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Geological Disaster Recognition on Optical Remote Sensing Images Using Deep Learning

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Abstract

Geological disaster recognition, especially, landslide recognition, is of vital importance in disaster prevention, disaster monitoring and other applications. As more and more optical remote sensing images are available in recent years, landslide recognition on optical remote sensing images is in demand. Therefore, in this paper, we propose a deep learning based landslide recognition method for optical remote sensing images. In order to capture more distinct features hidden in landslide images, a particular wavelet transformation is proposed to be used as the preprocessing method. Next, a corrupting & denoising method is proposed to enhance the robustness of the model in recognize landslide features. Then, a deep auto-encoder network with multiple hidden layers is proposed to learn the high-level features and representations of each image. A softmax classifier is used for class prediction. Experiments are conducted on the remote sensing images from Google Earth. The experimental results indicate that the proposed *wav*DAE method outperforms the state-of-the-art classifiers both in efficiency and accuracy.

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Keywords: target recognition; deep learning; remote sensing image

1. Introduction

Geological disasters always affect the development of human society and economic progress [1]. Landslide is a serious natural disaster next only to earthquake and flood, which accounts for 50% - 90% of the total number of the geological disasters each year [2]. Thus, landslide recognition is of vital importance in disaster prevention, disaster monitoring and other applications [3]. Most of the existing research in landslide

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recognition focuses on synthetic aperture radar (SAR) images. Comparing with SAR images, optical remote sensing images have higher resolution and richer contents, which provide us more chances to recognize landslide disasters. Although some valuable studies have been conducted in the field of landslide disaster recognition, those research fruits are only applicable for SAR images rather than optical remote sensing images. As the number of satellite increases, the volume of optical remote sensing images is increasing dramatically. Therefore, automatic landslide recognition on optical remote sensing images has become a research hot spot in recent years [4, 5, 6].

Deep learning is a hot topic in machine learning and artificial intelligence, which imitates the mechanism of human brain in interpreting data [7]. Recently, deep learning showed great promise in many practical applications. For example, Google and Microsoft reduced the error rate of speech recognition by 20% - 30% by using deep neural network in 2012 [8]. Krizhevsky *et al* [9] used convolutional neural network (CNN) in ImageNet large scale visual recognition challenge (ILSVRC) in 2012, where the error rate of the first 5 options was reduced from 26.2% to 15.3%. By using CNN as the deep learning model, the DeepID project of Chinese University Hong Kong [10] achieved 97.45% accuracy in the outdoor face recognition database, and the DeepFace project of Facebook [11] achieved 97.35%, respectively. Then, the DeepID2 project of Chinese University Hong Kong improved the accuracy of the deep CNN model to 99.15% [12]. Based on the successful applications in the problem of object recognition, deep learning is promising in landslide disaster recognition.

Therefore, in this paper, we would like to explore disaster recognition on optical remote sensing images using deep learning based model and method. Particularly, auto-encoder has the ability to learn features from a large number of unlabeled samples with unsupervised learning. So we use deep learning model based on auto-encoder in our work. The proposed landslide recognition method consists of two phases, pre-processing (normalization and wavelet coefficients) and classification model training (landslide feature representation and recognition). The contribution of this paper can be summarized as follows:

1) Introduced 2-D wavelet coefficients in landslide raw images processing;

2) Implemented the deep auto-encoder network model;

3) Introduced corruption into the training model.

In order to demonstrate the performance of our proposed model, support vector machine (SVM) and artificial neural network (ANN) are implemented as the counterparts. Experiments were performed on a set of optical remote sensing images downloaded from Google Earth. Higher recognition rate was achieved by using our deep learning based method when comparing with SVM and ANN.

The rest of this paper is organized as follows. Section 2 overviews some related work on geological disaster recognition. Section 3 briefly introduces the basic deep auto-encoder algorithm. Section 4 describes the details of proposed model and method. Section 5 presents the experimental results and performance analysis. Section 6 summarizes the work and point out the future work.

2. Related Work

Research on geological disaster detection and recognition on remote sensing images has been conducted in recent years. For example, Japan and some European countries have made some achievements in landslide mapping, disaster monitoring and analysing, early warning, etc. [15]. Most of the methods for landslide detection and recognition include artificial visual interpretation [16], object oriented method and statistical model based methods.

In 1990’s and the first decade in the 20th century, high resolution aerial images were applied in landslide detection and recognition. With the emergence of high resolution remote sensing satellites, optical remote sensing images are being used in landslide detection and recognition. Object oriented method was proposed. For example, Barlow et al. [17] used object oriented method to detect landslide in Landsat ETM+ images in Cascade mountain area, and recognize landslide with the aid of digital elevation model (DEM) data. Martin et