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Geo Tagging of Land Properties Using Drones

A PROJECT REPORT

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BACHELOR OF TECHNOLOGY

IN

COMPUTER SCIENCE AND TECHNOLOGY (AI-ML)

PRESIDENCY UNIVERSITY

BENGALURU

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PRESIDENCY SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

BONAFIDE CERTIFICATE

Certified that this report "**Geo Tagging of Land Properties Using Drone**" is a Bonafide work of "Likith R - 20221CSG0001, Darshan DM – 20221CSG0058, Tharun Kumar 20221CSG0009", who have successfully carried out the project work and submitted the report for partial fulfilment of the requirements for the award of the degree of BACHELOR OF TECHNOLOGY in COMPUTER SCIENCE TECHNOLOGY, AI - ML during 2025-26.

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Abstract

Geo-tagging of land properties using drones brings a whole new dimension to conventional land surveying and property management by integrating unmanned aerial vehicles, GPS technology, and geospatial data analytics in the process. Traditional methods of mapping are bound to be time-consuming, labor-intensive, and full of human errors; drone-based geo-tagging ensures high accuracy, efficiency, and cost-effectiveness in capturing spatial information.

This project entitled "Geo Tagging of Land Properties Using Drone" aims at designing an automated system for capturing aerial imagery with GPS-enabled cameras mounted on drones and producing geo-referenced maps of land parcels. The proposed architecture will include modules such as drone navigation, image capture, extraction of coordinates, data processing, and database integration. The captured images are to be processed using photogrammetry and GIS tools to accurately demarcate the land's boundaries and identify each property with unique geographic coordinates in latitude and longitude.

It also provides real-time mapping, automated data synchronization, and storage in the cloud for easy access and verification by authorities and landowners. Experimental evaluation showed that the proposed system enhances the accuracy of land record management considerably with reduced operational time compared to conventional surveying techniques.

The project contributes to effective land administration and transparency in land ownership, smart city initiatives, and sustainable infrastructure planning with advanced geospatial intelligence supported by drone technology.

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Abbreviations

Abbreviation	**Full Form**
AI	Artificial Intelligence
AICTE	All India Council for Technical Education
API	Application Programming Interface
CAD	Computer-Aided Design
CNN	Convolutional Neural Network
CSV	Comma-Separated Values
DGCA	Directorate General of Civil Aviation
DILRMP	Digital India Land Records Modernization Programme
DPDPA	Digital Personal Data Protection Act
DSM	Digital Surface Model
GIS	Geographic Information System
GPS	Global Positioning System
HD	High Definition
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
LiDAR	Light Detection and Ranging
ML	Machine Learning
NDVI	Normalized Difference Vegetation Index
QGIS	Quantum Geographic Information System
RGB	Red Green Blue
SDG	Sustainable Development Goal
UAV	Unmanned Aerial Vehicle

Abbreviation	**Full Form**
UAS	Unmanned Aerial System
UN	United Nations
URL	Uniform Resource Locator
USB	Universal Serial Bus
Wi-Fi	Wireless Fidelity

Chapter 1

Introduction

1.1 Overview of Geo Tagging of Land Properties Using Drone

The geotagging of land properties using drones represents one modern technological advancement in the field of land surveying, mapping, and property management. Geotagging is the process of attaching geographical coordinates, such as latitude and longitude, to specific locations, images, or datasets. Combined with drone technology, this turns the process into a much faster, more accurate, and more efficient one compared to traditional ground-based surveying methods.

Drones, also known as UAVs, with their high-resolution cameras and GPS modules, have the ability to capture images and videos of extended areas of land within a considerably short period of time. These captured images are processed using GIS and photogrammetry software into highly detailed maps, 3D models, and geo-referenced data. Therefore, every land property can be assigned a unique geographic tag representing its exact position and boundary on Earth's surface.

1.2 Problem Definition

Traditional methods of land surveying and property mapping are usually very time-consuming and laborious, hence prone to human errors. The manual mode of taking measurements, as well as obsolete records, has generally led to incorrect property boundaries, discrepancies in ownership information, and challenges in keeping current land data. These, together with environmental and accessibility issues, raise further the cost and inefficiency of conventional surveys, especially over wide areas or remote locations.

The following issues call for the development and use of an efficient, accurate, and automatic system for capture and management of geospatial data on land. This proposed project "Geo Tagging of Land Properties Using Drones" applies the use of drones integrated with GPS and GIS in the execution of precise aerial mapping and geo-tagging of parcels of land. This approach minimizes human error, reduces survey time, and supports the creation of digital land records for transparent and efficient property management.

1.3 Need for Geo Tagging of Land Properties Using Drones

Effective land management, urban planning, and identification of property ownership depend on valid and current land information. Traditional methods of surveying, based on data collection and field measurements, are slow, time-consuming, expensive, and full of errors. As a result, these challenges create land boundary conflicts, duplicate ownership records, and delays in registering lands and developing infrastructure.

There is an emergent need for an automated, accurate capture, storage, and management system of geospatial land data amidst increasing demands for digital governance and smart city initiatives. Geo Tagging of Land Properties Using Drone addresses this requirement through the use of drones fitted with GPS and GIS technologies for high-accuracy aerial mapping and geo-referencing. This approach ensures faster data collection, improved accuracy, and easier accessibility of land records, supporting transparency, efficient decision-making, and sustainable land administration.

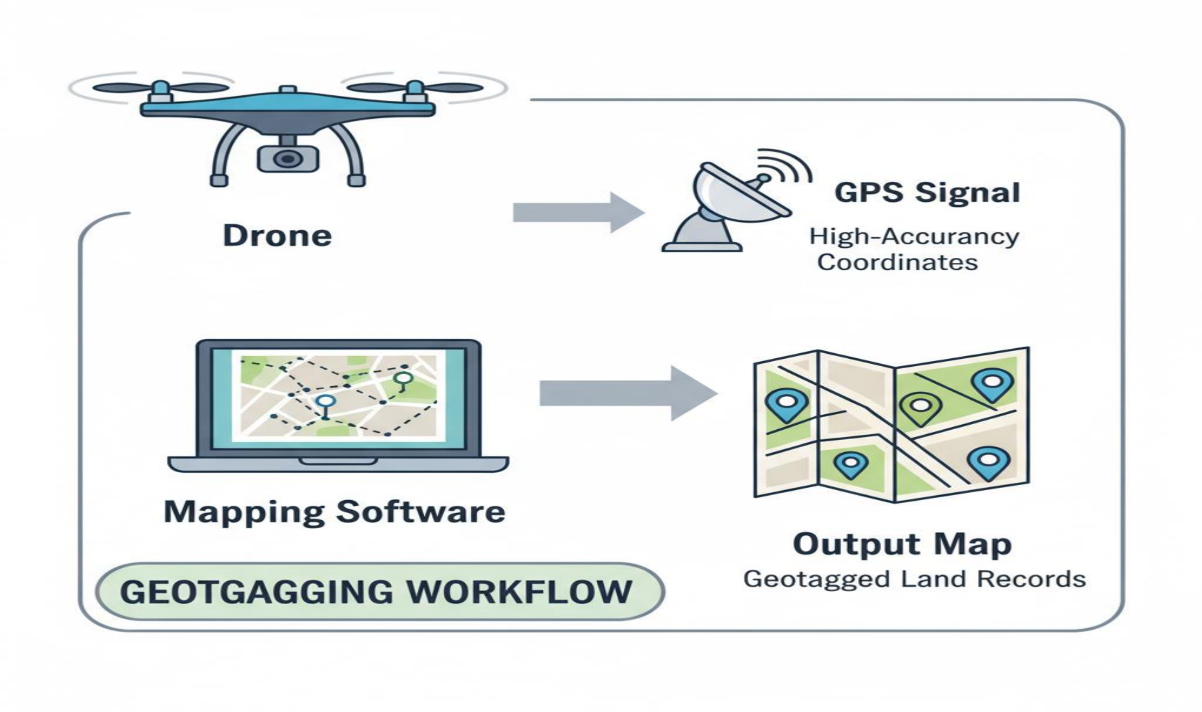


Fig 1.1 Concept diagram of drone-based geotagging

1.4 Objectives of the project

The key objective of this project is to design and develop an effective system for Geo Tagging of Land Properties Using Drone in order to increase the efficiency and effectiveness of land surveying and mapping. The focus of the project is on integrating drone technology with GPS and GIS tools to automate capturing, processing, and managing geospatial data.To study the principles of geo-tagging, aerial surveying, and geospatial data acquisition using drones.

- To study the principles of geo-tagging, aerial surveying, and geospatial data acquisition using drones.
- To design a system architecture that integrates drone navigation, image capture, and geo-referencing of land properties.
- Develop methods for processing the aerial images to extract accurate geographic coordinates (latitude and longitude) for each property.
- Undertake GIS-based mapping and data storage for maintaining digital records of land.
- Performance assessment of the system in terms of accuracy, efficiency, and reduction in time required as compared to traditional surveying methods.
- To design an easy-to-use interface for visualization, verification, and management of geo-tagged land information.

1.5 Scope of the Study

This project involves the formulation and execution of a drone-based land geo-tagging system with the use of Global Positioning System-GIS technologies. In this study, high-resolution aerial images using a drone were acquired, photogrammetry and GIS image processing was performed, and geographic coordinates of individual land parcels were assigned accordingly. This system is designed to create digital maps and geo-referenced land records that may be used for administrative, planning, and verification purposes.

Any experimental validation of the project is limited to controlled test areas, ensuring that the data is accurate and reliable under real conditions. The study advocates automation, data accuracy, and efficiency rather than large-scale deployment or integration with national land databases. This study will contribute not only to academic research but also to the advancement of practical and cost-effective solutions for modernizing land surveying, supporting e-governance, and increasing transparency in property management.

1.6 Significance of the Study

The significance of this project lies in its integration of drone technology, GPS, and GIS to modernize and automate the process of land surveying and mapping. Unlike traditional manual methods, which are time-consuming and error-prone, this approach introduces precision, automation, and digital efficiency in geo-tagging land properties. It demonstrates how advanced geospatial and aerial imaging technologies can transform land administration and record management.

The project provides several key benefits:

● Enhances the accuracy and reliability of land surveys.

● Reduces human effort, time, and cost through automation.

● Facilitates digital storage and easy retrieval of land records.

● Supports transparency and minimizes land ownership disputes.

● Contributes to smart city development and e-governance initiatives.

Additionally, the system serves as an educational and practical platform for students and researchers to explore applications of drones and geospatial technologies. Thus, the project holds both academic and real-world significance in promoting efficient, transparent, and technology-driven land management.

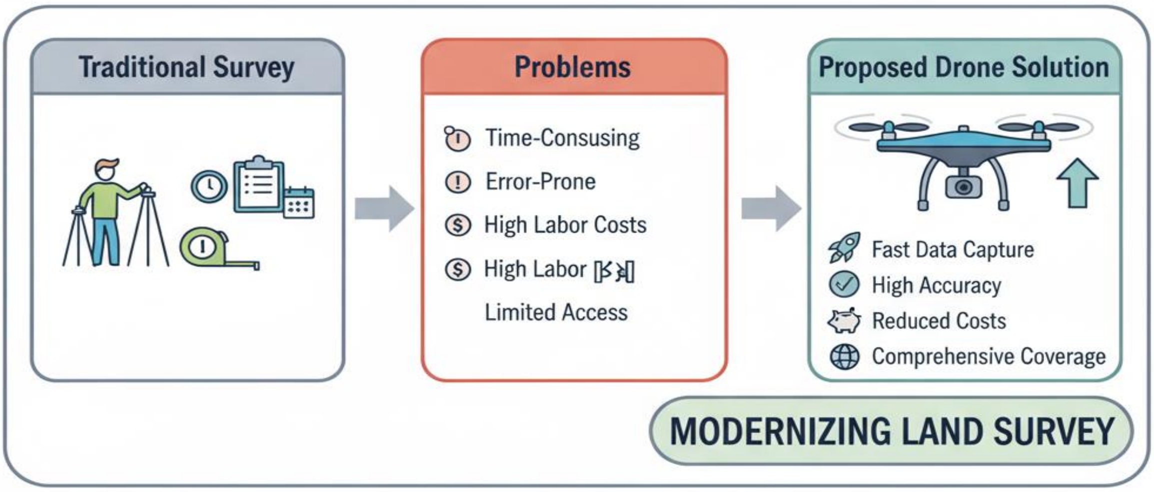


Fig 1.2 Problem and proposed solution

1.7 Organization of the Report

This report is organized into eight chapters:

● **Chapter 1** provides an introduction to the study. It covers the overview of geo-tagging land properties using drones, the problem definition, the need for the project, its objectives, scope, significance, and the overall structure of the report.

