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UAV Based Smart Monitoring of Distribution Lines

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Abstract: *Electrical distribution lines are essential components of the power system and are continuously exposed to electrical loading, temperature variations, wind, rain, pollution, vegetation, mechanical stress and ageing of components. Conventional inspection methods generally depend on manual patrolling and visual examination, which can be time-consuming and may expose maintenance personnel to electrical and environmental hazards. This paper presents a UAV-based distribution-line monitoring approach that combines aerial inspection with electrical, thermal, visual and positional information. The proposed system uses a UAV platform carrying a camera, a clamp-type current measurement arrangement, a temperature sensor, an ESP32-based data acquisition unit and GPS information. During inspection, the current and temperature of the monitored line section are acquired, while the camera captures images or video of conductors, insulators, poles, joints and other components. GPS information is recorded to associate the inspection observations with their geographical location. The collected data are stored and Measured values can be compared with reference or normal-condition data, while visual information is examined for visible abnormalities such as corrosion, damaged conductors, defective insulators, loose connections and other physical defects. The proposed system provides a systematic foundation for safer and faster preliminary distribution-line inspection. It can reduce the need for continuous manual patrolling, improve fault localization and support preventive maintenance.*

Keywords: *Distribution line monitoring, camera-based inspection, GPS tracking, fault detection.*

I. INTRODUCTION

Electrical distribution networks are one of the most important components of a modern power system because they deliver electrical energy from substations to residential, commercial, agricultural, and industrial consumers. However, overhead distribution lines are continuously exposed to environmental and operational conditions such as high electrical loading, temperature variations, wind, rain, dust, vegetation growth, mechanical stress, corrosion, and ageing of electrical components. Traditionally, inspection of overhead electrical lines is carried out manually by maintenance personnel who travel along the line route and visually examine conductors, insulators, poles, joints, and other equipment. Unmanned Aerial Vehicles (UAVs), commonly known as drones, have emerged as a promising technology for monitoring electrical power infrastructure. A UAV can fly along a predefined distribution-line route while carrying different sensors and imaging devices, GPS systems and other sensors for power-line inspection.

In addition to thermal monitoring, the proposed system considers current monitoring using a clamp meter/current clamp. A clamp-type current measurement method has the advantage of measuring current without requiring the conductor to be disconnected from the circuit. During the flight, the camera continuously captures images or video of the line and its components. At the same time, the current monitoring system measures the electrical loading condition, while the thermal/temperature-monitoring arrangement observes abnormal heating. The GPS module continuously records the position of the UAV. When a parameter crosses its predefined threshold, the system can mark the location as a potential fault point. The collected data can then be transmitted to a ground station or stored for further analysis. The proposed approach aims to provide a safer, faster, and more systematic alternative for preliminary distribution-line inspection. By combining electrical, thermal, visual, and positional information, the system can support early fault identification and help maintenance personnel take corrective action before a minor abnormality develops into a major failure or prolonged power outage.

A. Problem Statement

Conventional monitoring of electrical distribution lines mainly depend on manual inspection, which is time consuming, costly, and may expose workers to electrical and environmental hazards. Faults such as overcurrent, abnormal temperature rise, damaged conductors, equipment damage. Therefore, there is a need for an efficient, safe monitoring of distribution-line system. The proposed research focuses on using an Unmanned Aerial Vehicle (UAV) equipped with a camera, current-measuring clamp meter, temperature sensing, and GPS to inspect distribution lines remotely. The system aims to collect electrical and visual information, identify abnormal conditions, and provide the location of detected faults for faster maintenance and corrective action

B. Scope of the Present Work

The present work focuses on the development of a UAV-based system for monitoring electrical distribution lines with the objective of improving the safety, efficiency, and reliability of line inspection. The proposed UAV is equipped with a camera, current-measuring clamp meter, temperature sensor, and GPS module to collect electrical, thermal, visual, and location-based information during inspection. The collected data can be transmitted to a monitoring station for further analysis and documentation. The proposed approach aims to reduce dependence on conventional manual inspection, minimize inspection time and human exposure to electrical hazards, and support timely maintenance of distribution lines.

