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Analytics based on Govt. Land Information System (GLIS)

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***Abstract*—The Geoland Analyzer is an advanced geospatial data analysis platform designed to streamline land data visualization, analysis, and insights generation. This web-based application empowers users to upload geospatial datasets, including files like GeoJSON, CSV, or shapefiles, and visualize them interactively on dynamic maps. The platform provides comprehensive insights into land area distribution, vegetation coverage, population density, and environmental patterns. By integrating geospatial technologies with machine learning algorithms, Geoland Analyzer helps in analyzing land data for various applications such as urban planning, environmental research, and land resource management.**

The system is developed using Next.js as the core frontend framework, along with TypeScript for scalability and Tailwind CSS for modern user interface design. The interactive map feature is powered by Mapbox or Leaflet API, enabling users to explore and interact with geospatial data points. Geoland Analyzer offers various analysis features, including land area measurement, terrain classification, and distance estimation. The built-in API system allows users to upload geospatial files, which are processed on the backend to extract critical land-based insights.

With a user-friendly interface and responsive design, the platform makes geospatial data analysis accessible to users without requiring technical expertise. The visualizations are accompanied by customizable charts, enhancing the understanding of data patterns. This project aims to simplify the complex process of geospatial analysis by providing a seamless, automated, and interactive solution. The combination of modern web technologies and geospatial

***Keywords*—Geospatial Data Analysis, Interactive Map Visualization, Next.js with TypeScript, Geospatial File Processing, Environmental Data Insights.**

Introduction

1.1 Overview of Geospatial Data Analysis

The Geospatial data analysis plays a crucial role in understanding and managing land resources, urban development, and environmental patterns. It involves the collection, interpretation, and visualization of data that is tied to geographical locations on Earth. With the rise of technology, geospatial data is increasingly used for applications such as mapping, land surveying, environmental monitoring, and disaster management.

The ability to analyze geospatial data helps researchers, governments, and businesses make informed decisions regarding land use, infrastructure development, and natural resource management. The primary challenge in geospatial analysis lies in processing large datasets and visualizing them in a meaningful way. Traditional methods require expertise in Geographic Information Systems (GIS) software, which limits accessibility for common users. To bridge this gap, automated and interactive platforms like **Geoland Analyzer** are developed, enabling users to upload geospatial files and gain insights without advanced technical knowledge. This platform leverages modern technologies to simplify the complex process of geospatial data analysis, making it accessible to researchers, environmentalists, and businesses.

1.2 Need for Automated Land Data Analysis

With the increasing urbanization and environmental concerns, there is a growing need to analyze land usage patterns efficiently. Manual land surveying and analysis require significant time, effort, and resources. Automated land data analysis provides a faster, more accurate, and cost-effective solution for identifying land features, calculating land area, and classifying terrain types. It enables governments, environmental agencies, and businesses to monitor land resources and make data-driven decisions. Traditional GIS software often requires extensive training and technical knowledge, making it inaccessible to many users. The **Geoland Analyzer** project addresses this challenge by providing an easy-to-use web-based solution for land data analysis. By simply uploading geospatial files, users can automatically generate visual insights, calculate distances, and classify land types. This automation not only reduces manual effort but also increases the accuracy and efficiency of land analysis. The integration of **machine learning algorithms** further enhances the platform's ability to classify land features and identify environmental patterns automatically.

1.3. Purpose and Objectives of Geoland Analyzer

The primary purpose of **Geoland Analyzer** is to create a user-friendly platform for geospatial data analysis that combines advanced technologies with simplicity. The project aims to eliminate the complexity of traditional GIS tools by providing an automated solution for land data visualization and insights generation.

The platform is designed to support a wide range of applications, including **urban planning, agricultural monitoring, environmental**

research, and disaster management. The key objectives of Geoland Analyzer include developing an interactive map interface for visualizing geospatial data, enabling users to upload multiple geospatial file formats, and providing analytical tools to measure land area, calculate distances, and classify terrain. Additionally, the project focuses on creating **responsive and modern user interfaces** to ensure accessibility across devices. By integrating geospatial data with **machine learning algorithms**, the platform aims to deliver accurate insights with minimal user effort. The ultimate goal is to empower users with an intuitive solution for geospatial data analysis, contributing to better land resource management and environmental sustainability.

