Advanced Science and Technology Letters
Vol.85 (Information Technology and Computer Science 2015), pp.14-19
http://dx.doi.org/10.14257/astl.2015.85.04

Combination of Two Textural Features for the Improvement of Terrain Segmentation

Hoang Lam Le[1] and Dong-Min Woo[1]

[1]Department of Electronics Engineering, Myongji University
San 38-2 Namdong, Cheoin-gu, Yongin, Gyeonggido, 449-728 South Korea
lehoanglam20000@gmail.com; dmwoo2000@gmail.com;

Abstract. The good segmentation of satellite imagery is very meaningful for fully getting information inside and processing in the later step. This paper introduces a combination of two textural features which can achieve a very good result on either recognition or image segmentation. The experiment result shows much improvement when the two features are together utilized instead of each individual one. We implement co-occurrence, Haar-like feature and their combination to run respectively with Back-propagation neural network (BPNN) and Adaboost. The integration of co-occurrence and Haar-like features ameliorates the accuracy from 88.19% to 94.54% in region classification and approximately 9% increase per each class in pixel classification running with Adaboost. The pixel classification results in the segmented image, which can be qualitatively evaluated by visualization.

Keywords: Haar-like feature, co-occurrence feature, neural network, Adaboost, satellite image classification

1 Introduction

In pattern recognition, the input data is normally too big or repetitive of presented values. Therefore, feature extraction is used to transform this big data into a number of feature values, which can be a basis for the terrain segmentation. The new feature vector is assumed to include the relating information from the input data, so that the algorithm model could be executed by using this reduced representation. Feature extraction plays an important role in pattern recognition as it decreases size of input data and strongly affects the classification performance. During the past decades, many researchers realized the root problem in pattern recognition has the great dissimilarity within a class, while some of different classes are strongly close to each other. Even though some powerful feature descriptors have been proposed to deal with the inter-class relation, it is obviously not enough to solve all cases. In this context, the combination of multi-features to make a stronger one has been considered thoughtfully to tackle this issue. This paper will follow that direction by presenting an improvement of terrain classification using the combination of two features.

Among many features which have been developed so far, texture features such as co-occurrence, Haar-like or Local Binary Pattern (LBP) are extensively used in classi-

ISSN: 2287-1233 ASTL

fication of remotely sensed images, and it is well acknowledged to obtain prominent feature of samples [1][2][3]. Besides, feature combination has been researched for years in some fields such as text categorization, object recognition and others. A good overview and a comprehensive survey of both selecting features and feature combination have been established in text categorization [4][5]. Evaluation of feature combination approaches for this area is made as well [6]. Combination of several widely used features is made in the experiments [7], and certain combination methods have showed a big improvement [8].

This paper presents terrain classification and segmentation method using Haar-like, co-occurrence and the combination of two features with Adaboost and BPNN. From the given 2048x2048 ortho image and DEM, objects with the size of 15x15 are collected and classified into four categories: road, grass, white block and tree shadow.

2 Implementation of Features

2.1 Haar-like Implementation

Haar-like feature is a real-time processing feature in the application of object recognition [9]. Haar-like feature simply considers subtraction value between dark and bright areas. Particularly, it divides sample into multi adjacent rectangular regions, aggregates the pixel intensities in each region, and computes the deviation between the two final summations. The equation of Haar-like feature is shown as follows:

$$f(x) = \sum_{n}^{N} \sum_{i,j}^{w,h} P_{ij} - \sum_{m}^{M} \sum_{i,j}^{w,h} Q_{ij} \ , \quad (1)$$

where N and M respectively are the number of dark and bright regions, and P and Q are subareas inside the image sample.

In Fig. 1, two features A and B are designed to compute Haar-like value based on two sub-regions of darkness and brightness. In case of feature *C*, the value is the subtraction of the two bright rectangles and one dark block. Finally in feature *D*, the sum of dark rectangles subtracted from the sum of bright rectangles will be calculated.