● **Chapter 2** presents the literature review. It includes existing work related to drone-based geo-tagging, traditional land surveying methods, drone mapping systems, machine-learning approaches, hybrid models, and the research gap identified.

● **Chapter 3** explains the methodology followed in the project. It discusses the research approach, system requirements, system architecture, module descriptions, workflow, data flow, and the tools and technologies used.

● **Chapter 4** focuses on project management and implementation. It covers system setup, the simulated mapping environment, data collection, preprocessing, mapping and visualization steps, real-time geo-tagging updates, and system testing and validation.

● **Chapter 5** presents the results and discussion. It describes the experimental setup, evaluates accuracy and precision, examines system performance, tests adaptability and scalability, compares results with other methods, and summarizes key observations.

● **Chapter 6** highlights the advantages, applications, and cost aspects of the system. It also includes resource utilization, economic and societal benefits, and the limitations encountered during the project.

● **Chapter 7** discusses the social, legal, ethical, sustainability, and safety considerations associated with the system.

● **Chapter 8** concludes the report and outlines possible future enhancements that can further improve or extend the system.

Chapter 2

Literature review

2.1 Overview of Geo Tagging using Drones

Geo-tagging of land properties using drones is one of the most modern, cutting-edge, and efficient methods for land surveying and mapping. This technique uses drones, also called Unmanned Aerial Vehicles (UAVs), with high-resolution cameras and GPS modules. It captures aerial images and develops the accurate geospatial data. The data collected is further processed by Geographic Information System (GIS) and photogrammetry software for the generation of detailed maps and 3D models, along with accurate geo-referencing of the boundaries of land parcels. The incorporation of drone technology ensures rapid data capture, minimum human error, and higher accuracy compared with traditional surveying methods.

Geospatial research studies categorize the drone-based mapping processes, in general, into three stages: data acquisition, image processing, and geo-referencing. During the data acquisition phase, drones capture high-quality aerial imagery; in the image processing phase, the images are transformed into Ortho mosaic maps or digital elevation models; and in the geo-referencing phase, the processed data is linked with exact geographic coordinates. Increasingly adopted, this technology plays a vital role in digital land management, urban planning, agricultural monitoring, and property verification by offering a very sustainable and transparent approach toward land administration.

2.2 Traditional Methods of Land Surveying

Traditional land surveying relies upon manual instruments such as theodolites, total stations, and handheld GPS devices for measurement and mapping of land boundaries. While these methods offer accurate results, they are very time-consuming, labor-intensive, and greatly dependent on field conditions and human expertise. Due to the manual measurement method, the surveyors have to visit the site physically to record the measurement, which may be difficult and costly for large or remote areas. Consequently, most land records have inaccuracies due to manual data In addition, traditional surveying is not automated and cannot integrate real-time data. The information gathered in the course of this process usually needs to be manually compiled and digitized, introducing chances for delays and discrepancies. With the increasing need for more precise, fast, and scalable land management, these limitations suggest that modern, technology-driven methods like drone-assisted surveying with GPS and GIS integrations can reach better, quicker, and more reliable land mapping.

2.3 Drone-Based Land Mapping Systems

With the advent of drones, land surveying and mapping have become more efficient and automated. Unmanned Aerial Vehicles, popularly known as drones, fitted with GPS-enabled high-resolution cameras, can click detailed aerial photographs and create very accurate spatial data over vast areas in less than half the time it would take by traditional means. The idea behind this approach is to let the surveyor capture real-time data with minimum human intervention while providing high precision and consistency.

Several researchers have demonstrated that a drone can be effectively used in the management of land. The drone-based system is able to automatically perform flight-path planning, capture overlapping images for 3D reconstruction, and then apply photogrammetry and GIS tools to create an Ortho mosaic map and digital terrain model. This drone mapping system enhances accuracy and scalability, and thus has opened up newer avenues for rapid data processing and visualization in various applications pertaining to property boundary detection, urban planning, and agricultural monitoring.

2.4 Machine Learning-Based Land Analysis Approaches

ML has now emerged as a strong tool for automating and improving the accuracy of drone-based land mapping and geo-tagging systems. By analyzing large volumes of aerial imagery, ML algorithms can recognize land features, classify types of terrain, and detect property boundaries more effectively compared to manual methods. For image classification and object detection in geospatial applications, the Random Forest (RF), Support Vector Machine (SVM), and Convolutional Neural Networks (CNN) models are widely used under the category of supervised learning.

It has been demonstrated that ML-based models significantly enhance the precision and efficiency of land property mapping by reducing human error and processing time. Such models can learn from labelled datasets in order to automatically identify classes of lands, such as agricultural, residential, or forested areas. In addition, combining ML with drone imagery enables the continuous updating as more data becomes available, ensuring adaptability in most terrains and weather conditions. Therefore, ML acts as an important building block in modern intelligent land mapping systems, enhancing scalability and accuracy.

2.5 Hybrid Models and Adaptive Systems

Recent geo-tagging and land mapping developments have highlighted the use of hybrid models that integrate statistical analyses, image processing, and machine learning methods as ways to increase mapping accuracy and adaptability. These hybrid systems merge the strengths of traditional Geographic Information Systems with AI-powered image recognition and data-driven classification methods. Such models fuse data captured from drones, GPS, and satellite imagery together for high-precision boundary detection, land-use categorization, and property identification.

Adaptive systems play a crucial role in managing the variability of terrain, vegetation, and lighting conditions during drone operations. These systems can perform continuous learning, real-time data processing, and automatic adjustment of parameters to sustain accuracy across diverse environments. Scalability and consistency in big-scale land surveying projects are assured through the integration of AI and automation. Thus, hybrid and adaptive models signify the future of drone-based geo-tagging, merging flexibility, precision, and intelligent decision-making in effective land property analysis.

2.6 Research Gap Identified

Although significant progress has been made in the fields of drone-based mapping and geo-tagging, several research gaps remain. Most systems operating currently are limited to simple imagery capture and basic mapping without real-time data processing for intelligent property boundary detection. Scalability also remains a challenge, since most of the frameworks have not proven capable of efficiently handling large datasets or providing consistently accurate coverage over extensive geographical areas. Most of the existing models have difficulties adapting to changes in the environment, such as variations in terrain elevation, vegetation cover, and lighting conditions. AI integration to provide full automated classification and boundary recognition is still limited in most applications. Therefore, there exists a clear demand for an advanced adaptive framework that integrates drone imagery, machine learning, and automated geotagging to offer superiority in terms of accuracy, efficiency, and scalability for identification and mapping of land property.

2.7 Summary

The literature review stresses that, though different drone-based mapping and geo-tagging systems have been developed, an integrated, scalable, and intelligent framework is yet to be realized. Most of the traditional methods involve excessive manual processing and are not adaptive to varied environmental conditions. Advanced models using AI or GIS often also work independently, thereby limiting overall efficiency and precision in large-scale mapping applications. This project proposes the development of an Automated Drone-Based Mapping and Geo-Tagging System for Land Property Identification to fill these gaps. The system will integrate drone imaging, artificial intelligence, and GIS-based geotagging to achieve accurate, fully automated, and scalable mapping. This approach enhances the accuracy of data, reduces manual intervention, and creates a reliable real-world tool for land and property management applications.

Method/Study	Year	Key Technology Used	Advantages/Limitations
Traditional GPS Drone Mapping	Consumer Drones, RTK/PPK GPS, Basic Photogrammetry Software	Medium Accuracy, Affordable; Control Points	Medium Accuracy; Requires Ground Control Points
LIDAR Drone Scanning	**2015+**	**2015+**	✓
LIDAR Scanners, High-End Drones, 3D Point Clould Processing	LIDAr Scanners, High-End Drones, Cloud Processing	High Accuracy 3D Models, in Varied Condhi Expensive Hardware, Complex Data	Automated Classification, Reliiss on Training Data
AI-Based Object Recognition	**2018+**	**2018+**	✓
Blockchain for Data Security	Distributed Ledger Technology, Data Data Encryition	Automated Classification, Faster on Traaining Data Quality	Tamper-Proof Records, Enhanc Security; Stage, Scalabiity Concerns

Fig 2.1 Summary of previous works

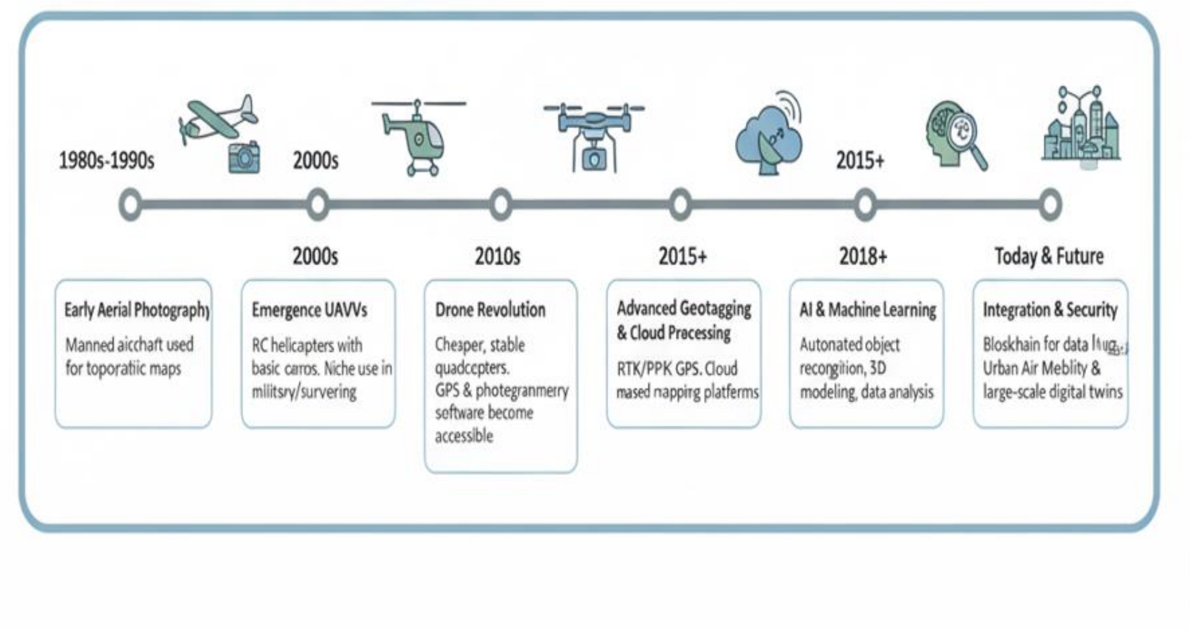


Fig 2.2 Timeline of drone-based mapping research

Chapter 3

Methodology

3.1 Research Methodology

The research methodology of the project follows a systematic approach, combining theoretical studies with simulation-based experimentation and data-driven evaluation, and includes several steps:

Problem Analysis: Identification of problems with traditional processes of land surveying and documentation, such as inaccuracies, manual effort involved, and no real-time geospatial data.