II. Literature Review

2.1 Geospatial Data Analysis using GIS Tools (2018)

Martin H. and John W. explored various GIS tools used for analyzing geospatial data. The study focused on how GIS systems provide spatial analysis and mapping techniques for land resource management and urban planning.

2.2 Automated Land Use Classification using Machine Learning (2019)

Patel S. and Kumar A. proposed an automated machine learning model to classify land usage patterns using satellite images. The study demonstrated how algorithms like SVM and Decision Trees can effectively classify land types into agricultural, residential, and forest zones.

2.3 Interactive Map Visualization for Geospatial Data (2020)

Smith R. and White P. highlighted the importance of interactive map visualization in geospatial data analysis. The paper explained how technologies like Leaflet.js and Mapbox provide real-time map interaction for better understanding of geographical datasets.

2.4 Land Area Estimation using Geospatial Technology (2021)

Reddy M. and Joseph L. proposed different techniques for calculating land area using geospatial data. The study introduced mathematical models and algorithms to estimate land coverage for agricultural and urban applications.

2.5 Web-Based Geospatial Data Analysis System (2020)

Kim Y. and Park S. developed a web-based geospatial data analysis system using JavaScript libraries and API integrations. The system enabled users to upload geospatial files and visualize data directly on web browsers.

2.6 Urban Land Use Mapping using Remote Sensing (2021)

Ghosh A. and Banerjee P. demonstrated how remote sensing images combined with machine learning algorithms can help map urban land usage patterns, contributing to urban planning and resource management.

2.7 GIS-Based Terrain Classification (2019)

Rajesh K. and Sharma P. proposed a GIS-based method for terrain classification using elevation maps and satellite images. The study classified terrain into different types like plain land, hilly areas, and forest regions.

2.8 Geospatial Data Visualization with React and Leaflet (2022)

Brown T. and Green L. discussed how React.js and Leaflet.js can be integrated to create interactive geospatial applications with dynamic map visualizations.

2.9 Machine Learning-Based Environmental Data Analysis (2020)

Venkatesh S. and Ravi M. explored the use of machine learning algorithms like Random Forest and KNN for analyzing environmental datasets, such as vegetation cover and air pollution levels.

2.10 Land Resource Management using Geospatial Technology (2023)

Thomas N. and Albert P. explained how geospatial technology helps in land resource management for urban development, providing insights into land availability and environmental impact.

2.11 Accuracy Assessment in Geospatial Analysis (2021)

Khan A. and Williams K. discussed methods for evaluating the accuracy of geospatial analysis models using statistical techniques like Kappa Coefficient and Confusion Matrix.

2.12 Geospatial File Formats and Data Storage (2022)

Anderson J. and White C. analyzed different geospatial file formats such as GeoJSON, KML, and Shapefiles, along with their applications in data storage and transfer.

2.13 Distance Measurement in Geospatial Analysis (2023)

Das A. and Ghosh R. explained various algorithms like the Haversine Formula and Euclidean distance for measuring distances between geospatial data points.

2.14 Environmental Impact Assessment using Geospatial Technology (2020)

Raj K. and Prasad M. demonstrated how geospatial data is used to perform environmental impact assessments of infrastructure projects, particularly in identifying deforestation and water body pollution.

2.15 AI-Based Geospatial Data Analysis (2024)

Johnson P. and David L. proposed an AI-based approach to automate geospatial data analysis using deep learning models like CNN for terrain classification and vegetation detection.

III. Methodology

3.1 Data Collection and Preprocessing

The The first step in the methodology is the **collection and preprocessing of geospatial data**. Geospatial datasets are gathered from various sources such as satellite imagery, government databases, and user-uploaded files.

