DESIGN & FABRICATION OF UNMANNED AERIAL VEHICLE (UAV)

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Abstract: This paper goal is to design a (UAV) Un Manned Aerial Vehicle (Quad copter) capable of self-sustained flight via wireless communications while utilizing a microcontroller. Quad copter is an aerial vehicle operated to fly independently and is one of the representations of a UAV.Drones are of different types and have different configurations for example, bi-copters, tri-copters, quad-copters, hexa-copters, etc. They have different uses and accordingly respective configurations are used. Control of motion of vehicle is achieved by altering the rotating rate of one or more discs, there by changing its torque and thrust/lift characteristics. Quad-copters have different structures and designs according to the work needed to be done by it. Components like motors, batteries electronic speed controllers (ESC's) also vary according to the power needed and work done by the quad-copter. Also enhancements like GPS trackers or cameras or infrared cameras are used also that they could add value to missions like disaster relief, search and rescue, agriculture and 3D mapping of the geography of an area.

Key Words–Quad Copter, Wireless Communication, Bernoulli's Principle, Newton's Third Law,, GPS, Micro Controller

INTRODUCTION

A Quad-copter, also called a quad rotor helicopter or quad rotor, is a multi rotor helicopter that is lifted and propelled by four rotors. Quad-copters are classified as rotor craft, as opposed to fixed-wing aircraft, because their lift is generated by a set of rotors (vertically oriented propellers).

Quad-copters generally use two pairs of identical fixed pitched propellers; two clockwise (CW) and two counter clockwise (CCW). These use independent variation of the speed of each rotor to achieve control. By changing the speed of each rotor it is possible to specifically generate a desired total thrust; to locate for the centre of thrust both laterally and longitudinally and to create a desired total torque, or turning force.

Quad-copters differ from conventional helicopters, which use rotors that are able to vary the pitch their blades dynamically as they move around the rotor hub. In the early days of flight, quad-copters were seen as possible solutions to some of the persistent problems in vertical flight. At a small size, quad-copters are cheaper and more durable than conventional helicopters due to their mechanical simplicity. Their smaller blades are also advantages because they possess less kinetic energy, reducing their ability to cause damage. However, as size increase, fixed propeller quad-copters develop disadvantages relative to conventional helicopters. Increasing blade size increases their momentum. Due to their ease of construction and control, quad-copter aircraft are frequently used as amateur model aircraft project.

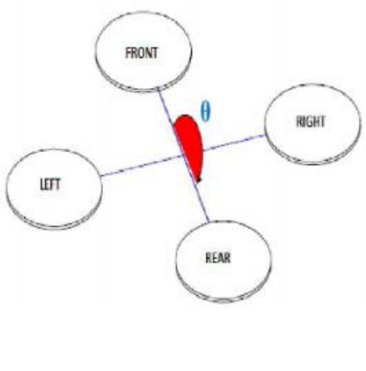
Principle of operation:

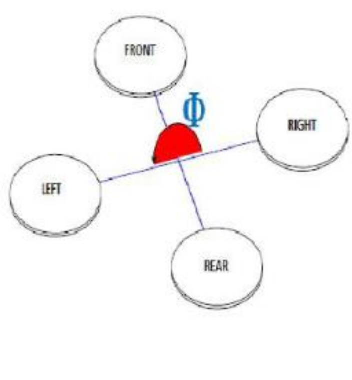
The principle and working of a propeller is based on Bernoulli's principle and Newton's third law, Bernoulli's principle states that for an flow, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. Newton's third law states that every action has an equal and opposite reaction.

An aero foil of a propeller is shaped so that air flows faster over the top than under the bottom. There is, therefore a greater pressure below the aero foil than above it. This difference in pressure produces the lift. Lift coefficient is a dimensionless coefficient that relates the lift generated by an aerodynamic body such as a wing or complete aircraft, the dynamic pressure of the fluid flow around the body, and a reference area associated with the body.

Mechanism:

Quad-copter can be described as a small vehicle with four propellers attached to the root located at the cross frame. This aim for fixed rotors is used to control the vehicle motion. The speeds of these four rotors are independent. By independent pitch, roll and yaw attitude of the vehicle can be controlled easily. Pitch, roll and yaw attitude of Quad-copter.





