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Rough sets for Eliciting Symptoms for Landuse Class Conflict

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Abstract

Conflicts are one of the most characteristic attributes in remote sensing multilayer imagery. Many models for conflict resolution and analysis have been proposed and studied till time. Class conflict occurs when there is presence of spectrally indiscernible distinct classes and how the human experts understand it based on his/her expertise. In this paper we try to outline a new approach to conflict analysis using rough set theory. The paper deals with the idea of eliminating the spectral band causing the conflict between opinions of two experts. It also highlights how the training data set can be used for this class conflicts analysis

Keywords

Rough Set Theory(Fuzzy Logic) Image Classification, Conflict Analysis, Remote Sensing.

1. Introduction

Earth-orbiting satellites transmit earth imageries in different spatial, radiometric & temporal resolution to the ground stations around the world. Satellite imagery is made up of tiny pixels (picture element) , each of a different gray shade or color. and represent the relative reflected light energy recorded for the objects on the ground. A primary use of remote sensing data is in classifying the myriad features in a scene (usually presented as an image) into meaningful categories or classes. The image then becomes a thematic map (the theme is selectable e.g., land use, geology, vegetation types, rainfall). A farmer may use thematic maps to monitor the health of his crops without going out to the field. A geologist may use the images to study the types of minerals or rock structure found in a certain area. A biologist may want to study the variety of plants in a certain location. For example, at certain wavelengths, sand reflects more energy than green vegetation while at other wavelengths it absorbs more (reflects less) energy. Therefore, in principle, various kinds of surface materials can be distinguished from each other by these differences in reflectance (Fig.1)

Certain satellite sensors can record reflected energy in the red, green, blue, or infrared bands of the electromagnetic spectrum, a process called multispectral remote sensing. The improved ability of multispectral sensors provides a basic remote sensing data resource for quantitative thematic information, such as the type of land cover. In real life sometimes, pixels which are in the interface region of two classes e.g. vegetation & water body, can not be clubbed together to a single category, say vegetation, because these pixels do not follow any one particular class's spectral signature. These type of pixels are generally known as mixed pixels. This is the case where a class conflict arises. This conflict may be resolved by inviting opinions of other experts. Why this conflict arises after all & what are the spectral bands responsible for this conflict in experts' opinions?
The motive of this paper is to attempt to provide answer this question using the Rough Sets Theory & identify the conflicting spectral band and elicitate class conflicts. The answer is: Rough Set Theory.

2. Rough set Theory

The Rough set concept is a new mathematical approach to vagueness and uncertainty. The rough set philosophy is founded on the assumptions that with

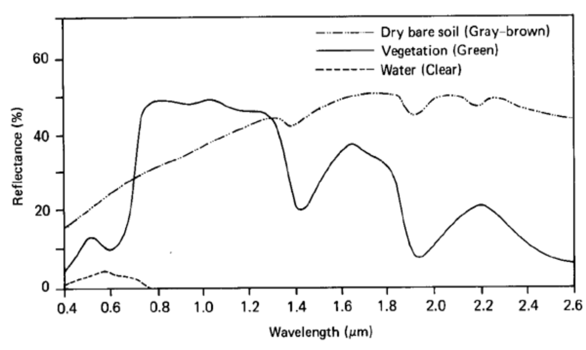

Figure 1: Spectral Response of terrain features

every object of the universe of discourse we associate some information. Any set of indiscernible (similar) objects is called elementary set, and form a basic granule of knowledge about the universe. Any union of some elementary sets is referred to as crisp (precise) set, otherwise it is rough (imprecise, vague). Each rough set has boundary line cases, i.e. objects which cannot be with certainty classified as members of the set or of its complement. Vague concepts, in contrast to precise concepts, cannot be characterized in terms of information about their elements. So we assume that any vague concept is replaced by a pair of precise concepts- called the lower and the upper approximation of the vague concept. The lower approximation consists of all objects which surely belong to the concept and the upper approximation constitutes the boundary region of the vague concept [2].

