Int J Appl Earth Obs Geoinformation 80 (2019) 218–229

Contents lists available at ScienceDirect

Int J Appl Earth Obs Geoinformation

journal homepage: www.elsevier.com/locate/jag

A phenology-based spectral and temporal feature selection method for crop mapping from satellite time series

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ARTICLE INFO

Keywords:
Feature selection
Crop mapping
Phenology
Separability index
MODIS
SVM

ABSTRACT

Accurate information on crop distribution and its changes is important for food security and environmental management. Although time series analysis is a widely-used and useful tool to characterize the seasonal dynamics of crops, the traditional image stacking approach misses important phenological events. This condition makes it difficult to identify the spectral and temporal features that are potentially important for crop identification, and therefore, makes it difficult to determine the optimal feature inputs for classifying crops with both high accuracy and low computation time. To address this gap, we developed a method to automatically select the spectro-temporal features by mining crop phenology information so as to improve the accuracy of crop classifications. This method of Phenology-based Spectral and Temporal Feature Selection (PSTFS) contains two major components: to identify the features with the highest separability between each pair of classes, and to prune redundant features to retain the best for classification. Using this optimal set of features and support vector machines (SVMs), we generated a high-quality corn cultivation map of China's Heilongjiang Province for 2011. The corn map had accuracies greater than 85% and agreed well with the corn census areas. We also demonstrate the goodness of this method for selecting features with high interpretability: it identified two phenological stages (three leaf and milky mature) that could best separate corn from other land use classes in the region. Our approach indicates the great potential for using the PSTFS method in conjunction with SVM classifiers to accurately map crop types based on satellite time series data.

1. Introduction

Information on the spatial distribution of crops is important for crop growth monitoring, acreage surveys, yield estimation, and water management. Due to its wide spatial coverage, high temporal resolution, and low observation costs, remote sensing provides the most effective tool for crop extent monitoring (Biradar et al., 2009; Song et al., 2017b; Zhang et al., 2014). However, despite the large volume of remote sensing observations of earth's surface, there are great challenges in identifying different crop cultivation practices. One example of these challenges is the lacking guidance on how to select the appropriate spectral and temporal features to accurately identify crops from satellite data (Peña-Barragán et al., 2011; Zhong et al., 2011).

Previous studies have demonstrated that multitemporal images are better than a single-date image for crop type classification. Multitemporal information can capture the different phenological stages (e.g., emergence, greenup, and senescence) of different crop types that have well-defined crop calendars with specific planting times and unique seasonal growth patterns (Foerster et al., 2012; Pan et al., 2012). Chang et al. (2007) used a time series of MODIS normalized difference vegetation index (NDVI) data and time-integrated metrics to estimate the areas of soybean cultivation across the United States using a regression tree approach. Zhong et al. (2014) used the random forest classification algorithm to discriminate between corn and soybean cultivation in Kansas and showed that including phenological metrics resulted in accuracies higher than 88%. Most of these studies classified

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https://doi.org/10.1016/j.jag.2019.04.014
Received 15 December 2018; Received in revised form 5 April 2019; Accepted 23 April 2019
Available online 01 May 2019