II. LITERATURE SURVEY

The monitoring and inspection of overhead electrical lines have traditionally relied on manual inspection and helicopter-based methods. These approaches can be time-consuming, expensive, and potentially hazardous for maintenance personnel. Recent research has therefore focused on using Unmanned Aerial Vehicles (UAVs) to collect inspection data more safely and efficiently.

Table I. Summary of Reviewed Literature

Sr. No.	Title	Authors	Journal / Year	Findings
1	Detecting Power Lines in UAV Images with Convolutional Features and Structured Constraints [1]	Authors from Wuhan University and LIESMARS	Remote Sensing, 2019	Proposed a method for detecting power lines in UAV images using convolutional features and structured constraints.
2	An UAV Inspection Method for Overhead Lines in Distribution Networks [7]	Y. Nan	2025 IEEE 3 rd International Conference on Sensors, Electronics and Computer Engineering (ICSECE),2025	Proposed integrating RFID identification with UAV inspection so that pole identity, coordinates images, flight information, and monitoring data can be associated for distribution line inspection and maintenance.
3	Power Transmission Line Inspections: Methods, Challenges, Current Status and Usage of Unmanned Aerial Systems [2]	Faiyaz Ahmed, J. C. Mohanta, Anupam Keshari	Journal of Intelligent & Robotic Systems, 2024	Reviewed existing powerline inspection techniques and UAV applications, emphasizing reduced labour, lower inspection effort, and easier inspection under different geographical and environmental conditions

4	A Drone Based Transmission Line Components Inspection System with Deep Learning Technique [8]	Zahid Ali Siddiqui, Unsang Park	Journal Energies (MDPI), Volume 13, issue 13, in 2020	Developed a real-time drone inspection system for detecting transmission-line components such as insulators, splitters, dampers, and power lines, with the aim of identifying component defects.
5	Intelligent Monitoring and Inspection of Power Line Components Powered by UAVs and Deep Learning [6]	Van Nhan Nguyen, Robert Jenssen, Davide Roverso	IEEE Power and Energy Technology Systems Journal, 2019	Developed a UAV-based vision inspection concept using deep learning. It addressed challenges such as limited training data, class imbalance, and detection of small components and faults.
6	Monitoring Powerlines and Vegetation Risks: From Conventional Methods to Digital Twin [3]	Damos A, Ayobo, Wael Jaafar, Rami Langar	IEEE Access, 2025	Reviews traditional and modern power line monitoring approaches. Introduced digital twin based approach for real time monitoring, predictive risk analysis and vegetation management to enhance distribution network reliability
7	An improved lightweight RT-DETR Algorithm for High Voltage Transmission Line Inspection [4]	Dongfeng Pei, Wei Guo, Ming Li, Xuwu Ge, Zhengkun Zhao, Shuohe wang	IEEE Access, 2025	RT-DETR-MBD, an advanced light-weighted object detection algorithm, was introduced for the detection of power-line devices in drone images. This algorithm had an accuracy of 94.3% in detecting the objects, reduced the model size by 46%, and increased the inference time by 36%.
8	UAV Inspection Algorithm for Power Transmission and Distribution Lines Based on Satellite Ground Fusion Network [5]	Chao Huang, Jigao Song, Lin Zhang, Wenwei Chen, Liang Han, Jiaxu Song, Jiaying Lian	2024 International Conference on Advances in Electrical Engineering and Computer Applications (AEECA 2024)	The satellite-ground communication integration model for UAV-based inspection of power lines was proposed. Emphasis on mountainous areas and disaster-hit zones was made. The optimization of UAV inspection area and inspection sequence resulted in energy savings and increased inspection efficiency.