The basic concept of the RST is the notion of approximation space, which is an ordered pair A=(U,R), where

- U: nonempty set of objects, called universe
- R: equivalence relation (sometimes represented *by IND*) on U, called indiscernibility relation. If x, y € U and xRy then x and y are indistinguishable in A

Each equivalence class induced by R, ie, each element of the quotient set R~= U/R, is called an elementary set in A. An approximation space can be alternatively noted by A=(U,R~). It is assumed that the empty set is also elementary for every approximation space A. A definable set in A is any finite union of elementary sets in A. For x € U let $[x]_R$ denote the equivalence class of R, containing x. For each X € U, X is characterized in A by a pair of sets − its lower and upper approximation in A, defined respectively as:

$A_{low}(X) = \{x € U \mid [x]_R € X\}$
$A_{upp}(X) = \{x € U \mid [x]_R \cap X \neq \emptyset\}$

A rough set in A is the family of all subsets of U having the same lower and upper approximations.
This paper is organized into five sections. The section following the introduction illustrates the concept of rough set and dependency of attributes. The third section describes the methodology. The fourth section reports the results and the analysis of our result through calculations. The last section summarizes the important findings.

2.1 Dependency of Attributes

Another important issue in data analysis is discovering dependencies between attributes. Intuitively, a set of attributes D depends totally on a set of attributes C, denoted C $\Rightarrow k$ D, if all values of attributes from D are uniquely determined by values of attributes from C. In other words, D depends totally on C, if there exists a functional dependency between values of D and C.
Formally dependency can be defined in the following way. Let D and C be subsets of A.
We will say that D depends on C in a degree *k* (0 ≤ *k* ≤ 1), denoted C $\Rightarrow k$ D, if

$$k = \gamma(C, D) = \frac{|POS_C(D)|}{|U|},$$

$$POS_C(D) = \bigcup_{X \in U/D} \underline{C}(X),$$

$POS_C(D)$ called a positive region of the partition U/D with respect to C, is the set of all elements of U that can be uniquely classified to blocks of the partition U=D, by means of C:
Obviously

$$\gamma(C, D) = \sum_{X \in U/D} \frac{|\underline{C}(X)|}{|U|}.$$

If *k* = 1 we say that D depends totally on C, and if *k* < 1, we say that D depends partially (in a degree *k*) on C.
The coefficient *k* expresses the ratio of all elements of the universe, which can be properly classified to blocks of the partition U/D, employing attributes C and will be called the degree of the dependency.
It can be easily seen that if D depends totally on C then *IND(C)* $\subseteq$ *IND (D)*. This means that the partition generated by C is finer than the partition generated by D. Let us notice that the concept of dependency discussed above corresponds to that considered in relational databases.
Summing up: D is totally (partially) dependent on C, if employing C all (possibly some) elements of the universe U may be uniquely classified to blocks of the partition U/D [3]

3. Methodology

Our objective is to find out set of spectral bands which are causing experts to take differing view on the feature class of the terrain, of mixed pixels. We have taken a multi-spectral multi-resolution & multi-sensor image of Alwar area in Rajasthan. The 4-

spectral bands are in the visible bands namely: red, green, near-infrared (NIR) and middle infra-red (MIR) from LISS-III sensor of IRS-ResourceSat satellite. Also, two SAR images namely: low incidence S1 beam -20^0-27^0 (RS1) and other is High incidence S7 beam 45^0-49^0,(RS2) of the same area taken from Radarsat-1 satellite. The seventh image is digital elevation model (DEM) of the area (Table 1).

The ground resolution of these images from LISS-III, Radarsat-1 images have a 23.5m ground resolution of 10m. The DEM dataset is also generated from SAR interferometery using RS1 and RS2 and have 25 meter resolution.

The area is selected since it contains a good variety of land use features like urban, water body, rocky, vegetation & open areas. (Figure-3). The multi-spectral geo-referenced image-set consists of satellite images of dimension 472 X 546 pixels with the