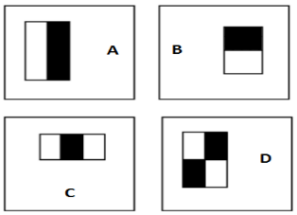


Fig. 1. Basic division of dark and bright regions in Haar-like feature

2.2 Co-occurrence Implementation

Co-occurrence is a statistical and strong feature extraction method in textural analysis and classification [1]. This feature is used to evaluate the spatial dependency in terms of a co-occurrence matrix, in which each element represents the number of itself occurrences. The co-occurrence matrix P can be defined as:

$$P(i,j) = \sum_{x=1}^{n} \sum_{y=1}^{m} \begin{cases} 1, if\ I(x,y) = i\ and\ I(x+\Delta_x, y+\Delta_y) = j \\ 0, otherwise. \end{cases} \quad (2)$$

Co-occurrence has been designed for homogeneous textures and used for terrain classification. In our experiment, we use twelve features derived from four directions of 0, 45, 90, 135 degree. Three textural features - Angular Second Moment (ASM), Contrast (CON) and Entropy (ENT) - are calculated from ortho image for four directions, and twelve another values are calculated from DEM.

3 Experiments

From ortho image and DEM (Digital Elevation Model) with size of 2048x2048, samples of road, grass, while block and tree shadow are manually accumulated with size 15x15, shown in the following summarized table. Each sample is transformed to Haar-like and co-occurrence feature vectors which will be later processed in object recognition. The ratio of training and testing data is 0.4 for both BPNN and Adaboost algorithms. Other configurations of two algorithms such as learning rate, maximum number of epoch, maximum number of weak classifier are fixed in order to maintain an impartial comparison.

There are four categories collected as samples, shown in Fig. 2, and the remaining area is assumed as urban area. Since we do not collect ground truth data for this class, its accuracy is not considered through evaluation. The small white square denotes the selected sample for each class.

(a) (b) (c) (d)

Fig. 2. Manually collected samples from ortho image: (a) Road, (b) Grass, (c) White-block, (d) Tree shadow

Co-occurrence works well with homogeneous data. Since road sample is always sloping and partially collected, the accuracy of this class is the lowest among four categories. Although co-occurrence does not show good result, its combination with Haar-like shows a high performance.

A window of 15x15 slides from top left to down right corner of satellite image. For each window, three descriptive vectors are defined. Those are co-occurrence, Haar-like and the combination of two feature vectors. Based on the trained models of BPNN and Adaboost, we classify these vectors and label 3x3 center pixels of current window. Each class takes a defined label grey value [road label = 2, grass label = 180, white-lock label = 254, tree-shadow label = 110], and produces a segmented image.

Table 1. Region of interest classification using three type of features with BPNN and Adaboost

REGION CLASSIFICATION RESULT BPNN – ADABOOST					
	Road	*Grass*	*White block*	*Tree shadow*	*Mean Accuracy*
Coccurrence(%)	24,1 - 81.1	69.2 - 88.1	78.4 - 94.6	98.3 - 88.3	61.6 - 88.2
Haar-like(%)	*89.1 - 92.4*	*87 - 89.8*	*96.1 - 98.1*	*71.3 - 90.4*	85.4 - 92.7
Co-oc+Haar(%)	*90.1 - 93.2*	*87.5 - 93.5*	*98.3 - 98.6*	*85.8 - 92.9*	89.8 - 94.5
Total number of samples					1571
Total number of Co-oc features					24
Total number of Haar features					162
Total number of features					186

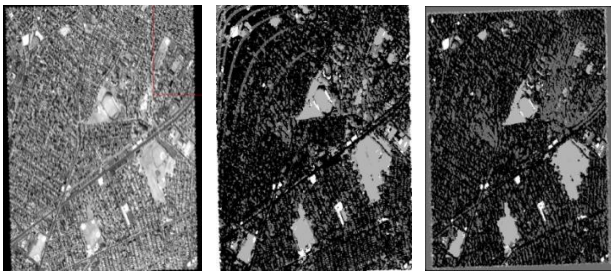
To evaluate the accuracy of this process, manually collected ground-truth samples that correctly show the labels of its regions will be utilized. Ground truth sample area has one label in the label collection. We then examine the difference of the label pixel by pixel between the ground-truth image and the segmented image.

