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ENHANCED WATER BODY SEGMENTATION VIA HIERARCHICAL NEURAL NETWORKS

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ABSTRACT

Segmentation of water bodies from remote sensing satellite images is crucial for processing and analysis. Efficiently extracting water body features is essential for various real-time applications such as water resource allocation, ecological services assessment, monitoring systems for water resource protection, and identification of flooding disasters. The interpretation of satellite images and the random extraction of water bodies are emerging tasks in remote sensing. Convolutional Neural Networks (CNNs) have shown promise in various remote sensing applications, including efficient segmentation of water bodies from satellite images. Several CNN-based approaches have been proposed for this purpose. Multi-scale Water Extraction CNN (MWEN) stands out as a particularly effective method for segmenting water from Geo-Fan-2 (GF-2) sensing satellite images. However, addressing the automatic extraction of water body segmentation from satellite images remains challenging due to the sparse arrangement of boundary pixels and the large number of training samples required. To enhance the performance of automatic water body segmentation from satellite images, we propose a Novel Optimized Multi-Feature Contour-based Hierarchical Neural Network (NOMFCHNN). NOMFCHNN incorporates expanding neural network features and layers inspired by inception models, which provide crucial information about network localization. This approach employs pixel matching with extended feature extraction. Extensive experiments on combined satellite image repositories demonstrate that our proposed approach improves segmentation accuracy and other key parameters compared to state-of-the-art methods for remote sensing satellite images.

Indexed Words: Water Body Segmentation System, Satellite Image Analysis, Feature Detection, Image Processing, Performance Evaluation, Remote Sensing, Data Analysis.

INTRODUCTION

Feature detection plays a pivotal role in satellite image analysis, serving as the foundational step in numerous applications, including stereo vision and water body segmentation systems. The detection of corners, blobs, and other distinctive features is a subject of extensive research, resulting in a plethora of methodologies documented in the literature. In our study, we delve into this domain by implementing three widely recognized algorithms specifically tailored for water body detection. These algorithms encompass the renowned Harris corner detector, the robust SIFT descriptor, and various operators designed to identify interest-point features within satellite images. Our report aims to provide a comprehensive overview of these techniques, elucidating their underlying principles and discussing their applicability in the context of water body detection. Furthermore, we meticulously detail the experimental setup employed to evaluate the performance of each algorithm. By conducting rigorous experiments and analyses, we aim to ascertain the detection rates and contrast values achieved by each method. This empirical assessment enables us to draw insightful comparisons between the different approaches and identify the most effective technique for water body detection. Ultimately, our findings contribute to advancing the field of satellite image analysis by providing valuable insights into the strengths and limitations of various feature detection algorithms in the context of water body detection.

High-resolution satellite remote sensing technology has revolutionized our ability to observe and analyze Earth's surface, offering unprecedented insights into various geographic phenomena. Among these, the detection and delineation of water bodies play a pivotal role in environmental monitoring, resource management, and disaster mitigation efforts. However, accurately extracting water bodies from satellite images remains a challenging task due to the complexity of the imagery and the inherent difficulties associated with differentiating water from other features.

In response to this challenge, this research proposes a novel approach to water body segmentation in satellite remote sensing images. Building upon advancements in multi-scale feature extraction and contour detection techniques, our methodology aims to improve the accuracy and efficiency of water body identification in complex satellite imagery.

The proposed method encompasses several key components:

1. High-Resolution Multi-Scale Feature Extraction: Our approach leverages multi-scale feature extraction to capture both local and global information from satellite images. By integrating low-level and high-level pixel data through a convolutional neural network (CNN), we aim to enhance the discriminating power of our feature representation.

2. Optimized Contour Detection-Based Segmentation: We introduce an optimized contour detection-based segmentation technique to achieve fine-grained delineation of water bodies. By refining the segmentation process at multiple scales, our method aims to produce more precise and accurate delineations of water bodies, even in regions with complex boundaries.

