move over compact areas and passages of variable sizes, thus aiding in better exploration during search and rescue operations.

Index Terms*: Quadrotor, Aerial Robot, Drone.

I. INTRODUCTION

QUADROTORS are receiving wide attention due to their varied usefulness. Specifically quadrotors with the capability of navigating autonomously find applications in search and rescue operations for the purpose of exploration. In the task of exploration, maneuvering in distorted environments imposes varied challenges. In such a scenario the aerial vehicles will be blocked by thin passages. It needs agility and adaptability in such scenarios. Though micro aerial vehicle can be used their payload is limited. Another option would be that using aggressive flight mechanism, but such mechanisms needed sophisticated cameras. Resizing of drone depending on scenarios would be an alternate option with limited complexity of quadrotors.

Falanga et.al [1] proposed an idea of varying the morphology of the quadrotors. In this, the quadrotors were able to modify three different shapes which is H morphology, T morphology, and O morphology. Every morphological design was used for the specific purpose for example T morphology is used for a flight of quadrator for close inspection purposes which is otherwise not feasible with common X morphology, H morphology is used of flight in narrow gaps and so on. Here Real-time stability is obtained using an adaptive control technique. Riviere et al. [2] introduced an elastic kind of methodology for changing its shape and control technique is used to tackle loss of stability due to the roll axis. Because of the folded structure, the robot was able to move through passages which are tapered. Due to the elastic kind of mechanism, the quadrotor returns immediately normal structure after passing through the slender passage. By use of control technique, the reconfiguration is done passively and dynamically also. State estimation, control, and planning for hard-line flight is achieved using one visual sensor and Inertial Measurement Unit by Giuseppe Loianno et. al [11]. The main advantage of this work is that it uses only one monocular camera for aggressive flight. But using this kind for tilting mechanism requires high refreshing rates of visual sensor and complex computations. Additionally, hardware overhead is needed for varying tilt angle of rotors. Quadrotors which do not change its morphology but varies its span spread was introduced by Desbiez et. al [4]. Two arms are joined in the form of X shape using a scissor type of connection, in which the movable upper arm is pulled to reduce the spread span of the quadrotors arm.

The above works describe changing into different morphology, reducing the arms spread area using elastic and scissor kind of mechanism and using visual sensors for tilting. Changing to a different morphology requires special mechanisms for maintaining stability. This work focuses on reducing the spread of quadrotor arm without altering the X geometry, thereby better stability because the centroid (angle of interest) remains unaltered. In this paper, two designs are proposed both of which has the capability to shrink without altering the X geometry. italics for emphasis; do not underline.

II. MECHANICAL DESIGN

In Fig.1 the overall block diagram of the entire system is shown. The flight control board, speed controller and motors with propellers form the generic block diagram of aerial vehicles.

Revised Manuscript Received on 30 July 2019.

* Correspondence Author
Varun Prakash. R*, Electronics and Communication Engineering, Mepco Schlenk Engineering College, Sivakasi, India.
Kirubakarn. G, Electronics and Communication Engineering, Mepco Schlenk Engineering College, Sivakasi, India.
Dinesh Kumar. D, Electronics and Communication Engineering, Mepco Schlenk Engineering College, Sivakasi, India
Vignesh Nainar. A, Electronics and Communication Engineering, Mepco Schlenk Engineering College, Sivakasi, India.

In addition to those conventional components, the proposed system includes Arduino and DC motor. These two additional components are included for the purpose of rack and pinion setup is used in controlling the arm of the drone. In this setup, a single DC motor is used to control all the four arms of the quadrotor compared to four motors in design-1. This setup consists of two gear placed one above another and connected by a shaft of the DC motor. This DC motor is placed at the center of the aluminum plate which is the base of the quadrotor. There are four racks with teethes which connects gear wheels in center and the rectangular arm made of aluminum. Among these two racks act as a connecting link between pipes and lower gear wheel in the shaft of DC motor. The other racks act as a connecting link between| pipes and upper gear wheel in the shaft of DC motor. All the rectangular aluminum pipes are fitted to the aluminum base plate with a specially designed clamp with provision for the inward and outward motion of the aluminum pipe along with the racks connected to it.

