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Satellite Based Mapping of Woodland and Waterbodies Detection

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Abstract: *This design focuses on developing an automated system for the discovery and mapping of trees and waterbodies from high- resolution satellite imagery. The lack of accurate spatial data on tree and water bodies distributions poses significant challenges across husbandry, environmental monitoring, and civic planning sectors. Inefficient ranch operation practices, hindered environmental monitoring sweats, and shy resource allocation are direct consequences of this data insufficiency. By using advanced image processing and machine literacy ways, this design aims to enhance decision-making processes in perfection husbandry, biodiversity conservation, and sustainable land use planning. The issues will empower stakeholders to ameliorate crop operation practices, cover environmental changes, and alleviate the impacts of illegal logging and deforestation, thereby contributing to global sweats in environmental sustainability and climate change mitigation*

Keywords: Satellite imagery, machine literacy, environmental monitoring, forestland discovery, water body discovery, Faster R- CNN, Graph Neural Networks

I. INTRODUCTION

Our design aims to revise environmental monitoring by using slice- edge satellite imaging and machine literacy technologies. The design is designed to automate the discovery and mapping of trees and water bodies across colorful geographies, offering a scalable and effective result to challenges in environmental operation.

By integrating advanced image processing ways with machine literacy algorithms, our system will deliver precise data on the distribution and health of natural coffers. This data is pivotal for informed decision- making in husbandry, forestry, land use planning, and biodiversity conservation. Our approach not only enhances the delicacy and effectiveness of covering sweats but also provides a important tool for combating deforestation, managing water coffers, and supporting sustainable development.

Through this design, we aim to contribute to global environmental sustainability enterprise, furnishing essential perceptivity for mollifying the impacts of climate change and icing the responsible stewardship of our earth's natural coffers.

II. LITERATURE SURVEY

Tree Seedlings Detection and Counting Using a Deep Learning Algorithm
Authors: Deema Moharram

The technique successfully locates and counts tree seedlings, exhibiting significant economic worth and a wide range of potential uses in forestry management. utilizing the tool and YOLOv5 object detection network algorithm .

Surface Water Detection and Monitoring Using Deep Learning Techniques: A Comparative Study Authors: Guy Farjon & Yael Edan

According to the study, U-Net is the best model for detecting surface water, and integrating temporal data with 3D-CNNs can enhance monitoring capabilities employing the U-Net, ResNet, and 3D-CNNs algorithm, technique, and tools.

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Deep Learning in Forest Tree Species Classification Using Sentinel-2 on Google Earth Engine: A Case Study of Qingyuan County

Authors: Tao He

For remote sensing classification, the algorithms/techniques/tools utilized were ResNet, DenseNet, EfficientNet, MobileNet, and ShuffleNet; PCA and NDVI for preprocessing; and ResNet outperforms other deep learning algorithms.

Development of Automatic Tree Counting Software from UAV Based Aerial Images With Machine Learning

Authors: Yaping Dai

On the campus of Siirt University, the technique proved to be highly effective in automatically counting trees, offering a dependable instrument for environmental and forestry monitoring. The method demonstrates how well UAVs and machine learning can be combined for environmental applications. For example, UAVs were utilized to take high-resolution photos at a height of 30 meters with a 20% overlap. The photo merge tool in Adobe Photoshop was used to fuse the images together. Bounding boxes were labeled in HSV, RGB, and grayscale modalities, and orthophoto maps were produced.

III. PROBLEM STATEMENT

Accurate and dependable discovery of woods and waterbodies plays a critical part in colorful disciplines, including environmental monitoring, sustainable land operation, disaster preparedness, and biodiversity conservation. Traditional approaches, similar as homemade ground checks and the use of low- resolution satellite imagery, are frequently labor-ferocious, time- consuming, expensive, and susceptible to mortal error. These styles struggle to meet the growing demand for large- scale, precise, and timely information.