ROLL DIRECTION PITCH DIRECTION

Takeoff and Landing motion:

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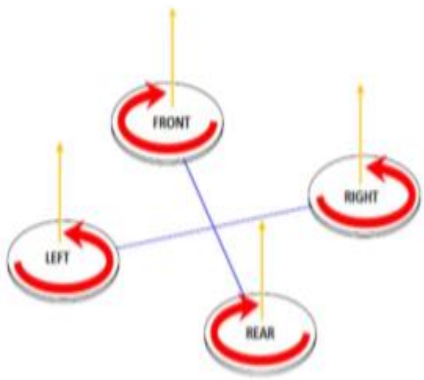
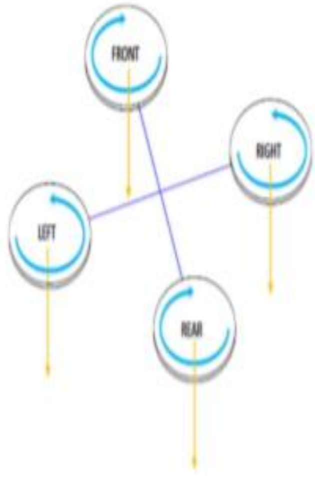
Hovering or static position:

The hovering or static position of the Quad-copter is done by two pairs of rotors, by rotating in clockwise or counter-clockwise respectively with the same speed. By two rotors rotating in clockwise and counter-clockwise position, the total sum of reaction torque is zero and this allows the Quad-copter to be in a hovering position.

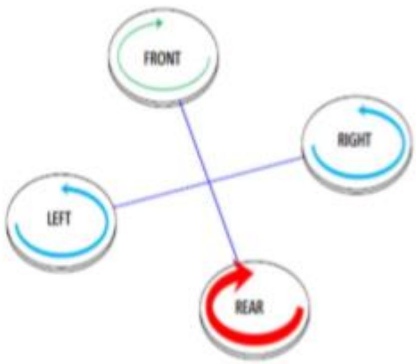


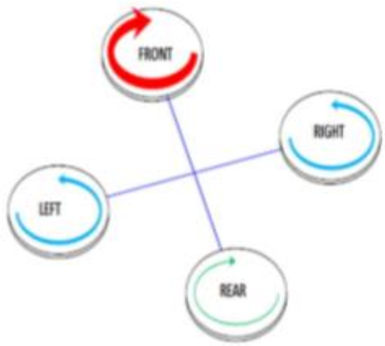


TAKE OFF MOTION LANDING MOTION

Forward and backward motion:

Forward (backward) motion is controlled by increasing (decreasing) speed of rear (front) rotor. Decreasing (increasing) rear (front) rotor's speed simultaneously will affect the pitch angle of the Quad-copter.

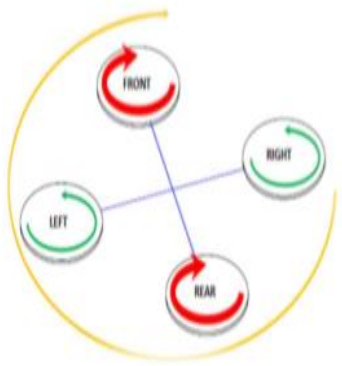




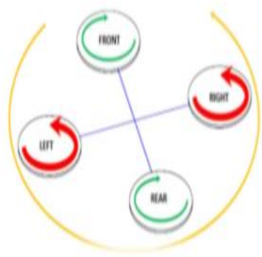
FORWARD MOTION BACKWARD MOTION

Left and right motion:

For left and right motion, it can be controlled by changing the yaw angle of the Quad-copter. Yaw angle can be controlled by increasing (decreasing) counter-clockwise rotors speed while decreasing (increasing) clockwise rotor speed.



RIGHTMOTION



LEFTMOTION

Materials used and their specifications:

S.NO	MATERIALS	NUMBER OF PARTS USED	SPECIFICATIONS
1	Brushless DC Motor	2	KV 1200 shaft size-5mm
2	Propellers	4	14 inches Hub6mm
3	Servo Motors	4	1400KV
4	Flight Control Board (KK2.1.5)	1	AVR Interface standard 6 pin
5	UBEC	1	Size 30*9*6 mm
6	Battery	1	2100mAh 11.1V 3cells
7	Transmitter	1	2.4 GHz FHSS

Major components and Specifications :

