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TOPICBERT:BUILDING CHANGE DETECTION USING ATTENTION-BASED FEATURES (AFDE-Net) SATELLITE IMAGE DIFFERENTIAL ENHANCEMENT

Mrs.M.MOUNIKA[1], MATURI GAYATRI REDDY[2], GODISHALA SOWJANYA[3], SAWDA AFREEN[4]

[1] Assistant Professor, Department of Computer Science and Engineering, Sridevi Women's Engineering College, Hyderabad, India

Email: mounicamanya@gmail.com,

[2,3,4,]B.Tech Student, Department of Computer Science and Engineering, Sridevi Women's Engineering College, Hyderabad, India

Abstract: Building change detection (BCD) from satellite imagery is critical for monitoring urbanization, managing agricultural land, and updating geospatial databases. However, complex variations in building roofs that resemble the background of their surroundings pose challenges for deep-learning-based change detection methods due to their focus on color and texture. Additionally, down sampling can result in the loss of spatial information, leading to incomplete buildings and irregular output boundaries. To address these challenges, a novel Siamese network called AFDE-Net is proposed, which combines differential image features and attention modules using a learnable parameter. The AFDE- Net employs an ensemble spatial-channel attention fusion (ESCAF) module, along with a deep supervision (DS) module, to mitigate the loss of spatial information and refine deep features in high-dimensional inputs. Besides, we have created a new dataset (EGY- BCD) comprising high- resolution and multi temporal satellite images captured in four urban and coastal areas in Egypt to detect building changes. The EGY-BCD dataset includes images with complex types of change, such as tall and dense buildings with roofs that resemble the background of their surroundings, which is a challenge for deep- learning algorithms. The proposed method outperforms other methods on the EGY-BCD dataset with an overall accuracy (OA) of 94.3%, an F1-score of 88.8%, and an mIoU of 86.6%. The datasets and codes will be released at https://github.com/oshholail/EGY-BCD.

Keywords: Building Change Detection, Satellite Imagery, Siamese Network, AFDE-Net, Ensemble Spatial-Channel Attention Fusion (ESCAF) module, Deep Supervision (DS) module, High-resolution Multi-temporal Satellite Images, EGY-BCD Dataset, Urbanization Monitoring, Geospatial Databases.

1. INTRODUCTION

Building Change Detection (BCD) from multi temporal satellite imagery is a highly relevant and active research area within the fields of remote sensing and computer vision. It holds significant importance for a variety of applications, including monitoring urbanization, land management, and updating geospatial information databases. traditional change detection methods are often time-consuming

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large amounts of high-resolution satellite imagery, the task of BCD remains a challenging problem. This is due to the varying temporal conditions during image capture, as well as the diversity in appearance, geometry, and spectral characteristics of the buildings, challenges, researchers have turned to more powerful semantic segmentation methods to detect changes from bi-temporal images. One promising approach is the use of convolutional neural networks (CNNs), such as a Siamese U-Net architecture.

The field of remote sensing has witnessed significant advancements in change detection methodologies, playing a crucial role in monitoring alterations within landscapes over time. In the pursuit of enhancing change detection accuracy, researchers have explored diverse approaches and technologies. Yadav et al. [1] delve into the realm of building change detection, employing multi-temporal airborne LiDAR data, highlighting its potential applications. Melgani et al. [2] contribute valuable insights with their work on unsupervised change-detection methods for remote-sensing images, providing techniques applicable to various environmental monitoring scenarios.

Remote sensing data often involves complex analysis, and Munyati [3] explores the utility of principal component analysis (PCA) in wetland change detection, focusing on the Kafue flats in Zambia. The integration of deep learning techniques has also gained prominence, as seen in Ronneberger et al.'s U-Net [4] and Fang et al.'s SNUNet-CD [5], both leveraging convolutional networks for image segmentation and change detection in very high-resolution (VHR) imagery.

The literature is rich with resources for practitioners and enthusiasts alike. Bhattacharya and Karthikeyan's "Deep Learning for Remote Sensing Applications" [6] and Canty's "Image Analysis, Classification, and Change Detection in Remote Sensing" [7] offer comprehensive insights into the applications and algorithms of remote sensing technologies. Moreover, foundational knowledge in software engineering [8], unified modeling language [9], and object-oriented programming [10] is essential for the development and implementation of robust change detection methodologies. This dynamic interplay of traditional methods and cutting-edge technologies underscores the evolving landscape of remote sensing in understanding and monitoring changes in our environment.

