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Design and Development of Drone for Agricultural Applications

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Abstract: The aim of this paper is Design and Fabrication of Drone for agricultural applications. Agriculture and allied sectors are the most crucial sectors of the Indian economy, but agriculture sector is facing lot of difficulties now-a-days one of the main reasons include unavailability of labor for the farming processes. Other reasons are prone to chemicals, unwanted diseases caused by insect/animal bite. The drone will be helpful in spraying fertilizers, pesticides and crop protection products while being controlled by a single person operating from a safe area. By changing the type of container used, the device can be used for spraying fertilizers, pesticides and crop protection products like manure etc. There by greatly reducing the time taken and maintaining the safety precautions for the farmer while spraying fertilizers. The system works mainly in the principle of thrust and lift. The drone contains four rotors each connected to four rotary wings containing fins or blades. It will be able to regulate the thrust/lift through varying the speed of the rotors through a radio controller. This RC will be fitted with a micro controller programmed to avoid obstacles through sensors and vary the speeds of rotary wings compatible with ATMEGA/ARDUINO software programming. The proposed work in this paper recommends the use of unarmed vehicles (UAV) in the agricultural sector for spraying crop protection products like fertilizers and pesticides.

Keywords : Micro controller, Radio controller, Propeller, unarmed vehicle, drone, agriculture, fertilizers.

I. INTRODUCTION

The application of pesticides and fertilizers inagricultural areas is of prime importance for crop yields. The use of aircrafts is becoming increasinglycommon in carrying out this task mainly because ofreduction in cultivated land, labour shortage, unscientific and out-dated method. Manual spraying of pesticides and fertilizers are mainly responsible for the increase in the number of chronic diseases. The potential health effects of pesticides include asthma, allergies, and hypersensitivity, and pesticide exposure is also linked with cancer, hormone disruption, and problems with reproduction and fatal development. However, some factors may reduce the yield, or even cause damage (e.g. crop areas not covered in the spraying process, overlapping spraying of crop areas, applying pesticides on the outer edge of the crop). Climatic condition, such as the intensity and direction of the wind while spraying add further complexity to the control problem. In this paper, we describe an architecture based on unmanned aerial vehicles (UAVs) which can be employed to implement a control loop for agricultural applications where UAVs are responsible for spraying chemicals on crops [1]. The process of applying the chemicals is controlled by means of the feedback obtained from the wireless sensor network (WSN). The aim of this solution is to support short delays in the control loop so that the spraying UAV can process the information from the sensors. Moreover, we evaluate the impact of the number of communication messages between the UAV and minimize the burden of the farmer in spraying the fertilizers and pesticides.

Figure1: UAV spraying pesticide

Figure 2: Man operating UAV from a safe arena

The process of applying the chemicals is controlled by means of the feedback from the wireless sensors network deployed at ground level on the crop field [4]. The aim of this solution is to support short delays in the control loop so that the UAV spraying can process the information from the sensors. Furthermore, we evaluate an algorithm to adjust the UAV route under changes in the wind (intensity and direction) and the impact related

to the number of messages exchanged between the UAV and the WSN.
The information retrieved by the WSN allows the UAV to confine its spraying of chemicals to strictly designated areas. Since there are sudden and frequent changes in environmental conditions the control loop must be able to react as quickly as possible.

II. THE HARDWARE SYSTEM

KK 2.1.5 Multi Color Control Board

The KK2.1 Multi-Rotor controller manages the flight of (mostly) multi-rotor Aircraft (Tricopters, Quad copters, Hex copters etc.). Its purpose is to stabilize the aircraft during flight and to do this, it takes signals from on-board gyroscopes (roll, pitch and yaw) and passes these signals to the Atmega324PA processor, which in-turn processes signals according the users selected firmware (e.g. Quad copter) and passes the control signals to the installed Electronic Speed Controllers (ESCs) and the combination of these signals instructs the ESCs to make fine adjustments to the motors rotational speeds which in-turn stabilizes the craft. The KK2.1 Multi-Rotor control board also uses signals from your radio system via a receiver (Rx) and passes these signals together with stabilization signals to the Atmega324PA IC via the aileron; elevator; throttle and rudder user demand inputs. Once processed, this information is sent to the ESCs which in turn adjust the rotational speed of each motor to control flight orientation (up, down, backwards, forwards, left, right, yaw).

