Algorithm for image classification with overlapping classes

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Abstract. In this paper we propose an algorithm to raise the classification of satellite imagery that lets you work with non-homogeneous regions. There are different approaches for image classification using only pure classes. It is a motivation to develop a classifier for determining membership of the non-homogeneous regions with more than one class. Soft Computing is used because of its ability to handle the uncertainties present in nature.

Keywords: Classification, regions impure, soft computing, satellite images.

1 Motivation

Classification is the process of developing thematic maps from remote sensing images. Traditionally, classification was achieved by visual interpretation of features and the manual delimitation of their boundaries. However, with the advent of computers and digital imagery, attention has focused on the use of computer-assisted interpretation. Therefore, the majority of classification projects today make use of digital classification procedures, guided by human interpretation [1]. Each type of material interacts with electromagnetic energy by either refectling, absorbing or transmitting it. This interaction varies from one wavelength to the next – a pattern known as *Spectral Response Pattern* (SRP). The basis for classification is thus to find some area of the electromagnetic spectrum in which the nature of this interaction is distinctively different from that of other materials that occur in the image. SRP is a characteristic of this material. However, in practice, the determination of consistently distinctive signatures is difficult to achieve for the following reasons: 1) most vegetation types do not have consistent SRP, 2) changes in illumination and moisture variations, 3) most landcover consist of mixtures of elementary features that are sensed as single pixels and 4) for a given sensor, there is no guarantee that the wavelengths in which it senses will be the same as those in which a material is most distinctive.

Traditional classifiers can be called hard classifiers since they yield a hard decision about the identity of each pixel. In contrast, soft classifiers express the degree to

which a pixel belongs to each of the classes being considered. Thus, for example, instead of deciding that a pixel is either deciduous or coniferous forest, it might indicate that its membership grade in the deciduous class is 0.43 and coniferous is 0.57 (which a hard classifier would conclude is coniferous). Soft classifiers can give us better information as to the composition of a pixel within a satellite image. Some reasons are: (1) determine the mixture of landcover classes present and (2) measure and report the strength of evidence in support of the best conclusion that can be made.

2 Previous works in the area

Fuzzy logic (FL) provides a simple way to make conclusions from the information vague or ambiguous. The fuzzy theory has been used in [2] for the classification of ambiguous regions that can not be adjusted as belonging to a single class. In the same vein, in [3] propose an adaptive fuzzy system that works with positive and negative rules. Each rule can represent more than one class to improve classification. The advantage of combining artificial neural networks (NNs) and FL is that neuro-fuzzy systems have the ability to learn from training data and linguistic rules to generate sentences. In [4] is presented a neuro-fuzzy classifier system (NEFCLASS) in which a multilayer neural network is capable of learning fuzzy rules from training patterns, making the classification, and generates fuzzy linguistic rules. In [5] is reported a neuro-fuzzy method from a generic model of a three-layer fuzzy perceptron. The weights, input units and the activations of output units of the neural network are modeled as fuzzy sets for improved classification. The models presented above build a simple classifier to classify images. Another approach is represented by ensembles of classifiers that refer to the combined response of several individual classifiers for the classification. The model shown in [6] is composed of elementary neural-fuzzy classifiers (FNCs) organized in a multilayer structure with feed forward. Other works reported are: support vector machines in combination with neural networks (FSVM) [7], Bayesian approach [8], etc.

3 Hypothesis or research objectives

3.1 General Objective

Design an algorithm for classification of satellite imagery for classifying overlapped regions.

3.2 Specific Objectives

i. Propose (possibly extend) a segmentation algorithm able to segment at different levels of abstraction.

ii. Implement an algorithm to learn the best features of an image that helps to classify more accurately non-homogeneous regions.
iii. Propose an algorithm to classify satellite imagery with impure regions that determine the membership of the regions to classes.
iv. Verify the proposed algorithm to check its effectiveness against other proposals and with the expert domain.

4 Methodology

1. Review and analysis of the state of the art with respect to soft classifiers.
2. Figure 1 shows a diagram of the proposed method containing the following steps:
   a. Decomposition of the satellite image in 4 spectral bands (R, G, B, and NIR).
   b. Determining the pure regions in order to identify pure well-defined classes (basic categories). We will use a segmentation algorithm based on regions growing.
   c. Feature extraction using tools such as MATLAB or HALCON.
   d. Implementation of a wrap type algorithm for the selection of attributes.
   e. For each mixed region, identify its constituent pure classes. We will also use the context information provided by surrounding pixels.
   f. Determining the composition of each pixel with respect to pure classes. Fuzzy evaluation will be used to determine the membership of each pixel to the different classes that composes it.
3. Identification and characterization of the domain of application for classification of images.
4. Implementation of the proposed algorithm in a programming language.
5. Evaluation of results by conducting experiments.
6. Comparison of the results with other systems such as the NEFCLASS [4] and the FUZCLASS module of IDRISI Andes [2].
7. Publish articles.

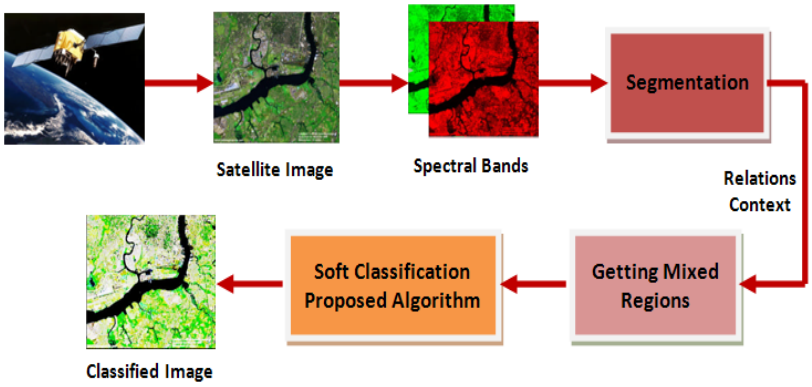

Fig. 1. Diagram of the proposed method for soft classification.

5 State of the research

Document review and analysis of the state of the art. Literature review of issues related to: soft classification, image segmentation and feature extraction applied to images. Analysis of the work closest to the proposed. Design and implementation of segment. Analysis of the segment proposed in [9] to propose an extension that allows us a first look to find the ambiguous regions in a satellite image.

6 Preliminary results (or conclusions)

The proposed research seeks to achieve the following contributions:

i. Extension of the segment images based on the work proposed by [9] to identify regions with this impure and assist the proposed classifier for classification with non-homogeneous images.
ii. Development of a classification algorithm applied to the impure regions classification of satellite images using soft computing.

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