1 Chassis or Frame:

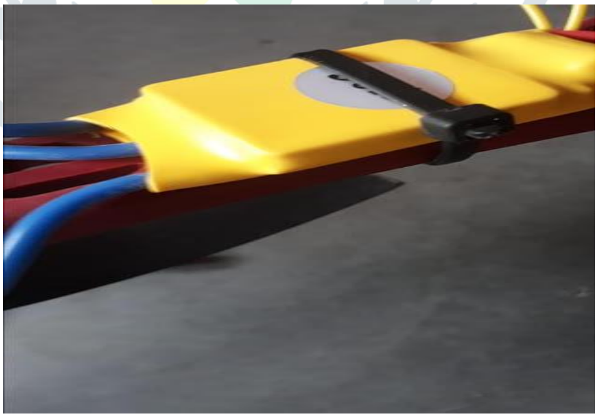
The skeleton of a quad-copter is the frame (chassis), some motors and propellers attached to the chassis. Let's look at the frame first. Quad-copter frames come in a variety of sizes and weight ratings. Most have the same basic appearance – a vague X shape. For hobbyists wishing to mount something with additional weight such as a camera, a sturdier frame rated for more weight is recommended. However, adding a sturdier material typically creates more weight itself, causing you to require longer propellers and a stronger motor to create the lift necessary to pull up the weight. There's always a delicate balance played by the manufacturers between flight speed, maneuverability, and flight time.

2 Propellers:

Propellers largely affect the speed at which the quad-copters fly, the load that they can carry, and the speed at which they can maneuver. To affect these various attributes you can increase or decrease the length of the propellers and the pitch of the propeller. The pitch is the shape and slant of the propeller. Longer propellers can achieve stronger lift at lower RPM than a shorter propeller, but take longer to speed up and slow down. Beyond a certain size, they're literally unable to fly. For heavier weights, you'll typically see manufacturers add more arms onto the frames (hexa-copters/octo-copters).

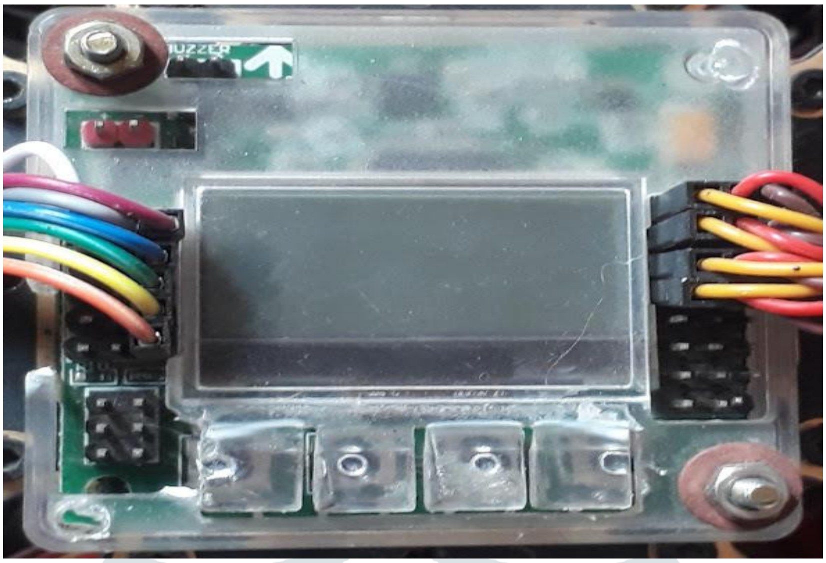
Shorter propellers allow the quad-copter to change speed quickly and do tend to produce better maneuvering capabilities, however they require more energy to spin them. This causes excess strain on the motors, which may lead to shorter life span for the motors. If you put everything together, an efficient quad will have properly sized, low RPM motors with very large props.

3 Electronic Speed Controller (ESC):



So far, we have the most obvious components of the quad-copter a chassis, motors and propellers for lift. But, a machine of this sophistication does have more to it than that. Yet, you'd be surprised at how little more there actually is. The next part needed is an electronics component called an electronic speed control, or ESC. There's an ESC for each of the four motors of the quad-copter.An ESC supplies the proper modulated current to the motors, which in turn produce correct rates of spin for both lift and maneuvering. There are fewer things to consider with an ESC than with other components since they're a fairly standard part, but there are two small factors. Most ESCs come with the Simon K firmware, which is designed for the precision timing of multiple rotors which a quad-copter uses. This is a standard feature in most ESC designs now. Usually ESCs also come with a battery eliminator circuit (or BAC), which allows the flight control and transceiver components to connect to the ESC rather than directly to the battery.

