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A Review on Landslide Detection Methods

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Abstract: Landslides are becoming most frequent and severe natural disasters in world wide. Landslide causes a huge damage for both human life and economy. There are various qualitative methods for detection of landslides. The goal of this paper is to discuss the various method involving neural network, segmentation and wireless sensor approach that have been proposed.

Keywords: Pixel-based analysis, Object Based Image Analysis (OBIA), Wireless sensor, Deep learning

I. INTRODUCTION

Landslide is an extreme natural phenomenon that takes a heavy toll on human life and property leaving far reaching consequence not only on economy but also nature and ecosystem of the affected region. Landslide susceptibility analysis can be helpful in such case as certain preventive measures can be taken in time to minimize future threat to human life in the best possible way.

There several methods for the detection of landslides based on wireless sensor method and image processing. There are several limitation in wireless sensors such as how to employ the sensors, life time etc. Due to the reason image processing more referred to detect the landslides. Related methods for the processing of optical and satellite images enable to exploit the abundant data more efficiently and with greater accuracy. Unmanned aerial and digital cameras have become more affordable and related photogrammetric processing methods have reached a higher degree of automation accessible also to no experts in the field of photogrammetry. Some methods require bi-temporal aerial photographs satellite images or point clouds while others rely on post-event datasets. There are research classifies methods into three groups: pixel-based, object-based, wireless sensor networks and deep learning.

II. PIXEL-BASED METHODS

Fern´andez *et al* [3] multi-spectral information and texture analysis are considered for classification, segmentation and GIS analysis is used for calculating correlation between images. By using histogram corner thresholding algorithm and rectangularity-filtering detection is analysed in [4]. The pre-processing sequence adopted such as orthorectifying and radiometrically for normalising the raw image In [7], pixel resolution difference is considered from linear-discriminant analysis, Factor analysis, Principal component analysis; residual analysis. In [9] 3D model of a landslide is obtained using structure from motion (SFM) process from aerial photographs. The COSI-Corr image correlation algorithm was applied to compute the horizontal displacements of landslide features. In [10] multivariate statistical technique and terrain classification model were used for training and validation of satellite images of landslide area. In [15] video data were used to obtain feature vector and super pixel segmentation method used analysis. In [16] otsu binary threshold algorithm and multi-scale segmentation voting decision algorithm are used in bi-temporal images. In [17] post and pre landslide events acquired from sentinel –SAR C band images are used for measuring the change in amplitude and coefficient in slant range. The changes in image are identified using photointerpretation method. The detection is done by morphological and radiometric signature. This method provides accuracy about 84% of landslide detection. In [22] very high resolution images are used for the k- mean clustering based on sand characterstics. The accuracy rate of pixel based method is limited to 77.9%. In [23] air photo interpretation is used over the satellite images. Pan-sharpening method increases the high correlation coefficient and accuracy about 70%. In [26] bi-temporal images are generate by using pre and post event of images and spatial and irregular manners of the post events are used for the multi-segmentation. Landslide inventory results are obtained by the combination of multi-segmentation and majority voting. Reference [30] uses spatial interpolation with H/V or Nakamura for provides the punctual information of depth. Detection is finalised by redundancy of information. In [32] detection is done, based on NDVI and PanTex feature, which can be updated with threshold values on GF-1CCD data In [34] gaussian matched filters and first order derivate in a multi-scale framework are used for semi-automatic detection of surface cracks using VHR aerial vehicles images. Receiver operating characteristics analysis is the method that used for the feature detection of surface instability.. In [35] the correlation between the images is considered in this monitoring method. On further threshold is calculated for the mapping of area. In [37] SAR images were considered to identification of landslide using pixel resolution. The

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polarimetric decomposition techniques and clustering algorithm are used for the classification of mountain region and pixel analysis is done by using before and after image analysis.
Overall, pixel-based methods often require extensive parametric tuning and precise geometrical correction or co-registration while simple and applicable to large areas.