Figure 3: KK Multi rotors Control Board

CT6B RC Transmitter and Receiver

Radio Control (RC) communication normally involves a hand-held (hobby) RC transmitter and RC receiver. For UAVs, you need a minimum four channels, and more are suggested, even if they are not used. Normally these channels are associated with: Pitch (which translates to forward / backward motion), Elevation (closer to or farther away from the ground), Yaw (rotating clockwise or counter-clockwise), Roll (to strafe left and right). Most drone pilots prefer handheld control, meaning RC systems are still the number one choice for controlling a UAV. On its own, the receiver simply relays the values input into the controller, and as such, cannot control a UAV. The receiver must be connected to the flight controller, which needs to be programmed to receive RC signals. There are very few flight controllers on the market which do not directly accept RC input from a receiver, and most even provide power to the receiver from one of the pins.

Propeller

Propellers for multi-rotor aircraft are adapted from propellers used in RC airplanes. Why not use helicopter blades? Although it has been done, imaginethe size of a hexacopter which used helicopter blades. Note that a helicopter-type system also requires that you vary the pitch of the blades which significantly adds to the mechanical complexity. You may also ask why not use a turbojet, turbofan, prop-jet etc.? These are incredibly good at providing a lot of thrust, but also require a lot of power. If the objective of the drone was to move really fast rather than hover in confined areas, one of these may be a good option.

Figure 4: Fly Sky CT6B RC system

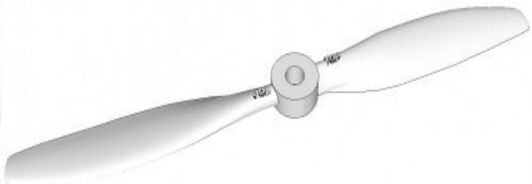

Figure 5: Propeller

UAV (Drone) Size

UAVs come in a variety of different sizes, from "nano" which are smaller than the palm of your hand, to mega, which can only be transported in the bed of a truck. Although both very large and very small UAVs may get quite a bit of attention, they are not necessarily the most practical for hobbyists. For most users who are getting started in the field, a good size range which offers the most versatility and value is between 350mm to 700mm. This measurement represents the diameter of the largest circle which intersects all of the motors. Not only do parts for UAVs in this size range come in a variety of different prices, there is by far the greatest selection of products available.

Figure 6: Drone sizes.

Smaller UAVs are not necessarily less expensive than medium sized ones. This is largely due to the fact that the technology and time needed to produce small brushless motors or small brushless motor controllers is the same for small parts or for large ones. The prices for the additional electronics such as the flight controller, remote control, camera etc. tend not to change at all. The frame is normally one of the least expensive parts of a UAV, so although the frame for a small UAV may be half the price of a larger one, theoverall price, with all parts needed, may still be very close.

III. DESIGN OF DRONE FOR ARGICULTURALAPPLICATIONS

The aim of this paper is Design and Fabrication of Drone for agricultural applications. The system works mainly in the principle of thrust and lift. The drone contains four rotors each connected to four rotary wings containing fins or blades. It will be able to regulate the thrust/lift through varying the speed of the rotors through a radio controller. This RC will be fitted with a micro controller programmed to avoid obstacles through sensors and vary the speeds of rotary wings compatible with ATMEGA/ARDUINO software programming.

Mass Estimation

All the different components that are needed to build the aircraft are found and an average weight of each component is calculated. Table 1 shows the components, their high and low weights, their average weights, and the accumulated total weight.

Propellerand Motor Selection

Now that a method for calculating static thrust, an understanding of DC motor power, and an estimated aircraft weight has been established, the proper propellers and motors can be determined. Table 2 is a condensed list of motors from Amazon along with all the necessary motor parameters.

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Block Diagram

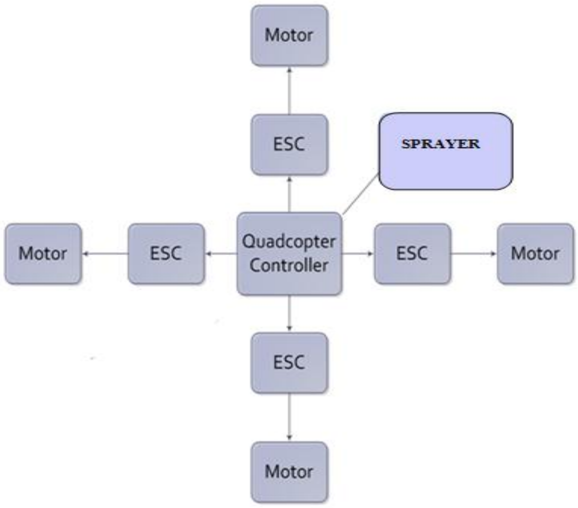

Figure 7: Block Diagram

Table 1: Mass estimation of aircraftTable 2:Ideal motor rpm from motor specifications