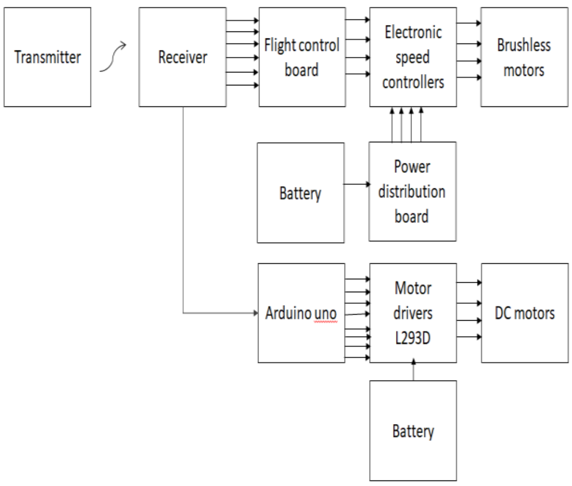

Fig. 1: Block Diagram

A. Resizable Arm using hollow cylindrical pipes

Two hollow concentric arms are used. During shrinking, the cylindrical arm of small diameter is pulled within the arm of larger diameter. A line of the hole is made in the outer cylindrical arm which provides the movement space. The shaft of the motor is present along the axis of the inner arm. This shaft is connected with the inner arm and outer arm using a nut and bolt. Rotation of the shaft causes the movement of the inner arm in and out of the outer arm. The shaft which runs along the axis of the inner pipe is connected with the motor clamped along the four corners of the body of quadrotor. This motor makes the inner arm to move out or to squeeze in for the purpose of varying the spread area of the arm. The pipes are clamped on the base by the use of U-clamps in a way that it holds the pipe firmly and resists the vibration when on the flight. At the end of the inner arm, a provision is made for connecting brushless motor and propellers. Design-1 of a quadrotor using concentric pipes is shown in Fig.2.

