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Research Paper

## Subpixel level mapping of remotely sensed image using colorimetry

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## ABSTRACT

The problem of extracting proportion of classes present within a pixel has been a challenge for researchers for which already numerous methodologies have been developed but still saturation is far ahead, since still the methods accounting these mixed classes are not perfect and they would never be perfect until one can talk about one to one correspondence for each pixel and ground data, which is practically impossible. In this paper a step towards generation of new method for finding out mixed class proportions in a pixel on the basis of the mixing property of colors as per colorimetry. The methodology involves locating the class color of a mixed pixel on chromaticity diagram and then using contextual information mainly the location of neighboring pixels on chromaticity diagram to estimate the proportion of classes in the mixed pixel.

Also the resampling method would be more accurate when accounting for sharp and exact boundaries. With the usage of contextual information can generate the resampled image containing only the colors which really exist. The process is simply accounting the fraction and then the number of pixels by multiplying the fraction by total number of pixels into which one pixel is splitted to get number of pixels of each color based on contextual information.

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## 1. Introduction

Remote sensing is a well-established information technology, the value of which for applications in land and natural resources management are now widely recognized. Remote sensing is a technology of extracting information about ground features on the surface of the earth without in physical contact with them. At the edge of technological advancement Remote sensing technique helps to gather information in various domain like: Geosciences, Biomedical, Forensic, using various platforms (Earth Observation Satellites) equipped with different sensor. Remote sensing not only gives the information about object but also gives the information about landscape changes through the Land cover/ land use mapping. In the present scenario, Land use and land cover mapping is of great significance in scientific, research field, and also in sustainable development. Regional land use pattern reflects the character of interaction between man and environment and the influence of distance and resources based on mankind's basic economic activities. Land is assuredly one of the most important natural resources

(Prasad et al., 2015), where aliveness (in terms of various habitat or flora-fauna) and developmental (in terms of social, economic environmental) activities are taken place.

Generally hard classification and their accuracy assessment used to produce thematic maps and land cover information. Hard classified image gives single land cover class information within each pixel. However this leads to loss of actual information required as mostly more than one land cover class might be present over geographic surface covered by single pixel. The mixed pixel probability is higher for coarse resolution. Soft classification provides multiple land cover information within pixel and use to overcome from this problem but, here accuracy assessment of soft classified image is again an issue. Researcher and analysts have made great efforts in developing advanced classification methods and techniques for improving classification accuracy (Pal and Mather, 2003; Lu and Weng, 2007; Mandla and Franco, 2012; Shi and Wang, 2015). Conventional methods of accuracy assessment required hardening of land cover information. This again leads to an inexact assessment. This requires better understanding and implementing of these methods to achieve accurate classified data and accuracy parameters for soft classification. Soft classification and accuracy assessment for soft classified data are latest trends to deals with mixed pixel problem (Wang et al., 2014) and

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(Medjahed et al., 2016), it attract for further exploration in this area.

### 1.1. Related work on subpixel classification methods

Mixed pixels at training stage have been incorporated in different classification methods such as maximum likelihood classification (MLC) (Eastman and Laney, 2002) and (Dadras et al., 2015). In MLC, mixed pixels may be incorporated by using fuzzy means and fuzzy variance covariance statistics (Wang, 1990; Eastman and Laney, 2002; Sinha et al., 2015) instead of using the conventional statistical parameters computed from pure pixels. In the same way mixed pixels can be incorporated at training stages of fuzzy c-means (FCM) possibilistic c-means (PCM) and support vector mission (SVM) based classifiers. At testing stage of fraction images, the conventional error matrix cannot be used. A number of alternatives such as, Euclidean and  $L_1$  distances, cross-entropy, root mean square error and correlation coefficients may be used (Masel et al., 1996) and (Shahi et al., 2015).

Research in field of classification is being pursued continuously and different potential methods have been suggested and used. In this paper, statistical, fuzzy set theory and statistical learning based sub-pixel classifiers have been studied. However, it is interesting to note that soft-classification methods have yet not found the proper place in the field of image classification. While referencing the research papers of last few years, it is found that little work has been done in the field of soft classification, using statistical learning based sub-pixel classifiers. Also, it has been found that these algorithms have not been evaluated with respect to topographic effect and different pixel resolution studies.

Atkinson (1997) compared three classification techniques of artificial neural networks (ANN), linear mixture modeling and Fuzzy c-Means for mapping the sub-pixel proportions of land cover classes. It was found that ANN was one of the accurate techniques (Jayanth et al., 2015); however supervised Fuzzy c-Means classification gave slightly better results than mixture modeling.