Part	High Weight(g)	Low Weight(g)	Average Weight(g)	Number Required	Final Averag Weight
AeroQaudSheild	22.6	22.6	22.6	1	22.6
Propeller	12.63	2.8	7.715	4	30.86
Collet	8	2	5	4	20
Remote Receiver	9	5	7	1	7
Motors	41	12	26.5	4	106
ESC	15	6	10.5	4	42
Battery	254	55	154.5	1	154.5
Sonar	7	5	6	1	6
Arduino Uno	27.6	27.6	27.6	1	27.6
IR Sensor	5	5	5	1	5
Frame (estimated)	249.5	249.5	249.5	1	249.5
Miscellaneous	125	150	137.5	1	137.5
Sprayer mass	756	626	691	1	691

Total weight (g)
808.56+691=1500g

MOTOR	Kv(rpm/v)	Max (rpm)	IDEAL (rpm)
BE2217-800KV Brushless Motor	800	8880	2220
A2212/13KV1000 Brushless Motor BLDC Hex Rotor Multi-copter.	1000	11100	2775
Robokart 1200KV Brushless DC Motor	1200	13320	3330
1600kv A2212 Brushless Motors For Quad copter.	1600	17760	4440
Robo kart 1800KV Brushless DC Motor	1800	19980	4995

Table 1 shows an estimated weight of Quadrotor about 809g and Sprayer part weighs about 691g. Total weight will be about 1500g which will now be used to acquire the appropriate motors and propellers.

Sample Calculations:

For 1600kv motor

RPM max.power= (Kv * 0.5 * Battery volts)/2

=(1600 * 0.5 * 11.1)/2

=4440

The next step is to determine the ideal rpm of the propeller. Ideal rpm for a propeller is found by combining Equations 1 and 6 and solving for rpm. Equation 9 shows the result of this mathematical manipulation.

$$rpm_{ideal} = \left(\frac{2}{\pi}\right)^{\frac{1}{2\omega}} \left(\frac{g^{3/2} m^{3/2}}{\alpha D \sqrt{\rho}}\right)^{1/\omega} \qquad (9)$$

ω = Power Factor from Aircraft-world.com
α = Power Coefficient from Aircraft-world.com
D = Diameter [m]
ρ = Air Density [1.225 kg/m^3]
m = Mass[kg]
g = Gravity [9.81m/s^2]

The mass that is entered into Equation 9 is the estimated mass of 1500 g divided by 4 because there are four motor/propeller sets that contribute to lift. Table 3 shows the results of Equation 9 for a range of different APC E propellers.

Table 3: Ideal Motor rpm from Momentum

Ideal Thrust	Propeller	Diameter (m)	PC	PF	Ideal rpm
0.375	6x4	0.1524	0.015	3.2	11118
	7x5	0.1778	0.042	3.2	7680
Air Density [kg/m^3]	8x4	0.2032	0.06	3.2	6590
1.225	8x6	0.2032	0.106	3.2	5516
	8x8	0.2032	0.148	3.2	4970
Gravity[m/s^2]	9x4.5	0.2286	0.09	3.2	5595
9.81	9x6	0.2286	0.129	3.2	5000
	9x7.5	0.2286	0.352	2.9	4178
	9x9	0.2286	0.448	2.9	3845
	10x5	0.254	0.144	3.2	4675
	10x7	0.254	0.223	3.2	4078
	10x10	0.254	0.68	2.9	3211
	11x5.5	0.2794	0.222	3.2	3963
	11x7	0.2794	0.301	3.2	3604
	11x8	0.2794	0.357	3.2	3417

Therefore, from Tables 2 and 3, it is clear that the APC E 10x4.5 propeller is the best match to the givenset of motors. To be more specific, the 10x4.5 propeller has an ideal rpm that would support hovering for the given estimated mass of the aircraft, and the ideal rpm of the propeller closely matches the ideal rpm of the motors listed in Table 2.In addition to the analysis performed above, there are other considerations in choosing a motor, like price and availability. Ultimate the 1600kv A2212 Brushless Motors forQuadcopter with a 10 A maximum current and APC E 10x4.5 propellers where chosen for this propeller.

Binding RF Transmitter and Receiver

1. Install the battery to the 2.4 GHz transmitter, and turn it off.
2. Insert the binding plug into the BAT port of the receiver.
3. Connect the ESC to Channel 3, or an external battery (5vdc) to any one of the other channels observing +/- polarity. Power up the receiver using the external battery, or connecting the main battery to the ESC. The LEDs should start to flash.
4. Press and hold the lower left button on the transmitter, and then switch on the transmitter's power switch.