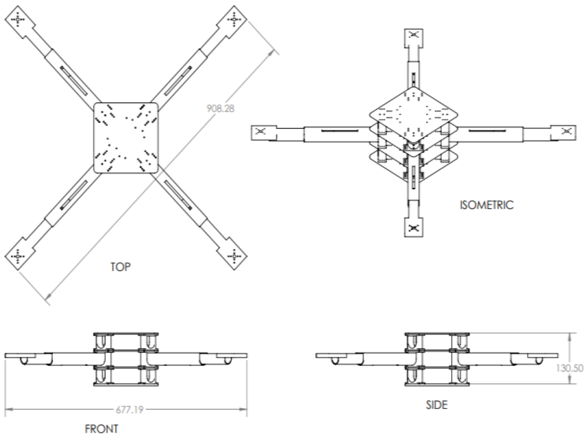

Fig.2: Resizable Arm Design-1

B. Resizable Arm using gear setup (Design-2):

The second design of resizable arm is shown in Fig.3. The

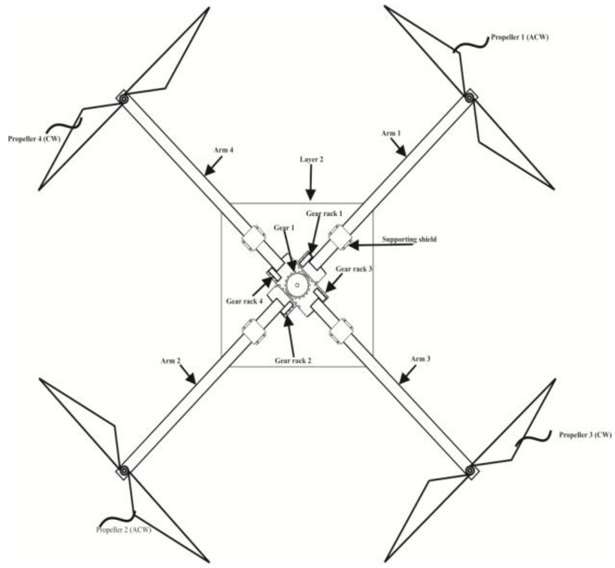

Fig.3: Resizable Arm Design-2

C. Fueselage of Quadrotor (& arm connections)

The body of quadrotor consists of three level compartments. The purpose of having three levels is that lowest level of the compartment is for holding the power supply and arm control units, the middle level of the compartment is used for accommodating the dc motors for arm span control in which the outer arm is clamped to the body, and the top level is for accommodating flight control units. This structure of fuselage is shown in front and side view of Fig.2. Both the designs use a similar structure for the body of quadrotor except that of materials used for construction differs.

III. FLIGHT AND CONTROL SYSTEM

A. Flight Control Word

The flight control board arducopter APM 2.8 is used to maintain the stability of quadrotor. Internally it consists of gyroscope and accelerometers to sense the imbalance in orientation. Whenever quadrotor experience tilts then flight control board controls the current to motors to maintain stability.

Retrieval Number: B2907078219/19©BEIESP
DOI: 10.35940/ijrte.B2907.078219
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

In addition to that, it receives commands from a user and these commands are used to control the brushless motors

B. Motor Interfacing

Two kinds of motors are used one is a brushless motor for controlling propellers and other is DC motors for the purpose of controlling the length of the arm.

All these motors are controlled based on the signal received from RF transmitter and receiver. In Design-2, only one DC motor is used for controlling the arms linear motion. When the motor rotates in a clockwise direction all the four arms pulled in, in the same way when motors rotate in a counter-clockwise direction all the four arms expands. But in Design-1, four motors are used, each for controlling arms linear motion in one direction.

The brushless motor and the propellers are connected at the end of the arm by means of nut and bolt. The DC motor is connected to the L293D motor driver and a 3S LiPo battery is connected to the L293D motor driver to provide the power supply to run the DC motor. The L293D motor driver is connected to Arduino Uno board The sixth channel of the receiver is connected to the Arduino Uno board to control the

C. Motor Interfacing

There are totally six channels in the transmitter and 10 channels in the receiver. These channels of the transmitter and receiver are allocated based on our requirement. Among the available channels, six were used for the entire control of the quadrotor. The first channel is used for the controlling of the throttle. The second, third and fourth channels are used to control the quadrotor in three different axes yaw, pitch, and roll. The fifth channel is for the selection of mode in which the quadrotor is operated. We operate the mode in the stabilized mode so on varying the size of the quadrotor the stability will be maintained. Moreover varying dimension in the same morphology ensures further stability. The sixth channel is used for controlling the arms of the quadrotor to make the squeeze in and squeeze out motion. The sixth channel of the receiver is connected to the Arduino UNO board to give input to the Arduino uno board. The Arduino uno board is connected to two L293D motor drivers and this driver board is connected to the 12V DC motors

