Stoch Environ Res Risk Assess (2015) 29:369–378
DOI 10.1007/s00477-014-0884-5

ORIGINAL PAPER

A multivariate geostatistical approach for landscape classification from remotely sensed image data

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Received: 27 November 2013 / Accepted: 15 April 2014 / Published online: 2 May 2014

Abstract This paper proposes a methodology to address the classification of images that have been acquired from remote sensors. One common problem in classification is the high dimensionality of multivariate characteristics. The methodology we propose consists of reducing the dimensionality of the spectral bands associated with a multispectral satellite image. Such dimensionality reduction is accomplished by the use of the divergence of a modified Mahalanobis distance. Instead of using the covariance matrix of a multivariate spatial process, the codispersion matrix is considered which have some desirable asymptotic properties under very precise conditions. The consistency and asymptotic normality hold for a general class of processes that are a natural extension of the one-dimensional spatial processes for which the asymptotic properties were first established. The results allow the selection of a set of spectral bands to produce the highest value of divergence. Then, a supervised maximum likelihood method using the selected spectral bands is employed for landscape classification. An application with a real LANDSAT image is introduced to explore and visualize how our method works in practice.

Keywords Multivariate spatial process · Spatial association · Codispersion matrix · Dimensionality reduction · Image classification

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1 Introduction

Landscape classification and dimensionality reduction techniques have been studied for a long time in many different contexts and fields. The classification of a large set of data is a general problem that extends to many different scenarios. One problem that presents itself in the classification of observations or categories in image processing is the dimensionality of the acquired images. One approach to dealing with such issues is to consider dimensionality reduction techniques that simply provide certain rules for decision-making that are easy to implement and computationally feasible. In general, this reduction can be addressed from at least two perspectives. The first one of these is based on linear transformations (Comon 1994; Loog and Duin 2004; Rueda and Herrera 2008), while the second is based on variable selection techniques (Jolliffe 2002; Zou Hastie and Tibshirani 2006).

Coefficients of spatial association have been increasingly used in several applied areas, such as hydrology and soil sciences (Goovaerts 1997; Pringe and Lark 2006). In particular, the codispersion coefficient, which was first introduced by Matheron (1956), has been receiving increasing attention in recent years from researchers because it allows the quantification of the existing spatial association between two processes in a particular direction (Ojeda et al. 2012). Computational and graphical tools