Segmentation and clustering of high resolution image time series

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Abstract

This paper is the continuation of the first one *Pre-state of the art article summary* in which we made a state of the art of the following topic : *Segmentation and clustering of high resolution image time*. In this paper we will briefly present again past algorithm and methods used in this field bu we will focus more on the latest method which relies on the use of Deep Auto Encoders (DEA). In order to keep this article condensed, we will analyze more the global trend in the use of image segmentation and clustering algorithm.

1 Introduction

The aim here is to analyse time series high resolution satellites images. Comparing two time-separated images allow us to identify changes and to automatically asses if those changes are trivial or not (interesting or not). Image segmentation and then clustering are already a difficult task for common images but reach a new level of difficulty when it comes to applying those algorithm to high resolution timed series data. Lack of labelled datamight also be a hurdle to model training and often forces to work on unsupervised algorithms

2 State of the art

There are many ways to perform image segmentation and clustering. A basic method was proposed in the following article [2]. The main idea in it was the use of Markov Random Fields (MRF) as a segmentation method. To achieve this goal it extract two primary features: the color of each pixels the *cartoon* (simplified image obtained after the use of MRF). The main problem with this method is that it isn't performing very well with high resolution images, this this algorithm needed to be improved to support higher image resolutions.

Another solution found was the use of Fuzzy c-mean clustering (FCM) [3]. This method takes a new property into account the *spatial information* that tends to be less sensitive to noises.

A combination of two previous methods was proposed in 2008 with the Fuzzy c-means clustering toward HMRF [4]. This article enligthed the fact that the use of MRF has a very high computational cost and perform quite poorly in presence of noise. FCM however tends to deal with noisy spot a lot better. By using a combination of both MRF and FCM they created the HMRF-FCM algorithm exploits the benefits of the two previous ones.

This algorithm is a good start but as we said we want to detect changes and perform clustering between two images, thus the implementation of a new method was needed.

As we said in the introduction, a new problem appears when it comes to comparing two images shot from spaces: they often has different alignments. Thus it was prior needed to normalize images before any analysis. Solutions were covered in the following article [5]. Many components must be considered when normalizing images such as geometric distortion (capturing 3D environment into 2D images cause distortion) and tangential scale and skew distortion caused by difference of satellite orbit and optic orientation. To achieve this task the radiometrical normalization will be used in the rest of the article.

A problem with satellite images is that it's hard to find big enough labeled dataset for algorithm training. One solution is the use of unsupervised learning algorithm and this is what most recent remote sensing image clustering has been focusing on.

3 Deep auto encoder

The latest developments in terms of remote image clustering are from this article of 2019 [6]. In this paper, authors took a concrete case : the Tohoku Tsunami in 2011 to demonstrate their algorithm. The pipeline is composed of three major steps:

1. The first step is pre-processing where we clean image, rectify their orientation (due to the nature of time series, the satellite orientation might slightly vary between each shot and this might be wrongly identified as changes so we have normalize the vertical orientation of each takes) thanks to *orthorectication*

2. Eventually group each adjacent pixels by *segments* to have a first idea of clusters of objects that might be present

3. Image from step (1) or (2) can now be used to classify and cluster objects. In this case this will be used in an unsupervised algorithm.

The main contribution of this paper is the use of Deep auto encoders. Two images Imb (before) and Ima (after) will be input in the DAE and recreate Imb' and Ima'. Image area that contains high changes will result in high error reconstruction whereas trivial changes will be easily encoded. High error will then be used to construct a mask that will be used to perform a classification.

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