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Application of Image Analytics for Tree Enumeration and Diversion of Forest Land

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Abstract
Accurate tree enumeration is essential for responsible forest land diversion in development projects. Conventional manual surveys are slow, costly, and prone to errors. This paper introduces a cutting-edge image analytics solution that leverages satellite imagery and aerial photos to automate tree counting. The primary objective is to develop a robust system that identifies and categorizes trees by crown size, and environmental conditions. Advanced computer vision algorithms are integrated with machine learning models to analyze the imagery. Rigorous validation processes, including comparisons with ground-truth data from manual surveys, ensure high accuracy and reliability. The results are impressive. This solution significantly accelerates tree enumeration, eliminating resource-intensive manual efforts. It consistently demonstrates precision with minimal false positives and negatives. Moreover, it categorizes trees efficiently by species, offering a comprehensive view of the forested area. This project significance lies in its contribution to responsible and sustainable land development practices. By automating tree enumeration, it equips stakeholders with timely, precise data for informed decisions about land usage, conservation, and environmental impact assessments. The solution strikes a balance between development and ecological preservation, optimizing resource allocation while minimizing environmental impact in forested regions. In conclusion, this innovative image analytics solution revolutionizes forest land diversion, enabling efficient and ecologically conscious decision-making. It addresses the critical need for accurate tree enumeration in the face of developmental challenges, fostering responsible land use and environmental stewardship.

Keywords: Machine Learning, Deep Learning, UAV imagery, Tree Enumeration.

Introduction

When forest land needs to be diverted for developmental projects, it is crucial to have an accurate understanding of the tree population within the affected area. Traditional methods of tree enumeration, such as manual surveys or ground-based assessments, can be time-consuming, expensive, and prone to errors. To address these challenges, the challenge is to develop an image analytics solution that automates the tree enumeration process using satellite imagery or aerial photographs. The proposed solution should address the following key aspects:

Image Data Analysis: Develop a computer vision algorithm that can analyze satellite imagery or aerial photographs to detect and identify trees within the designated forest areas accurately. The algorithm should account for variations in tree crown sizes, and environmental conditions to ensure reliable results.

Tree Counting and Categorization: Design a system that can count the number of trees in the specified area and categorize them based on their crown size or other relevant parameters. The solution should

provide accurate and detailed information about the tree population to facilitate decision-making during the land diversion process.
Accuracy and Validation: Create mechanisms to validate the accuracy of the image analytics solution by comparing the results with ground-truth data obtained through manual surveys or other reliable methods. The solution should aim to achieve a high level of accuracy and minimize false positives or false negatives in tree identification and counting.
Scalability and Efficiency: Develop an efficient and scalable solution capable of processing large volumes of image data within a reasonable timeframe. Consider optimization techniques and parallel processing approaches to ensure timely results, especially for large forest areas or time-sensitive projects.
Visualization: Provide visualizations or interactive interfaces that allow users to explore and interpret the results easily. This could include the generation of maps, reports, or other visual representations of the tree enumeration data.
Ethical and Environmental Considerations: Ensure the solution adheres to ethical practices, respects privacy concerns, and minimizes potential environmental impact. Consider the privacy of sensitive data, secure storage of images, and compliance with environmental regulations throughout the development and deployment of the solution. By addressing these aspects, the proposed image analytics solution will facilitate efficient and accurate tree enumeration for the diversion of forest land. It will provide stakeholders with vital information to make informed decisions regarding land usage, environmental impact assessment, and conservation efforts, ensuring responsible and sustainable development.

Automatic Tree Enumeration On Images (Related Work)

Researchers and experts have explored various approaches to address the challenge of automating tree enumeration for forest land diversion projects. Remote sensing and satellite imagery analysis have been key components in monitoring and assessing forest cover, with algorithms developed to detect, classify, and assess tree populations using multi-spectral and hyperspectral data. In the realm of computer vision and machine learning, Convolutional Neural Networks (CNNs) have been employed to segment trees from background vegetation and identify individual trees within images. Additionally, Lidar technology has allowed for the creation of detailed 3D forest models, enabling precise tree counting and characterization when combined with satellite imagery. Forestry agencies and organizations have established their methodologies, integrating field surveys, remote sensing data, and Geographic Information Systems (GIS) tools for tree enumeration and forest monitoring. Open data initiatives provide valuable resources for researchers, offering access to satellite imagery and ground-truth data for solution development. Moreover, environmental impact assessment efforts regularly utilize satellite imagery to monitor land-use changes and tree loss due to development. Ethical and privacy considerations are paramount in working with satellite imagery, with research emphasizing data protection and ethical compliance. Scalability and efficiency are addressed through techniques like parallel processing and distributed computing, ensuring the processing of large datasets on time. Lastly, user-friendly visualization tools play a crucial role in facilitating decision-making during land diversion processes and forest management.

