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Design and Implementation of Real-time Amphibious Unmanned Aerial Vehicle System for Sowing Seed Balls in the Agriculture Field

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ABSTRACT: The drone is used in agriculture as an unmanned aerial vehicle (UAV) which helps farmers in crop monitoring and production. To reduce manpower and pollution this kind of UAV is used in agriculture purposes. Drones are capable of working under strong winds and different climate conditions for agricultural applications in real-time. This article proposes an agricultural drone for sowing seeds that has the capability of working under strong winds. To increase its stability and biodiversity, we have used Naza v2 controllers. It is also useful to avoid deforestation in Indian country. Develop the real-time amphibious unmanned aerial vehicle system for the huge agriculture area have the major challenge to enhance the continuous flying time with load. To achieve this challenge, proper weight calculations should be done before it flies with the load. CATIA v5 software is used to design the drone from the top, bottom, right and left views with exact calculations. This project was designed in three phases i.e design of drones, the building of payload and evaluation of drone in PROTEUS and CATIA software. The design calculations along with thrust values are also calculated for payload weights. It is capable of complete autonomous operation and carries special payload bay with seed balls that contain different seed according to the biodiversity spread of the regions and it has the capability of dropping the seed balls at an interval of 15 m in all directions. One drone has the capacity of dropping 28800 seed balls in one eight-hour operation. In one-month, complete operation these drones can drop 8.64 Lakhs seed balls which hopefully brings back the serenity of this nation.

Keywords: BEC, BLDC, UAV, Seed sowing, Thrust, seed ball.

Abbreviations: BEC, Battery elimination circuit; BLDC, Brushless Direct Current Motor; UAV, Unmanned Aerial vehicle;

I. INTRODUCTION

The government and multinational companies are funding in UAVs because of cost-efficient and its demand for civil applications. This paper reports a survey of UAV's characteristics in the years between 2000 and 2015. The connectivity, privacy, and security were discussed which will helpful for upcoming projects [1] this paper the unmanned aerial vehicle is used as the base station for wireless communication applications such as a device to device communications, in a particular area as shown Fig. 1. As well minimum no of stops that UAV needs to cover the area. The coverage area and delay are explained [2].

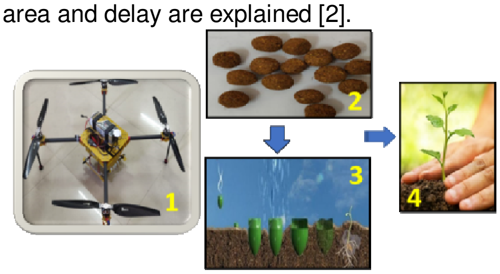

Fig. 1. Graphical abstract of the amphibious unmanned aerial vehicle system for sowing seed balls in the agriculture field.

The algorithm for UAVs base stations is proposed in this paper. The decoupling problem in UAV deployment is rectified. The simulation results suggest that this proposed algorithm is used for wireless services for different users with spatial distributions [3]. UAVs can also use to spray pesticides to increase the productivity of crops. This article reviews the implementation of UAVs for monitoring crops and pesticide spraying [4]. The nanotube-based on carbon was developed and installed on UAVs for the detection of volatile compounds in the air. The efficiency of gas sensors was measured by using the volatility of air. The Electronic nose was developed with a closed clean room and open-air wind environments. E-nose drone is used as detection of explosives and also for farmers in a scenario like cattle farms to emit the malodor problem [5]. The future generations need of precision agriculture monitoring for larger scales. The UAVs is employing for monitoring for smaller areas for the last few years. This article provides an approach for large scale monitoring with the division of land into sparse and dense fields [6]. This article highlights the UAVs in the market for crop quality monitoring and preventing fields from any damage [7]. The system was designed for spectral measurements of wheat, crops, and plants in the test fields. The drones have spectral imaging characteristics that enable imaging in different colors in visible light and