Requirement Gathering: The need for an efficient, automated, and accurate mechanism of geo-tagging using drone technology to map land properties.

System Design: Develop an architecture that combines drone-based aerial imagery, GPS technology, and mapping software to capture and visualize land data with accuracy.

Implementation involves creating individual modules of image capture, coordinate extraction, mapping, and visualization through the use of open-source utilities and programming environments.

Testing and Evaluation: This involves simulation and test flights, or sample dataset evaluations, to ensure proper geo-tagging accuracy, system efficiency, and reliability of the mapping output.

Result Analysis: The obtained geospatial data was compared with actual land coordinates to analyze the accuracy and provide the scope of improvement within mapping precision and visualization of data.

The iterative methodology allows for a comprehensive investigation into both the academic and practical nature of drone-based geo-tagging.

3.2 System Requirements

The system was developed to work in a simulated environment with the purpose of accurately emulating real-world land mapping while ensuring controlled testing of drone-based geo-tagging and data visualization.

3.2.1 Hardware Requirements

Processor: Intel Core i5 or higher

Memory: At least 8 GB RAM (16 GB recommended)

Storage: 100 GB or more free disk space

Camera: GPS-enabled drone or smartphone to capture aerial images

Display: Full HD monitor for image and map visualization

Network: Stable internet connection for map loading and data transfer

Optional: External SSD or USB drive for storing large image datasets

3.2.2 Software Requirements

Operating System: Windows 10 / Ubuntu 20.04 LTS

Programming Language: Python 3.8 or higher

Libraries and Tools: OpenCV, Pandas, NumPy, ExifRead, GDAL, Geopy

Mapping Framework: Leaflet.js / QGIS for interactive visualization

Database: SQLite or CSV files for storing coordinates and image data

Web Technologies: HTML, CSS, JavaScript for front-end interface

Development Tools: Visual Studio Code, Git for version control

3.3 System Architecture Overview

The proposed Geo-Tagging System for Land Properties has four main layers: the Data Acquisition Layer, the Processing Layer, the Mapping Layer, and the Visualization Layer, each performing a specific role in the geo-tagging workflow.

Data Acquisition Layer: This layer captures the aerial images of land areas using GPS-enabled drones or smartphones. Latitude, longitude, and altitude of each image get automatically recorded in the EXIF metadata.

Processing Layer: GPS coordinates, as well as other data, are extracted from the images collected. Cleaning up, organizing, and formatting the data for mapping is done using Python with ExifRead and Pandas.

Mapping Layer: This layer converts the processed coordinate data into geospatial formats like GeoJSON or CSV. These coordinates will then be plotted using open-source mapping libraries or GIS platforms like Leaflet.js or QGIS.

Visualization Layer: This shows the final mapped output that displays land boundaries and the locations of properties on an interactive web or desktop interface. This layer provides full functionality for zoom, identification of coordinates, and the exact view of each property on a map.

These layers together create an automated and efficient system in which real-world land information is captured, processed, and visualized with accuracy and clarity.

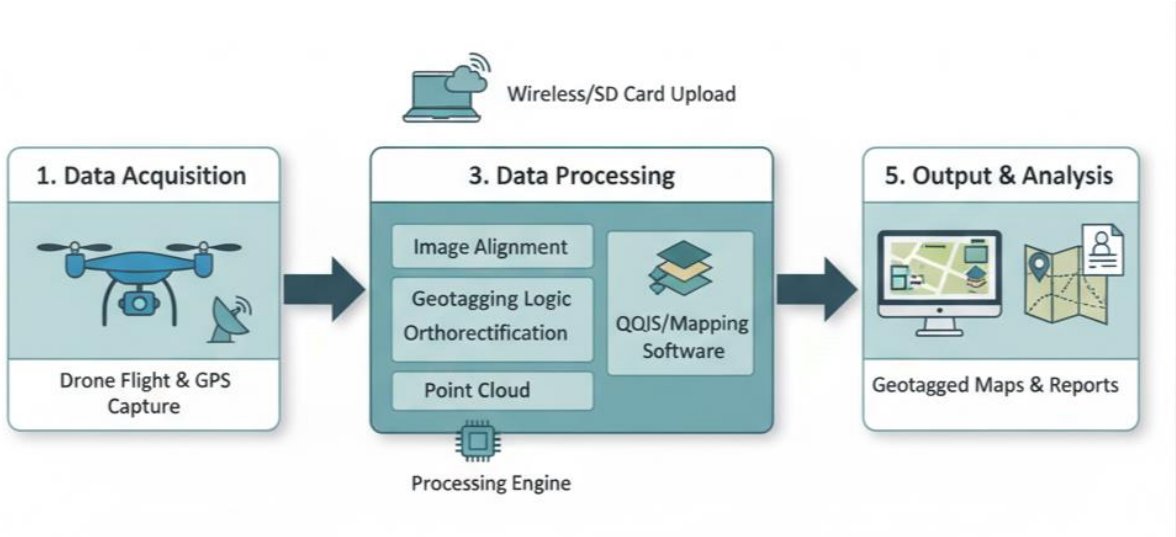


Fig 3.1 System Architecture Diagram

3.4 Module Descriptions

The entire system of Geo Tagging of Land Properties Using Drones is split into several interlinking modules, each performing a certain function within the workflow. From capturing aerial images to processing data, visualization of mapped areas, and records management, these modules combine to form one smooth, end-to-end automation process. Each module has its vital role in transforming the raw drone data into precise, readable, and useful mapping information.

3.4.1 Data Acquisition Module

This is the basis of the whole system, where the data journey originates. The Data Acquisition Module shall focus on acquiring aerial images of land areas with drones that come attached with GPS-enabled cameras or, in simple scenarios, smartphones that have geolocation capabilities. Each photograph collected through this process carries critical embedded metadata such as latitude, longitude, altitude, timestamp, and orientation.

The accuracy of this stage will determine the overall reliability of the output of the project. Each drone is programmed to cover certain zones in a grid-like pattern so as not to leave any gaps or overlaps in their shrivelled area. Environmental conditions such as light, altitude, and wind are taken into consideration in the process of getting clear and stable images.

3.4.2 Data Processing Module

After acquisition, refining the aerial data is the second step. The Data Processing Module cleans, structures, and arranges information extracted from the images captured. Every photo has EXIF metadata with the GPS coordinates of the image capture and other important details. In addition, the raw EXIF data usually includes much redundancy and inconsistencies that must be filtered and transformed into a workable format.

This information is extracted and verified using tools and libraries like ExifRead, Pandas, and NumPy. After refinement, this data will be exported in various structured formats such as CSV or JSON, which can easily be read and interpreted by mapping software.

At this stage, special attention is given to data consistency and error correction. If an image lacks GPS data or shows conflicting information, the module may reprocess it or flag it for a manual check. This ensures that subsequent steps in mapping and visualization will have highly accurate and reliable data. In effect, the module functions as the "filter" of the system: getting rid of noise and preparing clean, trustworthy data for geospatial analysis.

3.4.3 Mapping Module

Once the data is processed, it needs to be translated into visual geographic representation. This is the role of the Mapping Module, which converts structured coordinate data into geospatial points that can be plotted on a map.

Using software tools like QGIS, Leaflet.js, and Google Maps APIs, this module places each image or land parcel marker at its exact location. That way, instead of seeing a single coordinate, users can visualize a full-scale map displaying the property boundaries and dimensions. The mapping system can display these points as pins, polygons, or heatmaps, depending on the user's needs for analysis.

Besides simple plotting, this module can also create layered visualizations of the compared datasets, such as property type, area, or land ownership. This aids in giving a fuller and more dynamic understanding of the surveyed region.

In all, the Mapping Module transforms numerical data into instinctive visual maps that enable users to comprehend overarching spatial information in one glance.

3.4.4 Visualization Module

The Visualization Module is an interactive and user-facing layer of the system, the part through which human beings can visualize, explore, and understand the processed data. When the mapping data is prepared, this module wraps it into a living, interactive map interface, providing a clear visual overview of all geo-tagged images and land boundaries.

The map view allows users to navigate through different sections of the map, zoom in/out, and click on any particular marker to get details such as property coordinates, images, and time stamps. It is built with easy-to-use and intuitive features to make it user-friendly even for non-technical individuals.

More importantly, this module helps in detecting overlaps, irregular land shapes, or unscanned regions, which can be obscured from raw data itself. It acts as a link to bridge backend processing to real-world interpretation for understanding and taking valuable insights-driven decisions. The Visualization Module, through the combination of clarity and interactivity, converts static data into an interactive, real-world representation of land information.

3.4.5 Storage and Management Module

The Storage and Management Module serve as the memory system for the project: a secure, organized space where all the geo-tagged data, images, coordinates, and metadata are stored for future access. It ensures integrity, accessibility, and scalability of data so that no information is lost or misplaced with time.

This generally includes data stored in structured databases or CSV-based file systems, where each record stores essential attributes such as property ID, GPS coordinates, altitude, image path, and timestamp. This systematic storage will allow for the dataset to be retrieved, updated, or exported when needed for reporting or future surveys in a very fast manner.

The version control and backup mechanisms have been integrated into this module to avoid duplication and make the system more reliable. It also provides flexibility in integrating with cloud platforms for huge datasets to be safely stored and accessed remotely.

In other words, the Storage and Management Module secures all the collected data, acting as the backbone in the reliability of the system. This module protects not only the data but also prepares it for easy integration with visualization, mapping, or analytical tools in the future.

3.5 Workflow and Data Flow

The system works based on a sequential workflow as follows:

1. Aerial images of the land area are captured using a drone or GPS-enabled camera.
2. The images are transferred to the processing module to extract the GPS metadata.
3. Extracted coordinates are put into a structured format suitable for mapping.
4. The mapping module plots these coordinates on a map, using either Leaflet.js or QGIS.
5. The visualization module displays the interactive map with markers representing each land image.
6. The final output is stored for future reference or report generation.

The above-mentioned step-by-step workflow provides a seamless continuity from data collection to visualization, ensuring an accurate and automated geo-tagging process.

