DAYANANDA SAGAR UNIVERSITY

Devarakaggalahalli, Harohalli
Kanakapura Road, Ramanagara - 562112, Karnataka, India

Bachelor of Technology
in
COMPUTER SCIENCE AND TECHNOLOGY

Big Data &Deep Learning

Route Management Using Satellite Images

By

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CERTIFICATE

This is to certify that the Big Data project work titled **"Route Management using Satellite Images"** is carried out by **Allan Dsouza(ENG21CT0002), Hemal S (ENG21CT0009), Ayush Jaice S Joseph(ENG21CT0011), Shashank Hegde(ENG21CT0036) and Swaroop K R(ENG21CT0041),** bonafide students seventh semester of Bachelor of Technology in Computer Science and Engineering at the School of Engineering, Dayananda Sagar University, Bangalore in partial fulfillment for the award of degree in Bachelor of Technology in Computer Science and Engineering, during the year **2024-2025**.

Dr. Santosh Kumar	**Dr. M Shahina Parveen**
Associate Professor Dept. of CST, School of Engineering Dayananda Sagar University Date:	Chairperson CST School of Engineering Dayananda Sagar University Date:

Name of the Examiner **Signature of Examiner**

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DECLARATION

We, **Allan Dsouza(ENG21CT0002), Hemal S (ENG21CT0009), Ayush Jaice S Joseph(ENG21CT0011), Shashank Hegde(ENG21CT0036) and Swaroop K R(ENG21CT0041),** are students of seventh semester B. Tech in **Computer Science and Technology**, at School of Engineering, **Dayananda Sagar University**, hereby declare that the Big Data and Deep Learning project titled **"Route Management using Satellite Images"** has been carried out by us and submitted in partial fulfillment for the award of degree in **Bachelor of Technology in Computer Science and Technology** during the academic year **2024-2025.**

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TABLE OF CONTENTS

ABSTRACT

This report presents the development of an advanced automated system designed to detect changes caused by human activities using satellite imagery. The primary focus of the project is on identifying modifications in man-made structures, including vehicles, buildings, and roads, by utilizing data from Sentinel-2 and LISS-4 satellite datasets. By employing cutting-edge artificial intelligence (AI) and machine learning (ML) techniques, such as semantic segmentation and change detection, the system delivers valuable insights for various applications, including urban planning, environmental monitoring, and disaster response. Additionally, the system is designed to depict the best route from one location to another while minimizing damage to forests, rivers, and other natural ecosystems, supporting sustainable development and environmental conservation efforts.

CHAPTER 1: INTRODUCTION

Urbanization and human activities are transforming our environment at an unprecedented rate, necessitating effective monitoring and management. Satellite imagery provides a unique advantage in observing Earth's surface, capturing detailed data over time. Traditional methods of manually analyzing these images are inefficient, time-consuming, and prone to errors, making them unsuitable for addressing urgent environmental and urban challenges. This project introduces an advanced automated system that leverages AI and ML techniques to detect changes in man-made structures and identify sustainable routes, minimizing environmental damage. The system aims to deliver precise, actionable insights for urban planning, environmental monitoring, and disaster response, emphasizing sustainable development.

1.1. OBJECTIVE

 Automated Change Detection: Develop a system to detect changes caused by human activities in satellite images with high accuracy and reduced manual effort.

 Sustainability Assessment: Identify and depict optimal routes between locations that minimize environmental disruption, including damage to forests, rivers, and ecosystems.

 Support Decision-Making: Provide actionable insights to aid urban planning, disaster response, and environmental protection efforts.

 Scalable and Efficient Processing: Utilize diverse satellite datasets, such as Sentinel-2 and LISS-4, to ensure scalability and reliability.

 Enhanced Accuracy: Employ AI/ML techniques like semantic segmentation and change detection for precise analysis.

1.2. SCOPE

The scope of this project extends to multiple domains:

- **Urban Development:** Identify changes in man-made structures, such as buildings, roads, and vehicles, to support sustainable urban planning.