SWIR spectral bands [8]. Drones can be used in smart sensor networks in monitoring climate which helps in crop yielding.
They face challenges such as power consumption, flight time and long-distance communication. The Witricity technique can also be used to charge the UAVs. The flat spiral coil and multi-turn coil used in UAVs receiver which improves the efficiency of 85.25% with distance separation [9]. It provides a great opportunity for farming applications. The drone is used in the sensor nodes with infrared thermometers. This communication proposal for wireless networks [10], with simulated results, has a huge impact on the entire farm [11]. The agriculture drones have many advantages when compared to satellite imaging, aircraft with man, in such scenarios such as large forestry and agriculture mapping problems the single drone is not capable of covering the entire area. In this article, three key parts are analyzed which include a fleet of drones, path planning and signal processing [12]. This article explains the precision agriculture monitoring with the classification of vegetation into sparse and dense vegetation. The results are verified with drone images. when compared to satellite images. The seninel-2 data is also used for precision agriculture monitoring [13-14]. The UAVs are very popular now a day integrated with cameras, sensors, and modules with high efficiency. The machine learning tools and IoT concepts are integrated with a quadcopter for increasing the scope. This article shows the solutions of the drone with an integrated raspberry Pi-3 B module [15-17]. The speed control of the electric motor using sensors is explained [18]. Drone is designed as a quadcopter with four control commands, four velocity models are constructed by the step response experiments [19]. This paper exposes the Navigation and Control technology embedded in a recently commercialized micro Unmanned Aerial Vehicle (UAV), the Augmented Reality (AR) [20]. There is a research gap in the previous work that all the agriculture monitoring system fails to enhance the plant growth. The monitoring system provides the pesticides control, crops deficiency but it never gives the solution to grow the healthy seeds in to the plant."In this study an attempt has been taken to provide the healthy growth to the seeds for agriculture development". This work develops the real-time amphibious unmanned aerial vehicle system for the active seed growth in the agriculture field.

II. MATERIALS AND METHODS

A. Designing of drone

The general structure of the drone was designed by using CATIA V5 software Fig. 2 (a) (b). CATIA is the product design software developed for designing the 3D design structure, computer-aided engineering, and manufacturing solutions.

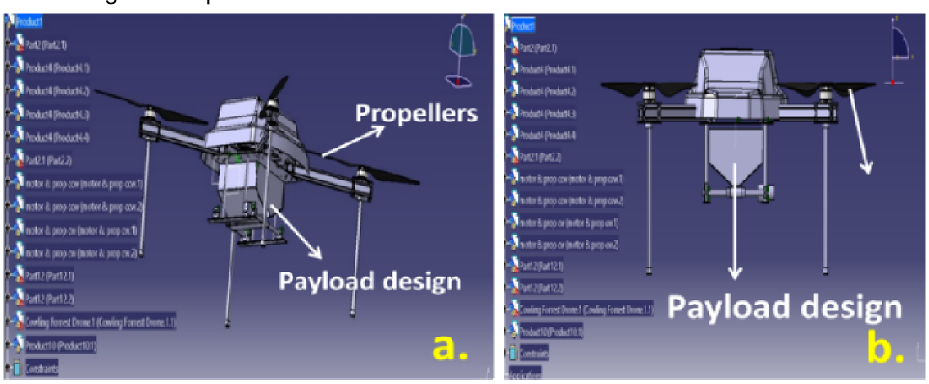

Fig. 2. Drone design using CATIA V5 software (a) Isometric view (b) Right view.

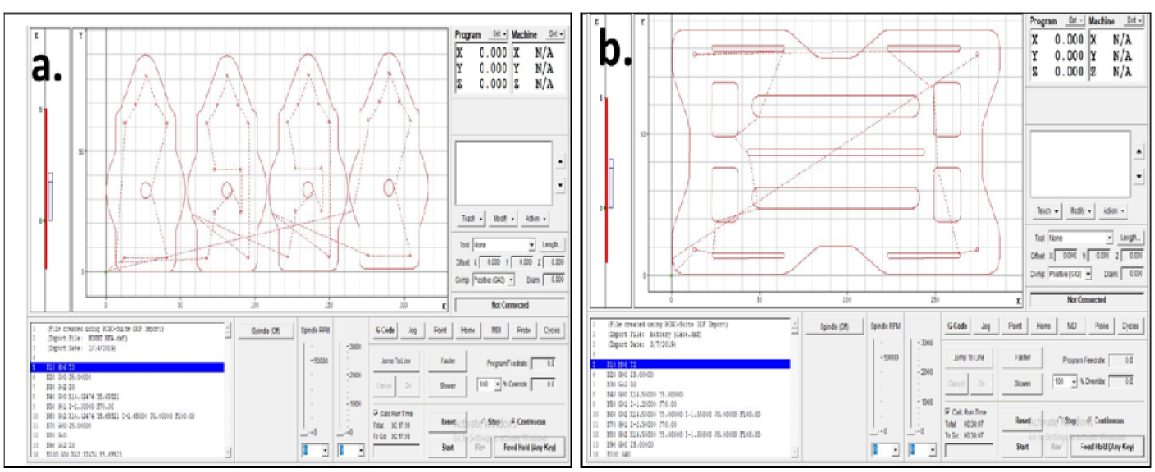

Fig. 3. Plate design using the CNC router (a) Motor mount plate design (b) Battery plate design.

