GENERATION OF ENTROPY BASED BINARY RANDOM FIELDS FOR IMAGE BUNDARY DETECTION BASED ON FUZZY SEMANTIC RULES

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ABSTRACT:
This work presents a high resolution image classification by generating binary random fields based on fuzzy semantic rules by means of descriptors such as form, texture and relations between objects and sub-objects. Fuzzy systems are capable of representing diverse, non exact, uncertain and inaccurate knowledge or information. They use qualifiers that are very close to the human way of expressing knowledge, such as bright, medium dark, dark etc. Fuzzy systems can represent complex knowledge and even knowledge from contradictory sources. They are based on fuzzy logic, which represents a powerful approach to decision making. . The images are derived from multiresolution segmentation. It allows a creation of different levels of segments supporting a hierarchical structure, generating spatial relations between objects and sub-objects.

Key words:
image classification, Fuzzy set, ROI, Semantic rules, Multiresolution and entropy.

INTRODUCTION:

Zadeh introduced the concept of fuzzy sets in which imprecise knowledge can be used to define an event. The relevance of fuzzy set theory to image classification problems has been adequately addressed in the literature [1-2]. In general, fuzzy set theory may be incorporated to handle uncertainties resulting from deficiencies in various stages of a image classification [6-8]. In particular, fuzzy image processing and classification is under rapid development. The reason for the increasing interest in fuzzy image processing mainly lies in the realization that many of the basic concepts in image analysis, such as that of an edge or a boundary, are ambiguous in nature and cannot be defined precisely .Fuzzy set theory appears to be a good approach to deal with such uncertainty issues involved in image processing and classification [3-4]. Image segmentation algorithms that exploit fuzzy set theory can be divided into three categories: threshold, clustering and edge detection. Each of these classes is similar to their non-fuzzy counterparts, with the only difference being that key parameters are determined with uncertainty taken into consideration. In this case, the classification is based on fuzzy logic. Each class of a classification scheme contains a class description. Each class description consists of a set of fuzzy expressions allowing the evaluation of specific features and their logical operations [5]. The control knowledge is represented explicitly by a set of rules. Each rule is composed of a condition and an action part. The condition is formulated by means of parameters or class descriptors the formulation of the rules for classification based on segmentation is carried out by the context information and relationships of the classes. A hierarchical network is topologically definite, i.e. the border of a super object is consistent with the borders of its sub objects. The classes were described using spectral and shape information. Generally in higher hierarchy spectral information can yield good results, such as mean, brightness and ratio. To distinguish different objects which are very close spectrally form parameters such density, asymmetry and shape index could be useful. The features concerning to texture are based on sub object analysis [9]. The texture features might be related to spectral information or spatial information of the sub objects. A fuzzy rule can have one single condition or can consist of a combination of several conditions, which have to be fulfilled for an object to be assigned to a class. On other hand parameters such shape as index and asymmetry can be used to discriminate objects, which differ in shape. The strategy for the classification was multiresolution segmentation, which uses information provided by small object primitives to label large scale objects. The selection of scale parameters was purely empiric.

FUZZY SYSTEM DESIGN:

Fuzzy system design consists of several steps some of main steps are

1. Design functional and operational characteristics of the system

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2. Define fuzzy sets by decomposing each input and output variable of the fuzzy system into a set of fuzzy membership functions.

3. Convert problem-specific knowledge into fuzzy if – then rules that represents a fuzzy associative memory.
4. Using a training set, determine systems performance.

FUZZY SETS AND FUZZY MEMBERSHIP FUNCTIONS:

When humans describe objects , they often use imprecise descriptors such as bright , large , rounded , elongated ,etc., For instance , fair – whether clouds may be described as small , medium dark or bright, some what rounded regions ; thunderstorm clouds may be described as dark or very dark , large regions- people are quite comfortable with such descriptions[1]. However, if the task is to recognize clouds from photographs of the sky automatically by using pattern recognition approaches[9-10], it

becomes obvious that crisp boundaries must be drawn that separate the cloud classes. It may be quite arbitrary to make a decision about the boundary location – a decision that a cloud region R1 characterized between average grey level g , roundness r and size s represents a thunderstorm cloud , while the region R2 characterized by average gray level g+1, the same roundness r and size s does not . It may be more appropriate to consider region R1 as belonging to the set of fair whether clouds with some degree of membership and belonging to the set of thunderstorm clouds with another degree of membership . Similarly, another region R2 might belong to both clouds sets with some other degree of membership. Fuzzy logic thus facilitates simultaneous membership of regions in different fuzzy sets.