The arrival of high- resolution satellite imagery provides an occasion for more accurate and automated identification of woods and waterbodies. still, several crucial challenges complicate this process

Spectral and Spatial Variability

Different types of foliage, different water textures, and seasonal variations(similar as leafage changes and water position oscillations) make it delicate to constantly classify features grounded on spectral autographs alone.

Mixed Pixels at Boundaries

Areas where woods and waterbodies meet frequently affect in mixed pixel values, complicating the bracket and reducing overall mapping delicacy.

Data Complexity and Computational Demand

High- resolution images contain massive quantities of information, making storehouse, processing, and analysis computationally ferocious and resource- heavy.

Need for robotization and Scalability

Homemade analysis of satellite images over large regions is impracticable. An automated system is essential for recycling expansive datasets snappily and constantly while minimizing mortal intervention.

Given these challenges, there's a clear need to develop a robust, effective, and scalable automated system that can directly reuse high- resolution satellite imagery for the discovery and mapping of woods and waterbodies. Such a result would significantly contribute to faster decision- timber, better environmental operation, and more effective policy planning.

IV. PROPOSED METHODOLOGY

The methodology of this research is divided into the following key stages as given in figure

Data Collection and Preprocessing

- Collect Data: Gather high-resolution satellite images specifically for Nagpur.

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- Preprocess Images: Perform normalization (scaling pixel values) and augmentation (like rotation, flipping) to increase data variety.
- Generate Graphs: Convert image data into graph structures, preparing them as input for Graph Neural Networks (GNNs).

Model Development

- Image Segmentation Use a modifiedU-Net model to member different regions(e.g., land use types) from satellite images.
- Incorporate GNNs Enhance the segmentation by bedding Graph Neural Networks to more capture spatial connections between regions.

Model Training and Validation

- Training Train the combined U-Net GNN model using the preprocessed dataset to learn meaningful patterns.
- confirmation Test the model's performance on a separate dataset to insure it generalizes well and produces accurate results.

Post-Processing

- Refinement Ameliorate the raw segmentation labors by applying morphological operations(like closing small gaps or smoothing boundaries).
- Temporal Analysis Integrate styles to cover how areas change over time(e.g., civic growth, foliage changes).

User Interface and Visualization

- Dashboard Development Build a stoner-friendly dashboard to display the results easily.
- GIS Integration: Use GIS (Geographic Information System) tools for deeper spatial analysis and better visual representation on maps.

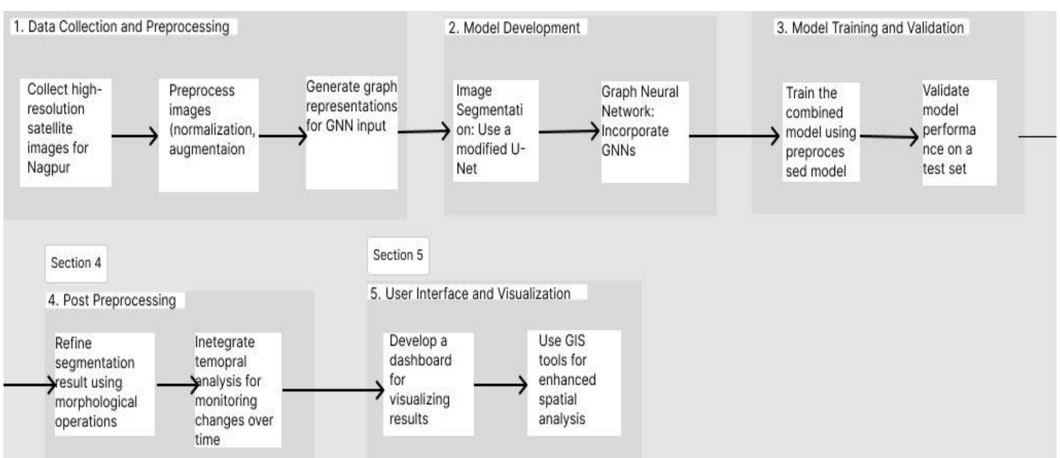

Fig. 1. Stages Involved in Proposed Methodology

In order to measure the effectiveness of the proposed system for forestland and water body discovery, some important parameters are applied. These set of criteria offer a clear assessment of how near the real values of the system are and how precise the system is as a whole. Speaking of the major criteria deduced in this exploration, these include Precision, Recall, F1- Score, and Accuracy. These criteria are helpful in relating the effectiveness of the system in detecting trees and water bodies from the satellite images.