4 FLIGHT CONTROLLER



Flight Controller:

Next, comes the brains of the quad-copter, the flight controller. The flight controller is basically the little computer which controls the craft, and interprets the signals the transceiver sends to guide the quad-copter. For builders of quad-copters, choosing a flight controller is more of a personal choice in many ways, not unlike choosing from various PC processors in the same power range. Each have various options that each manufacturer wants and may or may not be customizable. If this is something that needs to be fixed, start reading the forums and listen to hobbyists who recommend affordable, reliable controllers which work with most components easily.

Working: Its purpose is to stabilize the aircraft during flight. To do this it takes the signal from the 6050MPU gyro/acc (roll, pitch and yaw) then passes the signal to the Atmega644PA IC. The Atmega644PA IC unit then processes these signals according the users selected firmware and passes control signals to the installed Electronic Speed Controllers (ESCs). These signals instruct the ESCs to make fine adjustments to the motors rotational speed which in turn stabilizes your multi-rotor craft.

KK2.1.5 Multi-Rotor control board also uses signals from your radio systems receiver (Rx) and passes these signals to the Atmega644PA IC via the aileron, elevator, throttle and rudder inputs. Once this information has been processed the IC will send varying signals to the ESCs which in turn adjust the rotational speed of each motor to induce controlled flight (up, down, backwards, forwards, left, right, yaw).

Specifications:

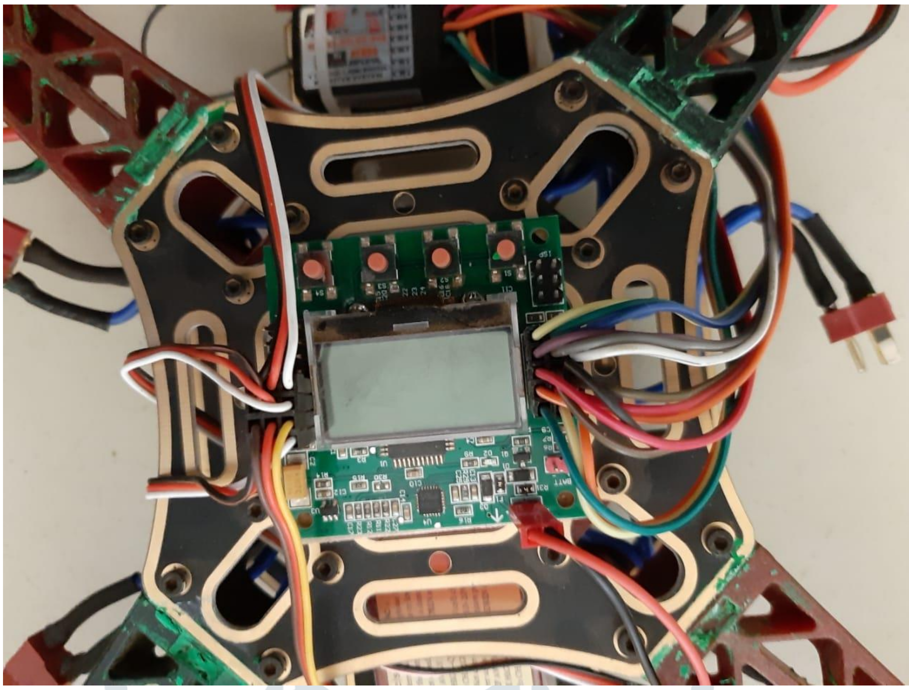
- Size: 50.5mm x 50.5mm x 12mm
- Weight: 21 gram (Inc. Piezo buzzer)
- IC: Atmega644 PA
- Gyro/Acc: 6050MPU Inven Sense Inc.
- Auto-level: Yes Input Voltage: 4.8-6.0V
- AVR interface: standard 6 pin

Flight controller KK2.1.5:

Firstly we need to "LOAD MOTOR LAYOUT", checking for the directions of 4 motors of clock wise and counter clock wise direction. Secondly we need to set PI controller settings as:

ROLL AXIS:
P Gain=75
P Limit=50
I Gain=40
I Limit=20
PITCH (Elevator):
P Gain=75
P Limit=50
I Gain=40
I Limit=20
YAW (Rudder):

P Gain=75
P Limit=20
I Gain=30
I Limit=10
P-Proportional Gain
I-Integral Gain



FLIGHT CONTROLLER BOARD KK2.1.5

MISK Settings:
Minimum Throttle=10
Height Damping=0
Height D limit=30
Alarm=1/10 volts=105
Server Filter=50
Acceleration SW filter=8