3. Innovative Water Body Segmentation Calculation: Our methodology incorporates a novel water body segmentation calculation method based on associative pixel matching. By exploiting associations between neighboring pixels, we seek to improve the performance of water body segmentation, particularly in regions with sparse boundary pixels or complex terrain.

4. Optimized Pixel Connection Strategy: To evaluate the segmentation process and classify segmented images, we employ an optimized pixel connection strategy. This approach facilitates the efficient identification of foreground and background pixels, enabling us to delineate water bodies with greater clarity and accuracy.

Through extensive experiments conducted on a diverse set of satellite images, including those from a novel satellite image repository, we demonstrate the effectiveness of our proposed approach. Our methodology achieves superior segmentation accuracy and outperforms existing techniques in capturing various water-related parameters from satellite imagery.

In summary, our research presents a comprehensive and innovative framework for water body segmentation in satellite remote sensing images, offering valuable insights and practical applications for environmental monitoring, resource management, and disaster response efforts.

Purpose of the Project:

A **satellite images retrieval** system is a computer system for browsing, searching and retrieving satellite images from a large database of digital satellite images. Most traditional and common methods of satellite images retrieval utilize some method of adding metadata such as captioning ', keywords or descriptions to the satellite images so that retrieval can be performed over the annotation words. Manual satellite images annotation is time-consuming, laborious and expensive; to address this, there has been a large amount of research done on automatic satellite images annotation additionally, the increase in social web applications and the semantic web have inspired the development of several web-based satellite images annotation tools.

Literature Work

1. **Authors :** Anatoly P. Shevyrnogov et al.,
   Title of the Paper: Application of Satellite Data for Investigation of Dynamic Processes in Inland Water Bodies - Lake Shira (Khakasia, Siberia).
   Implementation & techniques used: This work describes avenues to use satellite information to analyze dynamic processes in aquatic ecosystems was retrieved from AVHRR satellite sensor data. This study represents the first evaluation of the dynamic processes for Lake Shira based on satellite, ground-truth and modelling data. They developed CNN algorithms and various software to process satellite images to enable the reconstruction of time dependence of temperature and spectral reflectance of water bodies in the visible range, and to make computer-animated films visualizing the spatial and temporal dynamics of the study parameters.
2. **Authors :** Yanjun Wang et al.,
   Title of the Paper: Lightweight Deep Neural Network Method for Water Body Extraction from High-Resolution Remote Sensing Images with Multisensors.
   Implementation & techniques used: In this paper, a water body extraction method based on lightweight MobileNetV2 is proposed and applied to multisensor high-resolution remote sensing images, such as GF-2, WorldView-2 and UAV orthoimages. This method was validated in two typical complex geographical scenes: water bodies for farmland irrigation, which have a broken shape and long and narrow area and are surrounded by many buildings in towns and villages; and water bodies in mountainous areas, which have undulating topography, vegetation coverage and mountain shadows all over. The results were compared with those of the support vector machine, random forest and U-Net models and also verified by generalization tests and the influence of spatial resolution changes.
3. **Authors:** Zhang et al.,
   Title of the Paper: Blending MODIS and Landsat images for urban flood mapping.
   Implementation & techniques used: However, the trade-off between spatial and temporal resolutions of current satellite sensors limits their uses in urban flooding studies. This study applied and compared two data fusion models, the Spatial and Temporal Adaptive Reflectance Fusion Model (STARFM) and Enhanced Spatial and Temporal Adaptive Reflectance Fusion Model (ESTARFM), in generating synthetic flooding images with improved temporal and spatial resolution for flood mapping. The synthetic images are produced in two scenarios: (1) for real-time prediction based on Landsat and MODIS images acquired before the investigated flooding; and (2) for post-disaster prediction based on images acquired after the flooding.
4. **Authors:** Barton, I.J. Bathols, J.M.
   Title of the Paper: Monitoring floods with AVHRR
   Implementation & techniques used: During 1988 the movement of a flood down the Darling River in central eastern Australia was monitored using AVHRR imagery. During the observation period the thermal channels at night gave better contrast between the flood and the surrounding land than the visible and near

infrared channels during the day. The AVHRR is suitable for monitoring such floods as there is typically very little cloud cover over the area and, during the night, the contrast between the water temperature and the surrounding land is large. Although the spatial resolution of the AVHRR is 1 km, it has been possible to make some estimate of the area covered by the flood.