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Precision perfection calculates the number of their objects rightly labelled by a system as trees or water bodies, out of all the objects that were labelled by the system. Low false positive means that the system is precise in its operations of furnishing vaticinations with little crimes.

Precision = TP/ TP FP Equation(1)

Where, TP = True Positive, FP = False Positive

Recall Recall determine the chance of the true number of objects or the features present in reality(for illustration, trees or water bodies) which are directly detected by the system. The high value of recall means that the system rightly identifies nearly all objects that it's supposed to descry with many false negative.

Recall = TP/ TP FN Equation(2)

Where, TP = True Positive, FN = False Negative

F1 Score As the complementary of the number of true cons divided by the total number of true cons, false cons, and false negatives, the F1- Score is actually the normal of perfection and recall. It's particularly helpful when the classes are n't balanced and evaluates performance when perfection and recall values are noteworthy.

It provides the results of two measures — perfection and recall — in a single dimension.

F1 = 2 * Precision * Recall/(Precision Recall) Equation(3)

V. EXPERIMENTAL AND RESULTS

The findings attained by the proposed system prove that the system is effective in covering the terrain. The high value of perfection and recall rates indicate the capability of this system in the identification and recitation of trees and water bodies indeed within small civic settings. It was possible thanks to integrating spatial connections using graph neural networks, which helped increase the model's performance compared to object discovery models.

likewise, they claim that the system they've developed can be fluently gauged for using also large scale in monitoring operations. This makes it a useful tool to the civic itineraries and environmentalist in that they can fluently cover changes in natural coffers through satellite images as and when it do.

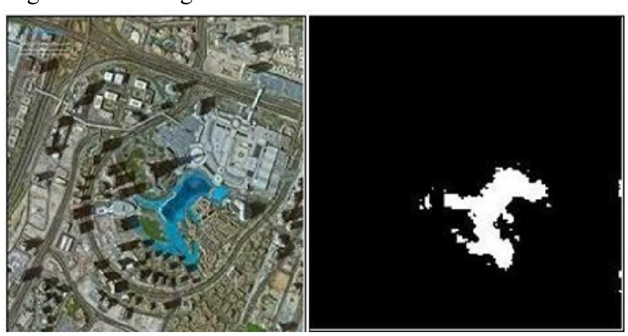

Fig. 2. Input satellite image & system output for Waterbodies detection

The model was trained on sets of images with reflections that give the true markers to the trees and the regions of water. The(fig. 2) shows the prognosticated mask of waterbodies which is made by the trained model while image analysis. Some of these data were insulated as part of the trial to check how the proposed system works. In proposed work we used satellite imaginary and labelled dataset for performing trial.

Satellite Images Vegetation ever tasted data was acquired from guard 2 with high resolution and SAR data of water bodies was attained from guard 2 satellite. These images were marker with blocks around trees and water features.

Marker Datasets Data about the spatial positions of trees and water bodies collected by timber authorities and available for download in the form of data sets were applied in the model. The(fig. 3 & fig. 5) shows the dataset used for the training the model. After the model trained the model give affair as following(fig. 2 & fig. 4). In the affair image the model make the conniving of boxes and in water bodies it make the prognosticated mask.

