Design, Modeling & Fabrication of Thermal imaging Drone

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Abstract-
Thermal imaging drones have become an essential tool in various fields, such as search and rescue, surveillance, agriculture, and environmental monitoring. These drones are equipped with infrared cameras that capture heat signatures, which can be used to identify temperature differences on the ground or in the air. This paper explores the technology behind thermal imaging drones, their applications, benefits, and challenges

***Keywords:** Infrared Camera Flight Controller,Unmanned Aerial Vehicle (UAV),Thermal Resolution,Battery Life/Endurance,Drone Frame and Materials, BLDC Motor,etc.*

1. Introduction

Thermal imaging drones are unmanned aerial vehicles (UAVs) equipped with infrared cameras that detect temperature differences. Unlike traditional cameras, which capture visible light, thermal cameras detect heat emitted by objects. This technology has found numerous applications, from assisting emergency responders to monitoring crops in agriculture. The ability to "see" in the dark or through smoke and fog has made thermal imaging drones invaluable in many situations.

2. Research & Methodology

Define Objectives and Requirements

- Purpose*: Identify the use case such as search and rescue, wildlife monitoring, industrial inspection*
- Specifications*: Determine key requirements such as flight time, payload capacity, range, and resolution of the thermal camera*

Design the Drone Frame

- Material Selection: *Choose materials such as carbon fiber & polymide Nylon as we using Now.*

- Frame Design:*Use CAD software to design the frame, considering: Space for thermal and standard cameras. Placement for components such as motors, battery, controller, etc.*
- Fabrication:*3D print, CNC machine, or purchase a pre-made frame.*

Select and Assemble Components

- Thermal Camera: *Choose a compatible camera like FLIR Boson or Seek Thermal, based on resolution and sensitivity. Ensure compatibility with the flight controller and data transmission system.*
- Flight Controller: *Select a controller capable of integrating additional sensors*
- .Motors and Propellers: *Pick motors and props based on payload capacity and drone size.*
- Battery and Power System:*Calculate power requirements, considering the additional load of the thermal camera.*
- Transmission System: *Install a video transmitter and receiver for live thermal feed.*
- Landing Gear:*Ensure sufficient clearance to protect the camera during landing.*

Integration of Thermal Imaging System

- Mounting the Camera: *Attach the thermal camera to the drone using vibration-dampening mounts.*
- Wiring and Connections: *Connect the camera to the flight controller or a dedicated onboard processor. Ensure power and data cables are securely connected.*

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Software Configuration

- Flight Controller Firmware: *Install and configure firmware such as ArduPilot, for flight stabilization and camera integration*
- .Thermal Imaging Software: *Install software for processing and streaming thermal data software like FLIR tool.*

- Calibrate Sensors: *Calibrate the thermal camera and flight controller for accurate   readings*.

Testing and Optimization

- Ground Testing: *Test the thermal camera and other systems on the ground. Check live feed quality, data transmission, and camera angle.*
- Flight Testing: *Perform initial flights without payload for stability. Test with the full payload and evaluate performance*
- Adjustments: *Optimize flight parameters and adjust camera mount angles   for better imaging*

3.Design of Components

Arm
Material :-   polyamide nylon = 1.14 gram/cm^3
= 1140kg/cm^3

Calcu;ate the Total weight of drone with all component:-

Total weight= Frame weigh t+ Motor Weight + Battery weigh t+ Camera weigh t+
Other component + Payload weight

Suppose ,
The arm of drone length   = 150mm =15cm
Thickness = 6 mm = 0.6cm
Breath= 34 = 3.4cm

Volume of the rectangle = L * B * H
= 15 * 0.6 * 3.4
= 30.6 cm^3

Volume of triangle = B * H *L / 2
= 1.13 * 0.6 * 1 / 2
= 0.339 cm^3

Volume of Cylinder = π * R^2 * H
= 3.14 * 0.35^2 * 0.6
= 0.23cm^3

Total volume of arm = V(rectangle) – V(triangle) – V(cylinder)
=130.6-0.339-0.23
= 30.031 cm^3
= 3003.1mm^2

Weight of 1 arm = total volume of arm * 1.14
= 30.031 * 1.14
= 34.23 gram/cm^3

Weight of total arm = 4 * 34.23
= 136.941 g/cm^3

Volume of leg = L * B * H
= 5 * 0.6 * 1.7
= 5.1 cm^3
Weight of leg = 5.1 * 1.14
= 5.814
Total weight of arm and leg = 142.755g/cm^3

Base plate
suppose
Radius = 150mm = 15 cm
Hight = 6 mm = 0.6 cm

Volume of the base plate = π * R^2 * H
= 3.14 * 15 * 15 * 0.6
= 423.6 cm^3

Remaining part = A(reactangle) + A(two semi circle) * thickness

Rectangle Width = 0.65*2
= 1.3 cm

Area of rectangle = 0.65*1.3
= 2.535cm^2
= 253.5mm^2
Area of two semi circle = π *R^2
= 3.14*0.6^2
= 1.32 cm^2
=132.73mm^2

Total Area of remaining part = 2.535 + 1.32
= 3.86 * 0.6
= 2.316 cm^3
Total no. of hole = 4*2.316
= 9.264 cm^3

Total Volume of base plate = 423.9 – 9.264
= 413.34

Weight of base plate = 413.34 * 1.14
= 471.20 g/cm^2

Total weight of frame = 136.941+ 471.2
= 608.141 gram
= 0.6 kg

Suppose
The lipo battery of 2200 mAh = 175 gram
Camera = 13 gram
ESC 40A = 27 gram
Flight comtroller = 40 gram
Payload = 500 gram