5. **Authors :** Gang Zhao et al.,
   Title of the Paper: An enhanced inundation method for urban flood hazard mapping at the large catchment scale
   Implementation & techniques used: The main highlights are EIM was proposed for urban flood hazard mapping at the large catchment scale. SWMM model was introduced in floodwater generation process. Floodwater spreading was based on topological relation of depression outlets. Floodwater from lower depression elements was considered in EIM. The performance of EIM was validated in terms of inundation locations and depths.

Existing and Proposed Work

High resolution based satellite remote sensing is the advance emerging technology, different types of unnamed aria related images are collected to present novel challenge to geographic related workers. Interpretation of image is an emerging research filed in remote sensing results and used in different applications like mapping of digital, monitoring of urbanization, monitoring of water resources in satellite images and environment related to different resources.Extraction of water body from remote sensing satellite images is significant and emerging concept in monitoring of different water resource application. Multi scale water extraction CNN (MWEN) is one of the best CNN approach to handle segmentation of water extraction from Geo-Fan-2 (GF-2) sensing images. But it is not sufficient to explore automatic extraction of water body segmentation from satellite remote sensing images because of sparse arrangement of boundary pixels and high amount of training sensing image samples. Due to this work we are facing some challenges such as

- Less Accuracy
- More Time Duration
- Poor Performance

To overcome this we are presenting high resolution based multi scale feature extraction to explore bodies of water from satellite remote sensing images at complex frames. Present optimal multi scale feature is define to explore receptive feature data from low level and high level pixel with basic representation of encoding and decoding in feature extraction with CNN. Present optimized contour detection based multi scale feature extraction to employs fine gained segmentation of water body with approximate and accurate segmentation results from different labels Present a novel water body segmentation calculation method which is performed based on associative pixel matching and improve the performance. Implement optimized pixel connection approach to evaluate the process of foreground and background of image pixels and classify the segmented image with outline water body. Experiments performed on novel satellite image repository prove proposed approach and it achieves maximum segmentation accuracy and all relative water related parameters of segmentation of satellite images. The benefits of our proposed work compared to existing work is

