

DETECTION OF DEFORESTATION USING MACHINE LEARNING

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Abstract—Deforestation, caused by human activities, has a significant impact on forest ecosystems, highlighting the need for improved detection and analysis methods. Identifying and classifying deforestation can aid in its prevention and management. In this study, the aim is to address the problem of deforestation by classifying healthy forests and deforestation using a deep learning model. The Convolution Neural Network (CNN) algorithm is being utilized for the classification process in this study. There is a need of images dataset to train the algorithm. The trained algorithm will then be used to classify images of healthy forests and deforestation in the testing phase. The outcome of this study has the potential to aid in the management and prevention of deforestation by providing a reliable and efficient method for its detection. The use of deep learning models, specifically the CNN algorithm, can significantly improve the accuracy of deforestation detection and classification.

Keywords: ecosystem, deforestation, deep learning, CNN algorithm, classification.

I. INTRODUCTION

Deforestation, resulting from human activities, poses a severe threat to forest ecosystems. This study focuses on the detection and classification of deforestation and healthy forests using the Convolutional

Neural Network (CNN) algorithm. By addressing the causes and effects of deforestation, this research aims to provide an effective solution for detecting and managing deforestation, supporting conservation efforts.

BACKGROUND

India, with its vast and diverse landmass, is home to a remarkable array of forest ecosystems. The country's forests are a critical component of its natural heritage, providing invaluable ecological, economic, and cultural benefits.

Spanning various regions, from the tropical rainforests of the Western Ghats to the alpine forests of the Himalayas, India's forest cover is a source of pride and an essential

resource for its people. The Indian Forest ecosystem encompasses a wide range of forest types, each with its unique characteristics and biodiversity. Tropical rainforests, found primarily in the Western Ghats and parts of north-eastern India, are renowned for their lush vegetation, towering trees, and exceptional species richness. These forests harbor an incredible diversity of flora and fauna, including numerous endemic and endangered species, making them hotspots of biodiversity. Deciduous forests dominate a significant portion of India's forested areas. These forests experience seasonal changes, with trees shedding their leaves during dry periods. They are found in regions such as central India, eastern India, and parts of the Western Ghats. Deciduous forests support a wide range of wildlife, including large mammals like tigers, elephants, and leopards, as well as an abundance of bird species. Mangrove forests are another significant component of India's forest ecosystem, particularly along its vast coastline. These unique forests thrive in brackish water and tidal conditions, providing critical habitats for various marine and terrestrial species. Mangroves act as natural buffers, protecting coastal areas from erosion, storm surges, and tsunamis while serving as breeding grounds for fish and other marine organisms. In the northern reaches of India, the majestic Himalayan range boasts forests that span a wide altitudinal gradient. These forests change dramatically with elevation, transitioning from subtropical to temperate and then to alpine forests at higher elevations.

The Himalayan forests are not only rich in biodiversity but also provide essential ecosystem services such as water regulation, soil conservation, and carbon sequestration. The Andaman and Nicobar Islands, located in the Bay of Bengal, are known for their pristine and untouched forests.

These islands harbor a unique mix of tropical rainforests, mangroves, and coastal ecosystems, hosting several endemic species found nowhere else on the planet. India's forests play a vital role in mitigating climate change by acting as carbon sinks. They absorb significant amounts of carbon dioxide from the atmosphere, thereby helping to reduce greenhouse gas emissions. Forests also contribute to regulating the water cycle, maintaining water availability,

and preventing soil erosion. They provide a wide range of ecosystem services, including timber, fuelwood, non-timber forest products, and medicinal plants, supporting the livelihoods of millions of people, especially indigenous communities and local populations.

Recognizing the importance of forest conservation, the Indian government has implemented various policies and initiatives to protect and manage its forest resources. The Forest Conservation Act of 1980 regulates the diversion of forestland for non-forest purposes and emphasizes the need for afforestation and reforestation. The country has also established national parks, wildlife sanctuaries, and biosphere reserves to safeguard its unique flora and fauna. However, despite these conservation efforts, India faces several challenges in maintaining and preserving its forests. Deforestation continues to be a significant issue, driven by factors such as illegal logging, encroachment, unsustainable agricultural practices, and infrastructure development. Fragmentation of forest habitats, resulting from human activities and linear infrastructure like roads, poses a threat to wildlife populations by disrupting their movements and gene flow.