III. PROPOSED SYSTEM ARCHITECTURE

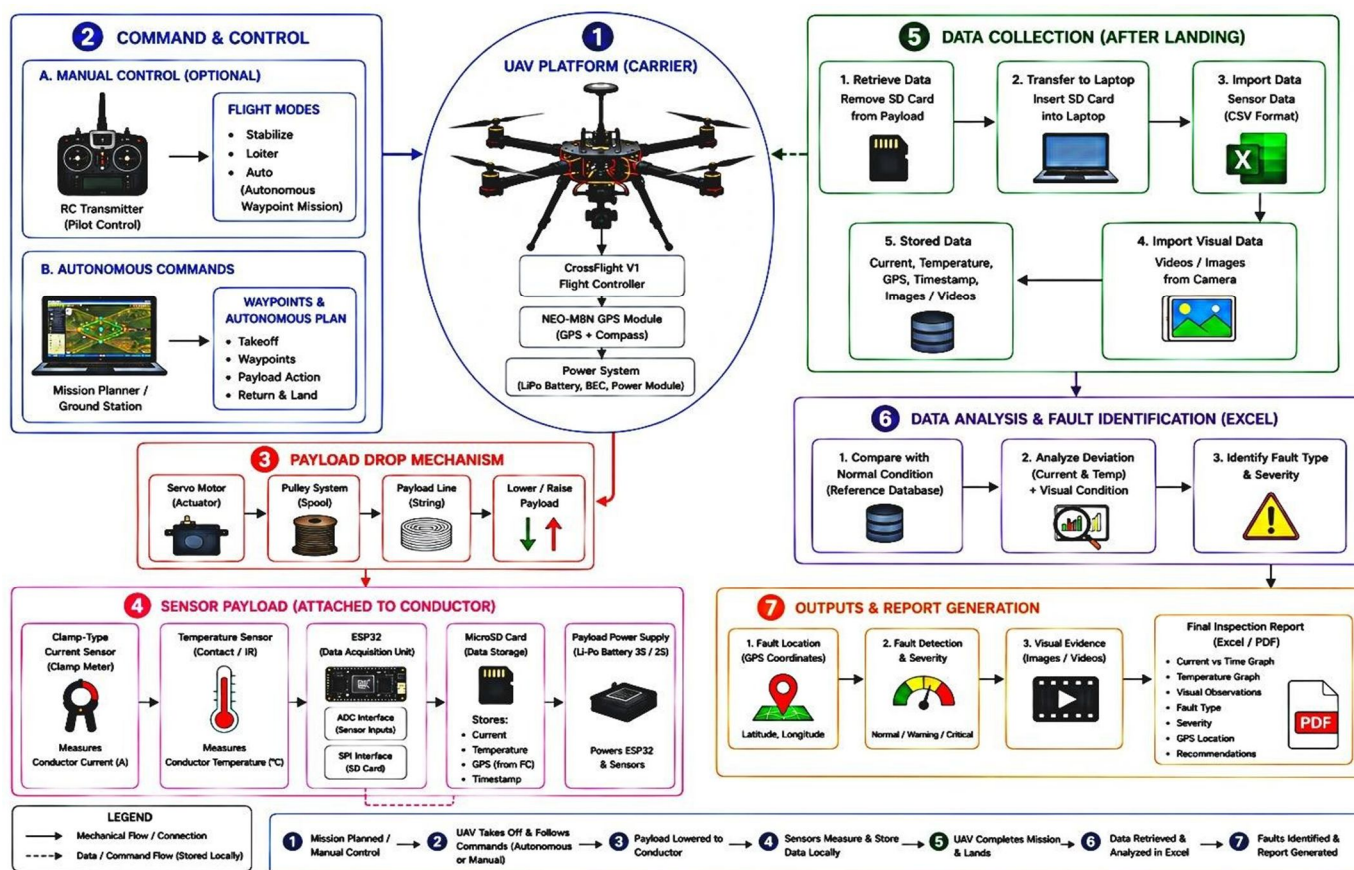


Fig. (1) Block Diagram of Proposed System Architecture

1) UAV Platform – Carrier

This is the main drone platform that carries all the required equipment.

- Cross Flight V1 Flight Controller: Controls and stabilizes the drone.
- NEO-M8N GPS Module: Provides GPS position and compass direction.
- Power System: Includes Li-Po battery, BEC and power module to supply power to the drone and payload.