A fuzzy set S in a fuzzy space X is a set of ordered pairs

$S=\{(x, \mu s(x)) | x \in X\}$

Where $\mu s(x)$ represents the grade of membership of x in S. The range of the membership function is a subset of non-negative real numbers whose supremum is finite. For convenience, a unit supremum is widely used.

$\text{Sup}_{x \in X}\ \mu s(x)=1$

The fuzzy sets are often denoted solely by its membership functions.

FUZZY SET OPERATORS:

Rarely can recognition be solved using a single fuzzy set and the associated single membership function. Therefore, tools must be made available that combine various fuzzy sets and allow one to determine membership function of such combination. In conventional logic, membership functions are either zero or one and for any class set S, a rule of non-contradiction holds: An intersection of set S with its complement S^c is an empty set.

$$S \cap S^c = \theta$$

Clearly, this rule does not hold in fuzzy logic, since domain elements may belong to fuzzy sets and their complements simultaneously. There are three basic Zadeh operators on fuzzy set: fuzzy intersection, fuzzy union, and fuzzy complement. Let $\mu_A(x)$ and $\mu_B(y)$ be two membership functions associated with two fuzzy sets A and B with domains X and Y.Then the intersection, union and complement are point wise defined for all x € X, y € Y.

The other definitions also exist as

Intersection $A \cap B$:

$$\mu_{A \cap B}(x,y) = \min[\ \mu_A(x) , \mu_B(y)\ ]$$

Union AUB :

$$\mu_{AUB}(x,y) = \max[\ \mu_A(x) , \mu_B(y)\ ]$$

Complement A^c :

$$\mu_{A^c}(x) = 1 - \mu_A(x)$$

ENTROPY:

Entropy is an essential terminology in the field of information theory. It was originally used to estimate how much of the data can be compressed [6]. The entropy H itself measures the average uncertainty of a single random variable X:

$$H(p) = H(X) = \sum_{x \in X} p(x) \log_2 p(x)$$

Where p(x) is the probability mass function of the random variable X and the above equation tells us the average bits we need to represent all the information in X. For example, if we toss a coin and make X be the count of head; X will be a binary random variable. In this paper fuzzy semantic rules are used to estimate entropy for boundary detection of image classification.

METHODOLOGY

In this case, the classification is based on fuzzy logic. Each class of a classification scheme contains a class description. Each class description consists of a set of fuzzy expressions allowing the evaluation of specific features and their logical operation. Based on fuzzy sets a novel method is proposed .In this method first, the ROI is determined where the object is present. Next, the frequency range in which the proportion of the background to the ROI varies is estimated through supervision. In the histogram of the ROI, let us denote the lower and the upper bounds of the background proportion as Hf and Hl, respectively. The rationale behind the range estimation can be justified as follows. As our purpose is to differentiate the object from its background, different elements will play different roles in the process. Specifically, those object elements with high, intensity and those background elements with low intensity are easy to identify, and the difficulty often comes from classifying the elements with medium gray levels. If the threshold is estimated based on the middle group, it will be less sensitive to outliers. In addition, more information from practice for a specific problem can be incorporated to tighten the proportion of these groups, which will help further reduce the chance for errors. Generally, the imaging process and the image quality should be taken into account, because imperfect imaging, noise, or partial volume effect could dramatically affect the variability of ROI as well as the variability of background portion. Finally, the threshold is determined by minimizing the classification error within the frequency range of background. For this purpose, we can accordingly modify the conventional histogram-based thresholding methods by incorporating into them the range constraint approach. Because the shape of histogram within the range is normally far from bimodal, the minimum error thresholding method will not be appropriate. For illustration, this method is formulated and presented in the following. For this method, the inputs are the ROI of the image to be segmented and the background lower and upper bounds in the ROI. Additional steps of this method are described below