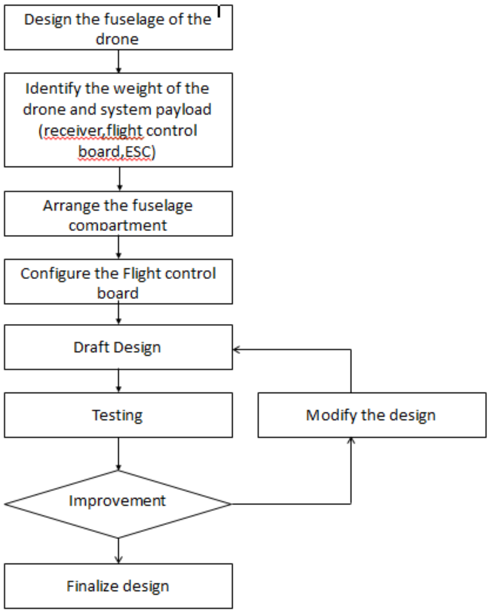

Fig.4: Design Flow Diagram

A. Transmitter and Receiver Control

There are totally six channels in the transmitter and 10 channels in the receiver. These channels of the transmitter and receiver are allocated based on our requirement. Among the available channels, six were used for the entire control of the quadrotor. The first channel is used for the controlling of the throttle. The second, third and fourth channels are used to control the quadrotor in three different axes yaw, pitch, and roll. The fifth channel is for the selection of mode in which the quadrotor is operated. We operate the mode in the stabilized mode so on varying the size of the quadrotor the stability will be maintained. Moreover varying dimension in the same morphology ensures further stability. The sixth channel is used for controlling the arms of the quadrotor to make the squeeze in and squeeze out motion. The sixth channel of the receiver is connected to the Arduino UNO board to give input to the Arduino uno board. The Arduino uno board is connected to two L293D motor drivers and this driver board is connected to the 12V DC motors.

The objective of the quadrotor was understood and the CAD design of the fuselage of the quadrotor was made based on our objective. Fig. 4 shows the sequence of steps followed to choose the appropriate brushless motor and propellers. The weight of every individual part of the fuselage of the quadrotor and the system payloads like Flight control board, Electronic speed controller and battery were measured and then the components were arranged into a three-level compartment and then the system payloads were connected and again the weight of the entire setup was measured. Based on the weight of the setup the brushless motors and propellers were chosen for the quadrotor. The fight control board is configured based on our necessity after completing the entire quadrotor. The drafted design is subjected for testing and until our necessity is complete the design is drafted and after our necessity is complete the design is finalized.

The weight of the entire setup is around 3 kg, so in order to lift the above weight the brushless motor of configuration 810 KV is chosen. Each brushless motor is capable of lifting 0.95 kg individually with 1045 propellers, so totally it has the capability to lift 3.8 kg. On using 1245 propeller, each brushless motor is capable of lifting 0.99 kg so totally it has the capability to lift 3.96kg.

IV. RESULTS

The weight of the drone was 3.6 kg initially and it was around 90% of the thrust which can be produced using all the brushless motor and so the brushless motor was not able to lift the drone and after reducing the weight of the drone to 2.8 kg the brushless motor was able to lift the drone.

For design-1 the completely stretched spread area is 0.4585 m^2. In the same way the when the outer arm is squeezed the area becomes 0.2508m^2, so the overall decrease in 45.3 % of the area. Fig. 5 shows the result of the quadrotor in the squeezed position. Fig. 6 depicts quadrotor in expanded form for design-1.

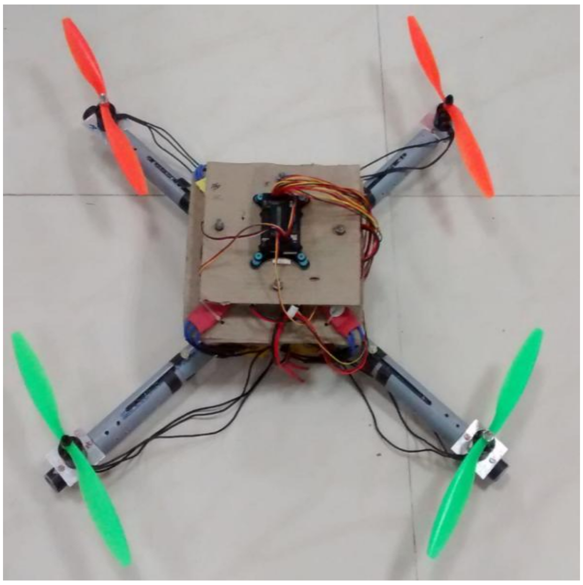

Fig.5: Quadrotor in Squeezed Form (Design-1)