2) Command & Control

This section shows how the drone is controlled.

A. Manual Control: - An RC transmitter is used by the pilot for manual control. Different flight modes are available: Stabilize, Loiter, Auto/autonomous waypoint mission

B. Autonomous Commands: - A Mission Planner Ground Station is used to create an autonomous mission.

The mission can include: Take off, Waypoints, Payload action, Return and landing

3) Payload Drop Mechanism

This mechanism allows the sensor payload to be positioned near or attached to the conductor.

It consists of:

- Servo motor: Works as the actuator.
- Pulley system: Controls the movement of the line/string.
- Payload line: Connects the mechanism to the sensor payload.
- Lower/Raise mechanism: Moves the payload downward or upward.

4) Sensor Payload

This is the main inspection and measurement section attached to the conductor.

- Clamp-type current sensor: Measures the conductor current in amperes without directly cutting or disconnecting the conductor.
- Temperature sensor: Measures the conductor temperature in °C.
- ESP32: Acts as the data acquisition and processing unit. It receives the sensor signals and manages data storage.
- MicroSD card Stores: Current, Temperature, GPS coordinates, Timestamp
- Payload power supply: A separate Li-Po battery (3S/2S) supplies power to the ESP32 and sensors.

5) Data Collection After Landing

After completing the inspection, the UAV returns and lands. The collected data is then transferred: **SD Card → Laptop → Excel**

Two types of data are imported:

- Sensor data: Current, temperature, GPS and timestamp in CSV format.
- Visual data: Images and videos captured by the camera.

6) Data Analysis & Fault Identification

1. Compare with normal condition: Measured values are compared with a reference or normal-condition database.
2. Analyse deviation: Abnormal changes in current, temperature and visual condition are examined.
3. Identify fault type and severity: Based on the deviation and visual evidence, the condition can be classified as:
 - Normal
 - Warning
 - Critical

7) Output & Report Generation

Finally, the analysed information is converted into an inspection report in Excel/PDF format.

The report contains:

- Fault location: Latitude and longitude
- Fault detection and severity
- Visual evidence: Images/videos
- Current vs. time graph
- Temperature graph
- Visual observations
- Fault type
- GPS location
- Recommendations

IV. METHODOLOGY AND WORKING PRINCIPLE

The Autonomous UAV-Based Power Asset Health Monitoring System with Real-Time Thermal Anomaly Detection, Corona Indication and Defect Analysis System is developed for efficient inspection and surveillance of electrical power transmission systems. Working of the system involves the utilization of the UAV with sensors, camera, GPS, ESP32, servo pulley and SD card in order to gather and store inspection data. Main objective behind the development of such system was to reduce efforts and provide safety to the inspector as well as detect the fault in the initial stage.

1) Mission Planning

The next step is Mission Planning. A path for the inspection is developed based on the location of the transmission line and the power assets to be inspected. Various waypoints are marked in the inspection path. Waypoints help the UAV in flying and making sure that the area under consideration is inspected. Proper mission planning makes sure that the UAV flies in a proper position and at the correct distance from the transmission line while inspecting.

2) UAV Flight

Finally, after completing mission planning, UAV flight is done. The UAV may either fly with the help of remote controller or automatically by considering the already determined waypoints. While the UAV flies along the already determined inspection path, it carries the sensor payload as well as the camera. This way the UAV is placed near the power asset so that necessary information could be gathered.

3) *Payload Release*

The next step involves the Payload Release. Sensor payload is released or placed using a Servo Pulley System. The pulley mechanism is controlled using a Servo Motor to facilitate the placement of the payload. The sensor payload can then be moved to the required point of inspection. Control of payload release enables better measurement capability in the system.

4) *Data Acquisition*

In the process of Data Acquisition, important electrical and thermal parameters of the power asset are measured. Electrical current in the conductor is measured using the current sensor. Temperature of the conductor is also measured using the temperature sensor. This information is very important since unusual values in such parameters indicate some abnormality in operation. Abnormally high temperatures could mean overheating and excessive loading. All sensor data will be gathered using the ESP32.

