Earth Science & Climatic Change

Boitt, et al, J Earth Sci Clim Change 2014, 5:9
http://dx.doi.org/10.4172/2157-7617.1000232

Using Hyperspectral Data to Identify Crops in a Cultivated Agricultural Landscape - A Case Study of Taita Hills, Kenya

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Abstract

Recent advances in hyperspectral remote sensing techniques and technologies allow us to more accurately identify larger range of crop species from airborne measurements. This study employs hyperspectral AISA Eagle VNIR imagery acquired with 9 nm spectral and 0.6 m spatial resolutions over a spectral range of 400 nm to 1000 nm. The area of study is the Taita hills in Kenya. Various crops are grown in this region basically for food and as an economic activity. The crops addressed are: maize, bananas, avocados, and sugarcane and mango trees. The main objectives of this study were to study what crop species can be distinguished from the cultivated population crops in the agricultural landscape and what feature space discriminates most effectively the spectral signatures of different species. Spectral Angle Mapper (SAM) algorithm together with some dissimilarity concepts was applied in this work. The spectral signatures for crops were collected using accurate field plot maps. Accuracy assessment was done using independent training vector data. We achieved an overall accuracy of 77% with a kappa value of 0.67. Various crops in different locations were identified and shown.

Keywords: Hyperspectral imaging; Spectral signatures; Spectral variation; Crop identification; Spectral angle mapper

Introduction

Hyperspectral remote sensing data can provide a significant spectral measurement capability over the conventional remote sensor systems and hence becomes very useful in identification and modelling of terrestrial ecosystem characteristics. Not long ago, mapping was mainly using satellite (space borne) data for large area mapping but for small regions, it used aerial images (air borne) and in most cases, the result was just a land cover map combining several classes of pixels having some broad similarity. The need to discriminate crop species to know their health, location and distribution has paved way in this decade due to available sensors which can detect at high spatial and spectral resolutions the natural and man-made features on the surface of the earth. The advancement not only on the sensor availability but also the technology used to discriminate the various spectra of different species has become a boost to mapping. Many technologies have been used for extracting terrestrial features from hyperspectral imagery. Principal Component Analysis (PCA) among other algorithms for crop classification has yielded good results [1]. Step-wise Discriminant Analysis (SDA) and Derivative Greenish Vegetation Indices (DGVI) to classify and characterize both vegetation and agricultural crops have been used [2,3]. Dissimilarity based approaches have also given good representation of hyperspectral data [4]. Tree species identification has been one area of interests for scientist dealing with forests and vegetation mapping. Statistical methods to identify tree species in forests have shown good and accurate results. Nevertheless, Artificial Neural Networks (ANN) and Linear Discriminant Analysis (LDA) have given reliable results in tree species identification.

Some other approaches in coastal environments have been made to identify mangrove species using both object-based and pixel-based classification methods. A comparison has been given and in this regard, results indicate that object based mapping approach is better than pixel-based approach with a difference of just about 7% overall accuracy and 0.1 kappa [5]. All these shows that crop species can be discriminated in a similar if not a different but close approach. The objectives of this study were (1) to examine the capability of hyperspectral data to distinguish selected crops in a cultivated agricultural landscape in the Taita hills in Kenya, (2) to evaluate the spectral angle divergence of various crops and use this to discriminate the crop species and (3) to assess the accuracy of the classification.

Study Area

Taita Hills, (03°20'S, 38°15'E) in Kenya are one of the biodiversity hot spot in Eastern Africa. A wide range of studies have been made recently in this area for instance; on land use, land degradation, soil erosion, biodiversity, urban growth and sacred forest remnants. The area is facing a population growth and intensification of agriculture, which is the major economic activity for the Taita community. Although the terrain varies from 600 m to about 2200 m.a.s.l, farmers cultivate various crops ranging from maize (*Zea mays*), bananas (*Musa paradisiaca*), fruits and even fodder crops for animals, which are normally put in zero-grazing system (Figure 1).

Hyperspectral data was collected using AISA Eagle VNIR sensor system. Its accuracy is ranging in the following domain: 9 nm and 0.6 m in both spectral and spatial resolutions respectively over a spectral range of 400 nm to 1000 nm. This gives 64 spectral bands. The fieldwork measurements were conducted simultaneously with hyperspectral data acquisition. The flying height was about 2,400 meters above sea level to maintain the spatial resolution of 0.6 m. Accurate photographs taken by the Nikon 3DX camera, which was attached together with the AISA sensor on board during the time of flight, were used to map every

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Received August 11, 2014; **Accepted** October 30, 2014; **Published** November 10, 2014

Citation: Boitt M, Ndegwa C, Pellikka P (2014) Using Hyperspectral Data to Identify Crops in a Cultivated Agricultural Landscape - A Case Study of Taita Hills, Kenya. J Earth Sci Clim Change 5: 232. doi:10.4172/2157-7617.1000232