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Prototype of Thermal Surveillance Drone

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***Abstract*—As the technology is developing there is a huge advancement in the drone industry. A primitive surveillance drone uses a FPV camera mounted on the drone but now there is introduction to the thermal camera which are used in surveillance, wildlife, rescue missions etc. The research shows the design and development of thermal drone using DJI f450 drone and MLX90640 thermal sensor. IT aims to provide real time thermal data along with aerial thermal visualization. The MLX90640 thermal sensor is a 34×24 infrared pixel array which is interfaced with ESP 32 for smooth and easy transformation of data and representation. The thermal data captured during the flight is processed for ground objects like human, animals etc. The experiment performed was under various environmental conditions to evaluate and ensure high accuracy. Result shows that the developed prototype can successfully capture and transmit the thermal data. The aim was to develop a cost-effective prototype of thermal drone highlighting future scooper for development.**

***Index Terms*—MLX90640, DJI F450, Thermal, Drone, Sensor.**

I. INTRODUCTION

Drone technology is one of the most crucial technologies in today's world. The use of UAV vehicles is increasing widely in defense, agriculture, monitoring etc. A thermal sensor camera detects the objects by sensing the body temperature. Infrared thermal sensor is a non-contact temperature sensor which measures the infrared radiation emitted by the body. Among the sensors, the MLX90640 is a compact, low powered thermal array sensor which provides two-dimensional temperature distribution. It works on the principle of Stephen Boltzman law which states that the infrared radiation emitted by the body is directly proportional to the fourth power of the absolute temperature.

1. 1 Problem Statement

The conventional technique uses optical camera for surveillance which are effective during day time but their utility is limited in low light environment such as fog, smoky environment and night time. Also, this technology has various drawbacks. If an object or trees come in between it is difficult to recognize what is under that. Hence there is a need of technology that can record the underlying object. Here comes the need of thermal sensor camera.

II. LITERATURE REVIEW

Mokhtar et al. developed a mathematical model of DJI F450 and used PID (Proportional –Integral-Derivative) for stabilization. The study shows that proper tuning of the PID is necessary for proper Flight stabilization. Goswami et al. utilized the MLX90640 sensor for non-contact human detection in low light and non-light condition. The study shows the sensor can detect humans irrespective of the background by capturing the body temperature making it suitable for surveillance.

III. DESIGN AND METHODOLOGY

Design includes the assembly of components required for final setup. It includes

1. A2212 1000KV Motor:

A2212 1000KV is a brushless motor which has a shaft of 3. 14mm and works in the range 7. 4V to 12V. In 2212 the 22 refers to stator diameter and 12 refers the stator height.

Figure 1: Motor

2. 30A ESC
30A Electronic Speed Controller used fpr brushless motor enables continuous rating of current of 30A. It includes a build in 5V – 2A BEC (Battery Eliminator Current) used for smooth linear response and throttle calibration.

Figure 2: ESC

3. KK 2. 1. 5 Flight Controller
KK 2. 1. 5 is a multi-rotor flight which uses Atmel Mega 644PA -8 bit AVR RICS microcontroller along with highly sensitive sensor like MPU6050 which includes 3-axis gyro + 3 axis accelerometer sensor for better stabilization. It operates at 4. 8V to 6V and support various multi rotor types like quadcopter hexacopter and trichopteran.

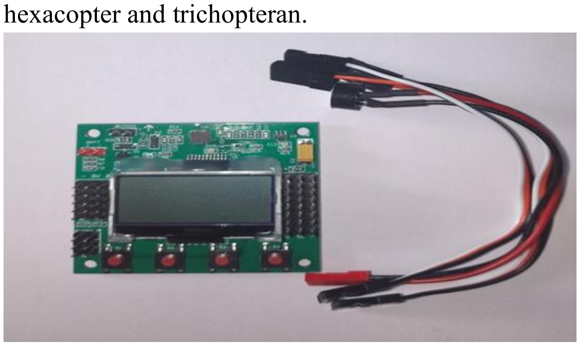
Figure 3: KK2. 1. 5 Flight Controller

4. DJI F450 frame
Frame is the skeleton of the drone. It has a wheel base of 450 mm made from reinforced polyamide nylon for low weight and high stability.