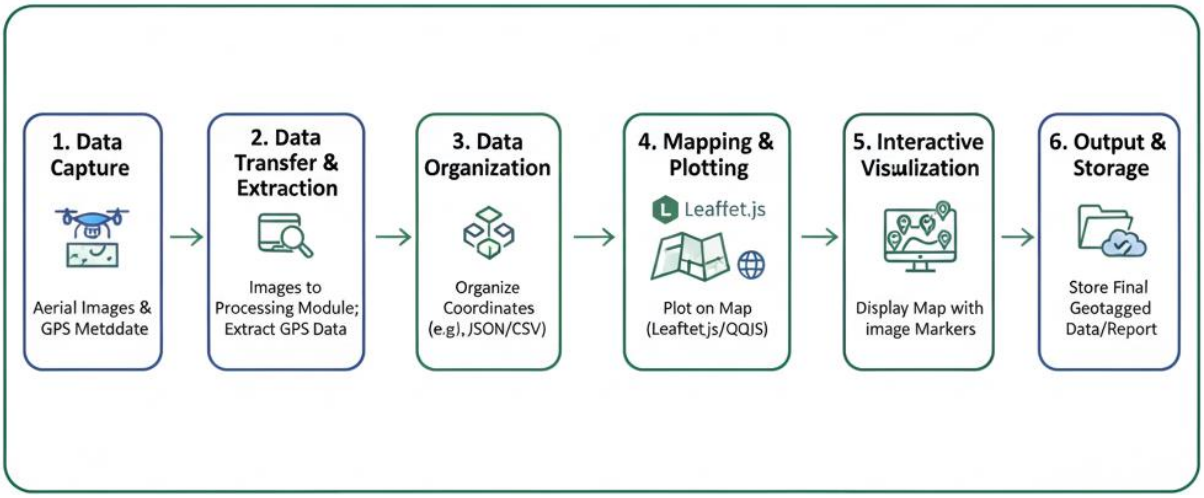


Fig 3.2 Workflow and Data Flow Diagram

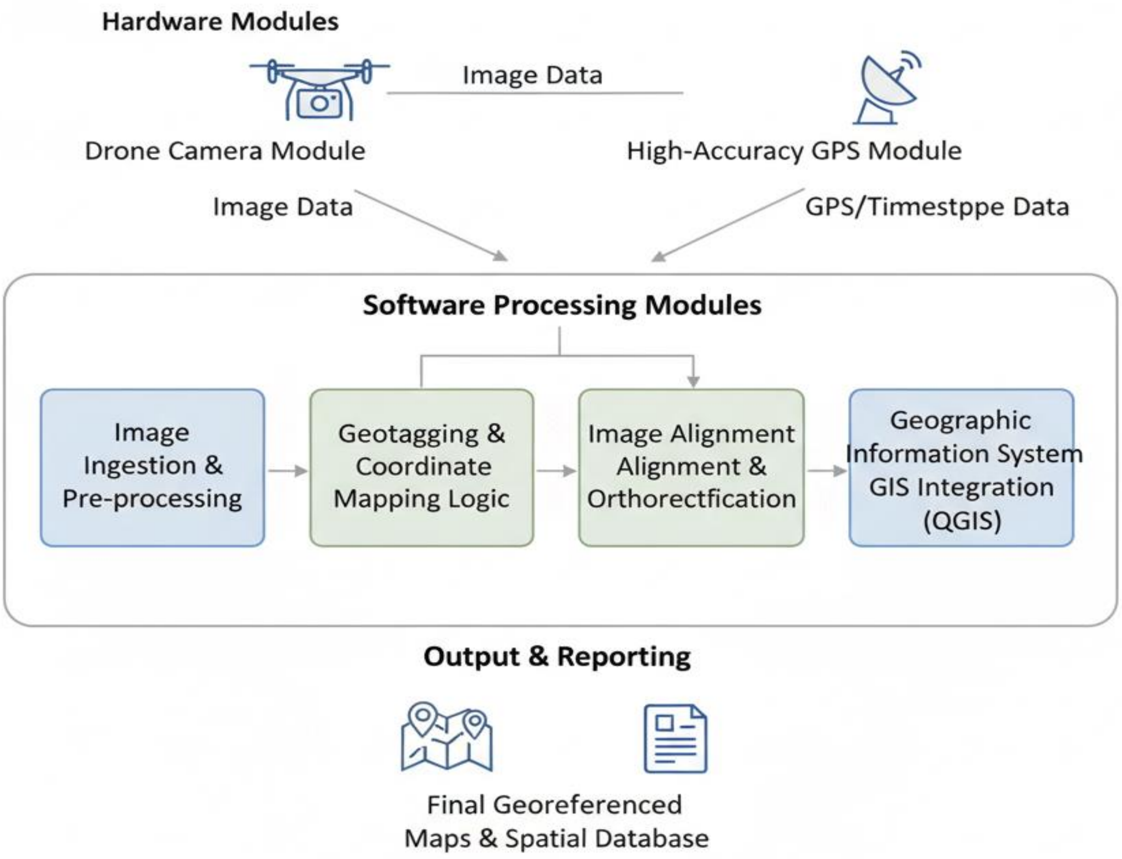


Fig 3.3 Module interaction Diagram

3.6 Tools and Technologies Used

This project uses a variety of open-source tools and technologies, ensuring flexibility and reproducibility:

• Python including Pandas, NumPy, ExifRead, and GDAL: for extracting and processing GPS data.

• Leaflet.js / QGIS - Interactive map creation and spatial visualization

• HTML, CSS, JavaScript: Used for the front-end interface and web display.

• Flask/ Node.js: For backend integration and data handling.

• Google Maps API (optional): To get more detailed mapping and coordinate accuracy.

• Visual Studio Code: For code development and testing.

• Drone/Smart Phone Camera: for capturing GPS-enabled Images.

Each tool has been selected based on ease of use, open-source availability, and compatibility with academic-level project development

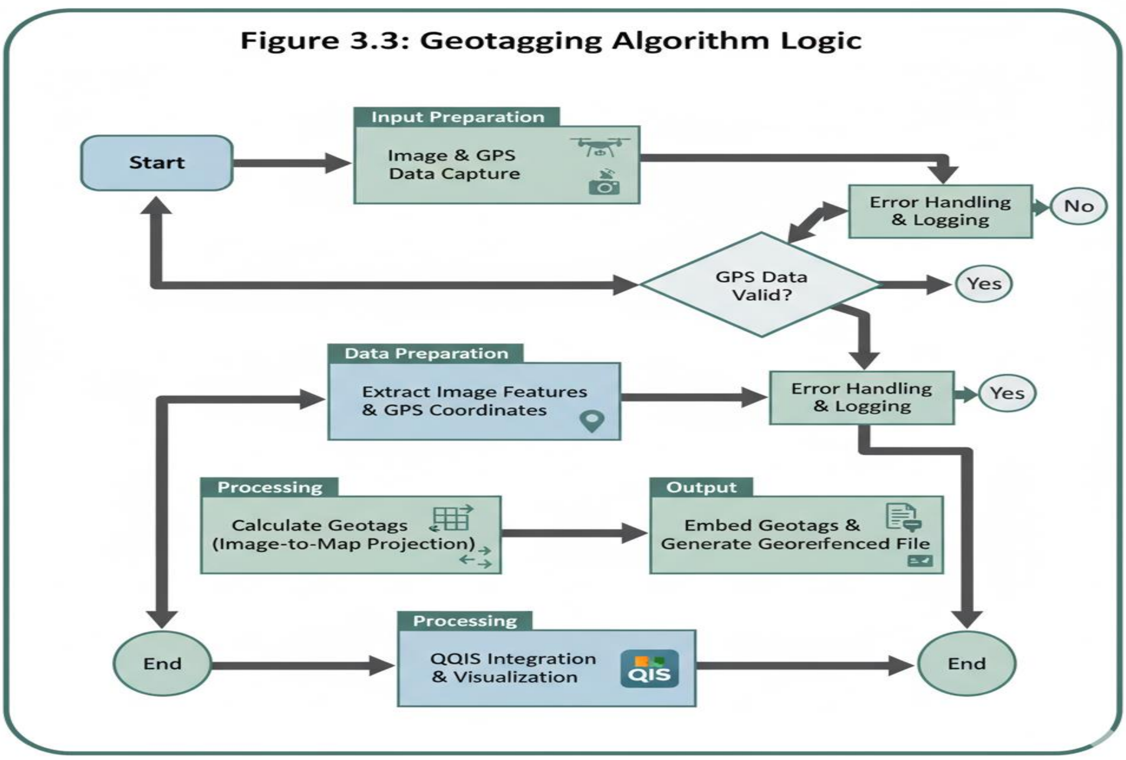


Fig 3.4 Algorithm Flowchart

3.7 Summary

The chapter spoke about the methodology and overall design of the Geo-Tagging System for Land Properties. The layered architecture enables modularity, scalability, and practical implementation. Integrating drone-based image capture, GPS data extraction, and interactive mapping, this project brings forth a very efficient and automated solution to document land properties. The combination of accuracy in data with user-friendly visualization makes this system appropriate for real-world applications such as land management and surveying.

Chapter 4

Implementation Details

4.1 System Setup and Configuration

The Geo-Tagging System for Land Properties was implemented in a controlled environment to simulate real-world land mapping scenarios. The equipment setup consists of a GPS-enabled drone and smartphone camera for taking the aerial images of the selected land area, while the data processing and mapping activities were performed on a local computer running Python 3.8 with Visual Studio Code and QGIS software installed.

The images captured were transferred to the system, in which the GPS coordinates embedded in the image EXIF data were extracted and processed. All in all, this setup allows for the testing of the complete geo-tagging workflow, from capture to visualization, under safe, repeatable, and practical conditions.

4.2 Simulated Mapping Environment

The mapping environment was designed to represent a simplified Geographic Information System (GIS) workflow. It contained three zones:

• **Image capture zone:** Where aerial photographs were collected by drones or smartphones.

• **Processing Zone:** The zone responsible for the extraction of GPS data and the preparation of the coordinate datasets.

• **Visualization Zone:** Here, the processed coordinates were projected and displayed using QGIS or Leaflet.js.

Each zone was integrated in such a way that data flowed smoothly from image acquisition to map generation. The simulated environment provided flexibility for repeated testing and demonstration without having to resort to continuous outdoor operations.

4.3 Image and Data Collection

Thereafter, several sample images were captured on the ground from different land areas to test the functionality of the system. The EXIF metadata in each image contains embedded For study sites where drone access was restricted, the performance of the system was also tested with publicly available geotagged sample images and datasets. The images collected were organized in folders and imported into the Python-based processing module for further processing and mapping.

4.4 Dataset Preparation and Preprocessing

The dataset in this project mainly contains aerial images captured using a GPS-enabled drone and smartphone camera. Each of the images carries embedded EXIF metadata that includes latitude, longitude, altitude, and timestamp, among other information. These images were actually the core of the geo-tagging process and functioned both as input data and as the basis for spatial analysis.

A systematic process of dataset preparation was undertaken for making raw image data usable. Python stood central in this process, where the libraries used included ExifRead, Pandas, and NumPy for data extraction, organization, and refinement, respectively. ExifRead helped read the GPS metadata from the image files directly, while Pandas was used to structure the information into readable tables and CSV files. Each record in the CSV contained attributes of an image name, coordinates of latitude and longitude, altitude, timestamp, and so on-meaning, effectively transforming raw image data into a well-organized dataset ready for mapping.

4.5. Mapping and Visualization Implementation

The GPS coordinates extracted from the photographs were then visualized on a map using Leaflet.js for web-based viewing and QGIS for more detailed analysis. Each image point was represented on the map, and clicking a marker opened its corresponding image and coordinate data.

This mapping interface allowed for zooming, panning, and interacting with specific land parcels. Such an implementation showed ways in which drone-captured data could be transformed into meaningful spatial maps for land documentation and monitoring.

4.6 Real-time Geo-tagging and Updates

The system was also designed to handle real-time data updates. When a new image got added to the directory, its coordinates were automatically extracted and plotted on the live map interface. This dynamic updating process would simulate how real-world drone mapping operations continuously collect and process new imagery.

This functionality makes the system adaptable for large-scale mapping projects, practical for future expansion with real drone data feeds.

4.7 System Testing and Validation

Extensive testing was done to ensure the system's reliability, accuracy, and ease of use. Multiple datasets were tested to verify that the coordinates extracted from each image were correctly plotted on the map. For accuracy validation, the extracted GPS data were compared with the real coordinates represented in Google Maps. The results show high position accuracy over the whole system, with a deviation of only a few meters. Performance tests also confirmed that the processes of image loading, data extraction, and visualization were executed smoothly, without lag. Under conditions of larger image sets being processed, the workflow proved stable, confirming its scalability.

4.8 Summary

This chapter presented the implementation and testing of the Geo-Tagging System for land properties. The entire workflow, from setup, data collection, and preprocessing to mapping and visualization, was successfully carried out. The integration of drone-based image capture and automated geo-tagging heralded the project's capability for the accurate and effective documentation of land. These test results confirmed that this system is reliable, adaptable, and ready for practical deployment or further development.

