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Thermal Imaging Drone: A Review

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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.

I. 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.

II. LITERATURE REVIEW

Drones are becoming key tools in disaster response and firefighting. In Cleburne, Texas, firefighters used a drone with thermal sensors to see through smoke and stop a grass fire before it reached homes. In Ukraine's Chornobyl Exclusion Zone, drones helped spot the worst wildfire areas despite heavy smoke. During floods and landslides in Vietnam, drones were used to find missing people, take aerial photos, and make 3D maps for rescue teams. These examples show how drones help save lives by making emergency responses faster and safer. Drishya is a drone that helps monitor social distancing and spot possible COVID-19 cases. It uses a regular camera and a thermal one to find people with high body temperatures. This helps quickly identify who might need further checks, without putting health workers at risk. It's especially useful in high-risk areas like red zones.

This study shows how drones with thermal cameras can help farmers in dry areas. By checking plant temperatures, drones can spot water stress and help manage irrigation better. It's a cheaper, accurate way to save water and boost food production in greenhouses. In Batang Toru, researchers used drones with thermal cameras to track Tapanuli orangutans in a 100-hectare area of Bulu Mario village. The survey ran from June to July 2023, helping count orangutans and measure their body temperature accurately by adjusting for the environment. The area is rich in wildlife and plants, making drone monitoring a useful tool.

The research was designed and carried out by a team of scientists, with data analysis and writing handled by several members. There were no conflicts of interest, and the work is original. It was funded by the National Natural Science Foundation of China and Hainan University, approved by Bawanglin Natural Reserve, and supported by local rangers and staff.

Thanks to better sensors, more stable flying, and built-in AI, thermal drones are now more accurate and efficient than ever. But there are still some issues—like making sure the temperature readings are correct, understanding the data properly, and dealing with privacy concerns, especially in crowded areas. Also, drone laws differ from country to country, which can make it hard for scientists to use them everywhere. During the COVID-19 pandemic, thermal drones helped safely screen people in crowded or high-risk places. Drones like Drishya used both regular and thermal cameras to spot signs of fever and check if people were keeping a safe distance. This reduced the need for direct contact and made things safer for health workers, especially in "red zones."It showed how useful drones can be for public health, especially during outbreaks or in areas with limited healthcare access.

Thermal drones are becoming more popular in wildlife research, particularly for tracking elusive or endangered species. For example, in Batang Toru, Indonesia, researchers such as H.Z. and colleagues (2023) used DJI Matrice 300 RTK drones with thermal cameras to track Tapanuli orangutans, allowing them to get accurate population estimates without disturbing the animals. Similar research has used drones to count sea turtles, elephants, and nesting birds in various ecosystems, making them a powerful tool for wildlife conservation.

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One of the key uses of thermal drones is in controlled environment agriculture (CEA) and crop monitoring. For instance, research by Zhang et al. (2023) found that thermal imaging can detect canopy temperature, which is closely linked to plant water stress. This helps farmers plan irrigation more accurately by calculating evapotranspiration rates, improving water use efficiency and boosting crop yields—especially in dry areas where water conservation is crucial.

A. Working Thermal Imaging Drones

Thermal imaging cameras on drones work by detecting infrared radiation (heat) emitted by objects. All objects with a temperature above absolute zero emit infrared radiation, and this radiation can be captured by special sensors in the camera. The camera then translates this information into a thermal image or video, where the temperature differences are shown in varying colors. For example, warmer objects might appear red or orange, while cooler objects are displayed in blue or purple. This allows operators to identify objects based on their heat signatures.

B. Key Applications

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.

Infrastructure Inspection: Thermal drones are also used to inspect buildings, power lines, and pipelines. They can detect heat leaks or overheating components that might indicate a malfunction, potentially preventing costly failures or accidents.

III. 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.

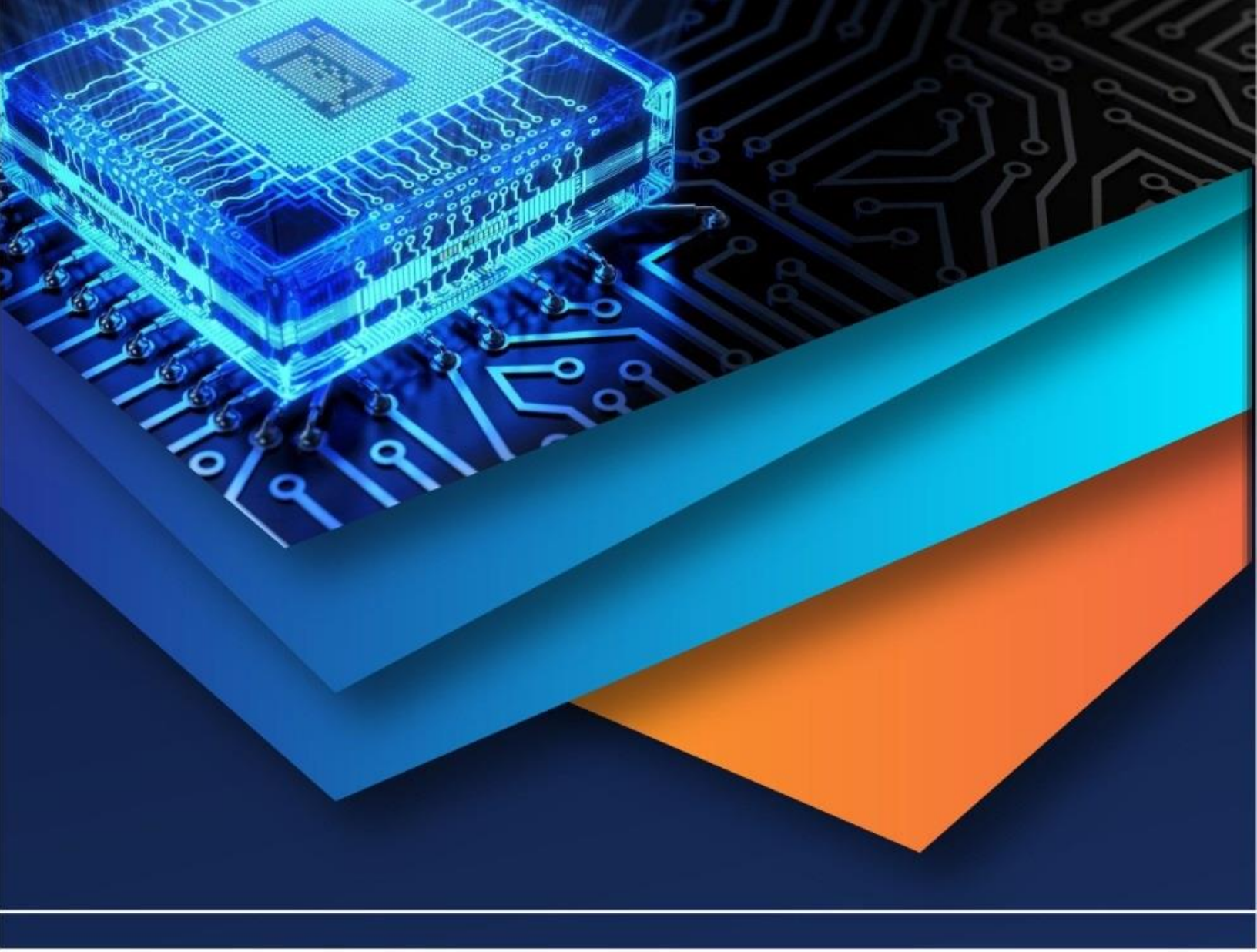
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