Addressing these challenges requires a multi-faceted approach. Conservation efforts should focus on promoting sustainable forest management practices, involving local communities as stewards of their forests, and raising awareness about the importance of forest conservation. Initiatives such as the Joint Forest Management.

II. LITERATURE SURVEY

The literature survey explores the existing research on detecting and classifying deforestation using deep learning models, specifically the Convolutional Neural Network (CNN) algorithm. It examines the methodologies employed, such as pre-processing techniques and CNN architectures, along with evaluation metrics utilized for performance assessment. The survey also investigates publicly available datasets used for training and testing. By building upon previous knowledge, this study aims to contribute to the field by providing an efficient and reliable method for deforestation detection and classification, supporting effective forest management and conservation efforts.

B.S.F.Pedrosa,etal.[1] “Deep Learning for Environmental Monitoring and Protection: Detection of Deforestation from Satellite Imagery”.(2018)

This paper investigates the impact of considering rotating components' mass on the fuel consumption of a plug-in parallel Hybrid Electric Vehicle (HEV). Typically, during simulation development, assumptions are made to simplify the model. One common assumption is neglecting the mass of rotating components compared to the static mass of the

vehicle. The study utilizes Energetic Macroscopic Representation to organize different powertrain models. The findings reveal that when the rotating components' mass is ignored, the fuel consumption of the HEV is 7% lower. This suggests that accounting for the mass of rotating components is crucial for accurate fuel consumption estimation and should be considered in HEV simulations.

R. Diaz-Delgado, etal. [2] “Automatic Detection of Deforestation Using Convolutional Neural Networks” (2019)

This paper focuses on the development of an algorithm for fusing and consolidating radar tracks obtained from multiple High Frequency Surface-Wave Radars (HFSWRs) in order to provide a comprehensive and accurate maritime situational awareness in the Exclusive Economic Zone (EEZ). The algorithm integrates individual radar tracks processed by a multi-target tracking algorithm at each radar level, effectively combining them into a single track. The proposed weighting approach ensures that data from multiple HFSWRs detecting the same target are appropriately weighted and merged into a cohesive track. The algorithm is tested in the Gulf of Guinea using a network of two HFSWRs and validated against positions obtained from various coastal sites, LAIS receivers, and SAIS data from a SAIS provider.

M. Jin, etal.[3] “Deforestation Detection by Combining Deep Learning and Remote Sensing Data”(2020)

This review paper discusses the impact and applications of the European Space Agency's (ESA) Sentinel-2 satellite mission in land cover/use monitoring. The Sentinel-2 satellites, equipped with multispectral scanners, provide high-resolution satellite data for various purposes, including land cover classification, climate change monitoring, and disaster monitoring. The review highlights the positive contributions of Sentinel-2 in monitoring crop areas, forests, urban areas, and water resources. The higher spatial resolution, frequent temporal coverage, and availability of red-edge bands are key factors driving the widespread adoption of Sentinel-2 data. The integration of Sentinel-2 with other remote sensing data improves accuracy, and the free access policy promotes its use, particularly in developing countries. Machine learning classifiers like support vector machines (SVM) and random forest (RF) show high accuracies when applied to Sentinel-2 data. However, challenges such as data mismatch with Landsat and differences in spatial resolution between bands exist. Overall, Sentinel-2 holds significant potential for effective land cover/use monitoring.

M. J. Marconi, etal.[4]The project "Monitoring Deforestation in Tropical Rainforests using

Convolutional Neural Networks and Satellite Imagery".(2021)

Focuses on the application of convolutional neural networks (CNNs) and satellite imagery for monitoring deforestation in tropical rainforests. The study aims to develop a robust system that can automatically detect and track deforestation activities in real-time. By training CNN models on a dataset of satellite images, the research demonstrates the effectiveness of the approach in accurately identifying deforestation patterns. The project contributes to the field of deforestation monitoring by providing a reliable and efficient method for monitoring and addressing deforestation in tropical rainforests using state-of-the-art deep learning techniques.

