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CHANGE DETECTION OF SATELLITE IMAGE USING DEEP LEARNING FRAMEWORK

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Abstract: Change detection (CD) in multitemporal images is an important application of remote sensing. Recent technological evolution provided very high spatial resolution (VHR) multitemporal optical satellite images showing high spatial correlation among pixels and requiring an effective modeling of spatial context to accurately capture change information. Here, we propose a novel unsupervised context-sensitive framework deep change vector analysis (DCVA)for CD in multitemporal VHR images that exploit convolutional neural network (CNN) features. To have an unsupervised system, DCVA starts from a suboptimal pretrained multilayered CNN for obtaining deep features that can model spatial relationship among neighboring pixels and thus complex objects. Deep change vectors are analyzed based on their magnitude to identify changed pixels. Then, deep change vectors corresponding to identify changed pixels are binarized to obtain a compressed binary deep change vectors that preserve information about the direction (kind) of change. Changed pixels are analyzed for multiple CD based on the binary features, thus implicitly using the spatial information.

Keywords: *Change detection (CD), Deep Change Vector Analysis (DCVA), Deep Features, Multi-temporal Images, Remote Sensing, Very High-Resolution Images.*

I INTRODUCTION

Change detection (CD) in multi-temporal images is an important application of remote sensing. Recent technological evolution provided very high spatial resolution (VHR) multi-temporal optical satellite images showing high spatial correlation among pixels and requiring an effective modeling of spatial context to accurately capture change information. Here, we propose a novel unsupervised context sensitive framework deep change vector analysis (DCVA) for CD in multi-temporal VHR images that exploit convolutional neural network (CNN) features. To have an unsupervised system, DCVA starts from a suboptimal pre-trained multilayered CNN for obtaining deep features that can model spatial relationship among neighboring pixels and thus complex objects.

This paper proposes an efficient unsupervised method for detecting relevant changes between two temporally different images of the same scene. A convolutional neural network (CNN) for semantic segmentation is implemented to extract compressed image features, as well as to classify the detected changes into the correct semantic classes. A difference image is created using the feature map information generated by the CNN, without explicitly training on target difference images. Thus, the proposed change detection method is unsupervised, and can be performed using any CNN model pre-trained for semantic segmentation.

Change detection has benefits in both the civil and the military fields, as knowledge of natural resources and manmade structures is important in decision making. The focus of this study is on the particular problem of detecting change in temporally different satellite images of the same scene. Current change detection methods typically follow one of two approaches, utilising either post-classification analysis [1], or difference image analysis [2]. These methods are often resource-heavy and time intensive due to the high resolution nature of satellite images. Post-classification comparison [1] would first classify the contents of two temporally different images of the same scene, then compare them to identify the differences.

Inaccurate results may arise due to errors in classification in either of the two images, thus a high degree of accuracy is required of the classification. The second approach, and the one that is followed in this study, is that of comparative analysis which constructs a difference image (DI). The DI is constructed to highlight the differences between two temporally different images of the same scene. Further DI analysis is then performed to determine the nature of the changes. The final change detection results depend on the quality of the produced DI. Since the atmosphere can have negative effects on the reflectance values of images taken by satellites, techniques such as radiometric correction [2] are usually applied in the DI creation. Techniques used to construct a DI include spectral differencing [3], rationing [4], and texture rationing [4]. In order to construct an effective DI, a convolutional neural network (CNN) [5] is used in this study. Deep neural networks (DNNs) have been used successfully in the past to aid in the process of finding and highlighting differences, while avoiding some of the weaknesses of the classic methods [6].

This study proposes a novel way to detect and classify change using CNNs trained for semantic segmentation. The novelty of the proposed approach lies in the simplification of the learning process over related solutions through the unsupervised manipulation of feature maps at various levels of a trained CNN to create the DI. The main objective of this study is to determine the efficacy of using the feature maps generated by a trained CNN of two, similar, but temporally different images to create an effective DI. Additionally, the proposed method aims to: • Accurately classify the nature of a change automatically. • Build a model that is resistant to the presence of noise in an image. • Build a visual representation of the detected changes using semantic segmentation.

Satellite images time-series analysis algorithms have been used widely these days. Among them, there are numerous ecological applications such as the analysis and preservation of the stability of ecosystems [1], the detection and the analysis of such phenomena as deforestation and droughts, real-time monitoring of natural disasters , study of the evolution of urbanization , crop changes follow up etc. While for some applications, we can create a training database with the objects presented in satellite image time series (SITS) for others it may be a challenging task as the nature of the researched spatiotemporal phenomena is often not known, unique or, on the contrary, has a lot of variations. For this reason, unsupervised and semisupervised change detection and time-series analysis have been a hot research topic for the past years. However, not so many successful studies are available for the proposed problematic.