5. Observe the LED lights on the receivers (main and satellite). Once the LEDs stop flashing, the receiver is bound to the transmitter. It will take about 10 seconds (or less) for the binding process to complete.
6. Release the match button on the transmitter. Remove power from the receiver, and turn off the transmitter.
7. Remove the receiver binding plug. Connect your servos and other channels as described in.
8. Test by turning on the receiver without pressing the match/bind switch. Power the receiver, and the LEDs should light steady meaning it is bound to the transmitter.
9. If the test failed, repeat this process.

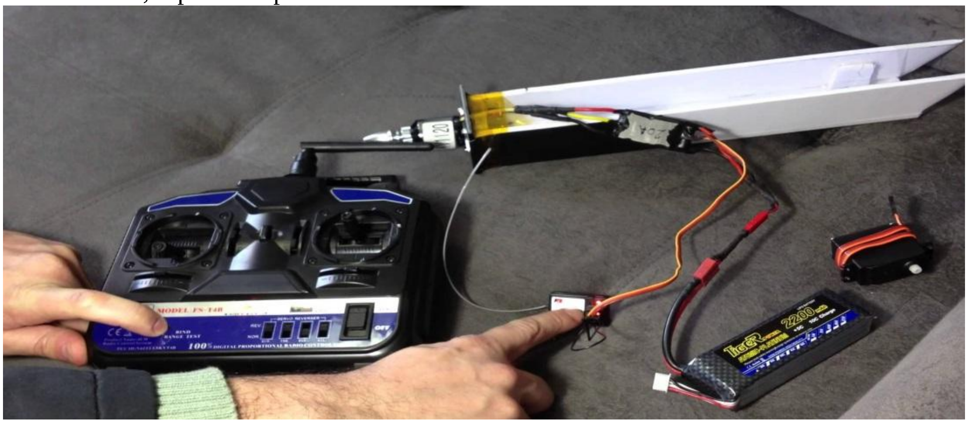

Fig 8: Binding RF transmitter and receiver

ESC Calibration

ESCs will work out of the box, but the signals (PWM) associated with maximum throttle might not correspond to what your transmitter is providing. You therefore need to "teach" each ESC what these values will be. As always, make sure the propellers are not mounted to the motors. Take a look at the user guide associated with your flight controller. Once an ESC has been reprogrammed, it retains that configuration even when it is not powered. You therefore should only need to program each ESC for your multi-rotor once, during the initial testing / setup. Normally there is a section in the flight controller's manual which talks about calibrating the ESCs and explains how. If not, you can try one of the methods suggested below. Once again, if your propellers are not already off, remove the propellers.

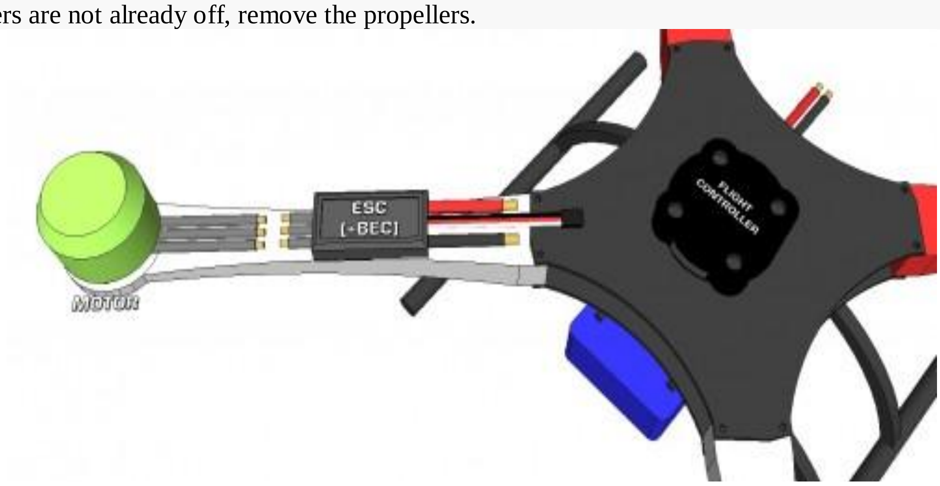

Fig 9: Esc calibration

1. Connect one ESC to your receiver's throttle pin. If your ESC does not have the BEC connected, you can connect the one BEC-enabled ESC to a different pin on the receiver (such as battery input) just to provide power to the receiver.
2. Connect the ESC to the associated motor (if it is not already connected)
3. Put the joystick associated with throttle to maximum (usually the left joystick, and full forward / up) and then turn your transmitter on.
4. Connect the LiPo battery to the PDB, or directly to that ESC (if the connectors are compatible)
5. The motor should beep three times (11.1V LiPo), followed by a short pause and then two short beeps (this sets the maximum signal)

6. Immediately after the short beeps, put the throttle to the minimum position (this sets the minimum signal)
7. The motor should beep three times (11.1V LiPo) followed by a long beep.
8. The throttle ranges for that ESC is now set and move on to the next one until all ESCs are calibrated.