J. R. Sanchez-Gonzalez, et al.[5] The project "Automated Deforestation Detection with Convolutional Neural Networks and Satellite Imagery"(2021)

Focuses on using convolutional neural networks (CNNs) and satellite imagery for automated deforestation detection. The study aims to develop an efficient system that can accurately identify deforestation areas by training CNN models on a dataset of satellite images.

III. EXISTING SYSTEM

This model emphasizes an existing method that which is designed using the ANN algorithm of deep learning. As the deforestation has a major impact on forest ecosystems and therefore its detection and analysis methods should be improved. Where, the classification of healthy forest and the areas of deforestation is important to recognize for which ANN is used that which can classify the deforestation area and healthy forest area.

Disadvantages of Existing System:

- Less feature compatibility
- Fixed size input and output
- Low accuracy

IV. PROPOSED SYSTEM

In our proposed method we are performing the deforestation classification using convolution neural network (CNN) of deep learning. Human-induced deforestation has a major impact on forest ecosystems and therefore its detection and analysis methods should be improved. Where, this type of detection or classification helps us to degrade the deforestations in future. In this project we are mainly focusing on the problem of deforestation, performing the classification of deforestation and the healthy forests with the help of deep learning model. CNN is the algorithm that which are been using here

for the classification process. We are preparing a dataset which is trained using the algorithm and classification will be performed in testing. The block diagram of the proposed system is shown in below figure.

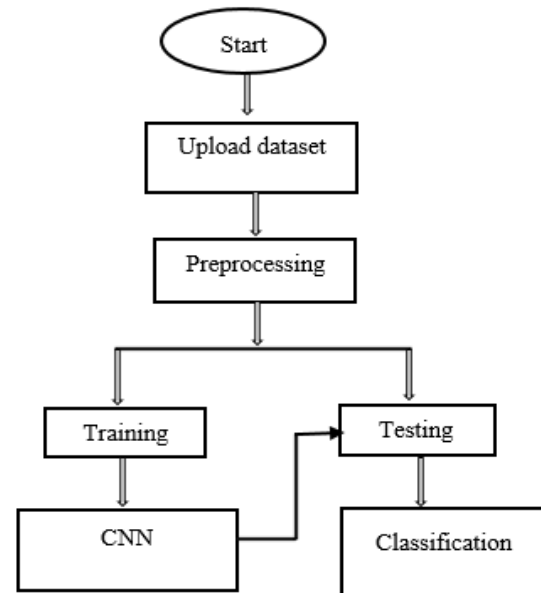


Fig.1 Block diagram of proposed method

Advantages of proposed system:

- Accurate classification
- Less complexity
- High performance

Applications:

- Image processing
- Picture retrieval
- Classifications

FUNCTIONAL REQUIREMENTS

- **Dataset Preparation:** Gather a comprehensive dataset of images containing both healthy forest and deforestation instances. The dataset should be diverse, representative of various geographical regions, and appropriately labelled for training purposes.
- **Data Pre-processing:** Implement preprocessing techniques such as image resizing, normalization, and augmentation to enhance the quality and variety of the dataset. This step helps to improve the model's performance and generalization.