II LITERATURE SURVEY

2.1 Sicong Liu, Qian Du, Xiaohua Tong, AlimSamat, Lorenzo Bruzzone, Francesca Bovolo, "Multiscale Morphological Compressed Change Vector Analysis for Unsupervised Multiple Change Detection", IEEE Journal of Selected Topics in Applied Earth Observation & Remote Sensing, 2017.

Anovel multiscale morphological compressed change vector analysis (M2C2VA) method is proposed to address the multiple-change detection problem (i.e., identifying different classes of changes) in bitemporal remote sensing images. The proposed approach contributes to extend the state-of-theart spectrumbased compressed change vector analysis (C2VA) method by jointly analyzing the spectral-spatial change information. In greater details, reconstructed spectral change vector features are built according to a morphological analysis. Thus more geometrical details of change classes are preserved while exploiting the interaction of a pixel with its adjacent regions. Two multiscale ensemble strategies, i.e., data level and decision level fusion, are designed to integrate the change information represented at different scales of features or to combine the change detection results obtained by the detector at different scales, respectively. A detailed scale sensitivity analysis is carried out to investigate its impacts on the performance of the proposed method.

The proposed method is designed in an unsupervised fashion without requiring any ground reference data. The proposed M2C2VA is tested on one simulated and three real bitemporal remote sensing images showing its properties in terms of different image size and spatial resolution. Experimental results confirm its effectiveness.

2.2. Jie Ding, Yu Xiang, Lu Shen, Vahid Tarokh, "Multiple Change Point Analysis: Fast Implementation And Strong Consistency", IEEE Transaction of Signal Processing, 2016.

One of the main challenges in identifying structural changes in stochastic processes is to carry out analysis for time series with dependency structure in a computationally tractable way. Another challenge is that the number of true change points is usually unknown, requiring a suitable model selection criterion to arrive at informative conclusions. To address the first challenge, we model the data generating process as a segmentwise autoregression, which is composed of several segments (time epochs), each of which modeled by an autoregressive model.

We propose a multi-window method that is both effective and efficient for discovering the structural changes. The proposed approach was motivated by transforming a segment-wise auto regression into a multivariate time series that is asymptotically segment-wise independent and identically distributed. To address the second challenge, we derive theoretical guarantees for (almost surely) selecting the true number of change points of segment-wise independent multivariate time series. Specifically, under mild assumptions, we show that a Bayesian Information Criterion (BIC)- like criterion gives a strongly consistent selection of the optimal number of change points, while an Akaike Information Criterion (AIC)-like criterion cannot.

Finally, we demonstrate the theory and strength of the proposed algorithms by experiments on both synthetic and real-world data, including the Eastern US temperature data and the El Nino data. The experiment leads to some interesting discoveries about temporal variability of the summer-time temperature over the Eastern US, and about the most dominant factor of ocean influence on climate, which were also discovered by environmental scientists.

2.3. Sicong Liu, Lorenzo Bruzzone, Francesca Bovolo, Massimo Zanetti, Peijun Du, "Sequential Spectral Change Vector Analysis for Iteratively Discovering and Detecting

Multiple Changes in Hyperspectral Images", IEEE Transaction on Geoscience & Remote Sensing, 2015.

This paper presents an effective semiautomatic method for discovering and detecting multiple changes (i.e., different kinds of changes) in multitemporal hyperspectral (HS) images. Differently from the state-of-the-art techniques, the proposed method is designed to be sensitive to the small spectral variations that can be identified in HS images but usually are not detectable in multispectral images. The method is based on the proposed sequential spectral change vector analysis, which exploits an iterative hierarchical scheme that at each iteration discovers and identifies a subset of changes.

The approach is interactive and semiautomatic and allows one to study in detail the structure of changes hidden in the variations of the spectral signatures according to a top-down procedure. A novel 2-D adaptive spectral change vector representation (ASCVR) is proposed to visualize the changes. At each level this representation is optimized by an automatic definition of a reference vector that emphasizes the discrimination of changes. Finally, an interactive manual change identification is applied for extracting changes in the ASCVR domain. The proposed approach has been tested on three hyperspectral data sets, including both simulated and real multitemporal images showing multiple-change detection problems. Experimental results confirmed the effectiveness of the proposed method.