2. LITERATURE REVIEW

Change detection in remote sensing plays a crucial role in monitoring environmental dynamics, urban development, and various other applications. This literature survey aims to provide a comprehensive overview of recent advancements in change detection methodologies, with a focus on multi-temporal airborne LiDAR data and deep learning approaches. Multi-Temporal LiDAR Data: Yadav et al. [1] delve into the utilization of multi-temporal airborne LiDAR data for building change detection. Their work explores the potential of LiDAR in capturing three-dimensional structural changes, offering a unique perspective for monitoring urban and rural landscapes over time.

Traditional Change Detection Methods: Melgani et al. [2] present unsupervised change-detection methods for remote sensing images, emphasizing the importance of automated techniques. Munyati [3]

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employs principal component analysis (PCA) for wetland change detection on the Kafue flats in Zambia. These traditional methods lay the foundation for understanding the challenges and limitations in change detection before the advent of deep learning.

Deep Learning Approaches: Rapid advancements in deep learning have significantly impacted change detection methodologies. Ronneberger et al. [4] introduce U-Net, a convolutional neural network (CNN), for biomedical image segmentation. This architecture's adaptability makes it relevant to remote sensing applications. Fang et al. [5] propose SNUNet-CD, a densely connected Siamese network specifically designed for change detection in very high-resolution (VHR) images. Their work showcases the potential of deep learning models in accurately identifying subtle changes in complex scenes.

Literature on Remote Sensing and Deep Learning: Bhattacharya and Karthikeyan [6] provide insights into the broader applications of deep learning in remote sensing. Their book, "Deep Learning for Remote Sensing Applications," serves as a valuable resource for understanding the theoretical foundations and practical implementations of deep learning techniques in the field. Canty [7] further contributes to the literature with "Image Analysis, Classification, and Change Detection in Remote Sensing," offering algorithms implemented in Python for image analysis.

Software Engineering Principles: In the context of implementing these algorithms, understanding software engineering principles is crucial. Pressman [8] offers insights into software engineering with a practitioner's approach, emphasizing the importance of robust and scalable software development practices. Booch et al. [9] contribute with "The Unified Modeling Language User Guide," providing a standardized approach to modeling systems and facilitating effective communication between stakeholders.

Programming for Implementation: Lutz [10] provides a comprehensive guide on programming in Python, a language widely used in the implementation of deep learning models. Understanding programming principles is essential for researchers and practitioners aiming to apply and extend existing change detection algorithms. Conclusion: This literature survey highlights the evolving landscape of change detection in remote sensing, emphasizing the integration of multi-temporal LiDAR data and the transformative impact of deep learning approaches. The combination of traditional methods, deep learning architectures, and software engineering principles forms a holistic approach for researchers and practitioners aiming to contribute to this dynamic field. As technology continues to advance, interdisciplinary collaboration and a solid understanding of both remote sensing and computational methods will be essential for pushing the boundaries of change detection accuracy and efficiency.

3. METHODOLOGY

In literature they introduced a new method for automatic building change detection using multi-temporal airborne LiDAR data. Their method uses the concept of height entropy to identify building change areas. The experiments were performed using LiDAR data from 2012 and 2014. The method also minimizes commission errors related to vegetation

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changes. In another work they introduced a deep learning model called DMINet, which is designed for change detection (CD) tasks in remote sensing images. Their model uses a multilevel feature aggregation technique with deep supervision in the optimization process to aggregate difference features from three levels. Their model outperforms other CD models in terms of both efficacy and efficiency, asshown in experiments conducted on four representative CD datasets. The datasets include LEVIR-CD, which includes 20,000 orthographic aerial pairs with a spatial size of 256 × 256 and a spatial resolution of 0.5 m, and SYSU-CD, which covers various types of targets in addition to buildings, such as vessels, roads, and vegetation.

Drawbacks:

1. DMINet, does not explicitly mention the use of attention modules to enhance feature representation. This indicates that DMINet might not be as effective at highlighting crucial features, potentially leading to suboptimal performance in complex change detection scenarios.

