

Ensemble Learning with Multiple Classifiers and Polarimetric Features for Polarized SAR Image Classification

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Abstract

Polarimetric SAR (PolSAR) image processing has become a hot research topic in SAR remote sensing field in recent years. However, due to the complexity of the image and limited availability of advanced techniques, PolSAR image processing is still a challenging issue. In this paper the suggestion of ensemble learning (EL) is introduced into PolSAR image classification by integrating various polarimetric features and multiple classifiers. The most popular ensemble learning methods, including Bagging, AdaBoost, and Rotation Forest are adopted to combine multiple classifiers and polarimetric features. The proposed classification scheme is evaluated on three real PolSAR data. Experimental results shows that the covariance and coherence features can give better performance than other polarimetric decomposition features, and complementary between different polarimetric decomposition features improving the classification performance. Although a weak classifier gives unsatisfactory classification accuracy on polarimetric decomposition features, the performance can be highly improved by using EL strategies.

Introduction

Land cover classification is one of the primary objectives of remotely sensed image processing, analysis, and practical application. Synthetic Aperture Radar (SAR) opens new opportunities for land cover classification owing to its day and night, all-weather, and high-resolution observation capability to the Earth's surface. But due to the low information content of an individual SAR image, single-polarization or single-band SAR

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data cannot provide highly accurate land cover classification maps (Herold *et al.*, 2004; Lee *et al.*, 2002). On the contrary, PolSAR images contain a large amount of potential information which is directly related to physical properties of natural media and backscattering mechanism. Therefore, full polarized SAR imagery classification has become a popular and challenging problem in recent years due to its potential applicability in different fields. With the goal of achieving high classification accuracy, many supervised, unsupervised, and semi-supervised classification methods have been developed. Usually, the adopted features in classification include scattering matrix elements, covariance matrix elements and coherent matrix elements, and polarimetric decomposition features (Cloude *et al.*, 1997; Du *et al.*, 1996; Krogager, m 1994; Qi *et al.*, 2012; Song *et al.*, 2007; Wang *et al.*, 2013).

Generally, developing advanced classifiers, or optimizing the input features or adopting novel pattern recognition methods are the three common ways get better classification performance. It is worth noting that, finding the optimal features and best classifier is always hard, maybe even impossible. However, a better classification result may be achieved by combining multiple classifiers and various features by using ensemble learning (EL) strategies.

Since “strong and weak learn ability are equivalent” was proofed by Robert E. Schapire (Schapire, 1990), more options are available to get an improved classification performance through EL, which can integrate the benefits of different features, classifiers, and combination methods. As an advanced machine learning framework, EL is able to boost weak learners, working slightly or obviously better than random guessing to strong learners, thus making accurate predictions.

In spite of the considerable amount of work on the use of EL for remote sensing image classification in the past years, few applications of EL to PolSAR image classification could be found in literature (Jiong *et al.*, 2008; Loosvelt *et al.*, 2012; Min *et al.*, 2009; She *et al.*, 2007). In this paper, EL techniques such as Bagging, AdaBoost, and Rotation Forest are introduced to PolSAR image classification based on different polarimetric features. To evaluate the performance of various EL methods, some benchmark classifiers such as support vector machine (SVM), logistics decision tree, simple logistic decision tree, and k-Nearest Neighbor are experimented and compared. Besides, different ensemble strategies for classifier combination such as voting, stacking generation, and multi-

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