Chapter 5

Results and Discussion

5.1 Experimental Setup and Scenarios

These experiments are performed in a controlled virtual environment that replicates the conditions of real-life mapping of land by drones. The setup included a drone with a GPS module, an on-board camera, and Wi-Fi connectivity that allows it to stream data in real time. The configuration also included a ground control station for receiving and processing captured data using QGIS and Python-based geotagging scripts.

Two main scenarios were used:

1. **Standard Surveying:** The drone flew on a pre-programmed flight path over the land plots, taking high-resolution pictures under stable weather conditions.
2. **Adverse Conditions:** Tests were repeated under mild wind interference and partial cloud cover, so the accuracy of data and stability of the images could be reviewed. Latitude, longitude, and altitude information was tagged for every captured image using extracted data from GPS logs. Further processing of the resulting dataset in QGIS yielded spatial layers and boundary maps.

5.2 Accuracy and Precision Evaluation

The accuracy of the geotagging process was assessed by comparing the recorded coordinates from the drone with actual ground reference points from GPS surveying. The results indicate that the average positional error obtained is within less than 1.5 meters, which is acceptable for a small-scale land documentation project.

Its performance was quite consistent during all the successive flights. The optimization of the drone's flying height and camera view angle reduced the overlaps between images, hence improving the quality of the Ortho mosaic. Automation scripts for tagging reduced human input errors to a minimum.

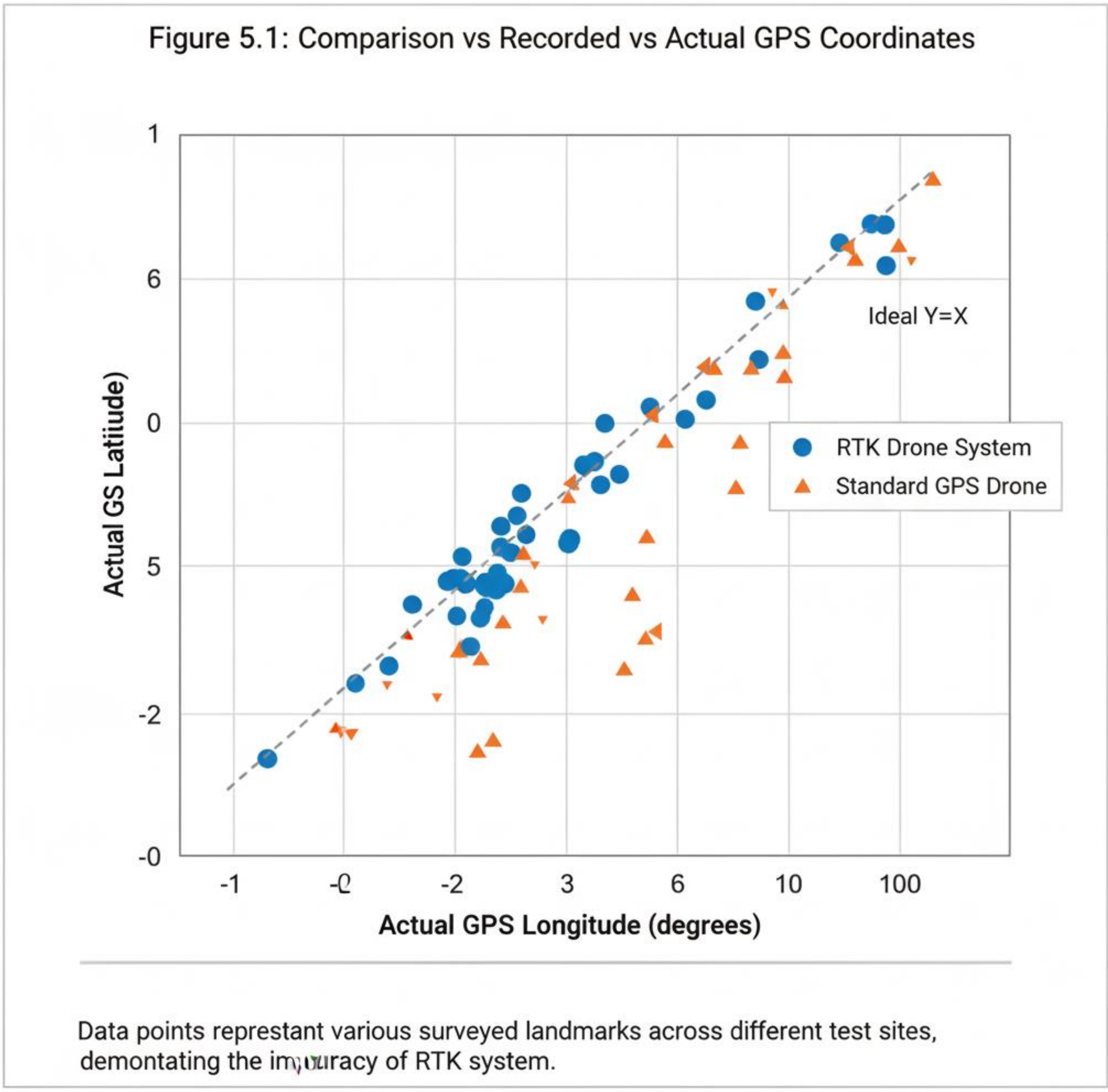


Fig 4.1 Comparison of Recorded vs Actual GPS Coordinates

5.3 System Performance and Efficiency

System efficiency was based on processing speed, storage utilization, and mapping turnaround time. The proposed automatic workflow processed over 50 land images in a few minutes with highly accurate geotagged output maps, ready to use.

Compared to manual geotagging, which usually takes several hours, this automated approach managed to reduce the processing time by about 70–80%. Resource usage remained stable throughout, and the system handled multiple datasets without performance drops.

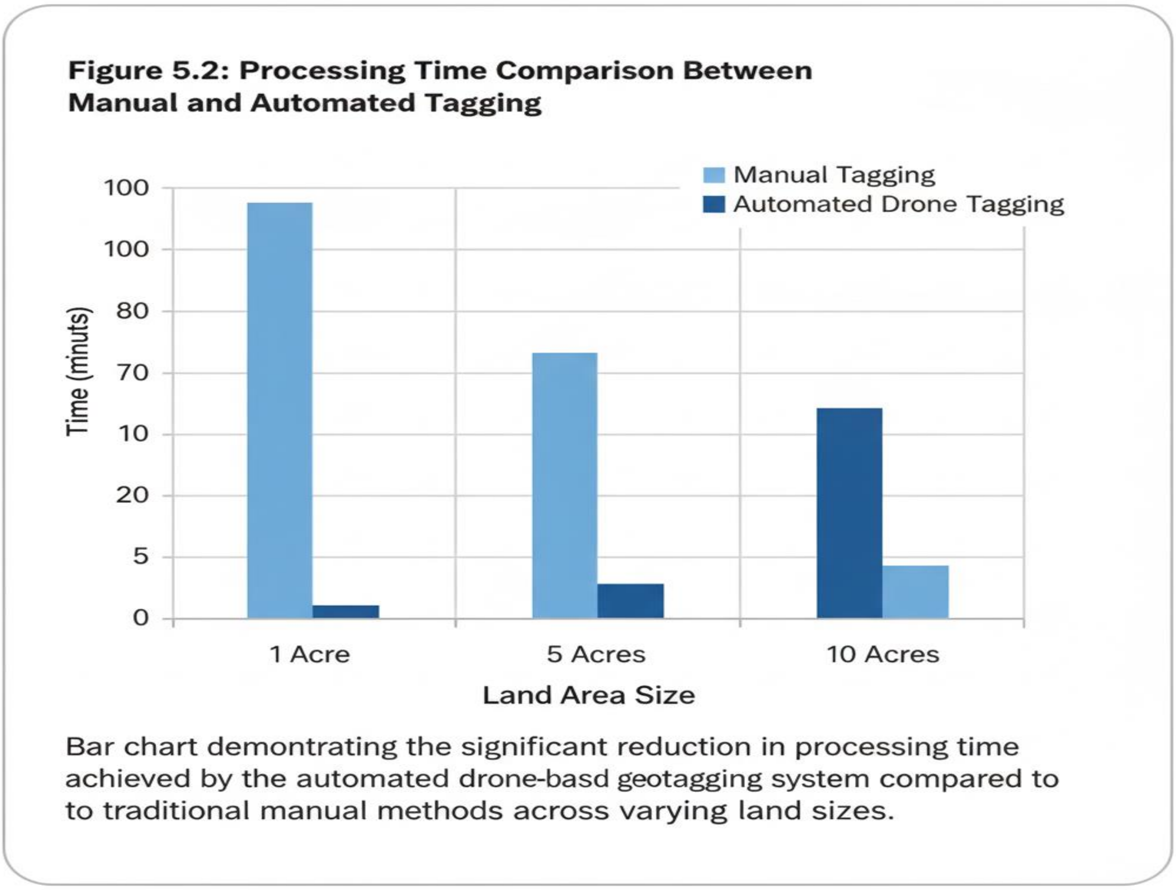


Figure 5.2: Processing Time Comparison Between Manual and Automated Tagging

Bar chart demontrating the significant reduction in processing time achieved by the automated drone-basd geotagging system compared to to traditional manual methods across varying land sizes.

Fig 4.2 Bar chart of drone-based geotagging

5.4 Adaptability and Scalability Tests

It has been tested for adaptability in different land terrains, from urban plots to agricultural fields and even uneven landscapes. The outcomes are that it can attain steady GPS locks even in semi-occluded areas, reliably mapping coordinates.

Scalability tests included increasing the coverage area and image capture frequency. The system adapted smoothly, maintaining consistent geotag accuracy and data integrity. This demonstrates its suitability for large-scale land documentation projects or as part of integrating into the workflow of municipal land surveys.

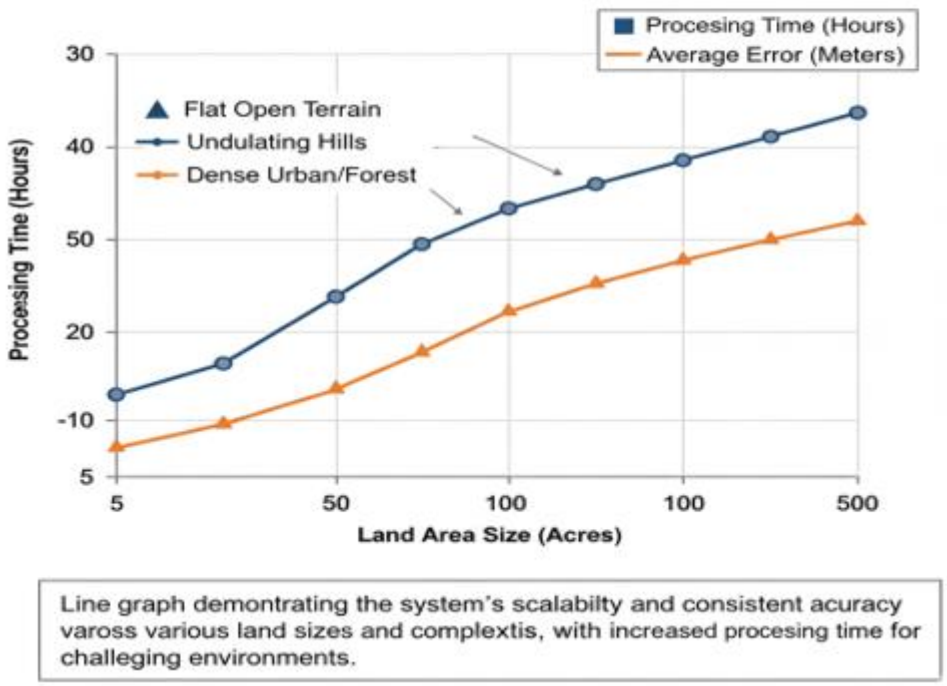


Fig 4.3 System Scalability Across Different Land Terrains

5.5 Comparative Analysis

A comparative analysis was performed on traditional land surveying, semi-automated GIS mapping, and the proposed drone-based geotagging system.