2. DMINet's multilevel feature aggregation may not effectively preservespatial information, which could result in reduced accuracy in identifying spatially significant changes.

3. DMINet's focus on building change detection could hinder its ability to generalize and detect changes in diverse objects or scenarios.

We propose a novel Siamese network called AFDE-Net, which combines differential image features and attention modules using a learnable parameter. The AFDE-Net employs an ensemble spatial-channel attention fusion (ESCAF) module, along with a deep supervision (DS) module, to mitigate the loss of spatial information and refine deep features in high-dimensional inputs, enabling highly accurate detection of changes in buildings in a binary format. Besides, wehave created a new dataset (EGY-BCD) comprising high-resolution and multi temporal satellite images captured in four urban and coastal areas in Egypt to detect building changes. The EGY-BCD dataset includes images with complex types of change, such as tall and dense buildings with roofs that resemble the background of their surroundings, which is a challenge for deep-learning algorithms. We conduct a comprehensive evaluation of the proposed method on the EGY-BCD and WHU datasets, in comparison to other baseline methods to assess its performance.

Benefits:

1. We integrates attention modules to enhance feature representation, improving the model's ability to capture important spatial and channel information for accurate change detection.

2. AFDE-Net's ensemble spatial-channel attention fusion (ESCAF) module effectively preserves spatial information, leading to improved accuracy in detecting spatially significant changes.

3. AFDE-Net demonstrates its capability to perform well on a diverse and challenging

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dataset (EGY-BCD), showcasing adaptability to complex change detection scenarios.

4. AFDE-Net's attention-based approach and deep supervision allow it to effectively detect changes in various objects and scenarios.

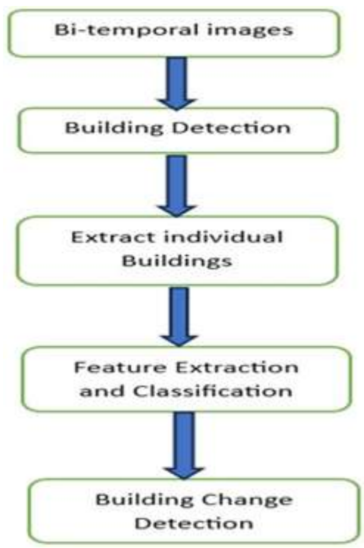

Fig 1 System Architecture

Modules:

The modules are:

- Data exploration: Using this module we will load data into system.
- Processing: Using the module we will read data for processing.
- Splitting data into train & test: Using this module data will be dividedinto train & test.
- Model generation: Building the model - AFDE NET – YOLOV5.Algorithms accuracy calculated.
- User signup & login: Using this module will get registration and login.
- User input: Using this module will give input for prediction.
- Prediction: Final predicted displayed.

4. IMPLEMENTATION

AFDE-Net

The AFDE-Net employs an ensemble spatial-channel attention fusion (ESCAF) module, along with a deep supervision (DS) module, to mitigatethe loss of spatial information and refine deep features in high-dimensional inputs

Besides, we have created a new dataset (EGY-BCD) comprising high-resolution and multitemporal satellite images captured in four urban and coastalareas in Egypt to detect building changes.

YOLO v5

YOLO v5 uses a new method for generating the anchor boxes, called"dynamic anchor boxes." It involves using a clustering algorithm to group the ground truth bounding boxes into clusters and then using the centroids of the clusters as the anchor boxes.

5. EXPERIMENTAL RESULTS

Dataset Description:

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The The EGY-BCD (Egypt Building Change Detection) dataset is a new dataset created for the purpose of building change detection from satellite imagery. The dataset is designed to address challenges posed by complex variations in building roofs, such as those resembling the background of their surroundings. The dataset comprises high-resolution and multi-temporal satellite images captured in four urban and coastal areas in Egypt.

Key characteristics of the EGY-BCD dataset:

Geographical Coverage: The dataset covers four urban and coastal areas in Egypt.

Imagery Types: The dataset includes high-resolution satellite images.

Multi-temporal images are provided, capturing changes over time.

Challenging Scenarios: Complex types of building changes are present in the dataset.