5) *Visual Inspection*

In addition to the sensor readings, Visual Inspection is done by the camera installed on the UAV. High-quality images of the conductor and other power system components are captured using the camera. Such images will help in identifying visible defects like corrosion, cracks, physical damage, wear, and others. Visual inspection will provide information that cannot be provided through current and temperature measurement alone. Thus, doing the visual inspection alongside the sensor measurements will make the inspection more comprehensive.

6) *Data Storage*

The information gathered during the inspection is stored in the Data Storage phase. The ESP32 saves the sensor readings, GPS coordinates, and other related information in the SD card. Information stored includes the current, temperature, GPS coordinates, and time of recording. Storing the data locally will enable the system to store the data even when the UAV is flying without being entirely dependent on the constant connection to the ground station. GPS coordinates are saved together with the data to help locate the abnormal condition.

7) *Data Transfer*

Having finished with its mission, the UAV lands back safely. After that, in the Data Transfer stage, all the gathered information is transferred to the laptop. All the data that have been gathered on the SD card of ESP32, together with all the taken pictures, are arranged in order to be analyzed next. The laptop serves as a good tool for viewing and analyzing all of the gathered information about the inspected assets.

8) *Data Analysis*

In the Data Analysis stage, all the collected data is reviewed to check on the condition of the inspected power asset. Both current and temperature measurements that were taken using the UAV are compared with the reference data using the Excel program. In case the values obtained are not within the expected range, this may signify some abnormal condition. Also, the pictures taken are reviewed for any defects that can be seen. The use of both sensor data, visual data, and GPS data makes the process more reliable.

9) *Fault Determination*

The collected data is utilized for Fault Determination. In case the parameters and images suggest some abnormalities, a possible fault or defect is recognized. For instance, excessive temperature suggests that there might be overheating, and abnormal images may indicate corrosion, cracks, damage to conductors, and any other physical faults. The abnormality detected is then evaluated according to certain reference and inspection criteria. In accordance with this process, the fault is classified based on its seriousness, e.g., mild, moderate, or severe.

10) Fault Localization

After the fault is found, Fault Localization procedure is carried out with the help of GPS coordinates collected from the inspection. The GPS coordinates corresponding to the abnormal parameters or images make it possible to localize the problematic area or the defective power asset. Thus, the maintenance workers will not need to inspect the entire transmission line manually.

11) Generation of Fault Report

This is the final step of fault detection where generation of fault report takes place after the inspection and analysis have been done successfully. The report will be compiled and will contain all the relevant information about the mission. It can contain the values of the current and temperature that were measured, the images taken, the GPS coordinates, the abnormality detected and the severity of the fault.

To sum up, the proposed methodology encompasses the use of the UAV, sensors, ESP32, GPS, camera based visual inspection, data storage and data analysis all in one power asset monitoring system. Using the UAV, transmission line assets can be efficiently inspected, while sensors and camera give the electrical, thermal and visual data. This data is then compared to the reference one in order to detect any abnormality, its severity and location with the help of GPS coordinates.

V. RESULTS AND DISCUSSION

The proposed UAV-based distribution-line monitoring system provides a practical approach for inspecting electrical distribution lines without requiring continuous manual inspection. During the monitoring process, the UAV can capture real-time images and videos of conductors, poles, insulators, and other line components. The camera data helps identify visible abnormalities such as damaged conductors, cracks, corrosion, and defective components.

The current-measuring clamp meter can be used to monitor the current flowing through the line and identify abnormal or overcurrent conditions. Similarly, the temperature sensor helps detect unusual temperature rises that may indicate overloading, loose connections, or other abnormal operating conditions. The GPS module provides the geographical location of the inspected section, which can help maintenance personnel identify the approximate location of an abnormality.