- **Environmental Monitoring:** Detect and assess the impact of human activities on natural ecosystems, enabling better conservation strategies.
- **Disaster Response:** Provide timely insights for responding to natural disasters by analyzing pre- and post-event changes.
- **Sustainable Route Mapping:** Suggest eco-friendly routes between locations that minimize disruption to natural habitats.
- **Scalability and Adaptability:** Ensure the system can process large volumes of data from multiple satellite sources and adapt to diverse geographical regions.
- **Integration with Decision Systems:** Provide outputs that integrate seamlessly with existing planning and management tools for actionable results.

CHAPTER 2: PROBLEM DEFINITION

Despite advancements in satellite imaging technology, change detection methodologies still face challenges in scalability, precision, and environmental impact assessment. Existing systems often rely on manual interpretation or basic image processing techniques, which are inadequate for handling the vast and complex data generated by modern satellites. These methods lack the robustness required to provide real-time insights into changes occurring in urban and natural landscapes and fail to address the critical need for sustainable development. The pressing need is for an automated, scalable solution that leverages AI/ML not only to accurately and efficiently detect changes in man-made structures and landscapes but also to identify eco-friendly routes that minimize disruption to forests, rivers, and other natural ecosystems.

CHAPTER 3: LITERATURE REVIEW

Change detection using satellite imagery is an essential field that has evolved with the integration of machine learning and artificial intelligence techniques. Over the years, several methodologies have been proposed for automated detection of changes in urban and natural landscapes. These changes are crucial for applications like urban planning, environmental monitoring, and disaster response. The ability to detect changes from satellite imagery helps in making informed decisions, such as route optimization that minimizes ecological damage.

1. **Semantic Segmentation and Change Detection** The primary technique for change detection is semantic segmentation, where each pixel in a satellite image is classified into categories such as buildings, roads, and vegetation. Deep learning models like Convolutional Neural Networks (CNNs) and U-Net have been widely used for this purpose. For example, the work of [Zhou et al., 2020] demonstrates how CNNs can be used for detecting urban sprawl by analyzing two time-stamped satellite images. The models efficiently detect changes like the addition of roads, buildings, and other man-made structures. This method is suitable for real-time applications and large-scale datasets.

2. **Satellite Image Change Detection Using Multi-temporal Data** [Ghosh et al., 2021] explored a method to detect land use changes using multi-temporal remote sensing data. Their approach utilizes satellite images from different years, applying machine learning algorithms to detect changes in land cover. These changes are important for monitoring urbanization and deforestation. This method is effective in detecting subtle changes over time and has proven useful in ecological and environmental studies.

3. **Integration of AI and Machine Learning for Change Detection** Machine learning algorithms have become essential in improving the accuracy and speed of change detection. The integration of AI techniques like Support Vector Machines (SVM) and Random Forests (RF) has enhanced the detection capabilities. The study by [Li et al., 2022] focused on the use of deep learning models to detect forest cover changes in satellite images. Their results show that AI-based models outperform traditional methods in detecting changes with high precision.

4. **Route Optimization for Ecological Preservation** Route optimization using satellite imagery has gained attention in ensuring the preservation of natural environments. The challenge is to calculate the most efficient routes while avoiding ecologically sensitive areas such as forests, rivers, and wetlands. [Kumar et al., 2023] presented a model that combines satellite imagery for change detection with geographic information systems (GIS) to optimize transportation routes. Their system was designed to identify areas that need protection, thus minimizing human impact on sensitive ecosystems.

5. **AI-Driven Environmental and Urban Planning** Recent studies in environmental planning have integrated AI to assist in urban growth analysis and infrastructure planning. [Sharma et al., 2023] used satellite imagery along with ML algorithms to propose sustainable urban expansion plans. Their work emphasizes the use of real-time data for planning urban spaces, considering both environmental and human impact factors, including avoiding construction in sensitive areas.