Table 1 shows the accuracy of region classification. In BPNN classifier, the combination of two features shows the balanced accuracy among four classes, while co-occurrence feature is much prone to unstable performance from 98.15% for tree shadow to 21.19% for road class. Haar-like feature presents a consistent output within four classes from 62.35% to 84.41% of accuracy. On the whole, the combination of co-occurrence and Haar-like feature vectors reaches over 80% of accuracy in pixel classification, shown in Table 2. In Adaboost classifier, the combination of co-occurrence and Harr-like scores best as well. When we use only one feature, Harr-like feature outperforms co-occurrence, except tree shadow class. On the whole, the combination of feature vectors achieves over 73.8% of accuracy in pixel classification.

Table 2. Pixel classification using three type of features with BPNN - Adaboost

PIXEL CLASSIFICATION RESULT BPNN - ADABOOST				
	Road	***Grass***	***White block***	***Tree shadow***
Co-occurrence (%)	21.2 - 66.1	60.1 - 75.7	71.8 - 56.8	92.2 - 67.1
Haar-like (%)	*78.4 - 73.7*	*84.4 - 78.5*	*78.8 - 74.5*	*62.4 - 63.6*
Co-oc + Haar (%)	*80.7 - 74.3*	*85.3 - 84*	*85.9 - 77.4*	*84.8 - 73.8*

Segmented images obtained from the combined features of Haar-like and co-occurrence show much clearer and well visualized segmentation in comparison with others obtained from a single feature. The resulting segmented images are shown in Fig. 3.



(a) (b) (c)

Fig. 3. Comparison between ortho image and two segmented images: (a) Ortho image, (b) Segmented image by BPNN, (c) Segmented image by Adaboost

4 Conclusions

In this paper, we have studied terrain segmentation by using three types of feature with two supervised algorithms. This approach starts with extraction of Haar-like, co-occurrence features and combines them into one descriptive vector. On the whole, the new combined feature vector shows a much better accuracy, comparing with each individual one, regardless of training with either Adaboost or BPNN. This new feature combination can help to enhance performance of satellite image segmentation, and to recognize textural patterns in object recognition problem. We also confirm that the combination of two or more features does not always improve the accuracy of classification, as shown in the case of the combination with LBP feature. In this context, the identification of the suitable combination of features based on certain criteria may also be a direction of our research.

Acknowledgments. This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No. NRF-2012R1A1A2004950).

Reference

1. Eleyan, A., Demirel,H.: Co-occurrence matrix and its statistical features as a new approach for face recognition. In: Turkish Journal of Electrical Engineering & Computer Sciences, vol. 19(1), pp. 97-107 (2011)

2. Lienhart, R., Maydt, J.: An Extended Set of Haar-like Features for Rapid Object Detection. In: Proceedings. 2002 International Conference on IEEE Image Processing 2002, vol.1, pp. I-900 - I-903 (2002)
3. Devi, O.R., Dr. Prasad, E.V., Reddy, L.S.S.: Robust Rule Based Local Binary Pattern Method for Texture Classification and Analysis. In: International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), vol.2, pp. 274-277 (2013)
4. Sebastiani, F.: Machine learning in automated text categorization. In: ACM Computing Surveys, vol. 34, pp.1–47 (2002)
5. Yang, Y., Pedersen, J.O.: A comparative study on feature selection in text categorization. In: Proceedings of the 14th International Conference on Machine Learning (ICML), pp. 412–420 (1997)
6. Neumayer, R., Nørvåg, K.: Evaluation of Feature Combination Approaches for Text Categorisation. In: Foundations of Intelligent Systems. LNCS, vol. 6804, pp 438-448 (2011)
7. Scott Olsson, J., Oard, D.W.: Combining feature selectors for text classification. In: Proceedings of the 15th ACM International Conference on Information and Knowledge Management, pp. 798–799 (2006)
8. Jian, H., Bo-Ping, Z., Nai-Ming, Q., Yong, Y..: Evaluating Feature Combination in Object Classification. In: 7th International Symposium, ISVC 2011, Las Vegas, NV, USA, 2011. LNCS, vol.6939, pp 597-606 (2011)
9. Viola, P., Jones, M.J.: Robust Real-Time Face Detection. In: International Journal of Computer Vision 57(2), pp. 137-154, (2004)
10. Woo, D.M., Park, D.C., Han, S.S., Nguyen, Q.D.: Terrain Classification Using 3D Co-occurrence Features and Neural Networks. In: Advances in Image and Video Technology. LNCS, vol. 4319, pp. 305-313(2006)

