Early Landslide Detection and Warning System Using Remote Sensing Imagery

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Abstract: In recent years, under the impact of global climate change, there were more and more of large-scale disasters, such as typhoons, and other large-scale collapses happened in Taiwan. Unfortunately, it is still in its infancy in Taiwan due to the lack of understanding its importance and development. In this case, this paper applied remote sensing and hyperspectral techniques to detect and develop novel and precise detection algorithms for warning system for Taiwan's mountain areas which have high-risk, high vulnerability, high exposure and high degree of harmfulness.

Keywords: Landslide, Image Classification, Machine learning

1. Introduction

Taiwan is located at the junction between two plates, the frequency of earthquakes is relatively high. Not only that, it is usually washed by heavy rain, in particular hillside is more serious. Landslide is a place of sparse vegetation and easily occurs earthflows, it always causes any property loss while typhoons. In order to prevent this situation early, we have to find dangerous hillside. In this paper, we use two classifiers for geological evaluation and predict where the location of landslides may occur. By using this novel techniques, those areas can be quantized and further analyzed for landslide warning system.

2.2. Experimental Methods

In order to achieve the purpose of this paper, at first, we use image processing techniques to extract the feature of non-ground collapse. In the second step, we use Support vector machine (SVM) [1] for the initial classification. In the third step, we use the classified data of the second step for iterative Fisher’s Linear Discriminant Analysis (FLDA) [2]. Finally, we use these data to analyze and calculate.

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2.1. Support vector machine (SVM)

Support vector machine is usually used for machine learning. It is a supervised learning method and mainly used in classification and regression. SVM is simultaneously applied to linear and non-linear classification algorithms. SVM classifies data by using training data to find a hyperplane, and then we can use this hyperplane for classifying testing data we wanted. In this paper, we randomly select each 30 points for landslide and other hillside and used RGB value of each pixel to be our training data, the label of landslide is 0 and other hillside is 1. Finally, we use these training data to classify the entire image as the first iterative data.

2.2. Fisher’s Linear Discriminant Analysis

In many practical applications, we often have to face the high-dimensional (multivariate) data, in order to facilitate analysis, dimensionality reduction is a necessary pre-treatment work. FLDA is an unsupervised learning method, and it performs dimensionality reduction based on statistical properties of the sample, and does not care about the follow-up data for these applications. FLDA classifies data by projecting data to a low dimensional space, it projects the data points of space R to a straight line which is through the origin, in order to achieve the effect of reducing the dimension of the sample. By changing the line, we want to find a best straight line to classify these data of projection better. In this paper, we using the SVM results to be training samples of FLDA.

2.3. Iterative Fisher's Linear Discriminant Analysis

In the previous section, we have introduced SVM and FLDA, but the results are not necessarily the best. Therefore, this paper apply iterative algorithms for FLDA. First, we use the SVM results to be training samples of FLDA. And then, we use the FLDA results last time as training samples for next FLDA. Repeat these actions until the SAM [3] is smaller than 0.004 between FLDA results of this time and last time. As shown in figure 1 describes the process of iterative method.

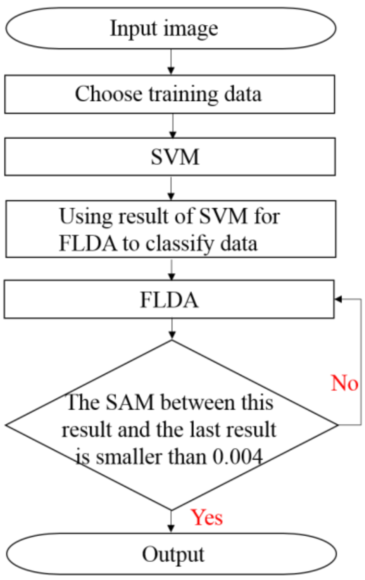


Figure 1. Iterative classified algorithm flowchart

3. Experimental Results

In this paper, we use the images of the two locations, as shown in the figure 2, 2(a) is located on Laiji Village, Alishan Township, Chiayi County and 2(b) is located on Xiaolin Village, Jiaxian Dist., Kaohsiung City.