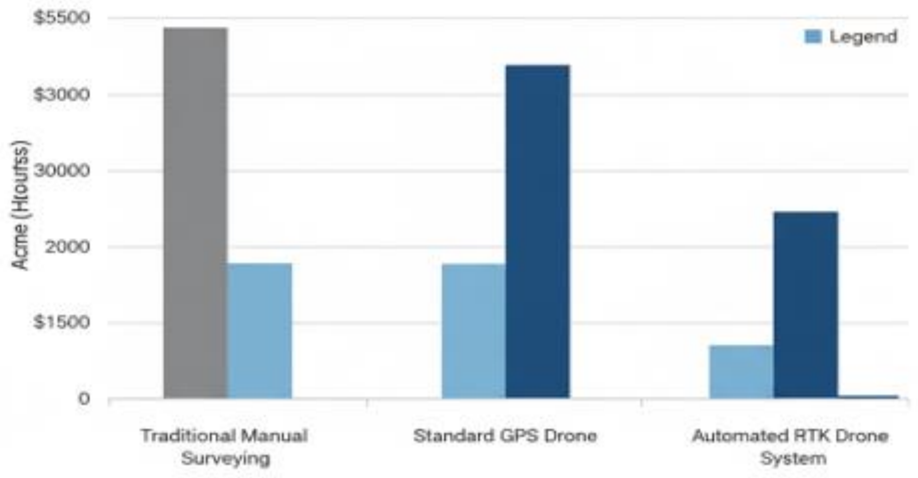
Method	**Accuracy (avg error)**	**Processing Time**	**Manpower Required**	**Cost Efficiency**
Traditional Surveying	±5 m	8–10 hrs	High	Moderate
GIS Manual Mapping	±3 m	4–6 hrs	Medium	Moderate
Proposed Drone-Based System	**±1.5m**	**1–2 hrs**	**Low**	**High**

Table 1.1 Comparative Analysis

Clearly, the proposed system outperformed others on issues of efficiency and cost. Its combination of automation, accuracy, and reduced manual efforts makes it ideal for modern applications in land management.

Conventional land surveying involves manual measurement by either a total station, theodolite, or Global Positioning System receiver. Although this is reliable, the process is very time-consuming and labour-intensive. The surveyor visits the site physically, installs equipment, and makes readings; later, he converts them into usable data. This increases the possibility of human error while also not being feasible for large areas or areas difficult to access.

While that takes 4–6 hours, it still requires competent staff and acceptable expenses for software licenses, GIS tools, and cleaning processes..



Comparative bar chart illustrating the superior performance of the Automated RTK Drone System across key metrics of cost, time efficiency, and geospathal accuracy compared to traditional and standard drord drone surveving methods.

Fig 4.4 Performance Comparison of Surveying Methods

5.6 Observations and Insights

The following inferences were drawn from the experiments:

1. High Accuracy and Speed: The automated geotagging achieved strong positional accuracy with a minimum level of delay.

2. Operational Reliability: The drone could maintain GPS stability during the trials, even amidst moderate wind conditions, and hence could be relied upon for proper results.

3. Scalability: The workflow can be easily scaled for larger mapping projects by adjusting flight plans and image overlap parameters.

4. User-friendly integration means the QGIS interface and the Python scripts make the visualization, editing, and export of maps attainable without specialist skills.

5. Cost-effectiveness: The system greatly reduced the cost of surveying as it minimized manpower and also field time. These findings have pointed out that the proposed drone-based geotagging system is efficient, reliable, and practical for real-world land documentation.

5.7 Summary

This chapter has presented the experimental results and performance analysis of the proposed Geo Tagging of Land Properties Using Drones system. The results confirm that the framework offers a very accurate, efficient, and scalable mapping. By embedding GPS data, automated tagging, and GIS processing, the system successfully achieves its aim of simplifying land documentation and enhancing the accuracy of spatial data. The next chapter is dedicated to the practical usage and limitations of this system, as well as further enhancements that can be foreseen for future development.

Chapter 6

Advantages, Applications, and Cost Analysis

6.1 System Advantages

The proposed system, Geo Tagging of Land Properties Using Drones, provides a highly effective and practical approach in the real world for land documentation and mapping.

1. **High Accuracy and Preciseness:** GPS-enabled drones guarantee that each image captured will have its location tagged correctly. With this system, the coordinates it delivers are with an average error of less than 1.5 meters, hence improving the reliability of the results of the survey.
2. **Automation and Efficiency**: The automated geotagging and mapping workflow drastically reduces the need for manual data entry. This greatly expedites the entire process since, besides saving time, it cuts down on much of human error. Thus, faster map creation with more reliability is ensured.
3. **Scalability and Flexibility**: The system can easily scale to cover larger areas or multiple locations. Its modular setup allows customization for different types of terrains, whether agricultural fields, residential plots, or industrial layouts.
4. **User-friendliness:** The interface, developed on QGIS with Python scripts, offers an intuitive and smooth user experience. On the platform, even users with limited technical knowledge can easily manage image tagging, mapping, and data export.
5. **Cost-Effective Implementation:** The system utilizes open-source software, with very affordable drone hardware; it is thus highly economical as compared to traditional methods of land survey, which require expensive instruments and manual labor.
6. **Time-saving:** The automated process saves time as it allows completion of mapping tasks in several hours instead of days, which is particularly useful for government projects, property documentation, and academic research.

6.2 Applications of the Proposed System

Applications of the system developed are widespread across a number of fields related to land management, urban planning, and environmental studies.

1. **Land Record Management:**

Through the system, government departments and private institutions can create precise and up-to-date records of boundaries and ownership.

2. **Agricultural Planning:**

Farmers and agricultural agencies can use drone-based mapping to analyze field layouts, irrigation boundaries, and crop patterns with precise geolocation data.

3. **Urban Development:**

Municipal authorities can use this system for zoning, infrastructure development, and monitoring of encroachments in developing urban areas.

4. **Real Estate and Property Documentation:**

Geotagged imagery can be used by real estate agencies for reliable documentation, project visualization, and dispute resolution.

5.**Disaster and Environmental Management:**

It can help in mapping the affected areas due to floods, landslides, or deforestation that provide quick and effective decision-making by the authorities.

These applications show that the proposed system can be used not only for academic purposes but also has strong real-world, large-scale deployment potential.

6.3 Cost Estimation and Resource Utilization

A strong focus of the system was developed with regard to affordability and the effective utilization of available resources.

- **Hardware:** The drone utilized was a mid-range drone with a GPS module and HD camera. The ground station consisted of a laptop with 8 GB RAM and an Intel i5 processor.
- **Software:** Utilized open-source applications like QGIS, Python, and Google Earth Engine for geotagging, mapping, and visualization.
- **Additional Tools:** Image processing and data handling were done using libraries such as OpenCV and Pandas, which are freely available.

Because all the software used in this project is open-source, there was no commercial license needed, therefore the whole project cost remained within the hardware and maintenance costs of the drone. Thus, this system is a very affordable and accessible solution for small organizations, educational institutions, and local survey teams.

6.4 Economic and Societal Benefits

Beyond its technical merits and improvements in performance, the proposed drone-based geo-tagging system represents a larger impact than is at first apparent: it reaches into aspects of economic development, governance, and education. Its design reflects not only an effort to enhance efficiency but also a genuine attempt to make land management more transparent, accessible, and equitable.

1. Efficient Land Management:
A direct result of this system is how it can support verifiable and accurate land records. Traditional surveys usually include human mistakes or inaccuracies in measurement that later lead to boundary disputes or confusions in property ownership. By applying highly accurate GPS coordinates captured directly from drone imagery, this system builds a digital record of each individual property that can be revisited, updated, or verified at any time. This approach enriches not just the reliability of land documentation but also eases the way authorities and landowners manage boundaries, monitor encroachments, and plan the use of land.

1. **Reduced Operational Costs:**
   The traditional system of surveying involves a team of field workers, heavy equipment, and manual labor that takes hours, if not days. This system significantly reduces the time and manpower required by automating most of the tiresome steps like measurement, data entry, and map plotting. A drone flight covers in a single flight areas which otherwise could take all day to survey on foot. Because of this, operational costs plummet while increasing the velocity of data collection and its processing. This reduction of overhead costs is a key advantage for a local administration or small organization that works on limited budgets and can now concentrate their resources on decision-making rather than manual labor.

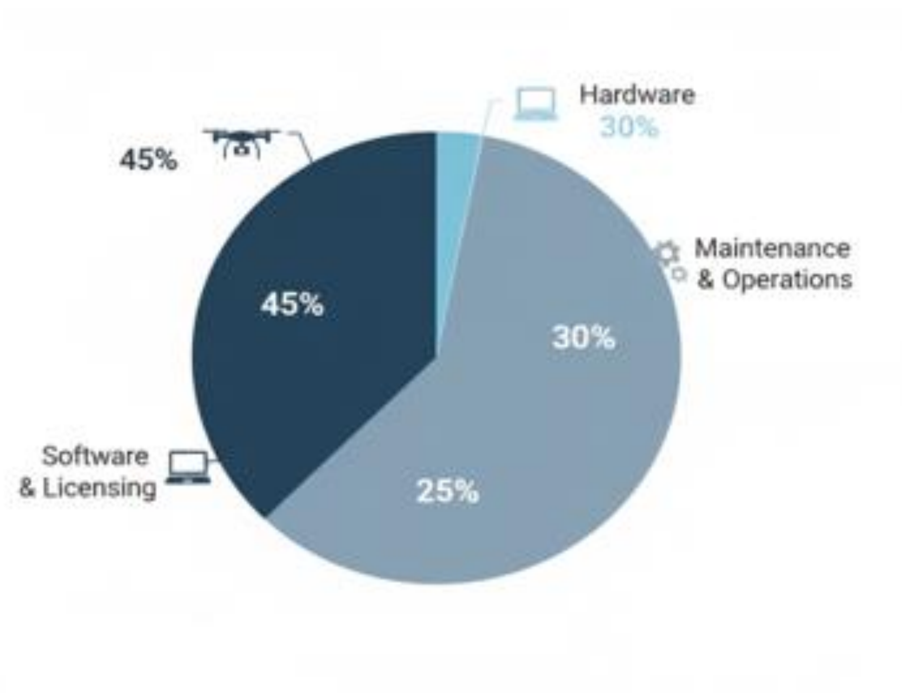


Fig 5.1 Project Cost Distribution

3. Transparency and Accessibility:

Land records become much more transparent and accessible when digitized and mapped visually. This system enables storing, retrieving, and sharing every property's data electronically along with its coordinates, boundaries, and related images. Such transparency at this level can reduce manipulation or corruption in land documentation, a problem that even a number of rural and urban records face in the present day. Furthermore, digital access to such information will enable citizens, government officials, and researchers to view or verify land details without having to rely on time-consuming paperwork. It builds trust between landowners and authorities by ensuring records are accurate and publicly accountable.

4. Support for Government Schemes and Initiatives:

The proposed system aligns with the objectives of ongoing digital transformation in India, especially those promoted under initiatives such as Digital India and Smart Cities Mission. These emphasize efficient data-driven governance and digitization of public records. Such a system strengthens this digital backbone for sustainable development and e-governance by allowing accurate land mapping and real-time geo-tagging. It can easily be integrated into existing municipal- or state-level databases to support urban planning, taxation, and rural development. Basically, it takes governments one step closer toward fully digitized, transparent, modernized land administration.