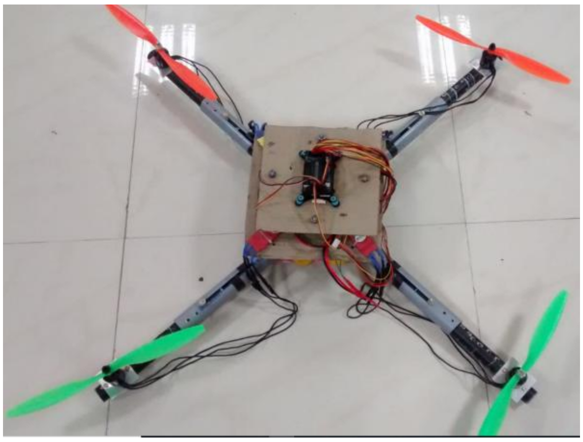

Fig.6: Quadrotor in Expanded Form (Design-1)

Fig.7: Quadrotor in Squeezed Form (Design-2)

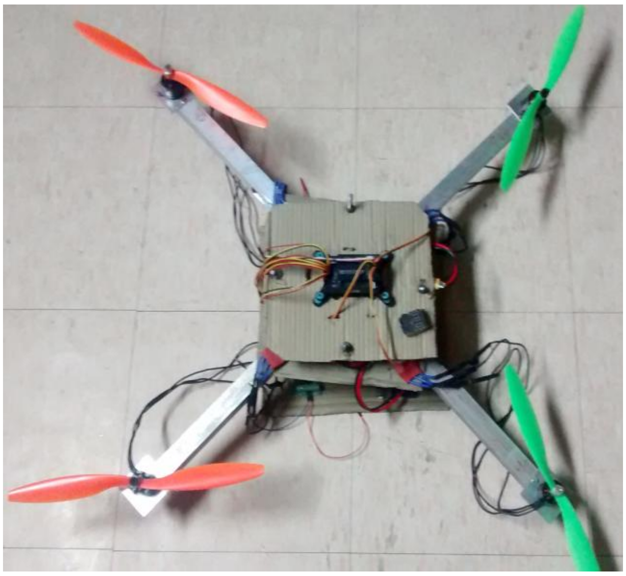

Fig.8: Quadrotor in Expanded Form (Design-2)

Design-2 output in squeezed and expanded form is shown in Fig.7 and Fig. 8 respectively. With respect to the spread area, there is no much change in the two designs. Whereas linear motion components weight contribution has been reduced one forth in Design-2. The reason being in design one each arm requires an individual motor to control its linear motion, but in design-2 it is achieved using a single motor. Comparisons of the two designs have been listed in Table.1.

V. CONCLUSION

In a quadrotor, while morphology is changed for the purpose of reducing the arms spread, it invariantly affects the angle between arms resulting in a change of inertia and center of mass. When inertia is affected then more additional efforts will be needed to maintain the stability of quadrotor. So this paper describes two quadrotor designs to reduce the arms spread area while maintaining the same X-geometry.

Retrieval Number: B2907078219/19©BEIESP
DOI: 10.35940/ijrte.B2907.078219
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

This work is implemented without any algorithm for maintaining stability at flight, so by further adding stability algorithms, the dynamic reconfiguration of arms can be done in a better way. The size, as well as the weight of the drone, can be decreased further if 3-D printing is used to reduce the size of fuselage and arms. By employing visual sensors further autonomous reconfiguration based on the path can be done.