(a) Laiji village (b) Xiaolin Village

Figure 2. Location of experimental images

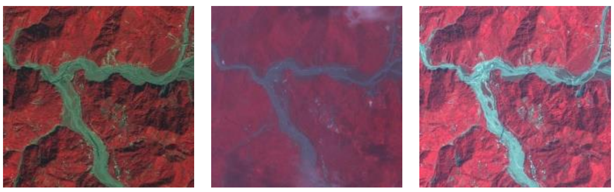
3.1. Laiji Village

3.1.1. Laiji Village images

We use the 2005-2013 remote sensing images [6] of Laiji Village to detect landslide and quantify the landslide areas. The images are 400x380 pixels and 1 pixel is 10^{-4} km^2.

(a) 2005 (b) 2006 (c) 2007

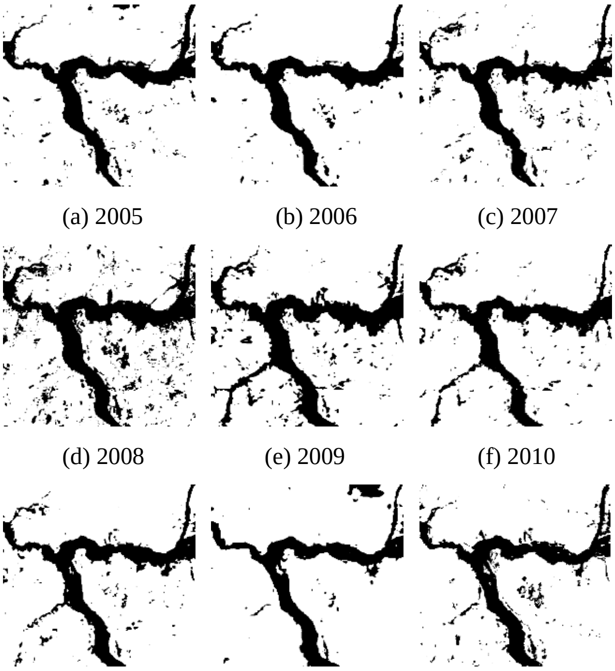
(d) 2008 (e) 2009 (f) 2010



(g) 2011 (h) 2012 (i) 2013

Figure 3. Remote sensing images Laiji

3.1.2. Laiji Village images results



(a) 2005 (b) 2006 (c) 2007

(d) 2008 (e) 2009 (f) 2010

(g) 2011 (h) 2012 (i) 2013

Figure 4. Classified results of Laiji

3.1.3. Laiji Village images experiments analysis

As shown in figure 5, we can see that the landslide area in 2010 is bigger than other years because Laiji collapsed in 2009 [7]. The typhoons happened in August 2009 and marked Laiji occur landslides and other natural disasters. Whenever heavy rain, the mudslides are more serious because the vegetation has been destroyed between 2009 and 2010.

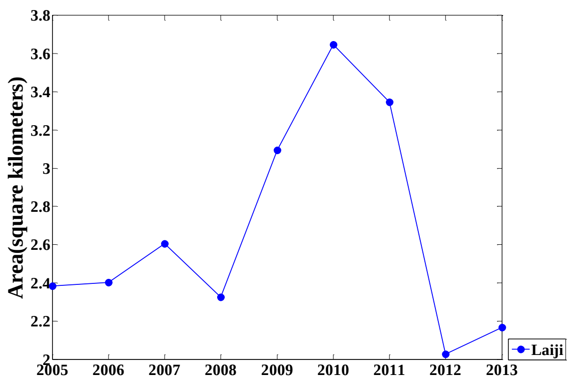
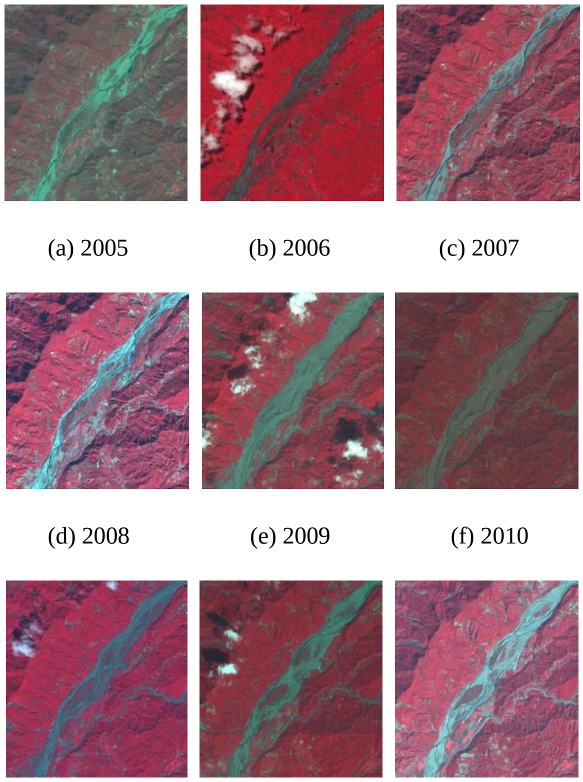