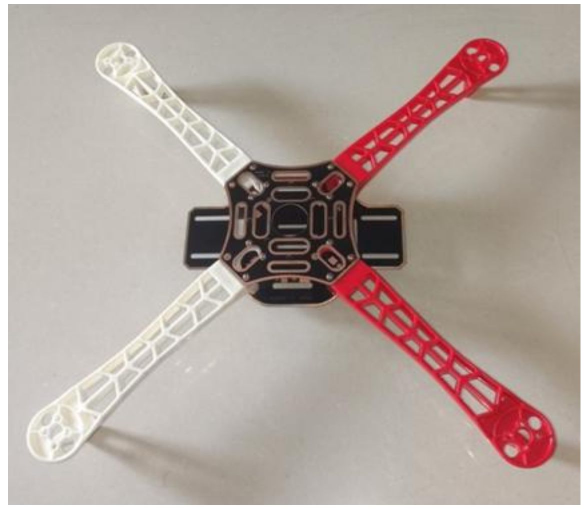
Figure 4: Frame

5. FS-CT6B Transmitter and Receiver
The Flysky FS-CT6B is a 6 channel 2. 4 GHz (Automatic Frequency Hopping Digital System) AFHDS which uses radio signal for operational command. It has a 0. 8W Radio Frequency power with a range up to 1km.

Figure 5: Transmitter and Receiver

6. Battery
The Battery has a specification of 11. 1V 2200mAh (3 cell in series).

Figure 6: Battery

7. 1045 Propeller

1045 propeller is a 10-inch diameter, 4. 5-inch pitch drone propeller mounted on the motor.

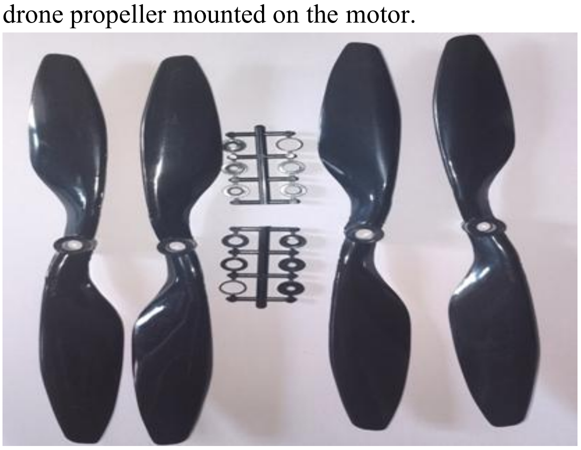
Figure 7: Propeller

8. ESP 32

ESP 32 is a low-cost powered system on a chip integrated with 2. 4 GHz Wifi + Bluetooth. It operated in the voltage range of 2. 2V to 3. 6V.

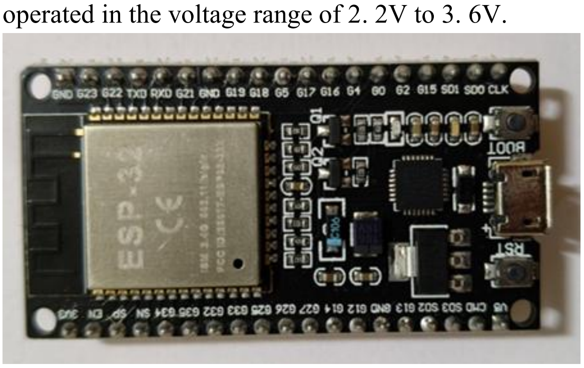

Figure 8: ESP 32

9. MLX90640 thermal sensor

MLX90640 is a high-resolution 32×24 pixel far infrared (FIR) with 728 pixel and has a thermal range of -40°C to 300°C with I^2C communication. It operates at 3. 3V and a 55° Field of View (FOV) with current consumption of less than 23mA.

Figure 9: MLX90640 thermal sensor

10. Assembly:

IV. CALCULATIONS

1. Thrust per Motor:

A 2212 1000KV + 1045 Propeller produces;
Minimum thrust ≈ 800g
Typical thrust ≈ 1000g
Maximum thrust ≈1200g
We have used these values for analysis.