REFERENCES

1. Davide Falanga, Kevin Kleber, Stefano mintchev, Dario Floriano, “TheFoldable Drone:A Morphing Quadrotor that can squeeze and Fly,” *IEEE Robotics and Automation Letters*, 2019, vol:4, pp: 209-216.
2. Valentin Riviere, Augustin Manecy, Stéphane Viollet, “Agile robotic fliers: A morphing based approach,” *soft robotics*, *Mary Ann Liebert, Inc*., 2018.
3. Davide Falanga, Elias Mueggler, Matthias Faessler and Davide Scaramuzza, “Aggressive Quadrotor Flight through Narrow Gaps with Onboard Sensing and Computing using Active Vision,” *International Conference on Robotics and Automation (ICRA)*, 2017, pp: 5774-5781.
4. A. Desbiez, F.Expert, M Boyron, J Diperi, S.Viollet, “X-Morf: a crash-separable quadrotor that morfs its X-geometry in flight,” *RED UAS 2017- Research, Education and Development of Unmanned Aerial Systems*, 2017, Linkoping, Sweden.
5. G. R. Flores, J. Escareo, R. Lozano, and S. Salazar, “Quad-tilting rotor convertible MAV: modeling and real-time hover flight control,” *J. Intell. Rob. Syst*, 2012, vol:65, pp: 457–471.
6. R. H. Stone, “The T-wing tail-sitter unmanned air vehicle: from design concept to research flight vehicle,” *J. Aerosp. Eng.*, 2014, vol: 218, no: 6, pp: 417–433.
7. A.-R. Merheb, H. Noura, and F. Bateman, “Passive Fault Tolerant Control of Quadrotor UAV Using Regular and Cascaded Sliding Mode Control,” *Conference on Control and Fault-Tolerant Systems (SysTol),Nice, France*, 2013, vol:4, pp: 330–335.
8. T. D. Stek, “Drones over Mediterranean landscapes. The potential of small UAV’s (drones) for site detection and heritage management in archaeological survey projects: A case study from Le Pianelle in the Tappino Valley, Molise (Italy),” *J. Cult. Herit*.,2016,vol. 22, pp. 1066–1071.
9. Achtelik, M., Bierling, T., Wang, J., Hocht, L., Holzapfel, F. “Adaptive Control of a Quadcopter in the Presence of large/complete Parameter Uncertainties” *American Institute of Aeronautics and Astronautics*, 2011.
10. Mestrinho, J., Gamboa, P., Santos, P.: Design Optimization of a Variable-Span Morphing Wing for a Small *UAV,” American Institute of Aeronautics and Astronautics*,2011.
11. Giuseppe Loianno, Chris Brunner, Gary G. Mcgrath and R. Vijay Kumar “Estimation, Control, and Planning for Aggressive Flight With a Small Quadrotor With a Single Camera and IMU” *IEEE Robotics and Automation Letters*, 2017, vol: 2, pp: 404-41.

AUTHORS PROFILE

R.Varun Prakash was born in the year 1988 in India. He received his B.E degree in Electronics and Communication Engineering from Mepco Schlenk Engineering College and M.E degree in Applied Electronics from SSN College of Engineering in the year 2010 and 2014 respectively. He is presently working as an Assistant Professor in the Department of Electronics and Communication Engineering in Mepco Schlenk Engineering College. His area of interest includes robotics perception.

G. Kirubakaran was born in the year 1993 in India. He received his B.E degree in Electronics and Communication Engineering from Kalasalingam Institute of Technology and M.E degree in VLSI Design from College of Engineering Guindy in the year 2014 and 2016 respectively. He is presently working as an Assistant Professor in the Department of Electronics and Communication Engineering in Mepco Schlenk Engineering College. His area of interest includes low power VLSI design and optimization.

D. Dineshkumar was born in the year 1988 in India. He received his B.E degree in Electronics and Communication Engineering from Mepco Schlenk Engineering College and M.E degree in VLSI Design from College of Engineering Guindy in the year 2010 and 2012 respectively. He is presently working as an Assistant Professor in the Department of Electronics and Communication Engineering in Mepco Schlenk Engineering College. His area of interest includes VLSI signal processing and architectures.

A. Vignesh Nainar was born in the year 1998 in India. He received his B.E degree in Electronics and Communication Engineering from Mepco Schlenk Engineering College in the year 2019. His area of interest includes Digital circuit design and Analog circuit design.