Initially, the basic design structure was estimated based on the weight of components used for the applications. The complete structure was designed through CATIA V5 software and it was followed by the fabrication steps. After the plate design, the Arduino breakout board was made to control the application using PROTEUS software. It is used for electronic design automation. Its application is schematic capture, simulation, and PCB layout design. Herein, the system used PROTEUS software to design the Arduino breakout board which can be used to program and control the application of drone. The breakout board design shows the Fig. 4.

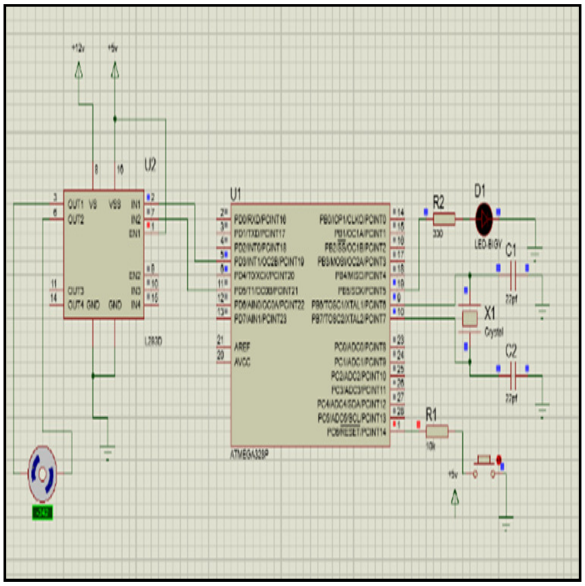

Fig. 4. Arduino breakout board design with a motor using PROTEUS software.

B. Payload design

Subsequently, the system was focused on the application part. Herein, the seed balls acted as a payload and it plays the application role in the system. The procedure for making seed balls is explained in the next section. The payload method was done by using the conveyer belt. The conveyer belt system was acting as a carrying medium of the objects which as shown in Fig. 5 (a) (b). The conveyer has a lot of types such as gravity conveyer, belt conveyer wire mesh conveyer, etc. In this mechanism, the motors are used to control the conveyer belt.

Fig. 5. Belt conveyer model for payload (a) Seed pan (b) conveyer belt.

The motors were controlled by using the Arduino board and it was powered by using the battery. In this system, the conveyer belt was made based on the estimated payload and also based on the estimated weight of the components used for the drone design.

C. Preparation of seed balls

The seed balls were prepared by the soil material and it covers the crop's seeds completely by the soil. The soil material was prepared by the mixture of clay, compost and coco peat. The clay helps to strong of the seed balls. The compost is a kind of fertilizer used to supply the essential nutrients to the plants. The coco peat helps to moisturize the seeds and it creates the growing medium. The seed balls preparation was shown in Fig. 6. The main advantage of the seed balls is to prevent the seed from the birds, insects, weather, miniature animals, etc. and gives healthy growth to the plants without spoiling.

Fig. 6. Seed ball preparation process. (a) Mixing of clay, compost and coco peat (b) Making seed ball (c) Seed Ball.

III. RESULTS AND DISCUSSION

The general structure of the drone has been pre-designed using the CATIA V2 and PROTEUS software. Theoretically, the weight of the components and payload has been estimated and calculated for the pre-designed drone and shown in Table 1. Furthermore, the components are assembled and fabricated as per the block diagram shown in the Fig. 7. Initially, the frame type has to be fixed for the drone design. Herein, the X-Frame type model was chosen for the drone design. The aerial drone for afforestation is done by the X-Frame model. It reduces the excessive weight. The frame weight was estimated at 1712 g. The motor was fixed in the diagonal section of the frame for specifying the clock and counter-clock direction. The first and third arms were fixed for counter-clockwise direction. The second and fourth arm fixed for the clockwise, third arm is considering as counter-clockwise and four arms were fixed for clockwise direction. The selection of motor is more important for the flying mechanism of the drone and should consider the relationship between the thrust and weight as given in the Eqn. 1.

$$\text{Ratio} = \frac{\text{Thrust}}{\text{Weight}} = \frac{ma}{mg} = \frac{a}{g} \quad (1)$$

Patel *et al.*, (2017) [18] explained that the vertical take-off and landing of the drone are potential when it satisfies the condition (a/g) > 1. The flying mechanism was shown in Fig. 8. The components begin with the selection of propellers for the drone flying. Each propeller has an estimated weight of about 47g per unit. The selection of motors is more important for each propeller to rotate in both clockwise and counter-clockwise directions.