Sr no	Components	Weight(g)	Quantity	Total Weight(g)
1	Motor	65	4	260
2	30A ESC	25	4	100
3	1045 Propeller	14	4	56
4	Battery	288	1	288
5	KK 2. 1. 5 Flight Controller	21	1	21
6	Frame	270	1	270
7	MLX90640	4	1	4
8	ESP 32	10	1	10
		Total Weight (g)		1009

2. Total Thrust of Drone:

$$T_{total} = \text{No of motor} \times \text{Typical thrust}$$
$$= 4 \times 1000$$
$$= 4000\text{g}$$

3. Thrust to Weight Ratio (TWR)

$$TWR = \frac{T_{total}}{Total_{weight}}$$
$$= \frac{4000}{1000}$$
$$= 4$$

TWR Value	Impact
1. 0	Barely Hover
2. 0	Safe and Stable
3. 0+	Agile
4. 0	Excellent Performance

4. Hover Thrust Required Per Motor:

At hover:

$$T_{hover,}\ \text{total} = w = 1009\text{g}$$
$$T_{hover}\ \text{per motor} = \frac{W}{n}$$
$$= \frac{1009}{4}$$
$$T_{hover\ per\ motor} = 252.\ 25\text{g}$$

5. Hover Throttle Percentage:

$$= \frac{T_{hover\ per\ motor}}{T_{weight(g)}}$$
$$= \frac{252.25}{1009}$$

Hover Throttle = 0. 25

$$= 25\%$$

6. Current Calculation:

From motor data,

Current at full thrust ≈ 12 A per motor

Total Maximum Current

$$I_{max} = 12 \times 4$$
$$= 48\text{A}$$

7. Hover Current:

$$I_{hover} = \text{Hover throttle} \times I_{max}$$
$$= 0.\ 25 \times 48$$
$$= 12\text{A}$$

8. Power Consumption:

Maximum power

$$P_{max} = V \times I_{max}$$
$$= 11.\ 1 \times 48$$
$$= 532.\ 8\text{W}$$

9. Usable Battery Capacity

80% battery is used to protect LiPo

$$C_{usable} = 0.\ 8 \times 5.\ 2$$
$$= 4.\ 16\ \text{Ah}$$

10. Flight Time Calculation:

$$\text{Hover Flight Time} = \frac{C_{usable}}{I_{hover}} \times 60$$
$$t = \frac{4.16}{12} \times 60$$
$$t = 20.\ 8\ \text{minutes}$$

V. METHODOLOGY

The development of prototype of thermal surveillance drone starts with requirement, analysis and planning execution. The objective is to design a cost-effective drone for smooth flying, capturing and transmitting the thermal images for surveillance application. The whole system is divided into three

parts: The flight control system, thermal imaging and communication. The flight control system consists of frame, motors, battery, ESC and KK2. 1. 5 flight controllers. The thermal imaging system consists of MLX90640, ESP 32 and battery.

The block diagram for flight control system is as follows:

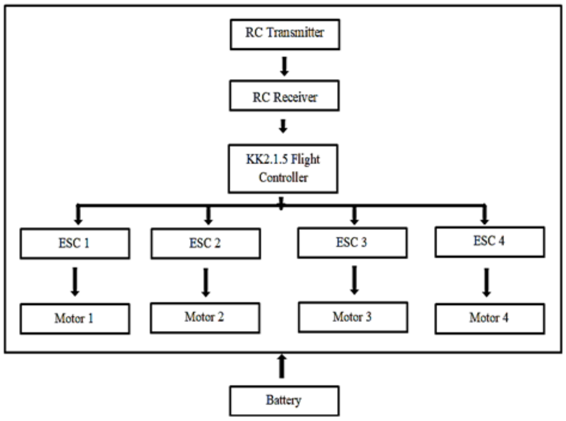

Figure 10: Block diagram of Flight Control System

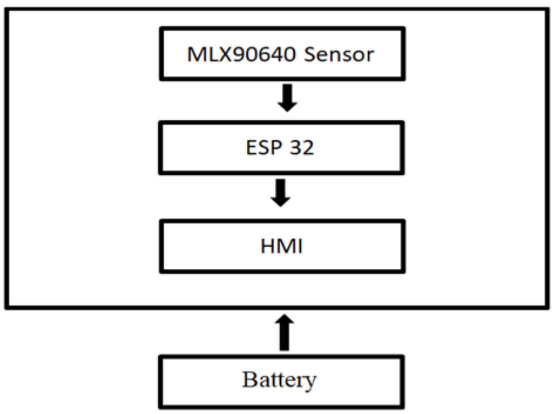

Figure 11: Block diagram of Thermal imaging

VI. EXPERIMENTAL SETUP

The research was conducted by capturing the thermal image from MLX90640 mounted on drone from different altitude. The process uses ESP 32 WROOM 38 pin Development Board integrated with Wifi and Bluetooth capabilities. The whole experiment was conducted in two environment: the closed room and the open ground.