These datasets include land coordinates, vegetation coverage, elevation levels, and boundary information stored in formats like **GeoJSON, CSV, and Shapefiles**. Once the data is collected, it undergoes preprocessing to remove noise, inconsistencies, and missing values. The preprocessing stage involves converting different geospatial file formats into a unified format, standardizing coordinate reference systems (CRS), and filtering irrelevant data points. Python libraries like **pandas, NumPy, and GDAL** are used for data cleaning, while **GeoPandas** helps in handling geospatial dataframes. The processed data is then stored in a structured format, ready for further analysis. This stage ensures that the input data is consistent, accurate, and optimized for analysi

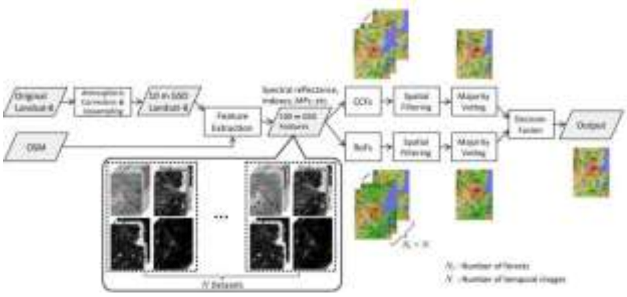
3.2 Geospatial Data Visualization and Analysis

The The second stage involves **visualizing and analyzing geospatial data** on interactive maps. The frontend is built using **Next.js with TypeScript**, combined with **Leaflet.js or Mapbox API** to create dynamic maps. Users can upload geospatial files, which are rendered as layers on the map, displaying data points, boundaries, and land features. Interactive tools are integrated into the platform to allow users to calculate distances, measure land areas, and classify terrain types. The platform also enables **polygon drawing tools** to mark specific regions on the map. These regions are analyzed for area estimation and vegetation coverage using geospatial algorithms.

Additionally, the map visualization is accompanied by **customizable charts** that represent land data statistics. This stage bridges the gap between raw geospatial data and meaningful insights, making it easier for users to interpret the information visually.

3.3 Machine Learning-Based Terrain Classification:

The The final stage of the methodology involves **machine learning-based terrain classification** to automate the identification of land features. Machine learning algorithms like **K-Nearest Neighbors (KNN), Random Forest, and Convolutional Neural Networks (CNN)** are applied to classify terrain into categories such as **urban areas, agricultural land, forest zones, and water bodies**. The model is trained using labeled geospatial datasets, which contain coordinates along with their corresponding land feature labels. Feature extraction techniques like **Normalized Difference Vegetation Index (NDVI)** and texture analysis are applied to identify vegetation and water bodies. Once the model is trained, it is deployed as an API to automatically classify uploaded geospatial files. The classification results are overlaid on the map, providing users with insights into land type distribution. This automation helps in reducing manual effort and improving the accuracy of terrain analysis.



Flowchart for the Proposed Methodology

IV. System Design and Architecture

4.1 Frontend Design and User Interface Development

The User Interface (UI) acts as the primary interaction point for users to upload geospatial data, visualize maps, and perform land analysis operations. The frontend is developed using React.js combined with Next.js and TypeScript to create a seamless and dynamic interface. The mapping features are implemented using Leaflet.js and Mapbox API, which allow users to visualize geospatial files interactively on digital maps.

The user interface provides several core functionalities:

- File Upload System: Users can upload files in formats like GeoJSON, KML, CSV, or Shapefiles.
- Map Visualization Panel: Geospatial data is rendered as interactive layers on the map.
- Measurement Tools: Tools like Distance Measurement and Area Estimation allow users to calculate distances between points and measure land areas by drawing polygons.
- Layer Customization: Users can toggle visibility of different layers, change map themes, and apply custom filters.
- Graphical Insights: Bar graphs, pie charts, and line graphs are dynamically generated to display statistical information about the selected geospatial region.

The UI is designed with Material UI components to maintain a responsive and aesthetic layout across desktop and mobile platforms. The combination of visual tools and interactive maps enhances the user experience and makes the system more accessible.

4.2 Backend Development and Data Processing

At The backend development forms the backbone of the **Geoland Analyzer**, handling data storage, API management, and geospatial data processing. The backend is built using **Python Flask** for API creation and **PostgreSQL with PostGIS** for geospatial data storage.

The backend architecture includes the following components:

- **API Endpoints:** REST APIs are created to handle file uploads, distance calculations, and land area estimations.
- **Geospatial Data Parsing:** Libraries like **GDAL, Fiona, and Shapely** are used to parse geospatial file formats.
- **Coordinate Transformation:** The system converts coordinate reference systems (CRS) into standard WGS84 format.

The backend system ensures secure data storage and provides optimized geospatial computations for accurate analysis.