- More Accuracy
- Less Time Duration
- High Performance

Architecture

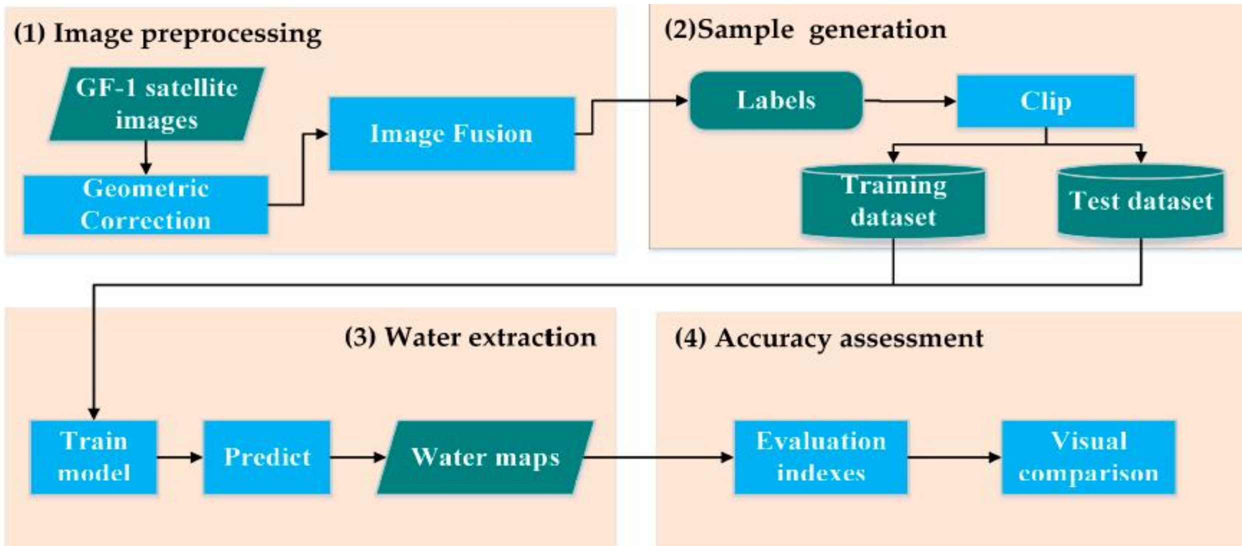

Figure 1: Architecture of our Project

Algorithm

Input: satellite image, sample binary mask image, ($\hat{u}_1(h)$)($\hat{u}2(h)$).

Output: segmented image with water body extraction

S1: Based on above equations evaluate multi scale feature instance from image

S2: identify the feature distance of each pixel present in satellite image and define classify the region is

$$R = \left\{h \mid \left(\hat{u}(h) > \hat{u}(h-1)\right) \& \left(\hat{u}(h) > \hat{u}(h+1)\right)\right\}$$

Where R be the Region of all the pixels present in water body

S3: Identify the threshold of all images with pixel locations from classified region is

$$K = \left\{h \mid \left(\hat{u}(h) > \hat{u}(h-1)\right) \& \& \left(\hat{u}(h) > \hat{u}(h+1)\right)\right\}$$

Where K be the all the pixel threshold of image based on height and weight of image

S4: Remove all the background pixels

$$\hat{u}(h+1) \neq \hat{u}(h-1)$$

S5: Check each foreground and background pixels values

If (h is high) &

Where R=R-h;

If (h is low) & $\hat{u}(h+1) \neq \hat{u}(h-1)$ then K=K-h;

S6: Based on interaction values of all the pixels in image evaluated and represented as