2.4. Sicong Liu, Lorenzo Bruzzone, Francesca Bovolo, Peijun Du, "Hierarchical Unsupervised Change Detection in Multitemporal Hyperspectral Images", IEEE Transaction on Geoscience & Remote Sensing, 2015.

The new generation of satellite hyperspectral (HS) sensors can acquire very detailed spectral information directly related to land surface materials. Thus, when multitemporal images are considered, they allow us to detect many potential changes in land covers. This paper addresses the change-detection (CD) problem in multitemporal HS remote sensing images, analyzing the complexity of this task. A novel hierarchical CD approach is proposed, which is aimed at identifying all the possible change classes present between the considered images.

In greater detail, in order to formalize the CD problem in HS images, an analysis of the concept of change is given from the perspective of pixel spectral behaviors. The proposed novel hierarchical scheme is developed by considering spectral change information to identify the change classes having discriminable spectral behaviors. Due to the fact that, in real applications, reference samples are often not available, the proposed approach is designed in an unsupervised way. Experimental results obtained on both simulated and real multitemporal HS images demonstrate the effectiveness of the proposed CD method.

2.5. Jun Geng and Lifeng Lai, "Quickest Change-Point Detection Over Multiple Data Streams via Sequential Observations", IEEE, 2018.

The problem of quickly detecting the occurrence of an unusual event that happens on one of multiple independent data streams is considered. In the considered problem, all data streams at the initial are under normal state and are generated by probability distribution P0. At some unknown time, an unusual event happens and the distribution of one data stream is modified to P1 while the distributions of the rest remain unchange. The observer can only observe one data stream at one time. With his sequential observations, the observer wants to design an online stopping rule and a data stream switching rule to minimize the detection delay, namely the time differ- ence between the occurrence of the unusual event and the time of raising an alarm, while keeping the false alarm rate under control. We model the problem under non-Bayesian quick- est detection framework, and propose a detection procedure based on the CUSUM statistic. We show that this proposed detection procedure is asymptotically optimal.

2.6. Kevin Louis de Jong, Anna Sergeevna Bosman, "Unsupervised Change Detection in Satellite Images Using Convolutional Neural Networks", in Proceedings of the IEEE, March 2019.

This paper proposes an efficient unsupervised method for detecting relevant changes between two temporally different images of the same scene. A convolutional neural network (CNN) for semantic segmentation is implemented to extract compressed image features, as well as to classify the detected changes into the correct semantic classes. A difference image is created using the feature map information generated by the CNN, without explicitly training on target difference images. Thus, the proposed change detection method is unsupervised, and can be performed using any CNN model pre-trained for semantic segmentation.

III SYSTEM ARCHITECTURE

In the proposed CD framework, we exploit a multilayered CNN designed for semantic segmentation and trained on aerial optical images (thus accepting NIR input) to obtain pixel wise multilayer deep features implicitly modeling the spatial context information of each pixels. Obtained deep features are suboptimal as they are obtained from a CNN trained on different data sets and tasks. However, they reasonably capture object-level information and the pretrained CNN weights are still useful even if they are derived on other kinds of images. We exploit those suboptimal deep features in a novel CD architecture.

The proposed CD framework is not dependent on image segmentation or explicit object detection. Object-level information is captured implicitly but effectively. CNN-based feature extraction strategy is robust to local spurious radiometric and geometric differences existing in multitemporal VHR images. Deep change vectors contain semantically rich information relevant to both binary and multiple CD. In contrast to the state-of-the-art CD methods based on deep learning, the proposed CD framework: 1) is completely unsupervised as it does not use any multitemporal image for training the CNN, thus it does not require training overhead in terms of computational time/resources; 2) exploits the recently popular deep learning paradigm to obtain multiple-change information, thus solving the challenging task of multiple CD in VHR optical images; and 3) is reusable as a new set of images does not need further training/tuning. DCVA is accomplished in the following steps:

1. Multitemporal image preprocessing
2. Multitemporal deep feature extraction
3. Deep feature comparison and selection
4. Binary CD and
5. Multiple CD