BLDC motor is the ideal choice for application with high reliability, high efficiency, and high power-to-volume ratio. Each motor has an estimated weight of about 171g per unit. It provides high torque and its lifetime is over 10,000 hours. It has tremendous benefits for long term applications.

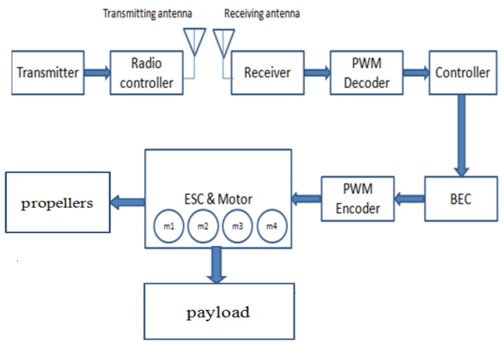

Fig. 7. Block diagram of the amphibious unmanned aerial vehicle design.

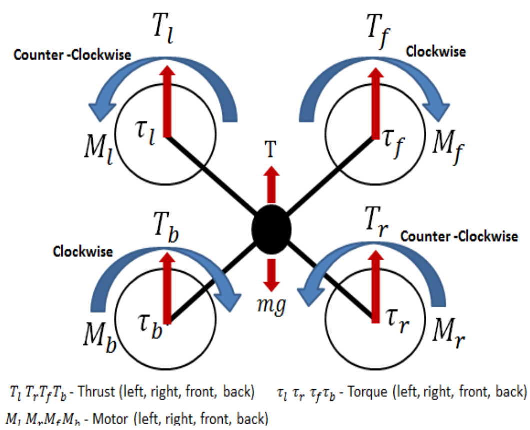

Fig. 8. Flying mechanism of the drone.

The Electronic Speed Control (ESC) is an electronic device that controls and regulates the speed of an electric motor. The estimated weight for ESC is about 46g per unit. It converts the PWM signal from the controller and drives BLDC by providing an appropriate level of electric power. Parts included in ESC are servo amplifier, MOSFET, buffer-m controller-MOSFET and bridge driver. ESC is used to manage the switching power (ON and OFF) of each motor and also useful for clockwise or counter-clockwise direction. Moreover, the communication system plays a major role in transmitting the signals from transmitter to receiver and vice-versa. The communication system is fixed to monitor the control signals. The number of connection slots in the receiver depends on several channels. Pulse width modulation (PWM) is the way of digitally encoding analog signal levels.

Through the use of high-resolution counters, the duty cycle of the square wave is modulated to encode a specific analog signal level. Battery eliminating circuit (BEC) is another eminent part of the drone to give power supply during the flying period. It is a small electronic device that gives the power supply to the controller. It draws higher voltage from batteries and converts to a suitable voltage level. It is used in the case of usage of more than 3 motors. The battery weight also estimated about 1386g. The flight controller is the brain of the drone. The continuous measurements were obtained through sensors to maintain the body level of the quadcopter and the speed of each rotor also monitored regularly. Its function is to direct the rpm of each motor.

Table 1: List of the components with their respective weight estimates.

S. No.	Component	Estimated weight per unit	Quantity	Total Weight
1.	Motor	171g	4	684g
2.	Esc	46g	4	104g
3.	Propeller	47g	4	108g
4.	Battery	1386g	1	1386g
5.	Frame	1712g	1	1712g
6.	Payload	700g	1	700g
Total Weight with the payload				4694g
Total weight without payload [4694g-700g (payload)]				3994g

Most of the flight controller uses sensors like a gyroscope for orientation to barometer for automatically holding altitude. GPS can also be used for autopilot. In this drone, Naza v2 controller was used to maintain the body level of the drone. Once the design part completed, then the flying process and its capacity of the designed drone were checked without payload. Now, the application part has to be focused. The design part of the payload was explained previously. Like the drone design, the payload design was also done by CATIA software and it was processed by CNC router. The payload was estimated at 700g. The total weight of the drone was estimated without payload about 3994g and for with payload was about 4694g as shown in Table 1.

Table 2: Thrust calculation with their respective weight estimates

Thrust	Result Analysis	Estimated weight per unit	Quantity	Total Weight
Motor Thrust at 50% throttle	Theoretical Analysis	1175g	4	4694g
	Experimental Analysis	1250g	4	5000g

Once the payload was estimated theoretically, afterward the payload (seed balls) was loaded inside the payload container box. The payload box was inbuilt with the conveyer belt. Once the motor-powered ON state, the conveyer belt starts rotation to drop the seeds as one by one in the following path. The belt conveyer system consists of two or more pulley and continues the loop system. This system was easy to handle and at the same time transportation of heavy and bulk materials also easy. Hence, this method was suggested for the drone.