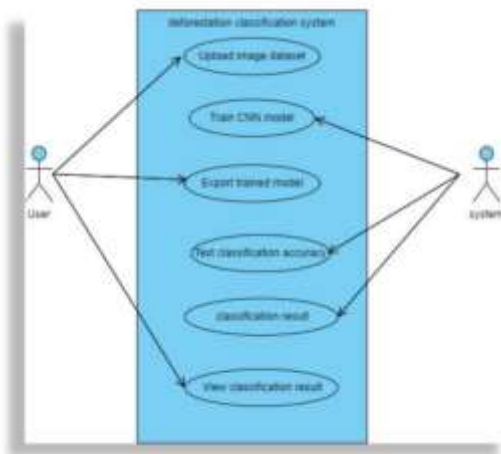


Fig.2 Use Case Diagram

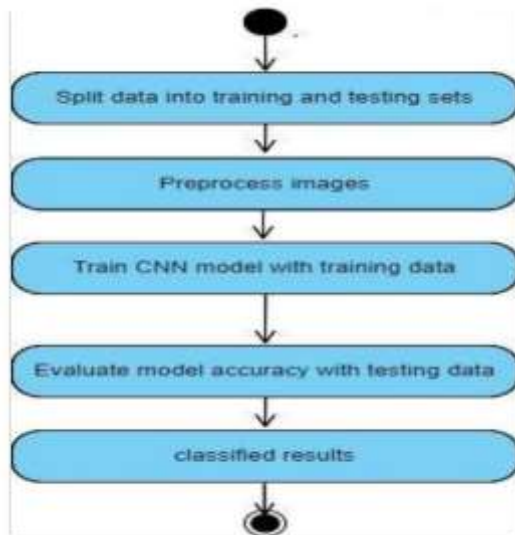


Fig.3 Activity Diagram

Model Development: Design and implement a Convolutional Neural Network (CNN) model capable of accurately classifying images of healthy forests and deforestation. The model architecture should be optimized for feature extraction and classification, considering factors such as network depth, convolutional layers, pooling layers, and activation functions.

Training and Validation: Train the CNN model using the prepared dataset, employing techniques like back propagation and gradient descent to optimize the model's weights and biases. Validate the model using separate validation data to assess its performance and make any necessary adjustments to enhance accuracy and minimize overfitting.

Testing and Evaluation: Use a separate set of test images, including unseen examples of healthy forests and

deforestation, to evaluate the trained model's performance. Measure metrics such as accuracy, precision, recall, and F1 score to assess the model's effectiveness in classifying deforestation accurately.

Deployment and Integration: Integrate the trained CNN model into a user-friendly interface or application that allows users to input images for deforestation classification. Ensure seamless deployment and efficient integration with existing systems or workflows for easy utilization. **Monitoring and Maintenance:** Establish a monitoring mechanism to continuously assess the performance of the deployed model and identify any potential issues or inaccuracies. Regularly update the model using new data to improve its classification accuracy over time.

NON-FUNCTIONAL REQUIREMENTS

Accuracy: The model should achieve a high level of accuracy in classifying images of healthy forests and deforestation. The system should strive for a low rate of false positives and false negatives to ensure reliable detection and classification.

Speed and Efficiency: The classification process should be efficient and time sensitive. The model should be able to process and classify images in a reasonable amount of time to provide real-time or near-real-time results, enabling timely decision-making and action.

Scalability: The system should be scalable to handle a growing dataset and increasing computational demands. It should be able to accommodate additional images for training and testing, as well as handle a larger number of users accessing the system concurrently.

Robustness: The model and the system as a whole should be robust and resilient to handle variations in input images, such as differences in lighting conditions, image quality, and perspectives. It should perform consistently across different environments and be able to handle noisy or incomplete data.

User-Friendly Interface: The user interface of the system should be intuitive, easy to navigate, and visually appealing. It should provide clear instructions for users, allowing them to input images and receive classification results without difficulty. The system should also provide visualizations or explanations to aid in understanding the classification outcomes.

Security and Privacy: The system should incorporate security measures to protect sensitive data, both in transit and at rest. It should comply with relevant data protection and privacy regulations to ensure the confidentiality of user information and prevent unauthorized access or misuse.

Adaptability: The system should be adaptable to changes and advancements in deep learning techniques and technologies. It should be designed in a modular and flexible manner, allowing for future updates and

In above screen loading all require python packages and classes. Packages are pandas, NumPy and Matplotlib etc.

In above graph we are finding states with more number of deforestation perform where x-axis represents state name and y-axis represents NUMBER of deforestation happen.



Fig.3 Screen reading values

In above screen reading and displaying dataset values. The dataset contain features such as country, subnational1,subnational2,thresholdvalue,area_ha,extent_2000_ha,extent_2010_ha,gain_2000_2012_ha and tc_loss_ha_2001 to tc_loss_ha_2020.