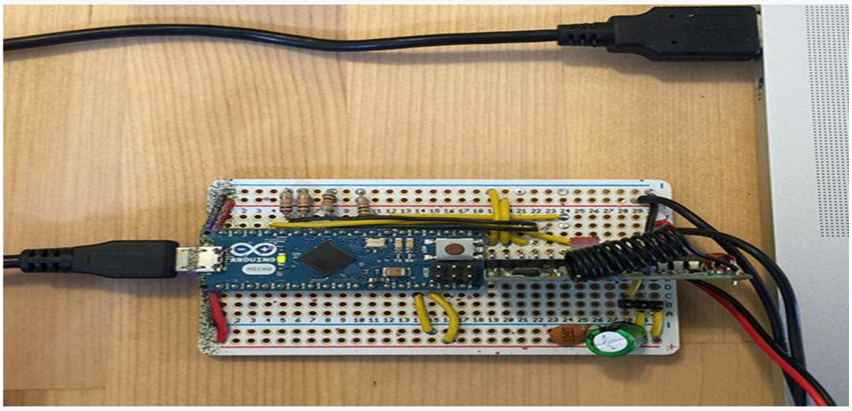

Fig 10: Sprayer Circuit assembly

Arduino Code for Spraying

```
#include <Servo.h>
Servo myservo;
inttriggerpin = 5;
intoffpin = 2;
intbuttonState;
intlastButtonState = LOW;
int button2State;
int lastButton2State = LOW;
void setup()
{
myservo.attach(9);
pinMode(triggerpin, INPUT);
pinMode(offpin, INPUT);
}
void loop()
{
buttonState = digitalRead(triggerpin);
button2State = digitalRead(offpin);
//On Off Spray
if ((buttonState != lastButtonState || button2State != lastButton2State))
{
if (buttonState == HIGH)
{
myservo.write(90);
delay(15);
}
else if (button2State == HIGH)
{
myservo.write(0);
delay(15);
}
}
lastButtonState = buttonState;
lastButton2State = button2State;
delay(1);
```

IV. RESULTS

The drone developed is more efficient and robust in nature compared to its contemporaries. It can fly across different terrains and varied weather conditions. The biggest advantage of the drone is that it is customisable according to the requirement. The drone will also be useful to spray not only fertilizers and pesticides but also can be used to spray paints, monitor fields with the help of Wi-Fi camera too.To ensure a high-quality product, diagrams and lettering MUST be either computer-drafted or drawn using India ink.

V. CONCLUSION

The main advantage of this paper is that our drone will be helpful for farmers in spraying fertilizers, pesticides and crop protection products while being controlled by a single person operating from a safe and secure location. The sprayer we have incorporated can also vary the amount of spray by varying the speed of servo motor.

Presently, the drone we have developed is for spraying crop protection products only but there is a lot of future scope for this concept such as crop surveillance for monitoring the health of the farm from a safe location

REFERENCES

Journal Papers:

[1] ASHISH LALWANI et al., “A REVIEW: AUTONOMOUS AGRIBOT FOR SMART FARMING”, Proceedings of 46th IRF International Conference, 27th December 2015, Pune, India, ISBN: 978-93-85832-97-0.

[2] Aneesh H. Nair et al., “Hovercraft Based Farming system”, International Journal For Research & Development in Technology Volume: 1, Issue: 2, JUNE 2014.

[3] P.D.P.R.HarshVardhan et al., “DEVELOPMENT OF AUTOMATED AERIAL PESTICIDE SPRAYER”, IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308.

[4] VarikutiVasanthaRao et al., “Multiple Power supplied Fertilizer sprayer”, International Journal of Scientific and Research Publications, Volume 3, Issue 8, August 2013 1.

Books:

[5] A Textbook on Microprocessor and Microcontroller by AP GODSE.

[6] A Textbook on Getting started with drone byFLITRY and ZOOKAL

[7] A Textbook on Spraying chemicals in agriculture by NAGOOR KANI