Sl.No	Title	Authors	Summary	Research Gap
1	Urban Sprawl Detection using Satellite Imagery	Zhou et al., 2020	Demonstrates the use of deep learning for detecting urban sprawl by analyzing two time-stamped satellite images. Focuses on detecting buildings, roads, and other man-made structures.	The approach needs to be tested for a wider range of environments and temporal differences.
2	Land Use Change Detection Using Multi-temporal Satellite Images	Ghosh et al., 2021	Uses multi-temporal remote sensing data to detect land use changes, providing insights into urbanization and deforestation patterns.	Lack of integration with real-time satellite data and predictive analytics.
3	AI and Machine Learning for Forest Change Detection	Li et al., 2022	Focuses on detecting forest cover changes using AI models like CNNs and RF. Provides better precision in detecting deforestation and forest degradation.	Limited to forest areas; requires cross-application in other types of land cover.
4	Route Optimization for Ecological Preservation	Kumar et al., 2023	Combines satellite imagery and GIS to identify and avoid ecologically sensitive areas during route optimization, ensuring minimal environmental impact.	Requires further development for larger-scale application and real-time optimization.
5	AI-Driven Sustainable Urban Expansion Plans	Sharma et al., 2023	Uses satellite imagery with machine learning to propose urban expansion plans that consider environmental factors and prevent construction in ecologically sensitive areas.	Needs to address issues of real-time data integration and dynamic urban growth.

table 3.1 Literature survey table

CHAPTER 4: EXISTING AND PROPOSED

➢ Existing Solutions:

Current change detection methods in satellite imagery face several challenges:

- **Manual Analysis**: Image analysis is often done manually, which is labor-intensive, time-consuming, and prone to human error. This process is inefficient, especially when working with large datasets.
- **Simplistic Algorithms**: Traditional algorithms, like basic image differencing, are not robust and struggle to handle varying conditions (e.g., lighting, weather). These methods can lead to inaccurate results.
- **Data Processing Issues**: With the increasing volume of high-resolution satellite data, current systems struggle to process large datasets efficiently, leading to delays and difficulties in drawing actionable insights.

➢ Proposed Solution:

The proposed system uses advanced **AI/ML techniques** to address these challenges, offering a more accurate and scalable approach:

- **Semantic Segmentation**: Using deep learning models (e.g., U-Net, DeepLab), each pixel of the satellite image is classified into predefined categories (e.g., buildings, roads, forests). This approach improves accuracy and robustness, adapting to changing environmental conditions.
- **Change Detection**: Segmented images from different time periods are compared to identify changes (e.g., new buildings, deforestation). This technique efficiently detects human-induced changes and minimizes false positives, providing accurate insights.
- **Route Optimization**: Based on detected changes and environmental sensitivity, the system calculates eco-friendly routes between locations. These routes avoid areas with significant environmental value (e.g., forests, rivers), reducing damage to natural ecosystems while ensuring efficient connectivity.

The proposed system automates change detection and route optimization, ensuring faster, more reliable results. It can handle large datasets efficiently and provide insights for urban planning, environmental monitoring, and sustainable development.

CHAPTER 5 : REQUIREMENTS

- **Software Requirements**:
  - Modern multi-core processor (e.g., Intel Core i5)
  - 4 GB RAM (8 GB recommended)
  - Several gigabytes of free disk space
  - Graphics card with OpenGL 3.3 support
  - QGIS Software
  - Semi-Automatic Classification Plugin
  - USGS and Copernicus Satellite Images
- **Hardware Requirements**:
  - Python
  - QGIS Software
  - SCP and Semi-Automatic Classification Plugins
  - Internet connection for online data access.
  - Storage: Program requires about 100 MB of storage space.

CHAPTER 6: METHODOLOGY

- ## Data Collection

High-resolution satellite images are sourced from Sentinel-2 and LISS-4 satellites. These datasets are suitable for analyzing urban and natural landscapes and support change detection and route optimization tasks.