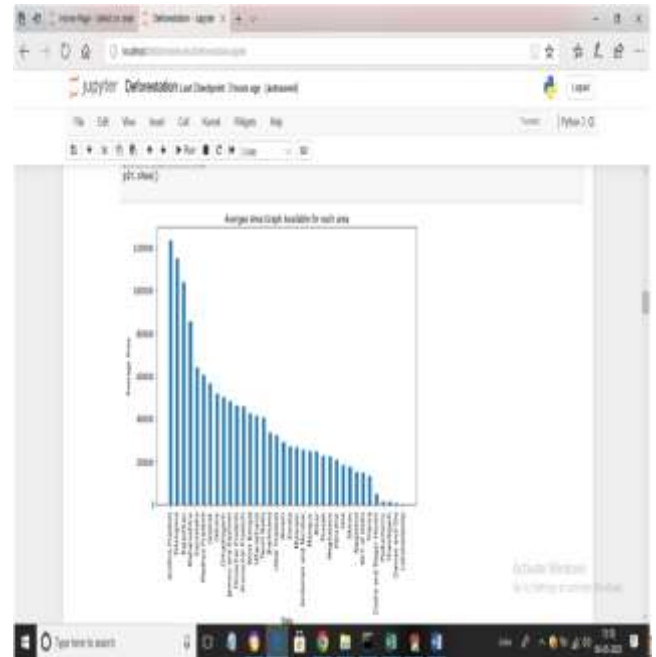


Fig.5 State and Y-axis represents screen

In the above graph, predicting total available area in HECTARE for different states where x-axis represents STATE and y-axis represents AREA in hectare.

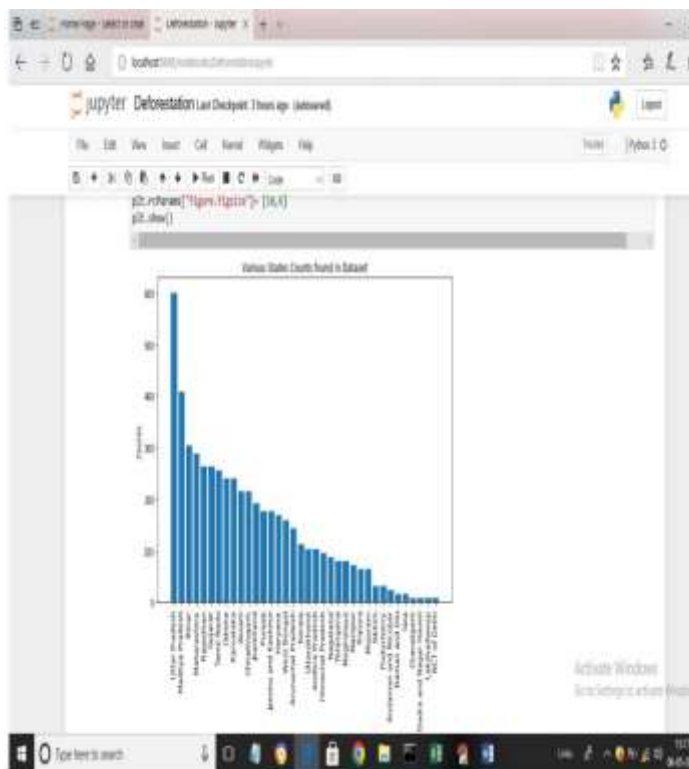


Fig.4 Y-axis Represents Screen

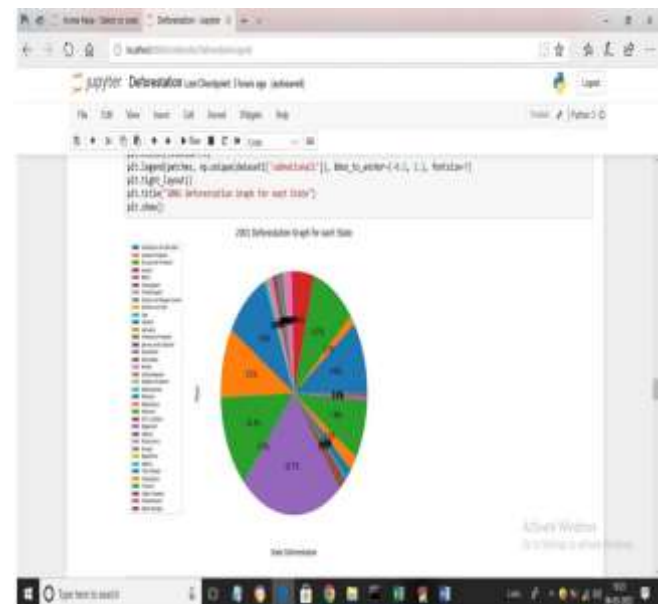


Fig.6 Plotting Percentage screen

The above graph is providing the percentage of deforestation done by each state.