Vails et al. (2004) proposed the use of support vector machines (SVMs) for automatic hyperspectral data classification and knowledge discovery. In this work several conclusions have been drawn. First of all, SVM yields better outcomes than neural networks related to accuracy, simplicity, and robustness. Secondly, training of neural and neuro-fuzzy models is unfeasible when working with high-dimensional input spaces with large size training data. Further, SVM performs in the similar manner for different training subsets.

Mantero et al. (2005) and Arun and Katiyar (2013) describes a classification strategy that allows the identification of samples drawn from unknown classes by applying of a suitable Bayesian decision rule, to provide a solution to a problem where the performances of supervised classifiers gets affected having erroneously assigned each sample drawn from an unknown class to one of the known classes.

### 1.2. Related work on super resolution mapping

Researchers worked on super resolution mapping using spatial relation between pair of pixel and sub pixels by defining rules to assign a land cover class to subpixel depending on location by remodeling pixel swapping algorithm which was proposed by Atkinson.

Atkinson (2005) proposed first subpixel mapping algorithm it was named as pixel swapping technique. The method was initially developed for binary case, but later extended for colored images. The output of supervised fuzzy c-mean soft classifier was used as input to algorithm. Then attractiveness function of a subpixel to a class was calculated which sum is of weighted distance between

a subpixel of interest and its neighbor. For example in case of binary image the least attractive subpixel is subpixel with value “1” and surrounded mainly by sub pixels with value “0” and most attractive subpixel is a subpixel with value “0” and surrounded mainly by sub pixels with value “1”. The swapping process is performed within a pixel not between pixels. The swapping is continued until it reached a threshold value or until no more swaps are to be made.

Verhoeve and De Wulf (2002) proposed that subpixel mapping can be formulated as a linear optimization problem and an isotropic variogram was derived from coarse resolution image which was used for spatial interpolation. Isotropic Variogram is a function defining the degree of spatial dependence (Lamyaa Gamal El-Deen Taha, 2014). It is defines as variance of difference between field values at two locations. However this process results in isolated sub pixels. (Suresh and Jain, 2015a,b) proposed a subpixel mapping algorithm based on spatial dependences attractive model which produces hard classification at high spatial resolution and they have considered spatial dependences to provide maximum attractiveness between subpixel and pixels.

With reference to the original pixel swapping method three improved method was proposed by (Niroumand et al., 2012) to obtain the spatial arrangement of land cover class in image obtained from soft classification. (Feng et al., 2010) proposed a unique subpixel shifts algorithm which reduced processing time and improved accuracy and this method has a initialization based on multiple subpixel shifted mapping.

At present, some of the remote sensing satellites have the capability to acquire data at different spatial resolution. Thus, it is important to know the information extracted from remote sensing data change with spatial resolution changes, from same remote sensing platform. In order to provide discrete variation in information, many sensors have the capability to acquire data in narrow bandwidth of the order of 10 nm or so Suresh and Jain (2016). This high dimensionality data set increases the burden in computer processing (Suresh and Jain, 2014). Hence, there is a need to identify the optimal number of bands required for analysis so that the information can be acquired within acceptable limits.

Topography also plays an important role, especially, in hilly areas, where the shadow masks out the background information. Normal procedures such as ratio or normalized differential vegetation index (NDVI) are able to eliminate the impact of shadow. However, this may have impact when sub-pixel classification procedures are adopted. Thus, there is a need to study the effect of terrain type on sub-pixel classification. This data was taken from the AVIRS Free standard data products downloads page at the website: <http://aviris.jpl.nasa.gov/html/aviris.freedata.html>. This is the Moffett field sample image in reflectance that was collected in 1997.

## 2. Methodology

### 2.1. Sub pixel mapping

Up-scaling and downscaling often generates noises as mixed pixel which often generates error in classification and poses problem in scene detection. One of the major contributions for this paper is the introduction of Commission International Emission (CIE) CIE-XYZ colorimetry for noise reduction in satellite data for scene detection. A simple and efficient algorithm for subpixel target mapping from remotely sensed Earth observation satellite images. Following an initial random allocation of “soft” pixel proportions to “hard” sub pixel binary classes, the algorithm works in a series of iterations. Subpixel swapping is also referred as sub pixel mapping (SPM) in classification of remote sensing process (Atkinson, 2009). Super resolution techniques reduces the spatial

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