- ## Preprocessing

1. **Resizing**: Standardizes image dimensions for consistent input to the AI/ML model.
2. **Normalization**: Adjusts pixel values across images to ensure consistency.
3. **Segmentation**: Divides images into smaller patches for focused and accurate analysis.

- ## Masking

Segmented patches are merged back into a single image with masks applied. These masks highlight areas of interest, such as buildings, roads, forests, or rivers, based on the labels assigned during segmentation. Masks also identify environmentally sensitive areas for route planning.

- ## Change Detection

The system compares labeled patches in images from different times:

- Example: A patch labeled as "empty land" in one image but "building" in another indicates a change.
- Changes in forest cover or water bodies are also detected to highlight environmental impact.

- ## Route Optimization

The system uses labeled data and environmental sensitivity information to calculate eco-friendly routes. These routes minimize damage to forests, rivers, and other natural ecosystems while ensuring connectivity and efficiency.

- **Final Output**

1. **Change Detection Map**: A map highlighting changes caused by human activities.

2. **Eco-Friendly Routes**: Routes that avoid sensitive areas are overlaid on the map, promoting sustainable development.

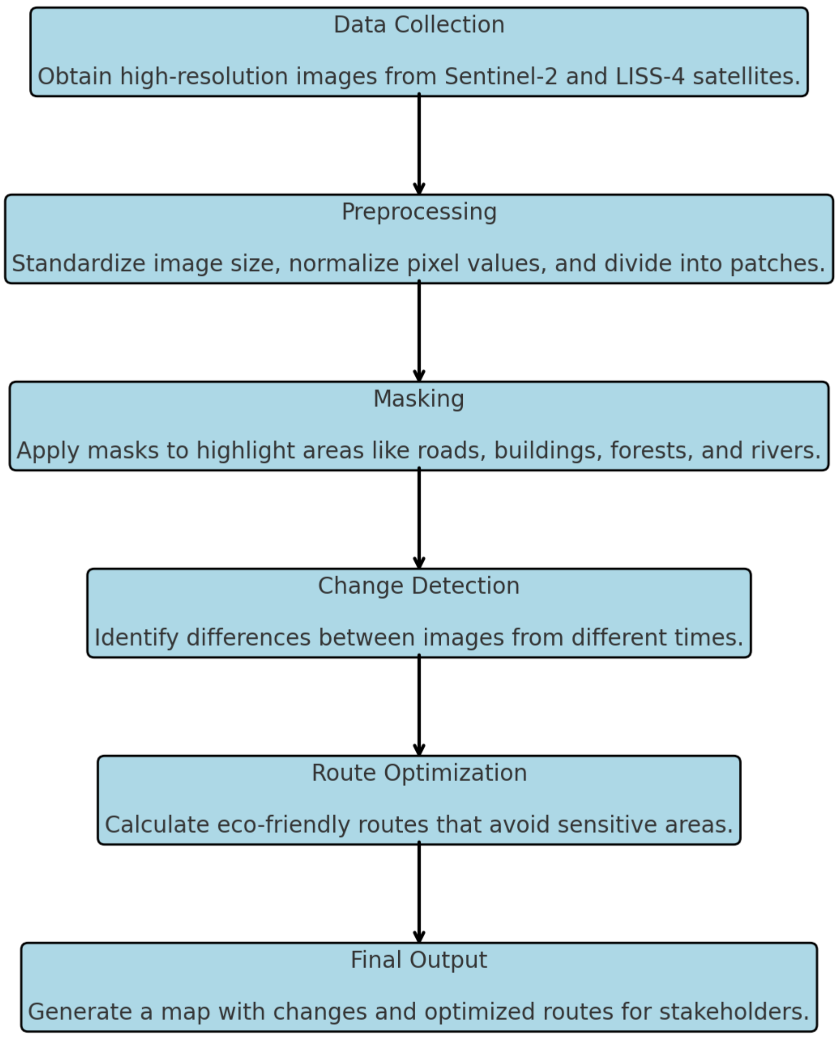

Fig 6.1 Implementation workflow

CHAPTER 7: RESULTS

Fig 7.1 Original Image

Fig 7.2 Masked Image

Fig 7.3 Original Image

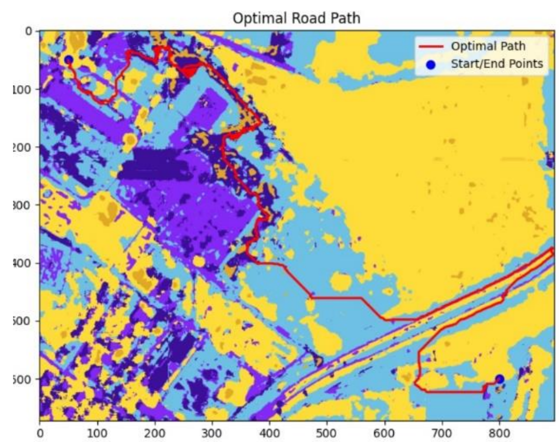

Fig 7.4 Masked Image with optimal path

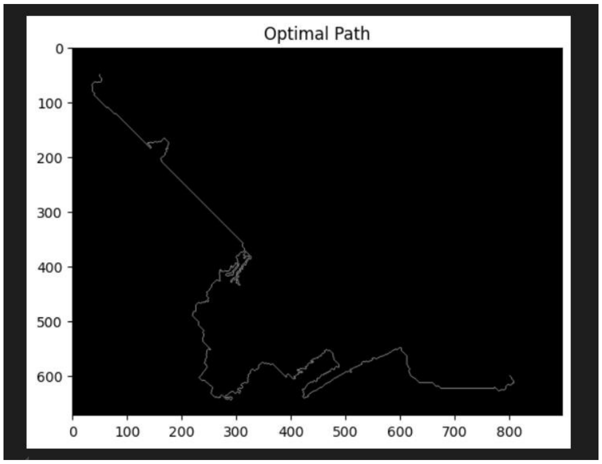

Fig 7.5 Final Optimal Path

This graph-based representation of the optimal path highlights the technical output of the system. With a black background, it clearly visualizes the route while minimizing visual distractions. The graph-based representation is derived from the processed data, showcasing the system's ability to optimize routes efficiently.