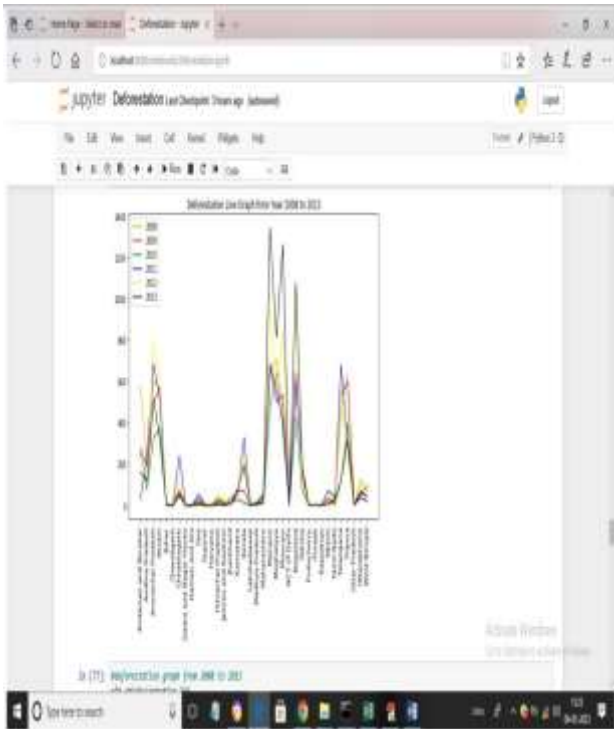


Fig.7 Graph from year 2008 to 2013

Above graph showing deforestation between year 2008 to 2013.

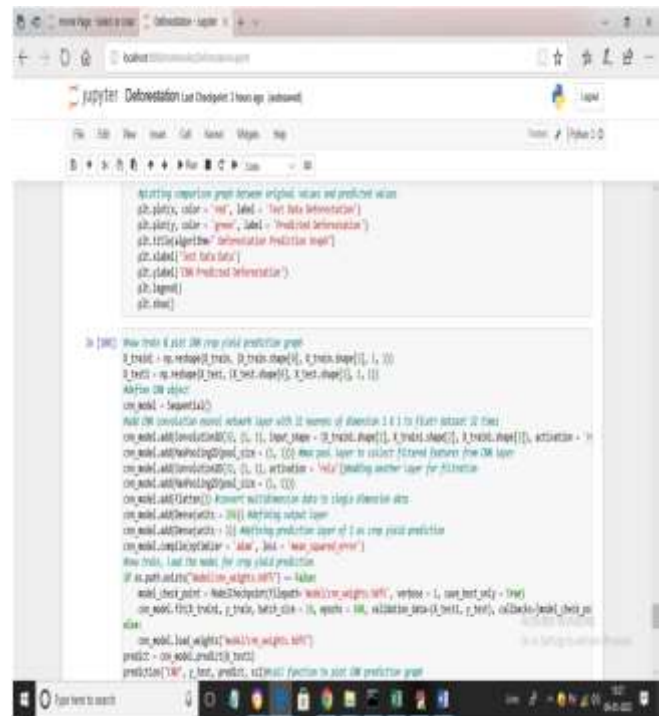


Fig.9 CNN2D Screen

In above screen shows training CNN2D algorithm with deforestation dataset and after training will get below output.