$$\{[1, i_1], [2, i_2], [3, i_3], \ldots, [n, i_n]\};$$

$$S_1, S_2, S_3, \ldots, S_{|n|}$$

S7: Segmented water body images like

Output Screens

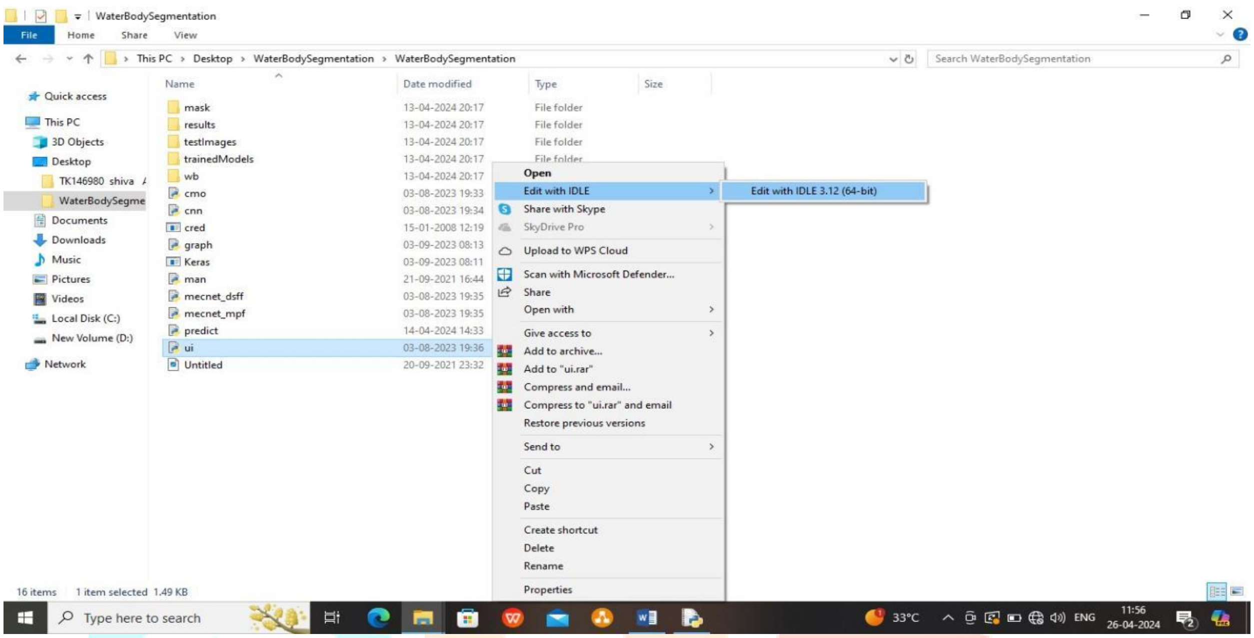

Figure 2: Select the project with Python

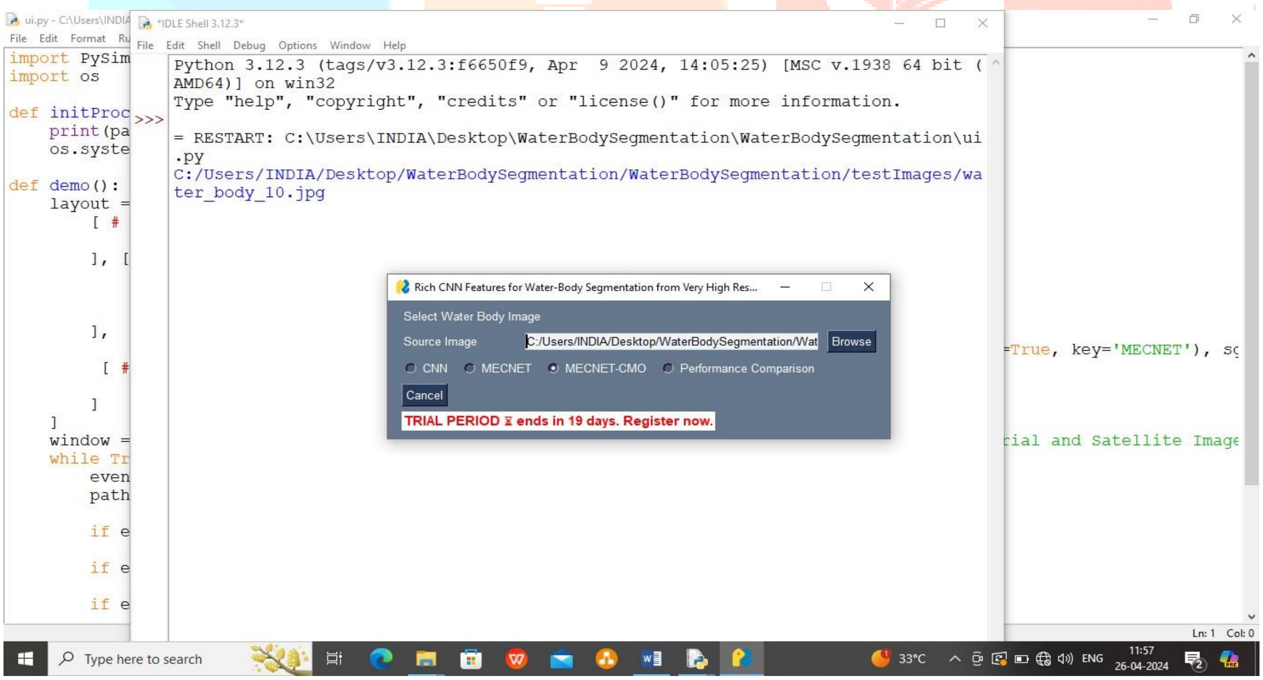

Figure 3: Browse the selected image from date source

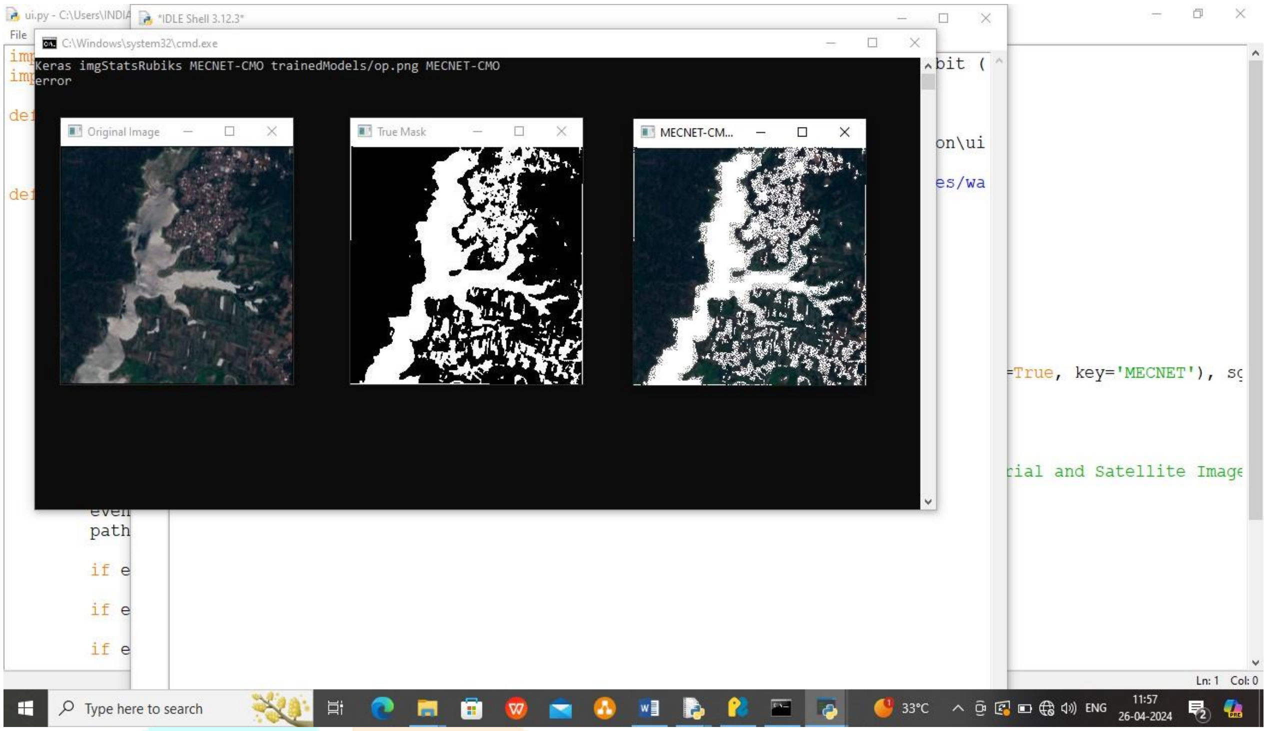

Figure 4: Water segmentation in proposed approach

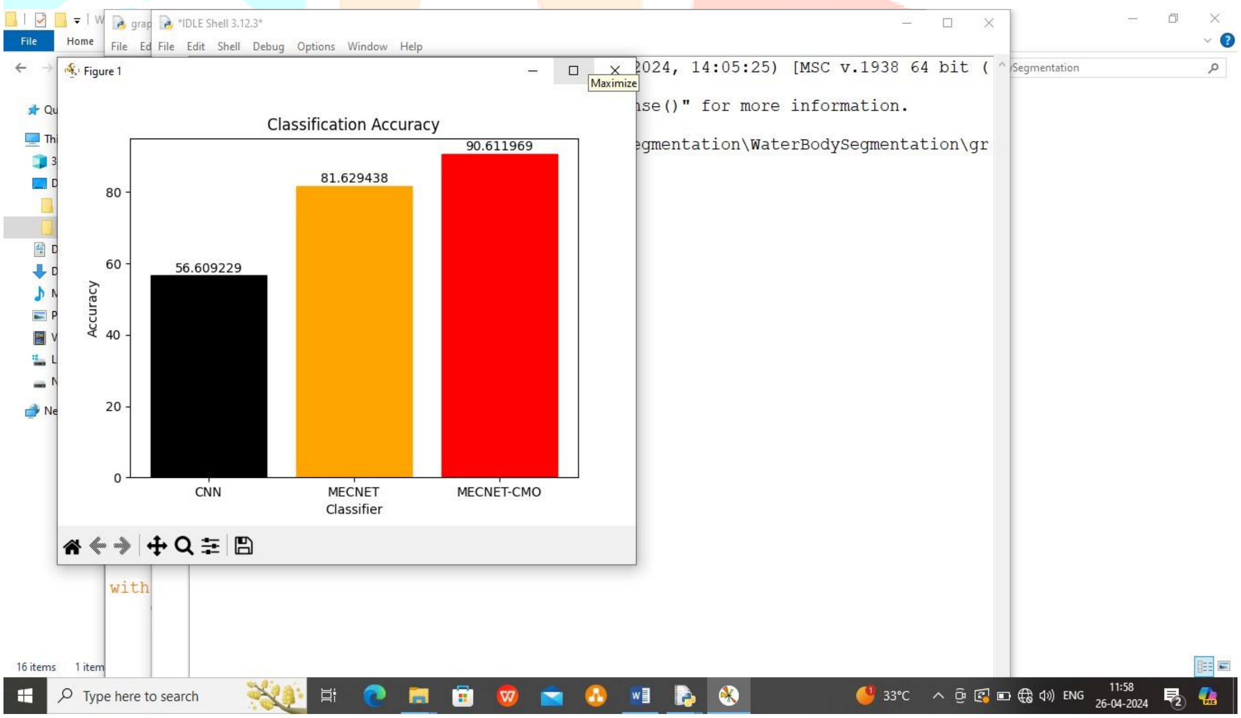

Figure 5: Classification Accuracy of our Project

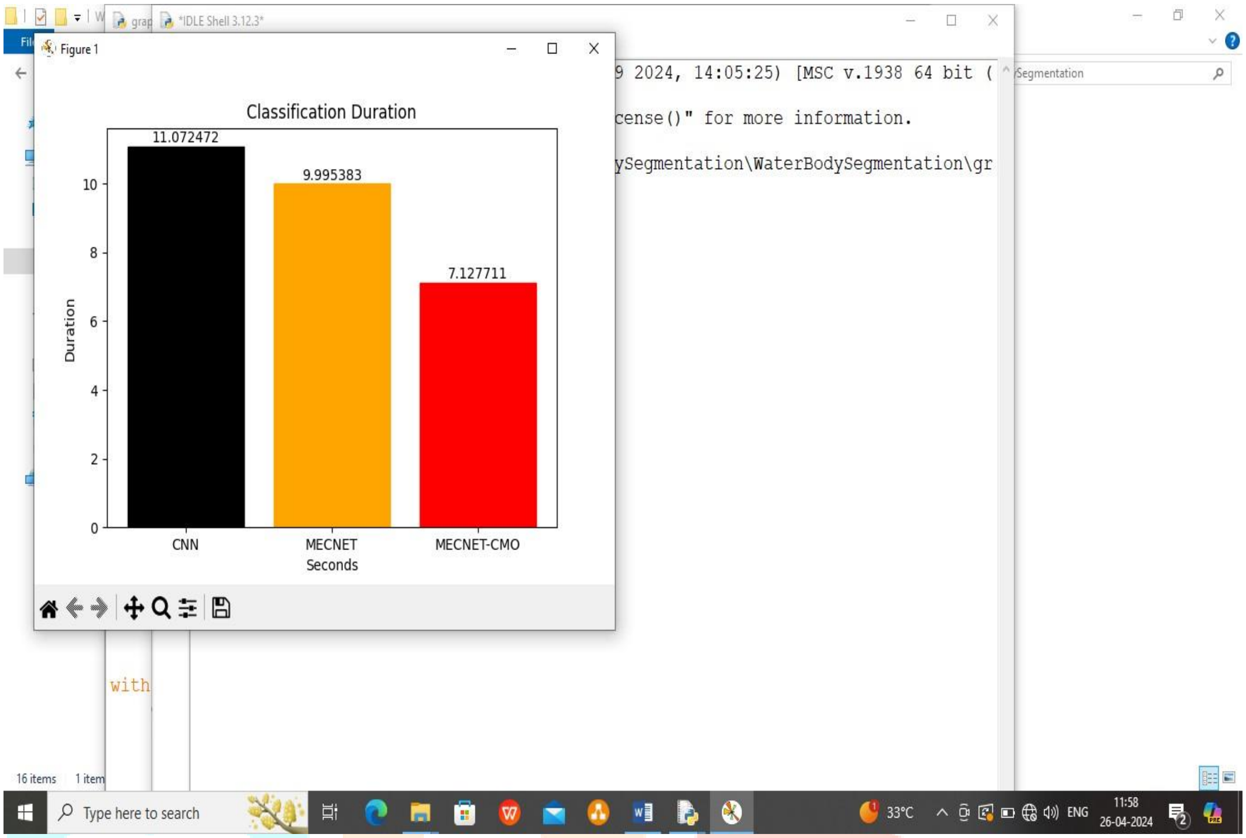

Figure 6: Classification Duration of our Project

Conclusion

In this paper, a principled approach has been proposed to extract scale-invariant water body based on color and saliency. This allows the use of color-based water body for arbitrary satellite images matching. A PCA-based scale selection