Tall and dense buildings with roofs that resemble the background of their surroundings are specifically included to challenge deep-learning algorithms.

Change Types: Various types of building changes are represented in the dataset, contributing to the complexity of the task.

Dataset Size:The dataset is of a significant size, providing enough samples to train and evaluate deep-learning models effectively.

To facilitate the development and evaluation of change detection methods, the proposed AFDE-Net method is introduced. AFDE-Net is a Siamese network that combines differential image features and attention modules using learnable parameters. The model employs an Ensemble Spatial-Channel Attention Fusion (ESCAF) module and a Deep Supervision (DS) module to address challenges related to spatial information loss and feature refinement in high-dimensional inputs.

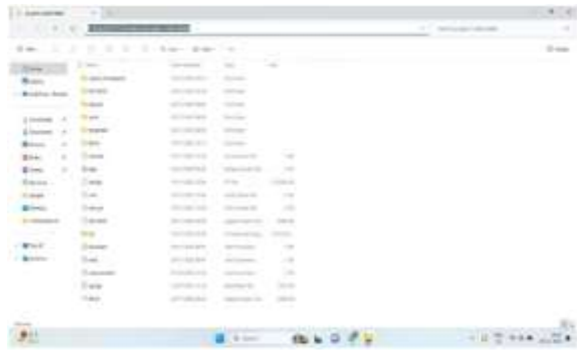

Fig 2 Path for Link Generation

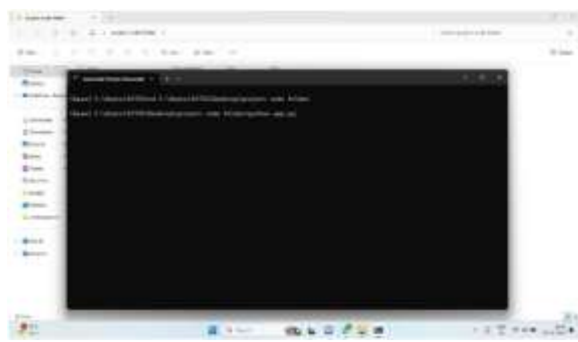

Fig 3 Anaconda prompt

Fig 4 URL

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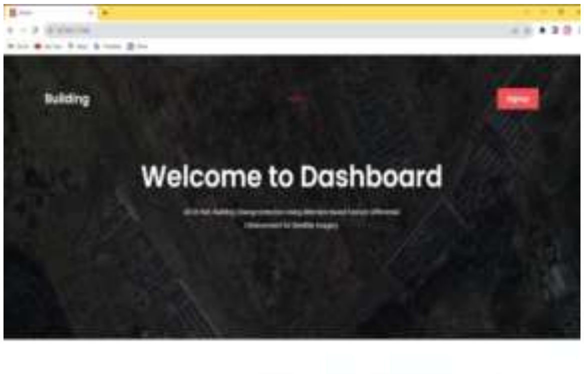

Fig 5 Link for website

Fig 6 Signup Credentials

Fig 7 Login Credentials

Fig 8 Upload image

Fig 9 Select image

Fig 10 Output image

6. CONCLUSION

CONCLUSION

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In this work, we proposes a novel approach to detecting changes in buildings from high-resolution satellite imagery using a deep Siamese network based on attention-based FDE, referred to as AFDE-Net. Additionally, we introduce a new dataset, named EGY-BCD, to assess the effectiveness of our proposed method. The experimental findings on the EGY- BCD dataset demonstrate the efficacy of our approach, with an high F1-score and mIoU, respectively, on the test set. These results indicate that our approach exhibits strong performance in building boundary completion and performs well on the EGY-BCD dataset. Furthermore, we observed that the best performance of F1 by AFDE-Net on EGY-BCD is lower than the WHU dataset according to the test set.

FUTURE ENHANCEMENTS

Furthermore, we observed that the best performance of F1 by AFDE-Net on EGY- BCD is lower than the WHU dataset according to the test set. Nonetheless, it should be acknowledged that there remains scope for further enhancement, such as enhancing the ground-truth data labels of the EGY-BCD dataset to improve the model's accuracy in detecting changes in small buildings. Additionally, our future work aims to expand the EGY- BCD dataset to include additional cities in Egypt, incorporating more complex data to improve the detection of building changes.

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