Let Ab/A_o be the fuzzy sets of fuzzy events, background/object, which denotes a fuzzy partition of the set $\{r_{low}, r_{high}\}$, with the membership function μ_{Ab}/μ_{Ao}, respectively. Probability of fuzzy events are defined by

$$P(A_i) = \sum_{j=rlow}^{rhigh} \mu Ai(j) h(j)$$

Where $A_i \in \{A_b, A_o\}$, and the entropy with this fuzzy partition can be calculated as

$$S = P(A_b)\log P(A_b) + P(A_o)\log P(A_o).$$

Let $r_{low} <= a < c <= r_{high}$. The membership function can be defined as follows:

$$\mu A_o(x) = \begin{cases} 1, & Flow \le x \le a \\ \frac{x-c}{a-c} & a < x < c \\ 0, & C \le x \le T_{high} \end{cases}$$

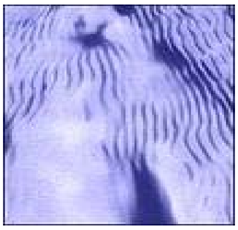
And

$$\mu A_b(x) = \begin{cases} 1, & Flow \le x \le a \\ \frac{x-c}{a-c} & a < x < c \\ 0, & C \le x \le T_{high} \end{cases}$$

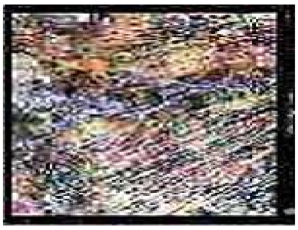
The optimum parameters a^ and c^ are chosen to maximize the entropy S, and the optimum threshold is

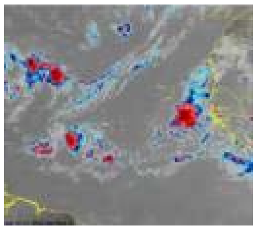
$$T = (a\hat{} + c\hat{})/2$$

EXPERIMENTAL RESULTS


Frogen continent1


Frogen continent2


Kalahari Desert1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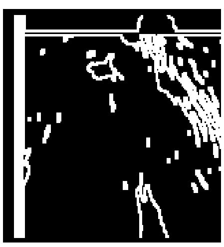
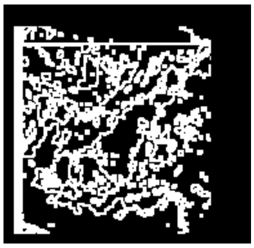
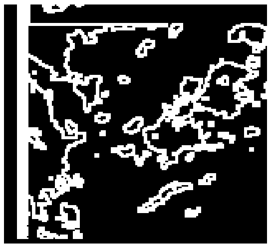

Frogen continent1


Frogen continent2


Kalahari Desert1


Kalahari Desert2

CONCLUSIONS

The proposed method is tested on forest, Kalahari Desert and continent images of size 150X150. The results are better than conventional entropy based methods like correlation entropy, ostu and maximum entropy. The advantages of the proposed method over their conventional counterparts are threefold. First the ROI is used instead of the whole image, so any irregularity outside the ROI will have no influence on estimating the threshold. Second, it provides a mechanism to handle cost differences of different types of classification error in response to practical requirements. Third, by appropriately specifying the lower & upper bounds of the background proportion within the constrained gray level range, the proposed method yields substantially more robust and more reliable segmentation. Experience from current applications demonstrates that Segmentation-based classification is in many instances superior to traditional methods mainly on high resolution images. Finally, it may be stated that the presented method and implementations are representing an important progress because it is obvious that a multisensoral analysis is needed to realize the full potential of remotely sensed data. Furthermore, for vegetation types detection, the context and semantic rules are fundamental to overcome the constraints of conventional classification methods.

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