A.Traditional Tree Enumeration And Detection Approaches

Traditional approaches to understanding forest conditions involve manual fieldwork and data collection methodologies. Foresters typically conduct tree counts by physically traversing the forest, visually enumerating trees, or conducting more detailed surveys that measure tree diameters at breast height using tape measures or calipers. Identifying tree species is crucial, relying on experts' knowledge to classify trees based on leaf, bark, or cone characteristics. Measuring diameters at breast height and estimating tree height using tools like clinometers or hypsometers are fundamental for assessing tree growth and biomass. Fixed sampling plots are established within forests to systematically gather data, serving as representative samples for broader assessments. Soil sampling is conducted to analyze soil nutrients, pH levels, and moisture content, providing insights into overall forest health. These traditional methods, while time-consuming, form the basis of forest inventories that detail species diversity, age distribution, and growth rates. Additionally, while not strictly traditional, remote sensing techniques using aerial photography, satellite imagery, LiDAR, and drones are increasingly incorporated to provide broader-scale insights into forest cover, health, and changes over time.

The Proposed Approach

A. Motivations And Overview

In line with the objectives outlined in the problem statement, our proposed approach addresses the challenge of tree enumeration while considering the additional parameters of tree crown size, age, and crown characteristics. To collect relevant aerial data on forested areas, we employ a data acquisition aerial vehicle system equipped with a multispectral sensor, which captures vital information about the forest canopy. The core motivation behind our approach is to automate the estimation process, ensuring a comprehensive understanding of the tree population within the designated forest areas, a crucial requirement for responsible and sustainable development when forest land diversion is necessary. same annotated dataset of multispectral images. This dataset includes instances of different tree crown sizes, ages, and crown characteristics. Through the integration of image processing and deep learning features, our approach ensures robust feature representation, addressing the inherent variation in tree appearance across different sizes, and age groups.

B. Proposed System Design And Architecture

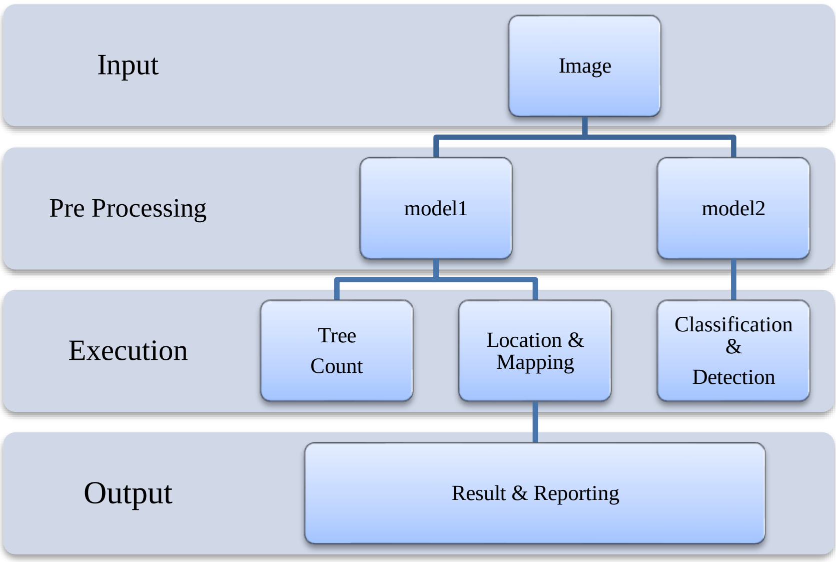

Figure 1: System Architecuture and Design

The provided figure encapsulates the diverse phases of the system architecture, providing a holistic view of the entire process from initial data input to the ultimate output. Beginning with the "Input" phase, where satellite imagery or aerial photographs are ingested, the system proceeds to "Pre-Processing," a crucial step for noise reduction, image enhancement, and feature extraction. The heart of the system is in the "Execution" phase, where "model1" is dedicated to "Tree Count," utilizing sophisticated algorithms to detect, enumerate, and characterize trees, including attributes like size, age, and crown characteristics. Concurrently, "model2" engages in "Classification & Detection," identifying and classifying objects within the images, providing a comprehensive understanding of not only the trees but also other elements in the forest. Subsequently, the system advances to "Location & Mapping," where spatial data is utilized to accurately map tree and object positions, essential for informed decision-making during land diversion and environmental impact assessment. Finally, the "Result & Reporting" phase generates comprehensive reports and visual representations, facilitating stakeholders with valuable insights into the tree population, species distribution, and environmental characteristics of the forested area, aligning perfectly with the objectives outlined in the original problem statement.

C. Use Case Diagram

This is Use Case Diagram that shows various actors and activities performed by them.