Figure 5. Landslide areas of Laiji

3.2. Xiaolin Village

3.2.1. Xiaolin Village images

We use the 2005-2013 remote sensing images of Xiaolin Village to detect landslide and quantify the landslide areas. These images are 430x460 pixels and 1 pixel is 10^{-4} km^2.



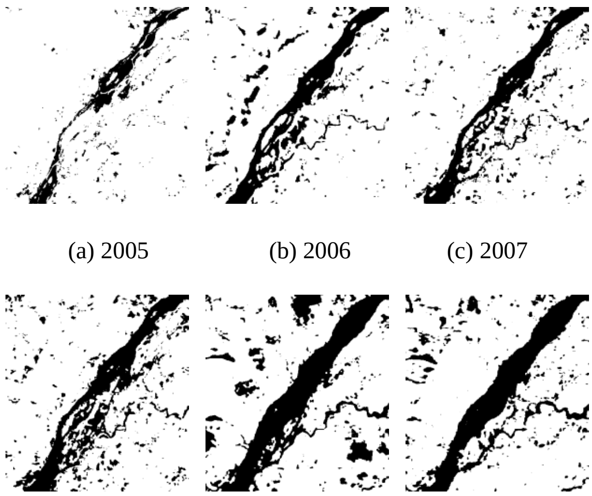
(a) 2005 (b) 2006 (c) 2007

(d) 2008 (e) 2009 (f) 2010

(g) 2011 (h) 2012 (i) 2013

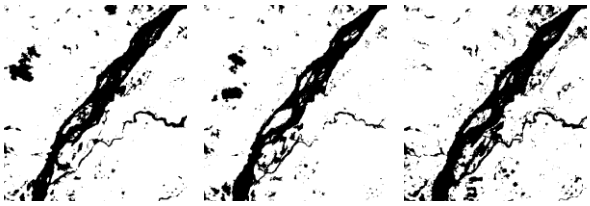
Figure 6. Remote sensing images of Xiaolin

3.2.2. Xiaolin Village images results



(a) 2005 (b) 2006 (c) 2007

(d) 2008 (e) 2009 (f) 2010



(g) 2011 (h) 2012 (i) 2013

Figure 7. Classified results of Xiaolin

3.2.3. Xiaolin Village images experiments analysis

Typhoon hit the Xiaolin Village in August 2009 and its rainfall is up to 507 mm. Therefore, exposed land has significantly increased between 2009 and 2010. As shown in figure 8, we can see that the landslide area is bigger than other years. Before the collapse happened, bare lands gradually increased.

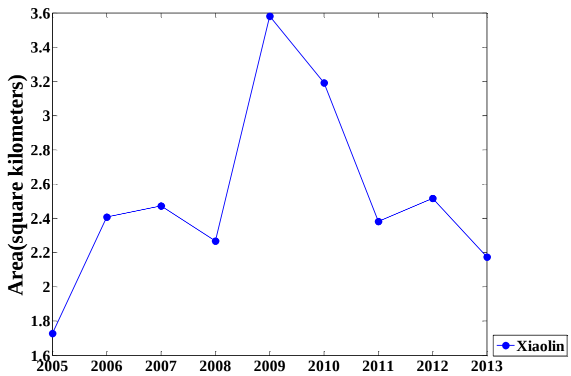


Figure 8. Landslide areas of Xiaolin

4. Conclusion

In this paper we combine two different classifiers to detect landslide areas and using iterative FLDA to improve the accuracy of detection. However, we can fast and precisely quantify the landslide areas by using this technique. We can find high risk areas during typhoons by detecting landslide areas of somewhere and warning people living there. Although this paper only uses two classifiers and through an iterative method to detect the landslide, but it may use more methods just like target detection to view the amount of change, we will be able to more accurately predict the position of landslide.

5. References

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