III.OBJECT BASED METHODS

Heleno *et al* [8] object based image analysis and SVM GeoEye-1 classifier are combined to test the VHR multispectral images. In [11] consider the Object Based Analysis (OOA) on regional based segmentation for outline region. K means clustering helps for the classification steps of OOA. Plateau objective function using Moran's I index and intra-segment variance identification of landslide. In [14] spectral, spatial and morphometric properties are combined in OOA. Digital elevation models are created from extracting feature vector. And the feature such NDVI, slope, flow direction hill shade, terrain curvature and stream network were obtained using GIS and image processing algorithms. In [18] three type of object based classification are combined using the DST method. Feature vectors are obtained by correlation based feature selection algorithm. The three type of classifier used are SVM, RF and KNN. In [21] Object Oriented Change Detection with LCCD is considered. There are several steps such as land cover type analysis, high resolution image classification and Land Cover Change Detection (LCCD) by comparing different multi temporal high resolution images and multi scale segmentation is performed. The trial-and-error method is used for the segmentation and 1-NN classification algorithm for the detection. In [22] ()mapper software is used for processing the data acquires .In this processing method consist of three steps. Initial process which include Automatic Aerial Triangulation (AAT),followed by bundle black adjustment. In following steps dense point clouds and mesh model are modelled and the final step is orthomosaics and DSM producing which uses Inverse Distance Weighted (IDW) algorithm. This model provides an accuracy rate higher than 80% for area based analysis. In [24] semiautomatic method is used having steps such as Fractal Net Evolution Approach (FNEA) used for multi-resolution segmentation followed by image transformation. The classification of done by using spectral angle mapper and reed-xiaoli detector which helps to remove false positive of image. In [25] visual photo interpretation technique is used for the calibration of qualitative landslide. The roughness feature vector of the landslide is analysed by object oriented analysis method. Reference [27] proposed a fusing Laser scanning data (LiDAR) and satellite imagery together using wavelet transformation method. taguhi method is used for segmentation and classification is done.
While OBIA offers extra features that distinguish landslides from other objects, however, it needs to optimize segmentation parameters and in these methods, the degree of automation is low compared to pixel-based methods.

IV.WIRELESS SENSOR METHODS

Ramesh *et al* [1] heterogeneous network which consist of sensors, wifi and satellite terminals is used along with the threshold based algorithm landslide is detected. In [5] the stability of the slope of landslide are check continuously monitored by using sensors and data is processed using ARM based microcontroller. UDP protocol is used for the communication. In [31] Wi-Sun acceleration sensors are used for the sensing and IEEE802.15.4g transmission protocol is used for communication purposes. The sensor supports for intra-correlation which reduces computation. Reference [33] the system consist of MEMS sensors with super capacitors which helps for self-energy harvesting power early warning system. Xbee radio module is used for communication.

V.DEEP LEARNING METHODS

Chen *et al* [2] spatial and temporal information are analysed from pre and post event images. The spatial temporal context learning and digital elevation model are modelled with the help of deep convolution neural network. Three methods are compared in this work [6]. The digitally processed images are given as input to GIS .landslide susceptibility maps are produced by using Decision Tree (DT), SVM, and adaptive neuro-fuzzy inference (ANFIS) methods. The accuracy rate are 83.07%, 82.80% and 81.46% for DT, ANFIS and SVM respectively. Ghorbanzadeh et al proposed this using optical data for CNN. The detection is done by comparing inventory dataset of landslide ground truth polygons though a Mean Intersection Over Union (MIOU) [12]. Sameen et al proposed a method having residual network and one layer CNN with two deeper counter parts. On further fusion is evaluated by CNN and ResNet architecture [13]. In [19] AIRSAR data SPOT5 are used comparison of SVM &IOE methods. The radial basis function and two-class SVM models were trained for landslide susceptibility. The performance accuracy of SVM is about 88.9% and IOE is about 82.6%. Reference [28] detected landslide using maximum likelihood classification method and Histogram-based threshold technique in remote sensing images. In [29] backscatter and texture features are used from the X-band synthetic aperture radar (SAR) data in order to train the support vector machine (SVM) classifier and testing. In [36] a probabilistic topic model maximum entropy discrimination latent Dirichlet allocation regression (MedLDAr) model is developed in order to learn from the before and after the event SPOT-5 images. In [38] proposed

decision making tree method on ALOS satellite images are considered for the automatic detection of landslide. Studies using deep learning to detect landslides are limited, and it is hard to make any conclusive statements about their performance compared to other pixel and object-based models. However, given their powerful ability to extract features from images, they may be a good choice for detecting landslides in data from different modes.

VI.CONCLUSION

Landslide can be caused by various reasons such as rainfall, earthquakes etc. There are several methods for the detection of landslide. Deep learning is one the currently using method with accuracy rate. Deep learning techniques, particularly convolutional networks, have shown to be successful in image recognition. They are also proved efficient for classifying remote sensing images, and other applications use spatial data. Recently, they outperformed other traditional machine learning methods for the detection of landslides.

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