method is proposed that provides robustness to scale changes. Perceptual color spaces are incorporated, and their advantages are directly passed on to the feature extraction. The use of color information allows for extracting repeatable and scale-invariant water body. Hence, more discriminative features and a sparser representation of satellite images for satellite images matching have been achieved. By reducing the number of features and providing a predictable number of sparse features, larger data sets can be processed in less time. Additionally, a stable number of features leads to a more predictable workload for such tasks. From experiments, it has been shown that the proposed color water body detector has higher repeatability than a state-of-the-art luminance-based one. Furthermore, a reduced number of color features increase the performance in satellite images retrieval. Our method gave comparable performance to the state of the art in water body categorization using only a subset of the features used for matching, reducing the computing time considerably.

Future Enhancement

NOMFCHNN represents a significant advancement in automatic segmentation of water bodies from satellite images, there remain avenues for further enhancement and exploration. One potential direction for future research is the integration of advanced data augmentation techniques to address the challenge of sparse boundary pixels and improve the model's generalization ability across diverse environmental conditions. Additionally, incorporating attention mechanisms or recurrent neural networks (RNNs) could help capture long-range dependencies and contextual information, thereby enhancing the model's ability to accurately delineate complex water bodies in satellite imagery. Furthermore, exploring semi-supervised or weakly supervised learning approaches could enable the utilization of large-scale unlabeled satellite imagery datasets, potentially improving the model's robustness and scalability. Finally, the development of efficient transfer learning strategies tailored specifically for remote sensing applications could accelerate model training and adaptation to new satellite sensor platforms. By pursuing these avenues, future research endeavors have the potential to further advance the state-of-the-art in water body segmentation from satellite imagery, ultimately benefiting a wide range of applications in environmental monitoring, resource management, and disaster response.

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