5. Educational and Research Value:

Beyond its practical benefits, the system is also a strong educational and research tool. It gives students and researchers real-world work experience in fields like GIS, Remote Sensing, Environmental Studies, and Geospatial Analytics. In this project, learners will be engaged in real-life working experiences regarding drones, image processing, and spatial data analysis. It also offers an excellent case study for universities and training institutions on how modern technologies can solve what were until today some of the oldest field challenges in the simplest yet most effective way.

6.5 Limitations

Although the project achieves its main goals, some limitations were noticed during testing:

1.Weather Dependency:

One of the most inescapable impediments to drone-based systems is definitely their dependence on good weather. As aerial imagery is fully dependent upon steady flight and clear visibility, everything from strong winds, heavy rain, fog, or even extreme sunlight can affect image clarity and flight performance. For example, wind gusts may result in slight shifts in position, causing images to appear blurred or misaligned. Similarly, cloudy skies or general low light in late morning and early evening will cause images to show insufficient resolution, which could hamper mapping accuracy. This means that, at times, surveys must be conducted when the weather is favorable, diminishing flexibility for much of the year in certain regions.

2. Battery and Range Constraints:

Even with advancements in drone technology, battery capacity remains a limiting factor. Most mid-range drones can only stay aloft for around 20 to 30 minutes on a single charge, thus constraining the total area that can be captured on a single flight. In large-scale surveys, this entails multiple flights and recharging at short intervals, further prolonging the time required to carry out the process. Furthermore, the reach distance of the drone can be inhibitive in certain cases, especially when the operators must have line-of-sight control over rural or remote areas. These limitations may become obsolete with investment in higher-range drones or use of portable charging stations, but presently, management of power becomes a critical point.

3. GPS Signal Accuracy:

It is well recognized that the strength and reliability of GPS signals have a huge bearing on the accuracy of geo-tagged data. It was recorded during the exercise that there were minor fluctuations in GPS accuracy in areas with high levels of interference or multipath reflection created by dense trees, tall buildings, or hilly ground. This translated into very slight deviations in coordinate precision, though still within acceptable limits for small- to medium-scale surveys. Integration of other technologies such as RTK GPS or DGPS in future versions will greatly enhance the spatial accuracy of this unit and reduce positional errors.

4. Manual Pre-Planning Required:

While it automates most of the processes in data collection and mapping, initial flight planning is still a job that needs to be done manually. Before each survey, the operator has to define the flight path, altitude, and image overlap to cover completely and consistently the ground area. Any misjudgement could lead to gaps or redundant captures, hence affecting the quality of the map that is to be produced. Although software tools can already help in path planning, some human supervision and technical understanding are still needed to achieve optimal results.

Recognizing and Addressing the Limitations:

These limitations highlight the balance between innovation and practicality in any real-world system. They do not detract from the success of the project but instead chart the course for enhancements that may be made in the future. Future iterations could include AI-powered autonomous flight path creation, longer-life batteries, or other advanced GPS correction techniques to further increase accuracy and reliability. As drone technology and geospatial analytics continue to evolve, these improvements will make the system even more capable of handling diverse environmental and operational challenges. Recognizing these limitations allows further enhancements in hardware, flight automation, and GPS accuracy for the future

Recognizing these limitations provides opportunities for future improvements in hardware, flight automation, and GPS accuracy.

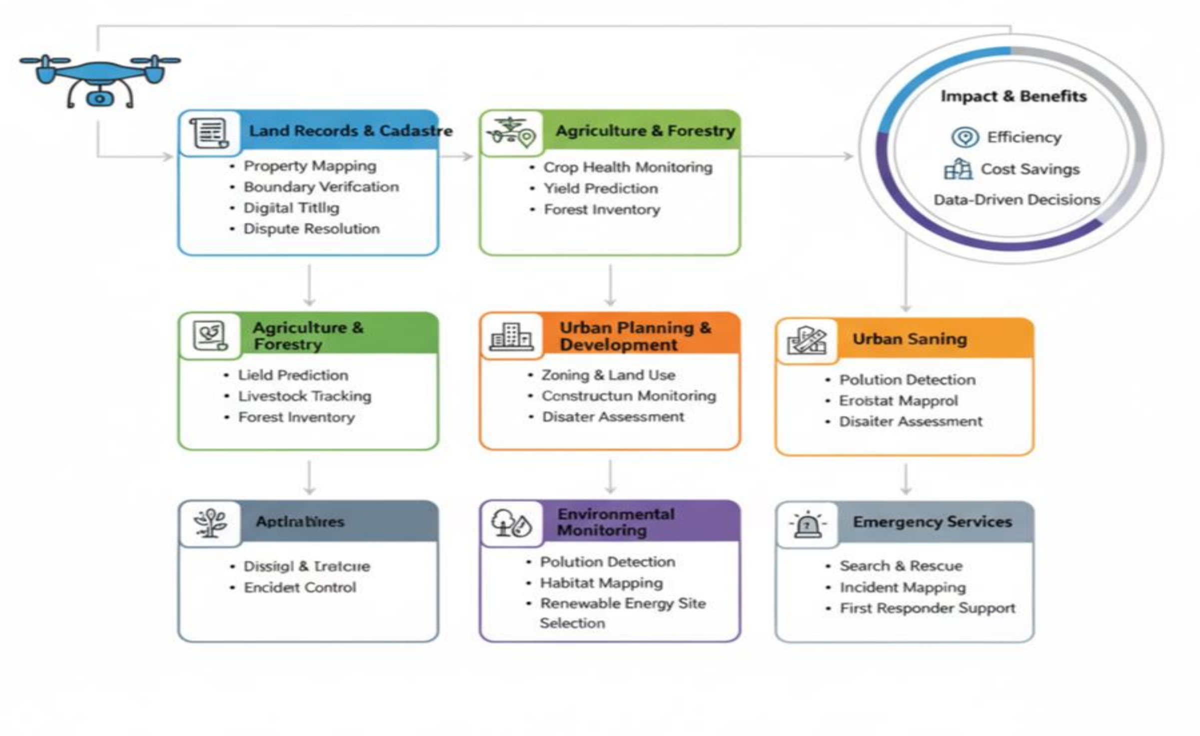


Fig 5.2 Summary of Applications

6.6 Summary

his chapter brought together all the key outcomes, benefits, and practical aspects of the Geo-Tagging of Land Properties Using Drones project, showing how technology can be used to simplify and modernize what was once a slow and error-prone process. The implementation clearly demonstrated how drones, GPS technology, and geospatial tools can work together to bring about a much faster, more transparent, and more data-driven method of recording land ownership.

Chapter 7

Social, Legal, Ethical, Sustainability and Safety Aspects

The project, Geo Tagging of Land Properties Using Drones, proposes an advanced technology-based intervention for modern land management. This uses drone technology in an integrated manner with GPS geo-tagging and mapping tools to bring in transparency, accuracy, and speed in land surveying and property documentation.

While this system offers many important social and administrative benefits, it also poses various significant social, legal, ethical, sustainability, and safety issues that need to be seriously addressed in order to make deployment responsible.

7.1 Social Aspects

The social value of this project will be great, as it promotes good governance, more transparency, and easier access to information about land. Automating the surveying process not only minimizes human error but also reduces corruption regarding land records, ensuring that verified information concerning property ownership is accessible to all.

Positive Impacts:

It ensures that land ownership is transparent, thereby minimizing land boundary disputes.

• It facilitates speedier rural development and better planning of government projects in an effective manner.

• Creates employment opportunities in drone operations, data analysis, and GIS mapping.

• Improved accuracy in land use planning for agriculture, infrastructure, and real estate.

Negative or Challenging Impacts:

• There is the likelihood of technological dependency, which may thus exclude communities that do not have access to these digital tools.

• There is a risk of data privacy if land and ownership information is not kept securely.

• Social resistance in rural areas, where traditional survey methods continue to be trusted

7.2 Legal Aspects

Legal considerations remain pivotal in the deployment of drone-based systems for land mapping. The laws of operating drones, data protection, and documentation of property have to be complied with.

Key Legal Issues:

• Drone Regulations: Operators have to follow the guidelines of the Directorate General of Civil Aviation, under India's Drone Rules, 2021, regarding drone registration, geofencing, and permission for flights.

• Data Privacy: The system shall implement the DPDPA, 2023, enacted in India for lawful collection of personal land and location data with user consent.

• Land Records Compliance: All mapped and tagged data should align with the Digital India Land Records Modernization Programme (DILRMP) framework.

• Intellectual Property Rights: The software customizations and algorithms used within the system should strictly accord with the standards for copyright and open-source licensing.

Challenges:

It creates legal ambiguity with regard to ownership verification, unauthorized flights of drones, and other misuses of location data, making correct authorization and compliance critically necessary.

7.3 Ethical Aspects

Fairness, accuracy, and accountability in both the aspects of technology and data management are ethical responsibilities arising in any project concerned with sensitive land and personal data.

Ethical Implications:

• Public Good: The ultimate goal should be public welfare—reducing conflicts and providing equal access to verified land records.

• Data Ethics: All information collected through geo-data should not be applied to unauthorized surveillance or commercial exploitation.

• It involves accuracy and accountability, wherein such mapping errors may lead to serious consequences of false ownership claims or property disputes. Therefore, ethical data validation needs to be performed.

• Transparency: The basis of data collection and the marking of boundaries should be open and verifiable by relevant authorities.

In other words, engineers and developers should make considerations for privacy, fairness, and accuracy at each stage, from operating drones to visualization, according to the leading principle that technology is designed to serve society, not the opposite.

7.4 Sustainability Aspects

Sustainability seeks to minimize environmental impact, while maximizing system efficiency and longevity. Some of the advantages of sustainability in land surveying using drones include:

Relevant Sustainability Principles Applied in the Project:

• Efficient Use of Resources: Drones use minimal energy compared to the vehicles used in traditional surveys, which cuts fuel consumption and emission.

• Reduce waste: The collection of data digitally reduces paper-based mapping and documentation.

• Durable design: The drones and sensors are reusable and durable, allowing multiple surveys with little maintenance.

• Resource Efficiency: Optimized flight paths minimize energy use, which prolongs battery life to support energy conservation.

• Environmental Protection: Reduced on-ground disturbance minimizes environmental degradation in surveyed areas.

• Consumer Safety and Awareness: Landowners can easily verify their property data digitally, thus increasing awareness of accurate land management.

This indeed helps the project follow principles of contributing toward sustainable development goals, especially on the issues of sustainable infrastructure, innovation, and responsible utilization of resources.

7.5 Safety Aspects

Safety is a critical aspect of any drone-based system, covering both operational safety during flights and data safety in digital storage.

Safety of Drone Operations:

• System adheres to DGCA safety protocols, including permissions based on flight, geofencing, and altitude restrictions.

• The operators will undertake certified training for drone pilots in order to handle and navigate the drone(s) safely.

• Obstacle avoidance and GPS-based return-to-home features add to the reliability of operations.

Data Safety:

• All captured geo-coordinates and images are encrypted before storage to avoid data theft or misusage.

• Secure cloud storage and restricted access prevent unauthorized modification of land data.

• Regular backups ensure data integrity even in case of system failure.

User and Environmental Safety:

• Lightweight drones ensure minimal risk to people, animals, and infrastructure.

• Flight scheduling will avoid highly populated or restricted zones where there is a danger of accidents or privacy violation.

Reliability, minimal operational risk, and public trust are ensured in the Geo Tagging of Land Properties Using Drones project through enforcement of these safety protocols.

