Canopy Sentinel

Satellite-Based Deforestation Monitoring System

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Problem Statement

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Deforestation is a critical global issue contributing to climate change, biodiversity loss, and environmental degradation. Forests play a vital role in carbon sequestration, soil preservation, and maintaining ecological balance. However, illegal logging, agricultural expansion, and urban sprawl are causing forests to disappear at an alarming rate. Despite the availability of satellite data, existing monitoring methods are often manual, time-consuming, and unable to provide timely alerts, especially in remote and vulnerable areas.

Governments, NGOs, and environmental agencies lack efficient tools that can analyze vast amounts of satellite imagery quickly and accurately. This leads to delays in identifying deforestation activities and hampers effective response and conservation efforts. Moreover, most current systems require high technical expertise, making them inaccessible to smaller organizations and communities that also need to protect their natural resources.

The need of the hour is an automated, scalable solution that bridges the gap between satellite technology and on-ground action. There is a clear demand for a system that can process multi-temporal satellite images, detect changes in forest cover, assess vegetation health, and generate actionable alerts in near real-time. This problem calls for an innovative approach combining computer vision, machine learning, and geospatial analysis to empower stakeholders with timely, data-driven insights for forest conservation. 🌍

Project Objectives

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1. **Automate Deforestation Detection:**
   Develop a system that automatically detects deforestation and land-use changes using multi-temporal satellite imagery.
2. **Near Real-Time Monitoring:**
   Provide timely alerts and updates on forest cover changes to enable quick action by governments, NGOs, and researchers.
3. **Integrate Advanced Analysis:**
   Apply computer vision techniques (image differencing, NDVI analysis) and machine learning models to classify deforestation patterns accurately.
4. **User-Friendly Deployment:**
   Create both desktop and web-based platforms to make the system accessible to a wide range of users, from technical experts to field workers.
5. **Geospatial Data Integration:**
   Ensure compatibility with GIS tools and databases (PostGIS) to allow seamless analysis, reporting, and mapping.
6. **Support Conservation Efforts:**
   Empower environmental protection initiatives by providing actionable insights and quantitative metrics on forest loss.
7. **Scalable Architecture:**
   Design the system to operate effectively on single machines as well as in cloud environments for large-scale monitoring.

Features:

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- Automated change detection
- NDVI-based vegetation health monitoring
- Machine learning classification of deforestation patterns
- Real-time deforestation alerts
- Dual deployment: desktop and web-based
- GIS-compatible output and reporting
- Scalable from local to cloud deployment
- User-friendly, intuitive interface
- Custom report generation
- Secure data handling and storage

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🔧 Tech Stack:

-Core Processing:

~ JavaCV (OpenCV): For image processing and computer vision tasks.
~ GeoTools: For geospatial data handling and analysis.
~Machine Learning: TensorFlow/ DeepLearning4J (optional for model integration)

Web Application:

~Backend: Spring Boot (Java)
~Frontend: React (JavaScript)
~Database: PostgreSQL + PostGIS (spatial database extension)
~APIs: NASA Earthdata, Google Earth Engine for satellite imagery

Desktop Application:

~JavaFX: For building the desktop user interface

~PostgreSQL + PostGIS: For local geospatial data storage and querying

Additional Tools And Libraries:

- Hibernate/JPA: For ORM (database mapping)
- Leaflet.js / OpenLayers: For map visualization on the web
- Maven/Gradle: For Java build and dependency management
- Docker: For containerized deployment (optional)
- Cloud: AWS/Azure/GCP (for scalable deployments)

System Architecture & Database Design

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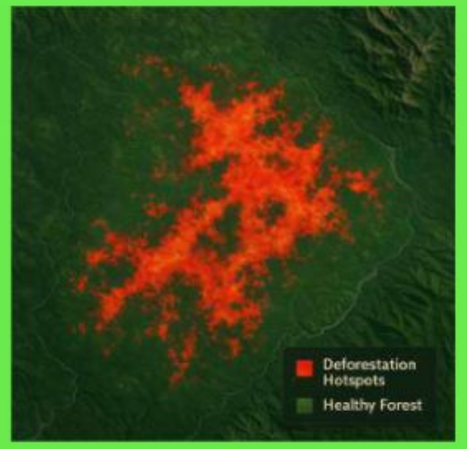
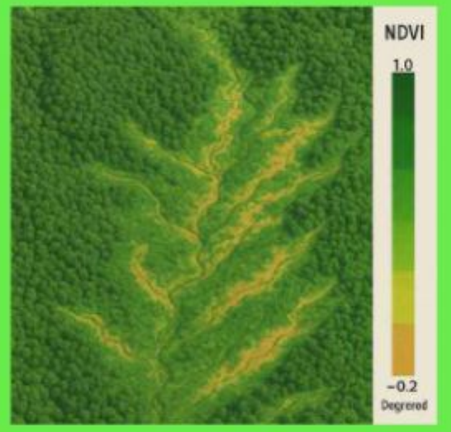
Data Ingestion Layer:

- Fetches satellite imagery from APIs (NASA Earthdata, Google Earth Engine)
- Supports multi-temporal image retrieval





Processing & Analysis Layer:

- Image Preprocessing: Noise reduction, alignment, and normalization using JavaCV (OpenCV)
- Change Detection:
  - Image Differencing to detect pixel-level changes
  - NDVI Analysis for vegetation health
- Machine Learning Engine: Classifies deforestation types (e.g., illegal logging, urban sprawl)

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Application Layer:

- **Desktop Application: JavaFX-based UI for local analysis and visualization**
- **Web Application:**
  - **Backend: Spring Boot REST APIs**
  - **Frontend: React for interactive data views and map overlays**
  - **Map Integration: Leaflet.js/OpenLayers for satellite map visualization**

Data Storage & Management:

- **Stores processed images, change logs, and classification results in PostgreSQL + PostGIS**
- **Supports export to GIS-compatible formats (e.g., GeoJSON, Shapefiles)**

Notification & Reporting Layer:

- **Sends real-time alerts**
- **Generates PDF/CSV reports on deforestation metrics**

Optional:

- **Cloud Deployment: Scalable via Docker + cloud services (AWS/GCP)**

Graphical User Interface (GUI) Screens

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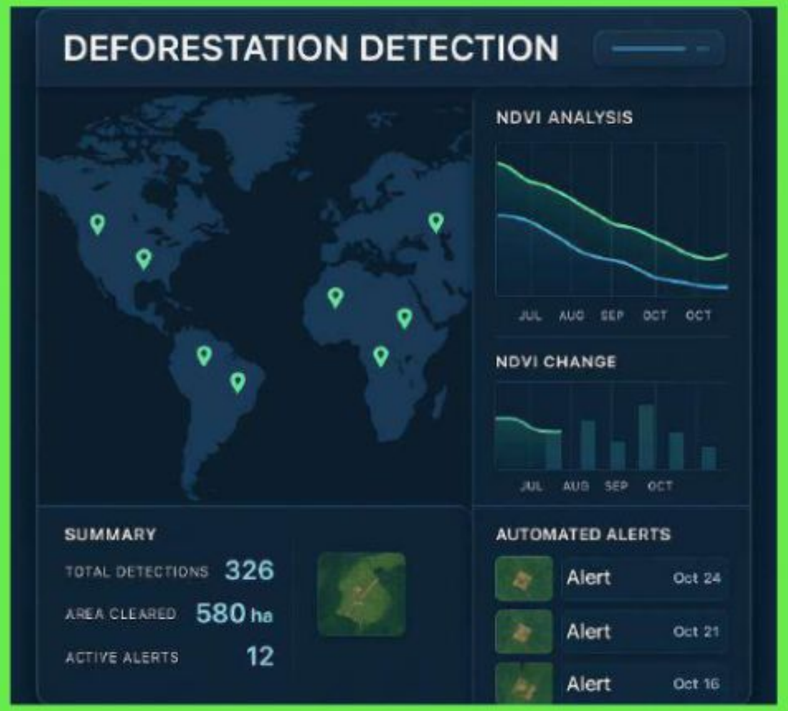
Login Screen:
- User authentication (Admin/ Researcher)
- Forgot password option

Dashboard:
- Overview of recent deforestation alerts
- Quick stats (area affected, locations)
- Map view with satellite overlays

Image Upload/Fetch Screen:
- Upload local satellite images or fetch from API
- View image metadata (timestamp, source)

User Management Screen (Admin):
- Add/edit/remove users
- Role assignment



Change Detection Screen:
- Side-by-side image comparison
- Highlighted change areas
- NDVI analysis results display

Classification & Analysis Screen:
- Machine learning results (deforestation type, confidence)
- Interactive filters (date, region, type)

Alert & Notification Center:
- List of real-time alerts
- Status tracking (new/ acknowledged)

Report Generation Screen:
- Custom report creation (PDF/ CSV)
- Download & export options

Settings & Preferences:
- API key configuration
- Notification settings
- Language/theme options

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Future Scope: The system can be enhanced with AI-powered predictive modeling and integrated with drone surveillance for finer monitoring.

Thank you!

Conclusion: Canopy Sentinel offers a robust, scalable solution for real-time deforestation detection, empowering swift environmental protection actions. ✅

Development Team

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Vayu Nandan Tripathi – Team Lead And Architect (GitHub:https://github.com/VayuTripathi09)

Alok Mishra – Backend Developer/database /sql (GitHub: https://github.com/Alokmisra53)

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