Table 3: Battery power consumption with 50% throttle.

Power consumption	Estimated power per unit (amps)	Quantity	Total power (amps)
Total power consumption at 50 % throttle	5.7	4	22.8

$$\text{Flying time} = \frac{\text{battery's capacity in amp hours}}{\text{average amp consumption}} \times 60$$

$$= \frac{10}{22.8} \times 60 = 26.31 \text{ min}$$

where,

– Total power consumption at 50% throttle = 22.8 amps

– Battery capacity = 10000 mAh

– Battery capacity in amp per hour = $\frac{10000}{1000} = 10$ amps per hours

For flying drones with payload, the thrust calculation is much important. Thrust is the force that moves an aircraft through the air. The thrust provides temporary thrust along any of the translation axes. Therefore, the thrust was estimated along with the throttle. The throttle affords a constant thrust along the forward/backward axis. Hence it is more useful to fly the drone. In this system, the thrust was calculated for each motor at 50% throttle. The theoretical and experimental thrust analysis was estimated at 4694g and 5000g respectively. Thrust calculation was shown in Table 2. The total battery power consumption at 50% throttle was also calculated by about 22.8 amps and shown in Table 3. Finally, the total flying time of the drone with payload (700g seed balls) had been estimated and calculated using Eqn. 2 as about 26.31 mins based on the thrust and battery calculation (Table 2 and 3). The complete design of the prototype was shown in Fig. 9 (a) and (b).

IV. CONCLUSION

A new unmanned aerial vehicle has been designed to incorporate the seed balls in the agricultural fields without damaging the seeds. It is a simple, portable and user-friendly drone to operate. The experimental and theoretical value has been estimated and calculated for the drone. The result analysis of the drone was done through the thrust calculation with 50% throttle. The flying mechanism of the drone was analyzed both with and without payload. The overall flying time of the drone with payload (700g seed balls) was found about 26. 31 mins based on the proper thrust calculation. The drone design was integrated with the thrust value concurrently on all rotors–propellers and able to achieve a calibration process of the flight control system in real-time. The results were validated by repeating the experiment in different fields. To improve the stability of the drone, the system is used for maximum speed and average thrust. From this experiment, it can be seen that the drone efficiently used for the production of agricultural lands and it can be concluded that this creates a good platform for the crop yielding without any damages for the seeds.

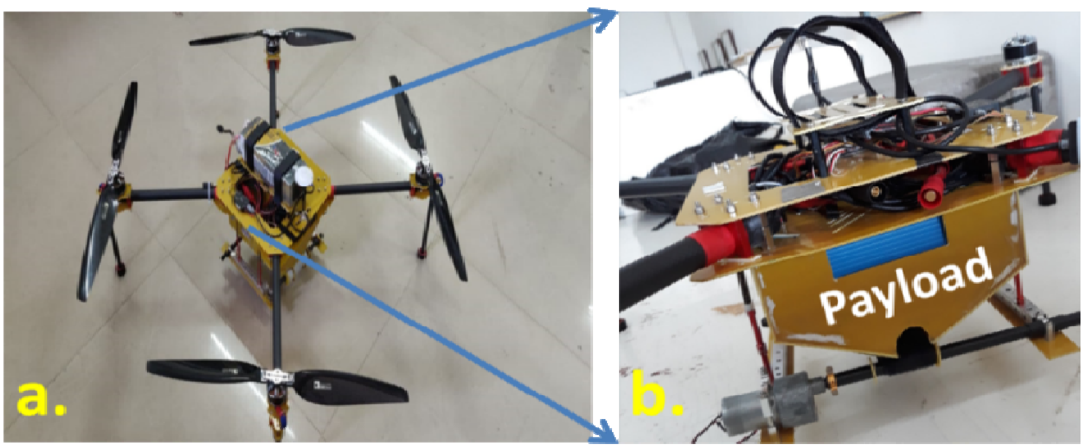

Fig. 9. Photograph image of the Drone (a) Complete design (b) Cross-sectional view for payload

V. FUTURE SCOPE

In this work we have designed a prototype UAV for the agricultural field. If the flying time of the UAV can be improved by increasing the motor capacity and other major components by considering the throttle percentage formerly it will be useful for huge agricultural area. This work has created a good platform to the UAV for various applications such as agriculture fields, pesticides carrier, medicine carrier and food supplier for the remote areas.

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Conflict of Interest. The authors declare that they have no conflict of interest.

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