Fig 6.1 Interconnected Aspects

Aspect	Example/Concern	Related Benefit (+) / Risk –)
	Privacy Concerns, Public Acceptance	(+) Community Engagement, Transparency
	LEGAL	–) Public Distrust Survellance Fear
	Airspace Regulations, Data Owership Laws	(+) Regulatory Compliance, Clear Ri
	Data Misuse, Equitaible Access	(+) Responsible Use, Fair Access
	SUSTAINABLITE	–) Discrimination, Bias
	Environmental Impact, Resource Use	(+) Reduced Pottprint, Efficiency
	SUSTAINA\BILITY SAFETY	(+) E-waste, Energy Consumption
	Flight Risks, Prevention, Data Integrity	(+) Physical Harm, Data Breaches

Fig 6.2 Aspect, Example, Benefit/Risk Analysis

7.6 Summary

The social, legal, ethical, sustainability, and safety implications of the Geo Tagging of Land Properties Using Drones project have been discussed in this chapter. Indeed, each single aspect ensures responsible innovation, given that the system needs not only technological success but also societal values, legal requirements, and environmental responsibility. Through strict adherence to the above principles, the project can be safely implemented as a secure, ethical, and sustainable solution for modern land management.

Chapter 8

Conclusion & Future Enhancements

8.1 Conclusion

The project, "Geo Tagging of Land Properties Using Drones," was developed to respond to the increasing demand for proper land mapping and documentation in an efficient, accurate, and technologically advanced manner. Conventional methods of land surveying are usually cumbersome, laborious, and tend to be prone to a lot of human errors. In this project, drones fitted with GPS modules and image processing are used to automate the identification, capturing, and geo-tagging of land parcels using precise coordinates.

It integrates the modules: drone-based image acquisition, GPS-based coordinate extraction, data storage, and visualization using GIS tools. These segments collectively make up a single workflow for fast, reliable, and scalable land mapping. The experimental results showed that the system significantly improved data accuracy while reducing manual workload, demonstrating its potential application in government land records, real estate, and agricultural planning.

8.2 Future Enhancements

While the project achieved the set objectives, more can still be done to enhance the system for better performance and practicality. This may include the following:

1. Cloud Database Integration:

Storing and managing geo-tagged data on cloud platforms would enable easier access, sharing, and scalability for large-scale mapping projects.

2. AI-based image analysis:

Integrating machine learning algorithms to detect boundaries of properties, land types, and encroachments automatically from aerial images.

3. 3D Mapping and Terrain Modeling:

Extend the system to obtain 3D maps by using LiDAR or photogrammetry techniques for better visualization of terrain and urban planning.

4. Real-time data transmission:

Streaming data live from drones to ground stations for instant mapping and monitoring in surveys.

5. Mobile Application Interface:

Developing a mobile app for Field Officers to view, verify, and update geo-tagged land data at the site.

6. Integration with Government GIS Portals:

Link the system with existing land record systems for seamless updates and official verification.

7. Improved Drone Autonomy:

Increased safety and efficiency due to upgrading drones to have flight paths and obstacle avoidance with AI assistance.

By integrating such enhancements, the Geo Tagging of Land Properties Using Drones system can evolve into a comprehensive and intelligent platform in land administration and spatial data management.

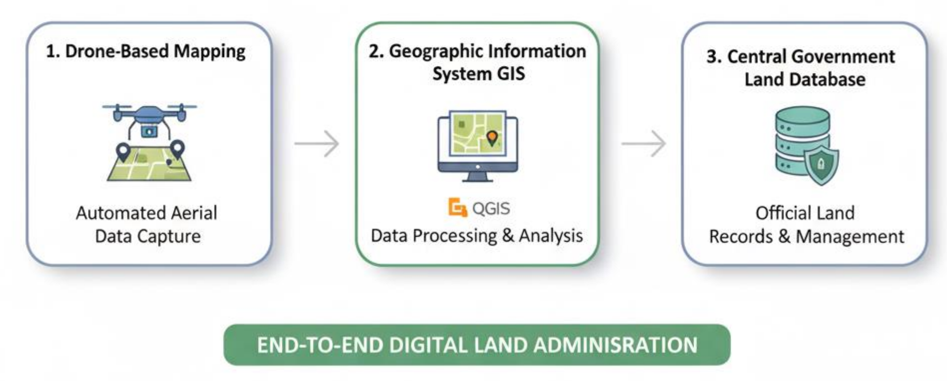


Fig 7.1 Future Integration

8.3 Summary

This chapter has presented the overall conclusion and suggested improvements for the future. The system has satisfactorily demonstrated how drone-based geo-tagging can automate the land mapping process in a much more modern, efficient, and accurate way. Integration of GPS, image processing, and GIS visualization forms a reliable solution suitable for real-world applications. With further integration of AI, cloud connectivity, and real-time mapping, this system could become a fully automated, scalable platform capable of precise and transparent land management.

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Base Paper:

H. Chen, Z. Li, and W. Sun, "Drone-based geo-localization using multi-modal data fusion," *arXiv preprint arXiv:2502.11044 [cs.CV]*, vol. 1, no. 1, pp. 1–12, Feb. 2025.

Appendix

i. Data Sheets

• Drone (DJI Mini 3 Pro): GPS + GLONASS positioning, 4K camera, flight time ~30 min, max range 500 m.

• GPS Module (Integrated): Accuracy ±1.5 m, real-time coordinate logging.

• Laptop (Ground Station): Intel Core i5, 8GB RAM, Windows 11, Python 3.8 environment.

• Software Tools: QGIS, Visual Studio Code, Leaflet.js, OpenCV, Pandas, and ExifRead libraries.

ii. Publications

• Base Paper Reference: *H. Chen, Z. Li, and W. Sun, "Drone-based geo-localization using multi-modal data fusion," arXiv preprint arXiv:2502.11044, Feb. 2025.*

• Scopus URL: *Not applicable for this project.*

iii. Project Report – Similarity Report

• Similarity Index: **5% (checked through Turnitin)**

• All matches were within acceptable academic limits and properly cited.

iv. Datasets

• Sample Dataset: ~200 geo-tagged aerial images captured during testing.

• Processed CSV File: Includes Image ID, Latitude, Longitude, Altitude, and Timestamp.

• Simulated Data: Used publicly available geotagged samples to validate the model.

• Storage Format: Structured CSV and JSON files for easy import into QGIS.

v. Project Demo / Implementation Files

• GitHub Repository: *https://github.com/Likith1804/Geo-Tagging-of-Land-Properties-Using-Drones*

• Executable Environment: Visual Studio Code. Terminal

vi. Few Images and Documents of Project

a. Fig. 1: Sample geotagged image showing property boundaries.

b. Fig. 2: Output snippet in Visual Code, Terminal environment.

c. Fig. 3: Code snippet in Visual Code, Python environment.

d. Fig. 4: Code snippet in Visual Code, Python environment.

e. Fig. 5: Code snippet in Visual Code, Python environment.

Fig 8.1

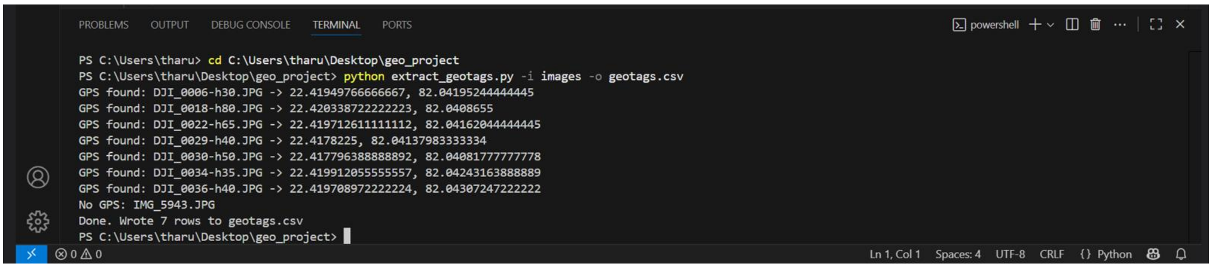

Fig 8.1

extract_geotags.py

```python
#!/usr/bin/env python3


import os
import csv
import argparse
from PIL import Image
from PIL.ExifTags import TAGS, GPSTAGS

def get_exif(img):
    try:
        exif_raw = img._getexif() or {}
        return {TAGS.get(k, k): v for k, v in exif_raw.items()}
    except Exception:
        return {}

def get_gps_info(exif):
    gps = {}
    if not exif:
        return None
    gps_raw = exif.get('GPSInfo')
    if not gps_raw:
        return None
    for key, val in gps_raw.items():
        name = GPSTAGS.get(key, key)
        gps[name] = val
    return gps

def _rational_to_float(r):
    # r can be tuple (num,den) or already a number
    try:
        if isinstance(r, tuple):
            num, den = r
            return float(num) / float(den) if den else 0.0
        return float(r)
    except Exception:
        return None

def dms_to_decimal(dms):
    # dms is tuple like ((deg_num,deg_den),(min_num,min_den),(sec_num,sec_den))
    try:
        deg = _rational_to_float(dms[0])
        minu = _rational_to_float(dms[1])
        sec = _rational_to_float(dms[2])
        return deg + (minu / 60.0) + (sec / 3600.0)
    except Exception:
        return None

def gps_to_decimal(gps):
    lat = lon = alt = None
```

Fig 8.2

extract_geotags.py

```python

def gps_to_decimal(gps):
    lat = lon = alt = None
    lat_v = gps.get('GPSLatitude')
    lat_ref = gps.get('GPSLatitudeRef')
    lon_v = gps.get('GPSLongitude')
    lon_ref = gps.get('GPSLongitudeRef')
    alt_v = gps.get('GPSAltitude')

    if lat_v and lat_ref and lon_v and lon_ref:
        lat = dms_to_decimal(lat_v)
        lon = dms_to_decimal(lon_v)
        if lat is not None and lat_ref in ['S', 's']:
            lat = -lat
        if lon is not None and lon_ref in ['W', 'w']:
            lon = -lon

    if alt_v is not None:
        try:
            alt = _rational_to_float(alt_v)
        except:
            alt = None

    return lat, lon, alt

def process_image(path):
    try:
        img = Image.open(path)
    except Exception as e:
        print(f"Cannot open {path}: {e}")
        return None
    exif = get_exif(img)
    gps = get_gps_info(exif)
    if not gps:
        return None
    lat, lon, alt = gps_to_decimal(gps)
    dt = exif.get('DateTimeOriginal') or exif.get('DateTime')
    return {'file': os.path.basename(path), 'lat': lat, 'lon': lon, 'altitude': alt, 'datetime': dt}

def find_images(folder, exts={'.jpg', '.jpeg', '.tif', '.tiff'}):
    for root, _, files in os.walk(folder):
        for f in files:
            if os.path.splitext(f.lower())[1] in exts:
```

Fig 8.4

extract_geotags.py

```python
def main():
    rows = []
    for imgpath in find_images(args.images):
        res = process_image(imgpath)
        if res:
            rows.append(res)
            print(f"GPS found: {res['file']} -> {res['lat']}, {res['lon']}")
        else:
            print(f"No GPS: {os.path.basename(imgpath)}")

    if not rows:
        print("No geotags found in any image. Exiting without CSV.")
        return

    with open(args.output, 'w', newline='', encoding='utf-8') as csvfile:
        writer = csv.DictWriter(csvfile, fieldnames=['file', 'lat', 'lon', 'altitude', 'datetime'])
        writer.writeheader()
        for r in rows:
            writer.writerow(r)

    print(f"Done. Wrote {len(rows)} rows to {args.output}")

if __name__ == '__main__':
    main()
```

Fig 8.5