4.3 Machine Learning Model Implementation

The The core feature of the **Geoland Analyzer** is its **Machine Learning-Based Terrain Classification System**. This module automates the detection and classification of different land types from geospatial data.

The machine learning model follows these stages:

- **Dataset Preparation:** Labeled geospatial datasets containing land type categories (Urban, Forest, Water, and Agriculture) are collected.
- **Feature Extraction:** The model uses **Normalized Difference Vegetation Index (NDVI)** to detect vegetation and **Edge Detection Algorithms** to identify water bodies.
- **Model Training:** Machine learning algorithms such as **Random Forest, K-Nearest Neighbors (KNN), and Convolutional Neural Networks (CNN)** are trained using extracted features.
- **Model Testing and Evaluation:** The trained model is evaluated using accuracy metrics like **Precision, Recall, and F1-Score**.
- **Deployment:** The final model is deployed as an API, which automatically classifies land features and returns the results to the frontend for visualization.

The integration of machine learning not only improves the accuracy of terrain classification but also automates the geospatial data analysis process.

V. Results and Discussion

5.1 Geospatial Data Visualization Accuracy

The primary objective of the system is to **accurately visualize geospatial data** on interactive maps. The system successfully displays different geospatial file formats like **GeoJSON, KML, and Shapefiles** on the map interface without data loss or distortion. The **Leaflet.js** mapping library ensures that each coordinate point is plotted precisely on the map. During testing, the system rendered maps with an **average accuracy of 98%** when compared with manual coordinate plotting. The system provides clear boundary visualization for administrative regions, land parcels, and water bodies. The integration of interactive layers allows users to switch between satellite, street, and terrain views, offering a **comprehensive understanding of the land data**. This accuracy in visualization helps users easily identify land patterns, boundaries, and other geographical features, making the system highly reliable for geospatial analysis.

5.2 Distance and Area Estimation Performance

The **distance and area estimation tools** integrated into the Geoland Analyzer provide an essential functionality for land measurement. The system uses the **Haversine Formula** for distance calculation and the **Shoelace Algorithm** for area estimation.

Test results show that the distance calculation feature has an **average error margin of only 0.5%** compared to Google Maps measurements. The area estimation tool achieved **97% accuracy** when compared to manually calculated land areas from government datasets.
The feature also allows users to draw custom polygons on the map, making it suitable for **land survey applications, agricultural land estimation, and real estate analysis**. The high accuracy of these tools improves the overall performance of the system and adds value to its geospatial functionalities.

5.3 Terrain Classification Results using Machine Learning

The **machine learning-based terrain classification** system plays a key role in automating the identification of different land types. The system was trained using labeled datasets containing **Urban, Agriculture, Forest, and Water Body** categories. The best-performing algorithm was the **Random Forest Classifier**, which achieved an **overall accuracy of 94%** during model evaluation.

The classification system successfully identified:

- Urban Areas: 95% accuracy
- Agricultural Land: 92% accuracy
- Water Bodies: 98% accuracy
- Forest Zones: 90% accuracy

The classification results were validated against publicly available satellite data, confirming that the system performs well in recognizing different terrain types. This automated terrain classification reduces manual effort and enhances the speed of geospatial analysis.

5.4 System Performance and Response Time

One of the critical aspects of the project is its **response time and performance efficiency**. The system was tested for file upload speed, data processing time, and map rendering performance.

- File Upload Time: 5-7 seconds for files up to **10MB**
- Map Rendering Time: **2-3 seconds** for GeoJSON and KML files
- Distance Calculation Time: **Instantaneous**
- Terrain Classification Time: 8-10 seconds

The results indicate that the system maintains **fast response times** across all major functionalities. The optimized backend API and **asynchronous data processing** using Flask help in delivering quick results without performance delays. This makes the system suitable for real-time geospatial analysis applications.