VII. RESULT AND DISCUSSION

The main objective of this study was to built and integrate thermal imaging concept on the drone. By the use of ESP32 the thermal sensing can be directly seen on the mobile by web.

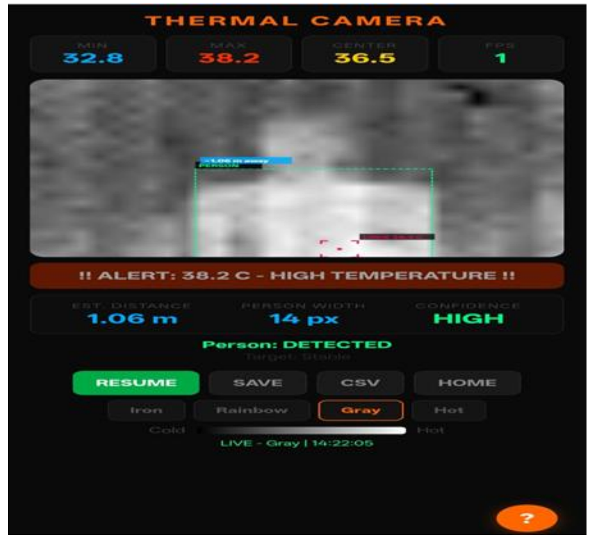

Figure 12 : Thermal image captured by MLX90640

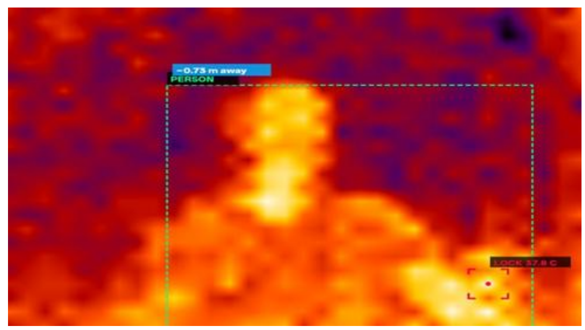
Figure 13: Thermal image

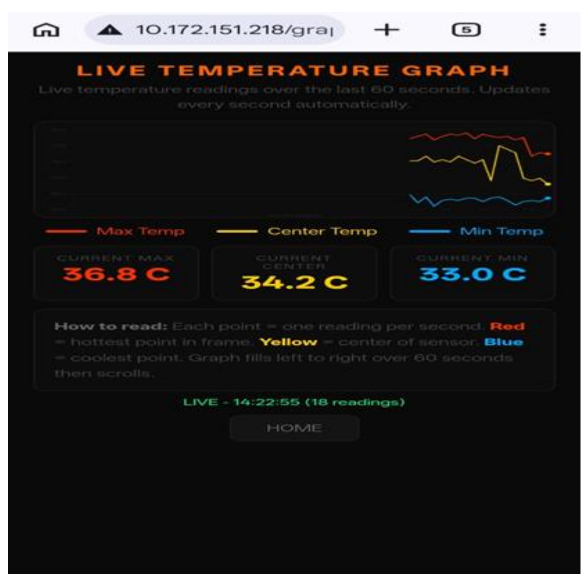

Figure 14 : Live Temperature graph

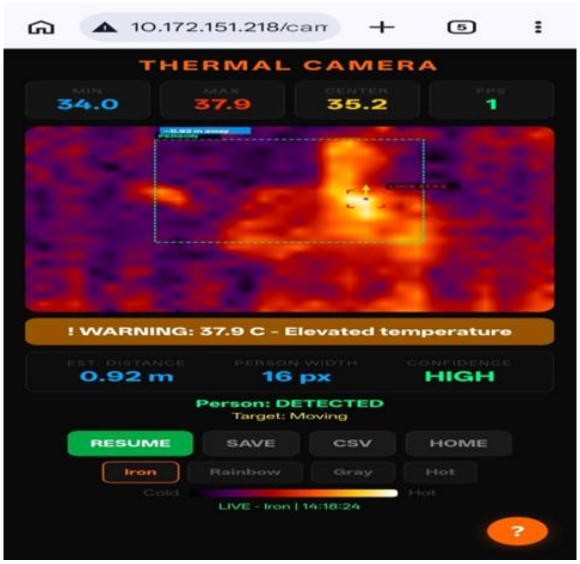

Figure 15 : Thermal image

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