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Fig. 3. Dataset for Waterbodies detection

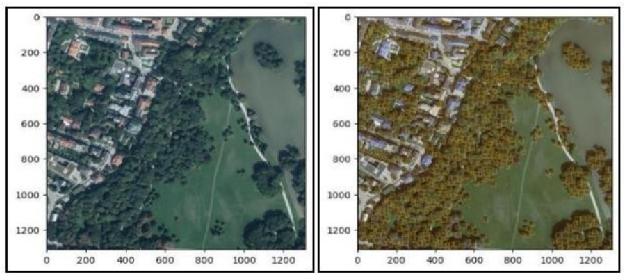

Fig. 4. Input satellite image & system output for Woodland detection

Fig. 5. Dataset used for Woodland detection

Sr. No	Result Analysis		
	Performance Metrics	***Tree Detection***	***Water Body Detection***
1	Precision	93. 5%	80%
2	Recall	92. 8%	80.2%
3	F1-Score	93. 1%	79.5%
4	Accuracy	94%	80%

TABLE 1: RESULT ANALITSYS

Regarding the performance of the system, it was caught on that the proposed algorithm achieved high delicacy when detecting trees and water bodies with little variation. The advancements in the discovery of objects were enhanced through the use of GNNs which captured the spatial relations between the objects. The results also show the effectiveness of the proposed system and the fact that the system can be applied for real- time monitoring especially for observing following factors.

Geospatial Expansion Using the system on different geographical locales to enhance the performance of the system. objectification of Multi-Spectral Data Taking advantage of multi-spectral imagery to ameliorate identification trustability when it comes to colorful types of foliage as well as water bodies.

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Climate Change Impact farther expanding the model to watch long- time environmental oscillations concerning climate change and the use of the land.

farther development of the specified model and its extension will produce the base of this system or have a significant eventuality to come an necessary tool in the frame of the conception of sustainable development and protection of natural coffers throughout the world.

VI. FUTURE WORK

The following are key areas for future applications and technological advancements:

Multi-Temporal Analysis

Extend the system to monitor changes over time, such as deforestation, seasonal waterbody fluctuations, and land use transitions using time-series satellite data.

Integration of Multi-Sensor Data

Combine data from different sensors (e.g., optical, radar, LiDAR) to improve detection accuracy, especially under challenging conditions like cloud cover or dense forest canopies.

Real-Time Monitoring System

Develop a near-real-time processing pipeline for continuous and live monitoring of woodland and waterbody changes, useful for disaster response (e.g., floods, forest fires).

Advanced Deep Learning Techniques

Explore the use of more advanced models like Transformers for Vision (e.g., ViT, Swin Transformer) or hybrid CNN-GNN models to enhance feature extraction and segmentation performance.

High-Resolution Change Detection

Implement change detection algorithms to automatically highlight significant environmental changes at high spatial resolution.

Automated Alert Systems

Create automated alert systems that notify stakeholders (e.g., government agencies, NGOs) about critical changes like illegal logging, forest fires, or drought-induced waterbody shrinkage.

Customized Regional Models

Build models fine-tuned for specific regions or ecosystems to account for local variations in vegetation and waterbody characteristics.

Scalability to Larger Geographies

Scale the system to cover larger areas (states, countries) by optimizing the model for speed and handling massive satellite datasets.

Integration with GIS Platforms

Develop plugins or APIs to integrate the detection system directly with popular GIS platforms like ArcGIS or QGIS for seamless visualization and analysis.

Community and Crowd-Sourced Validation

Involve local communities or citizen scientists for ground-truth validation, improving data quality and increasing system robustnes

VII. CONCLUSION

This research successfully designed a system for automatically extracting woodlands and water bodies from high-resolution satellite data. Various spatial analysis methods can detect natural resources with high accuracy through the implementation of machine learning models supported by graph neural networks.

The specified model's further development and extension will lay the foundation for this system or have significant potential to become an essential tool within the framework of global sustainable development and natural resource protection.

VIII. ACKNOWLEDGMENT

A significant task can only be accomplished effectively and satisfactorily when a variety of individual efforts, both explicit and implicit, are applied from all sides. Although books and other informative sources provide substantial knowledge gains through a wide range of desirable reading activities, actual competency is attained through relevant learning tasks and experience. We sincerely thank everyone who helped make this initiative a success, no matter how small or how much we may have taken it upon ourselves.

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