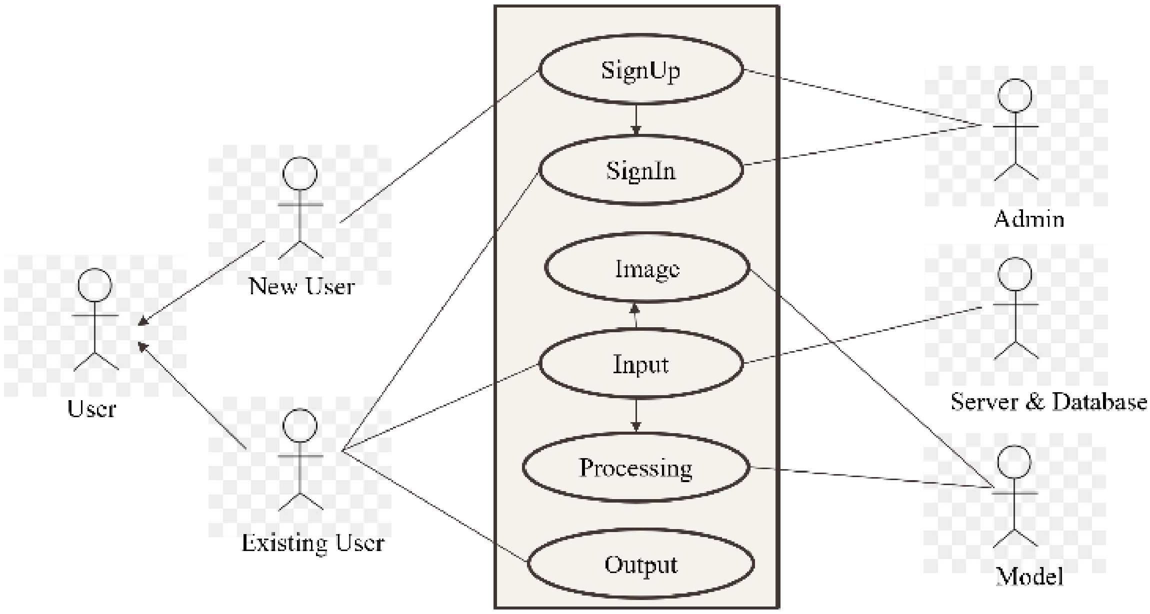

Figure 2: Use Case Diagram

In a system designed for tree enumeration and classification, there are distinct actors, each playing specific roles within the framework. These actors include users, administrators, and servers. Users encompass two types: new users and existing users. New users are required to undergo a SignUp process, while existing users engage in a SignIn activity. The activities within this system comprise SignUp, SignIn, input, processing, and output phases. During SignUp, new users provide the necessary information to create an account, while existing users authenticate their identity during SignIn. Input involves the submission of data or parameters related to tree enumeration and classification. Processing refers to the handling of this input, likely involving algorithms or methodologies to analyze and classify trees. Finally, the output phase presents the processed information, potentially in the form of reports, visualizations, or data sets. Admins oversee and manage user accounts and system functionalities, while servers handle data storage, processing, and communication between users and the system.

D. Proposed System User Interface

The proposed system provides easy interaction between the user and the system by providing a simple user interface. We can integrate the proposed system with various platforms like the web interface, mobile application interface, and desktop application interface. The web interface is more simple to use for the users simply visiting the website they don't need to download and install any software application. A simple user interface contains two main components user input where the user simply gives input to the system in the form of images other one is output which shows in the form of charts, graphs, CSV, PDF, and other visualization tools.

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REFERENCES

1. Martin Brandta,Rasmus Fensholta, "Deep learning enables image-based tree counting, crown segmentation, and height prediction at national scale" PNAS Nexus, 2023, 2, 1–16
2. F.Z. Bassine, A. Errami, M. Khaldoun "Real time Algorithm for Tree Detection, Recognition and Counting in a Video Sequence", J . Mater. Environ. Sci., 2020, Volume 11, Issue 3, Page 367-377
3. CHIA-YEN CHIANG, CHLOE BARNES "Deep Learning-Based Automated Forest Health Diagnosis From Aerial Images" accepted July 9, 2020, date of publication July 28, 2020, date of current version August 18, 2020.
4. WASSIM BOUACHIR, NIZAR BOUGUILA "Computer Vision System for Automatic Counting of Planting Microsites Using UAV Imagery" Received May 17, 2019, accepted June 8, 2019, date of publication June 19, 2019, date of current version July 9, 2019.
5. V. Lempitsky and A. Zisserman, ''Learning to count objects in images,'' in Proc. Adv. Neural Inf. Process. Syst., 2010, pp. 1324–1332.
6. V. Rabaud and S. Belongie, ''Counting crowded moving objects,'' in Proc. IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit., vol. 1, Jun. 2006, pp. 705–711.
7. K. Chen, C. C. Loy, S. Gong, and T. Xiang, ''Feature mining for localised crowd counting,'' in Proc. BMVC, 2012, vol. 1. no. 2, p. 3.
8. Y. Wang and Y. Zou, ''Fast visual object counting via example-based density estimation,'' in Proc. IEEE Int. Conf. Image Process. (ICIP), Sep. 2016, pp. 3653–3657.
9. G. Grenzdörffer, ''UAS-based automatic bird count of a common gull colony,'' Int. Arch. Photogram., Remote Sens. Spatial Inf. Sci., vol. 1, p. W2, 2013.
10. N. Ahuja and S. Todorovic, ''Extracting texels in 2.1 D natural textures,'' in Proc. IEEE 11th Int. Conf. Comput. Vis., Oct. 2007, pp. 1–8.
11. A. Krizhevsky, I. Sutskever, and G. E. Hinton, ''ImageNet classification with deep convolutional neural networks,'' in Proc. Adv. Neural Inf. Process. Syst., 2012, pp. 1097–1105.