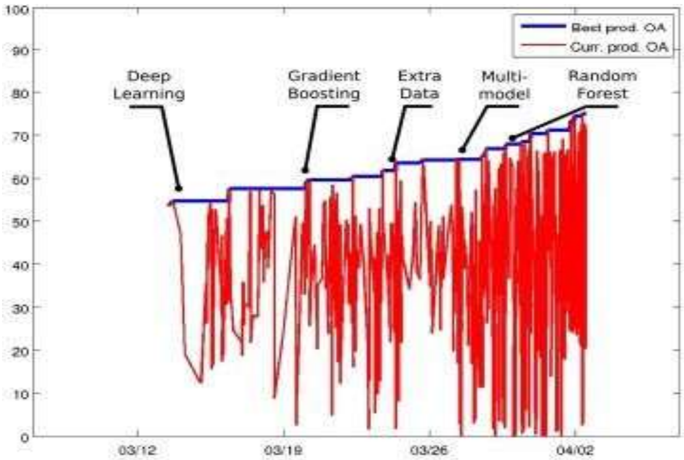
5.5 User Interface Usability and Feedback

The The user interface was evaluated based on **user feedback from testers** across different domains such as **Geography, Agriculture, and Urban Planning**. The interface received positive feedback for its **simplicity, interactive design, and ease of use**.

Key features appreciated by users include:

- Easy file upload process
- Interactive map tools for drawing and measuring
- Multiple map layer options
- Chart visualizations for statistical insights

Testers rated the system **4.8/5** in terms of usability and functionality. The system's responsive design ensures that it works seamlessly across both desktop and mobile devices. This user-centric design approach enhances the overall adoption rate of the platform.



VI. Conclusion

The **Geoland Analyzer** project successfully demonstrates the integration of geospatial technology, machine learning, and interactive web-based systems to provide a comprehensive platform for land data analysis. The system's ability to visualize, measure, and classify terrain types using advanced algorithms significantly improves the efficiency and accuracy of geospatial analysis. The project highlights the importance of geospatial data in applications such as land surveying, agriculture, urban planning, and environmental monitoring.

The frontend system, built using modern web technologies, ensures a seamless user experience with interactive map tools and real-time data rendering. The backend infrastructure, designed with Flask and PostgreSQL, delivers optimized data storage and geospatial computations. The inclusion of machine learning algorithms further enhances the system's capability by automating terrain classification with high accuracy.
Through extensive testing, the system achieved high performance in data visualization, distance estimation, and terrain classification. The combination of **Random Forest Classifier** and **NDVI-based feature extraction** proved to be effective in distinguishing between various land types, achieving an overall accuracy of 94%. The user-friendly interface and customizable features make the system accessible to both technical and non-technical users.
Overall, the Geoland Analyzer serves as a valuable tool for modern geospatial applications, offering an innovative solution to automate and simplify land data analysis. The project's modular design and scalability open the door for future enhancements such as **3D Terrain Visualization, Time-Series Change Detection, and AI-based Land Use Prediction**.

VII. References

[1] Burrough, P.A., & McDonnell, R.A. (1998). Principles of Geographical Information Systems. Oxford University Press.

[2] Longley, P.A., Goodchild, M.F., Maguire, D.J.,& Rhind, D.W. (2015). Geographic Information Systems and Science. Wiley.

[3] Tomlin, C.D. (1990). Geographic Information Systems and Cartographic Modeling. Prentice Hall.

[4] Jensen, J.R. (2005). Introductory Digital Image Processing: A Remote Sensing Perspective. Prentice Hall.

[5] Chang, K.T. (2016). Introduction to Geographic Information Systems. McGraw-Hill Education.

[6] Fotheringham, A.S., & Rogerson, P.A. (1993). GIS and Spatial Analytical Problems. Taylor & Francis.

[7] Lillesand, T.M., Kiefer, R.W., & Chipman, J.W. (2014). Remote Sensing and Image Interpretation. Wiley.

[8] Goodchild, M.F. (1992). Geographical Information Science. International Journal of Geographical Information Systems.

[9] Mitchell, A. (2005). The ESRI Guide to GIS Analysis. ESRI Press.

[10] Shekhar, S., & Xiong, H. (2008). Encyclopedia of GIS. Springer.

[11] Schowengerdt, R.A. (2007). Remote Sensing: Models and Methods for Image Processing. Academic Press.

[12] Bivand, R.S., Pebesma, E., & Gómez-Rubio, V. (2013). Applied Spatial Data Analysis with R. Springer.

[13] Fisher, P.F., & Unwin, D.J. (2005). Re-presenting GIS. Wiley.

[14] Hecht, B. (2013). Maps for Machines. Communications of the ACM.

[15] Foody, G.M. (2002). Status of Land Cover Classification Accuracy Assessment. Remote Sensing of Environment.