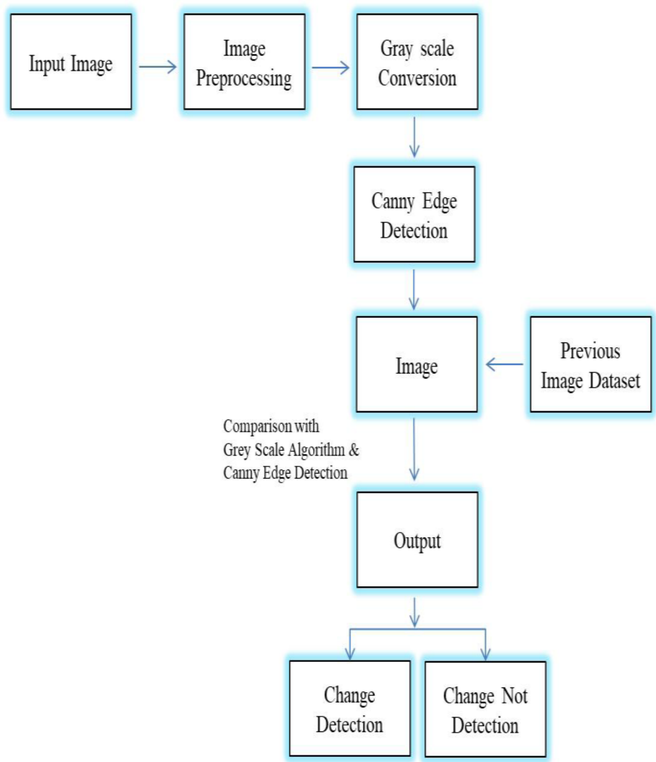

Figure 1: Architecture Diagram

However, limitations of such CNN architectures in the field of CD are as follows.

1) Pretrained CNNs are usually trained targeting RGB image classification. They are trained by the backpropagation method where an error is calculated at the final layer and is propagated back through the layers. In case of CNN architectures designed for image classification, the error is calculated based on the label of the entire image and not on pixelwise label. Thus, such networks are not trained for finer inference.

2) To obtain pixelwise features for an input image with spatial dimension RC, we have to evaluate the network RC times, each time centering on a pixel and taking a window around it as input to the CNN. Such a strategy is not computationally efficient. A possible solution to this problem is to ignore the fully connected layers and use only the pipeline of convolutional layers when extracting features. In this way, it is possible to obtain pixelwise features from input of any size at a single run. Such a solution is suboptimal as we are ignoring visual concept learned by fully connected layers when discarding them completely during feature extraction process.

3) Since fully connected layers can only deal with input of a fixed size, such architectures are restricted to accept input of predefined size only.

4) Most of the pretrained CNNs are trained to accept RGB input images, whereas satellite optical VHR images also have a near-infrared (NIR) channel that is important for CD, especially for vegetation analysis.

IV RESULT

In proposed system, data is stored on cloud. Before uploading Image on cloud, Image encrypted and then stores on cloud. While storing Image on cloud, it will take some time to write Image on cloud. In experiment, Image size considered in kb, as Image size increase required time to uploading increases exponentially Fig.1 Show how to upload image.

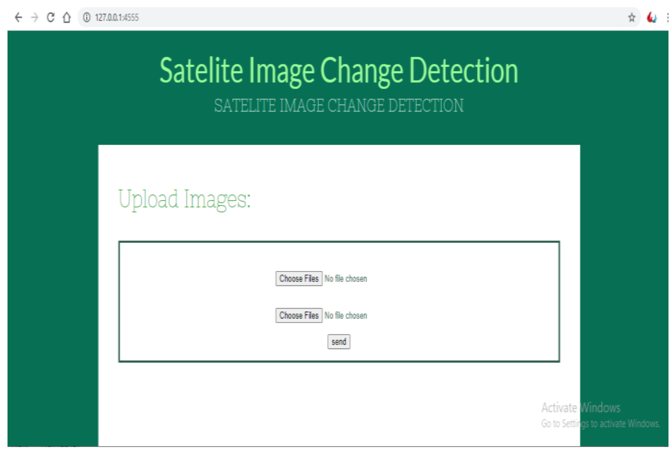

Figure 2: Image Uploading

Figure 3: Input Image

Figure 4: Original Image and Modified Image

Figure 5: Uploaded Images Result

V CONCLUSION

CNN-based unsupervised technique for detecting changes in multi-temporal VHR optical images has been proposed. We propose an unsupervised CD technique that exploits suboptimal (due to the lack of training samples) deep features extracted from a pre-trained multilayer CNN in a novel CD architecture. The proposed DCVA exploits these properties of deep features and processes those features through a layer wise feature selection mechanism that ensures that only change-relevant features are retained.

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