TOTAL WEIGHT = 608.141 + 175 + 13 + 27 + 40 + 500
= 1360.141

= 1.36 kg

Total Thrust = 2 * total weight
= 2* 1.36
= 2.72

Thrust / motor = total thrust / number of motor
= 2.72/4
= 0.68 gram / motor

Therefore we using U8 II efficiency Multirotor o
1000V BLDC motor

For power consumption of motor

The average velocity of drone = V1 =
$\sqrt{\frac{T}{2 \cdot \rho \cdot A}}$

Area of propeller rotation = π * R
= π *8
= 25.13cm^2
251,3mm^2
Air density from sea level = 1.225 km/sec

V1^2 = 2.72/2*1.225*10^-6*25.13
V1= 210 km/sec
V1= 21 km/hr

Power comsumption = P = T*V1/n
T= thrust of motor
V1 = average velocity
n = efficiency of propulsion system (constsnt)

P= 2.72 * 21/0.5
P= 114.24 Watt

Flight time = C*V*nb/P
C= battery capacity
V = battery voltage
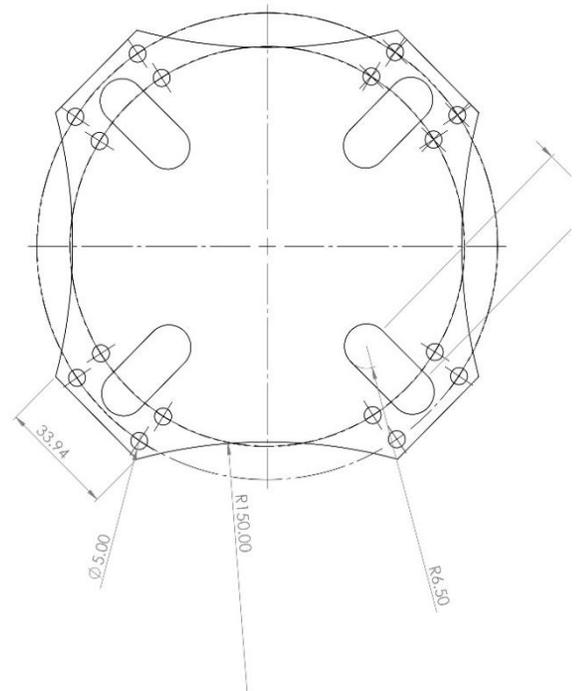nb = battery efficiency of lithem polymer is 0.85 –
0.95
P = power Cobsumption

C= 2200 mAh = 2.2 Ah
V= 11.1 V
nb = 0.90
P= 114.24 W

Flight time = 2.2*11.1*0.90/114.24
= 0.192 hr
= 11.54 min

4.Modeling of Components
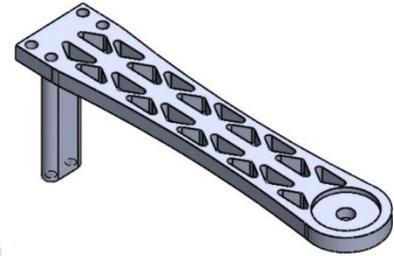
Arm of drone

Base plate of drone
5.Specification

Thermal imaging drones are used in several critical areas:

- **Search and Rescue**: In emergency situations, thermal drones help locate missing persons by detecting their heat signature, even in low visibility conditions like darkness, smoke, or fog.

- **Surveillance and Security**: Drones equipped with thermal cameras can monitor large areas for intruders or unauthorized activities, especially in areas where traditional security cameras may not be effective due to low light or bad weather.

- **Agriculture**: Farmers use thermal drones to monitor crop health. By detecting temperature differences in plants, drones can identify areas that may be

experiencing drought or disease, allowing farmers to take targeted actions.

- **Wildlife Monitoring and Conservation**: Researchers use thermal drones to track animals, especially nocturnal or elusive species, without disturbing their natural habitat. This technology helps in understanding animal behavior and protecting endangered species.

6.Advantages & Application

Advantages:

- **Visibility in Low Light:** They can see heat signatures, making them useful in dark or smoky conditions, where regular cameras would struggle.

- **Precision:** Thermal drones can pinpoint specific areas of heat, making them accurate for locating people, animals, or issues like fires.

- **Safety:** They help keep operators at a safe distance, especially in dangerous situations like fires, natural disasters, or hazardous environments.

- **Efficiency:** Thermal drones can cover large areas quickly and help in decision-making, saving time compared to traditional methods.

Applications:

- **Firefighting:** Detecting hot spots in fires, even through smoke, helps firefighters target the most dangerous areas.

  - **Search and Rescue:** Drones can find missing persons by detecting body heat, even in difficult terrains or during disasters.

  - **Wildlife Monitoring:** Researchers use thermal drones to track animals, like endangered species, without disturbing them.

  - **Infrastructure Inspection:** They can identify heat leaks in buildings or detect electrical faults in power lines and equipment.

  - **Agriculture:** Thermal imaging is used to monitor crop health by detecting temperature differences caused by pests or water stress.

7.Drone images

Conclusion

Thermal imaging drones are transforming industries by providing new insights and enabling tasks that were once time-consuming, dangerous, or impossible. From aiding in search and rescue operations to helping farmers monitor crops, these drones are proving to be invaluable tools in a wide range of sectors. While challenges remain, including weather interference, battery life, and privacy concerns, ongoing advancements in drone technology and thermal imaging will only increase their capabilities and applications. As the technology continues to evolve, thermal drones will become even more integral to modern-day operations across the globe.

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