Self level Settings:
P Gain=70
P Limit=20
Acceleration Trim Roll=0
Acceleration Trim Pitch=0

5 Radio Receiver and Transmitter:

A channel is a control input. If your quad-copter had no channels, it would just hover in place. A minimum of 4 channels is required to get the quad-copter to move. 2 channels would be available for each stick on the transmitter. Each additional channel allows you to add controls for accessories (like gimbal control) onto the transmitter. If you're going to stay with this hobby for a while, then it makes sense to in

Receiver:

A radio receiver is an electronic circuit that receives its input from an antenna, uses electronic filters to separate a wanted radio signal from all other signals picked up by this antenna, amplifies it to a level suitable for further processing, and finally converts through demodulation and decoding the signal into a form usable for the consumer, such as sound, pictures, digital data, measurement values, navigational positions, etc. vest in a good transmitter now, something that has up to 8 or 9 channels.

RADIO RECEIVER

Right Stick:

The right stick controls roll and pitch. In other words, it moves your quad-copter left/right and backwards/forwards.

Left Stick:

The left stick controls yaw and throttle. In other words, it rotates your quad-copter clockwise or counterclockwise, and it adjusts the height at which you are flying. If you first push your throttle to get your quad-copter off the ground, you may notice that the UAV automatically tilts and flies to one direction (or multiple). This happens when the controls are unbalanced. To balance them out, certain controls need to be trimmed.

Transmitter:

The transmitter itself generates a radio frequency alternating current, which is applied to the antenna. When excited by this alternating current, the antenna radiates radio waves. The term transmitter is usually limited to equipment that generates radio waves for communication purposes; or radiolocation, such as radar and navigational transmitters. A transmitter can be a separate piece of electronic equipment, or an electrical circuit within another electronic device. A transmitter and receiver combined in one unit is called a transceiver controls need to be trimmed.

Specifications:

1. Channels: 6channels
2. Model type: Heli, Airplane, Glider
3. RF power: less than 20db
4. Modulation: GFSK Code type: PCM
5. Sensitivity: 1024
6. Low voltage warning: LED warning
7. DSC port: yes
8. Charger port: yes
9. Power: 12V DC (1.5AAA*8)
10. Weight: 680g
11. ANT length: 26mm

6 Battery and Battery Charger:

Finally, to power the quad-copter you'll a power source, which is typically a Li Po (Lithium Polymer) battery. Li Po batteries use a C rating, which stands for it's capacity to discharge. You'll typically see a Li Po battery have "20C". So if you see a 25C 4000mAh Li Po battery, it means that you can get a maximum of 25C * 4 = 100A (A standing for Amps). The power of the battery is usually dictated by the energy draw required from the ESCs. For example if you motor's maximum draw is 19A, at the very least you'll want a 30A ESC to be safe. Now multiply that by the number of propellers you have (4 in this case) and you'll get the maximum draw for your entire quad – 4 * 19A = which is 76A. Your 4000mAh 25C Li Po would definitely be enough for this quad-copter.

A lot of battery types can be fully discharged, but the Li Pos have an minimum voltage requirements, which if gone beyond can cause damage to the battery. In most cases it's 3.0 volts, but can vary from battery to battery. This is generally about 80 – 85% usage of your battery. Once past this mark, battery power drops fairly quickly. So make sure you're landing or are about to land when you hit this mark.

You'll also notice that most quad-copters come with a battery charger specially designed for the battery. It's important to use the one they supply you with. It controls how much current is sent to the battery. Charging a Li Po battery past 100% could actually cause a fire. Make sure to charge batteries in a fire safe area. Allow your battery time to cool before charging again.

Li Po batteries have three main things going for them that make them the perfect battery choice for RC planes and even more so for RC helicopter over conventional rechargeable battery types such as NiCad, or NiMH.