The collected electrical, thermal, visual, and location data can be analysed together to obtain a more complete understanding of the distribution-line condition. Compared with conventional manual inspection, the proposed approach can reduce inspection time, improve worker safety, and support early identification of faults. However, the accuracy of monitoring can be affected by factors such as UAV stability, weather conditions, sensor accuracy, communication range, and camera resolution.

Table I. Current Monitoring

Observation No.	Date	Time	Current (A)
1	05-10-2026	22.10.29	3.75
2	05-10-2026	22.10.30	3.73
3	05-10-2026	22.10.31	3.76
4	05-10-2026	22.10.32	3.66
5	05-10-2026	22.10.33	3.71

The above table no. I shows the value of current monitor reading.

Table II. Temperature Monitoring

Observation No.	Date	Time	Object Temp_C	Ambient_Temp_C
1	05-10-2026	22.10.29	35.9	33.7
2	05-10-2026	22.10.30	35.8	33.7
3	05-10-2026	22.10.31	39.1	33.7
4	05-10-2026	22.10.32	68.2	33.8
5	05-10-2026	22.10.33	70.4	33.8

The above table no. II shows the value of temperature monitor reading.

Overall, the results indicate that integrating UAV technology with current monitoring, temperature sensing, camera-based inspection, and GPS tracking can provide a useful foundation for efficient distribution-line condition monitoring. Further testing under different loading and environmental conditions is required to quantitatively evaluate the accuracy and reliability of the proposed system.