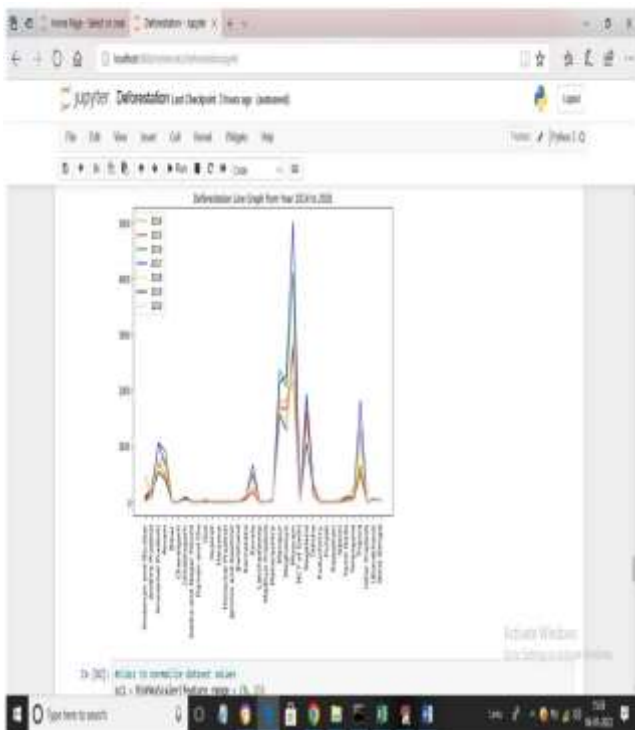


Fig.8 Graph from year 2014 to 2020

Above graph displaying deforestation between 2014 to 2020.



Fig.10 Output Screen

In above screen represents the CNN MSE (mean square error) as 0.0025. MSE refers as difference between True deforestation and Predicted deforestation so the lower the MSE the better is the algorithm. In above output we can see TEST data deforestation and CNN predicted deforestation AREA size in hectares. Below is the CNN deforestation prediction graph.

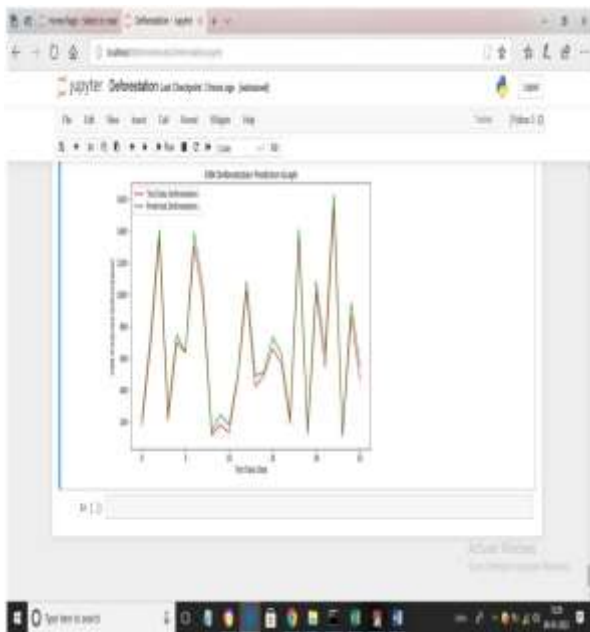


Fig.11 Output Graph

In above graph x-axis represents TEST Data count and y-axis represents size of deforestation in hectares. In above graph red line represents TEST data deforestation and green line represents CNN predicted deforestation and both lines are fully overlapping so test data and predicted data is accurate.



Fig.12 Interface screen

A user interface (UI) is the means through which users interact with a computer system or software application. It includes visual elements like buttons and windows, as well as non-graphical interfaces like command-line or voice-based interfaces. The UI allows users to input commands, receive feedback, and access the system's features and functionalities.

VI. CONCLUSION AND FUTURE SCOPE

In this section, providing the study's findings and future scope on using Convolutional Neural Networks (CNNs) to classify healthy forests and deforestation. We summarise the research's major results and contributions, emphasising the CNN model's accuracy in identifying and diagnosing deforestation. We also discuss potential areas for future research, such as improving the model's accuracy and generalisation, broadening its classification capabilities, integrating geospatial analysis, developing early warning systems, utilising data fusion techniques, and fostering collaborative platforms.

The research on classifying healthy forests and deforestation using convolutional neural networks (CNNs) shows significant potential in solving the crucial problem of deforestation brought on by human activity. The work seeks to properly recognise and distinguish between healthy forests and regions impacted by deforestation by training a CNN model using a collection of photos. This strategy can provide dependable and effective methods for regulating and monitoring deforestation to decision-makers, environmental organisations, and conservationists.

The study's future goals include improving the identification and analysis of deforestation. It entails improving the CNN model's accuracy and generalisation, extending its classification skills to incorporate numerous classes and fine-grained categories, and incorporating real-time monitoring systems for prompt intervention. Geospatial analysis, early warning systems, and data fusion methods may also be used to increase the study's effect. By following these future paths, the research may considerably help to deforestation prevention and control. Through collaborative platforms, it may give useful insights for policymaking and decision support, while also encouraging information exchange and coordinated approaches. Finally, these activities may help to promote sustainable forest ecosystems and biodiversity conservation efforts.

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