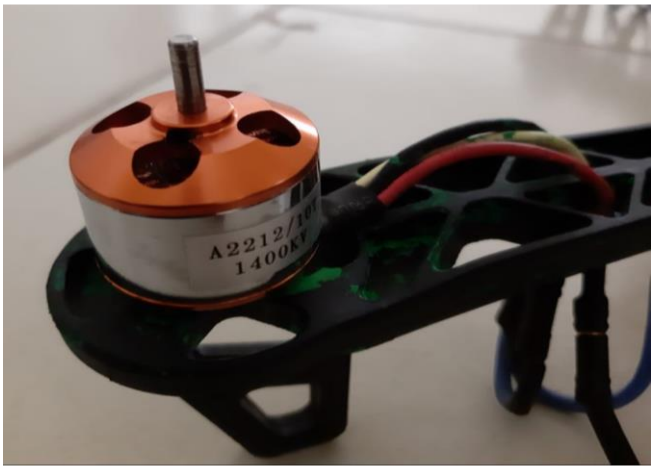
1. Li Po batteries are light weight and can be made in almost any shape and size.
2. Li Po batteries have high discharge rates to power the most demanding electric motors.
3. Li Po batteries hold lots of power in a small package.

Just as with other lithium-ion cells, Li Pos work on the principle of intercalation and de-intercalation of lithium ions from a positive electrode material and a negative electrode material, with the liquid electrolyte providing a conductive medium. To prevent the electrodes from touching each other directly, a micro porous separator is in between which allows only the ions and not the electrode particles to migrate from one side to the other.

Unlike lithium-ion cylindrical and prismatic cells, which have a rigid metal case, Li Po cells have a flexible, foil-type (polymer laminate) case, so they are relatively unconstrained. By themselves the cells are over 20% lighter than equivalent cylindrical cells of the same capacity.

BATTERY CHARGER

7 Motors:



BRUSHLESS DC MOTORS

The motors are the main drain of battery power on your quad, therefore getting an efficient combination of propeller and motor is very important. Motor speed is rated in kV, generally a lower kV motor will produce more torque and a higher kV will spin faster, this however is without the propellers attached.

There are many aspects to motor performance aside from raw thrust, high among these is how much current the motor draws from the battery. Remember to check the specs of your motors for their maximum amp draw, and ensure that your ESC's are rated to withstand this amperage.

Since this type of motor is driven by a DC power supply, it is also called simply a DC motor. To distinguish it from a permanent magnet synchronous motor (brushless DC motor), here we will call it a brushed DC motor. Since it is comparatively economical and easy to drive, the brushed DC motor is used for a broad range of applications. A brushed DC motor generates torque by mechanically switching the direction of current in coordination with rotation using a commutator and brushes. Shortcomings of a brushed DC motor include the need for maintenance due to wear down of the brushes and the production of electrical and mechanical noise. The PWM duty ratio can by adjusted using a microcontroller, etc. to change the applied voltage, thus allowing the speed of rotation and position to be controlled.

Conclusion

UAS, more commonly known as drones, have a long history stretching back to the early 20th century, but it was not until the turn of the 21st century that the technologies required to thrust them into widespread usage converged. Their design and sophistication began to advance in great leaps and bounds, while a handful of enterprising minds started putting them to use for real-world tasks. Sometime shortly after 2010, the growing academic hype finally blew up into the mainstream and drones started to find their way into retail stores. As for research applications of drones, although they have been firmly progressing for well over a decade now, my bibliometric analysis suggests that around 2015 marks the point when steady growth turned into exponential growth, taking into account that the marked upsurge in papers published in 2016 were — as is standard in scientific literature — based on work conducted a year or two prior. Whether it is because drones crossed some critical threshold in technological sophistication and usability, became more widely available and affordable off the shelf, became easier to implement thanks to adapting regulations, sparked a burst of interest thanks to the publication of a spurt of review papers, or all of the above, it appears that the revolution I alluded to earlier is now demonstrably underway. In this context, JUVS would seem to be on solid footing, and could even be said to have been ahead of its time, in providing a single consolidated forum for creators, users, and other stakeholders of this flourishing technology to share their research and perspectives. The advantages of such a forum are clear. For creators, JUVS unites researchers focused on the multiple distinct but intertwined engineering and design aspects of drones, promoting synergy in the development of these multifaceted robotic systems. Furthermore, it provides creators with a convenient window into the world of drone users, where the former can gain valuable insight into the needs and practices of the latter. Conversely for users, JUVS provides a convenient source of information on the latest technological advances in drones that could benefit their applications. Moreover, it is well recognized that many of the techniques and considerations involved in the successful use of drones cut across different fields of application, therefore JUVS represents a useful venue for researchers from a wide range of fields who are using drones to share their methods, experiences, and outlooks, and learn from each other. Finally, JUVS also offers other stakeholders, such as those involved in business or policy, an informative window into what is happening in the drone universe, as well as a platform to broadcast their own valuable insights and perspectives to the drone research community.

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