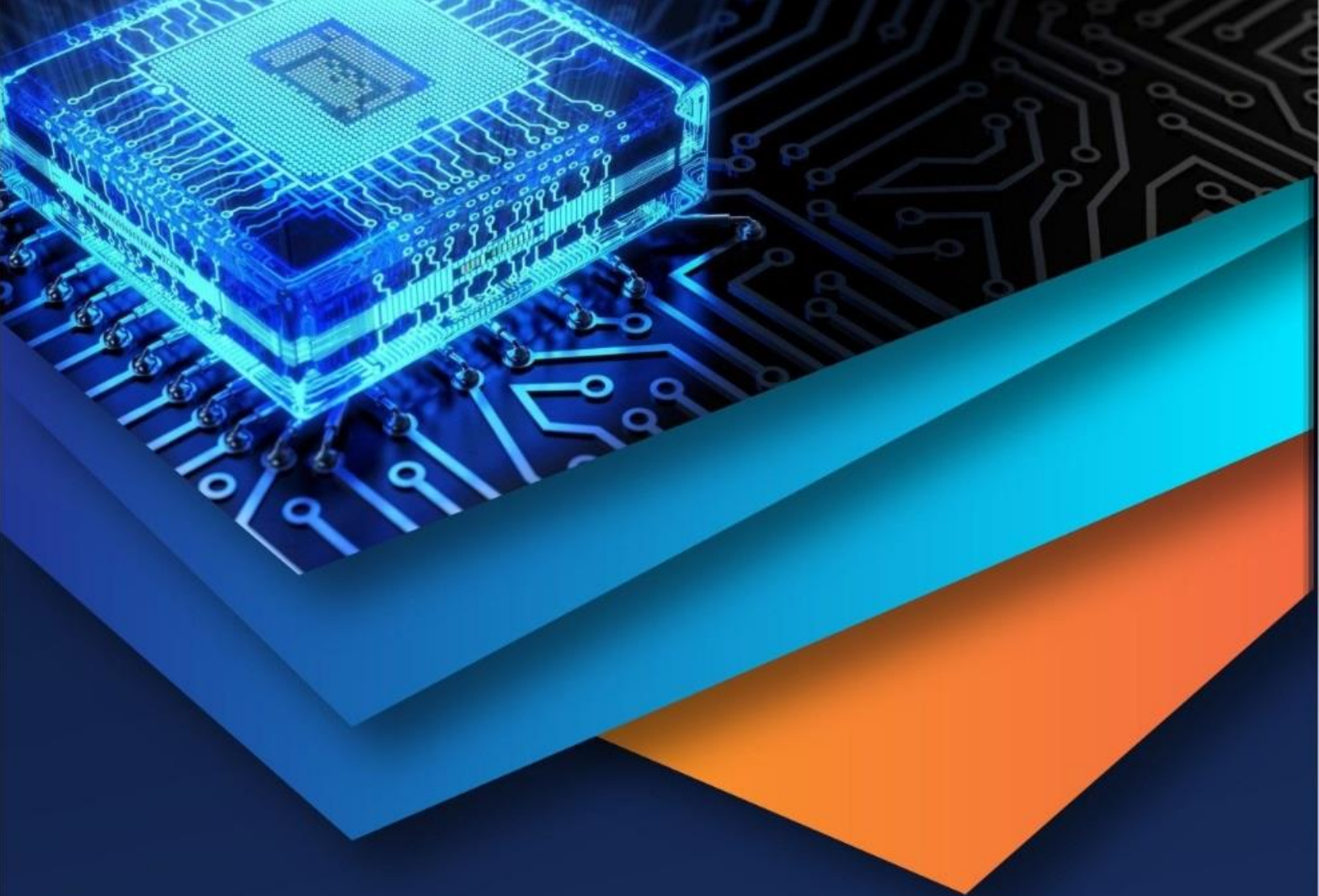
VI. CONCLUSION AND FUTURE SCOPE

The proposed UAV-based distribution-line monitoring system provides a safer and more efficient alternative to conventional manual inspection. By using a UAV equipped with a camera, current-measuring clamp meter, temperature sensor, and GPS module, important information about the condition of distribution lines can be collected remotely. The system can help identify abnormal conditions such as overcurrent, excessive temperature rise, conductor damage, and other visible defects, while GPS helps in locating the affected section. The use of UAV technology can reduce inspection time, minimize human exposure to electrical hazards, and support timely maintenance. Overall, the proposed approach can contribute to improving the reliability, safety, and efficiency of distribution-line monitoring.

AI-based fault detection – AI/ML can be integrated to automatically detect and classify different distribution-line faults. Cloud-based data storage – Inspection data can be stored on cloud platforms for future analysis and maintenance records. Advanced image processing – Computer vision can be used to automatically identify cracks, damaged conductors, broken insulators, corrosion, and other physical defects. Obstacle avoidance – Advanced sensors such as LiDAR or ultrasonic sensors can be incorporated to improve safe UAV operation near electrical infrastructure.

REFERENCES

- [1] An Advanced Unmanned Aerial Vehicle (UAV) Approach via Learning-Based Control for Overhead Power Line Monitoring: A Comprehensive Review IEEE Access, 2021, DOI: 10.1109/ACCESS.2021.3110159
- [2] Power Transmission Line Inspections: Methods, Challenges, Current Status and Usage of Unmanned Aerial Systems DOI:10.1007/s10846-024-02061
- [3] Monitoring Power Lines and Vegetation Risks: From Conventional Method to Digital Twin, IEEE Access 2025 DOI: 10.1109/ACCESS.2025.3623468.
- [4] An Improved Lightweight RT-DETR Algorithm for High-Voltage Transmission Line Inspection, IEEE Access 2025 DOI: 10.1109/ACCESS.2025.3625122.
- [5] UAV Inspection Algorithm for Power Transmission and Distribution Lines Based on Satellite-Ground Fusion Network, IEEE AEECA 2024 DOI: 10.1109/AEECA62331.2024.00063.
- [6] Intelligent Monitoring and Inspection of Power Line Components Powered by UAVs and Deep Learning, Van Nhan Nguyen, Robert Jenssen, Davide Roverso, IEEE Power and Energy Technology Systems Journal, 2019
- [7] An UAV Inspection Method for Overhead Lines in Distribution Networks, Y. Nan 2025 IEEE 3rd International Conference on Sensors, Electronics and Computer Engineering (ICSECE 2025) DOI: 10.1109/ICSECE65727.2025.11256823
- [8] A Drone Based Transmission Line Components Inspection System with Deep Learning Technique, Zahid Ali Siddiqui, Unsang Park, Energies, 2020



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