The images collectively illustrate the process and outcomes of the system. From identifying land features and detecting changes to planning environmentally friendly routes, the system demonstrates its ability to:

1. Extract critical insights from satellite imagery.
2. Highlight physical and environmental changes caused by human activities.
3. Propose optimal paths that minimize environmental damage, balancing developmental and ecological considerations.

These results underscore the effectiveness of the AI/ML-driven approach in analyzing satellite data and aiding decision-making in urban planning and environmental management.

CHAPTER 8: CONCLUSION

The proposed system for detecting human-induced changes in satellite imagery leverages advanced AI/ML techniques to address the limitations of traditional methods. By incorporating semantic segmentation, the system accurately classifies each pixel in the satellite images, adapting to varying environmental conditions and providing robust results. Change detection is performed by comparing segmented images taken at different times, enabling the identification of alterations in urban and natural landscapes, such as new buildings, roads, deforestation, and water body changes.

Additionally, the system includes a route optimization feature that calculates eco-friendly paths between locations. By considering environmental sensitivity, the system ensures that the chosen routes minimize damage to critical ecosystems, such as forests and rivers, while maintaining efficiency.

This comprehensive solution automates the analysis of satellite data, improving both the speed and accuracy of detecting human-related changes and providing actionable insights. The system is scalable, capable of handling large datasets, and provides valuable support for urban planning, environmental monitoring, disaster response, and sustainable development. Through the integration of change detection and route optimization, this system can significantly contribute to informed decision-making and the promotion of environmentally responsible practices.

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