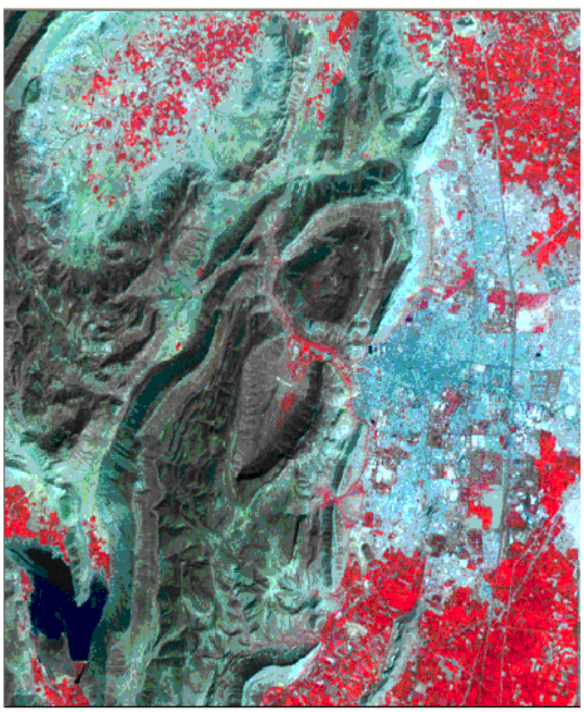

Figure 2: Image of Alwar area

We are having spectral signatures set from seven bands namely Red, Green, NIR, MIR, RS1, RS2, and DEM (Figure 4). This data set provided by the expert is divided into two portions namely the *training set*, that will be used to generate the classifier and the *validation set* for getting the classifier's accuracy assessment.

Table 1: The image data set

1.	Image- I	Red Band	Liss-III/IRS-P6
2.	Image-2	Green band	Liss-III IRS-P6
3.	Image-3	Near Infrared	Liss-III IRS-P6
4.	Image-4	Middle Infrared	Liss-III IRS-P6
5.	Image-5	LowInci,S1, 20^o-27^o	Radarsat-1
6.	Image-6	HighInc,S7,45^o-49^o	Radarsat-2
7.	Image-7	Digital Elevation Model (DEM) Res:25M	

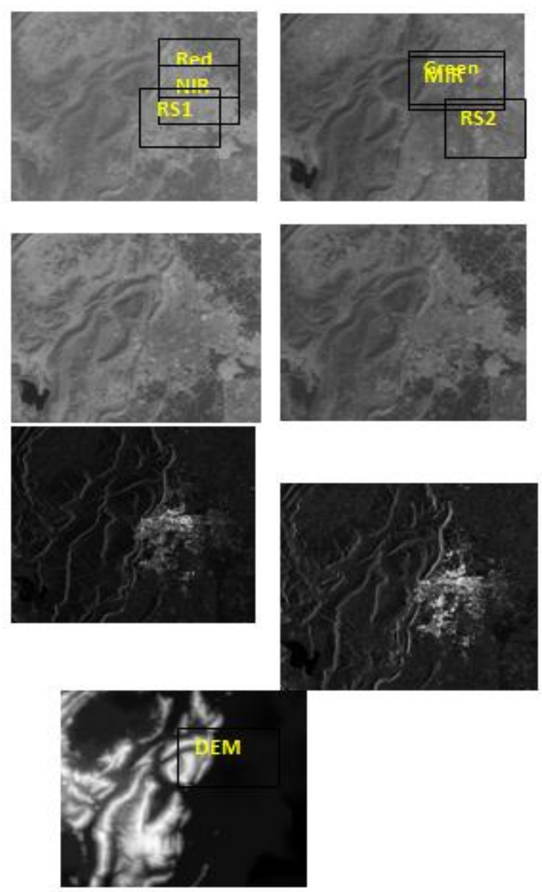

Figure 3: The 7-bands images

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The training data set (1432 pixels) can be represented in a tabular form similar to that of a relational database tables (Table 2). Rows of the table represent the training pixels and the DN values in the columns related to the 7-bands viz., Red, Green, NIR and MIR, RS1, RS2 & DEM. The table has, therefore,7 attributes.

3.1 Problem Definition

We may redefine our problem as:

i. The representative mixed pixel (of class water body-vegetation) is composed of 7 bands DN Values.
ii. Let three experts, based on their perception, experience and domain knowledge (Fig. 5), assign class tags to this pixel as: Expert1: water body Expert2: vegetation Expert3: Water body.Calculate attribute (Inter-bands dependency) on the class type using the formula

$$k = \gamma(C, D) = \frac{|POS_C(D)|}{|U|},$$

$$POS_C(D) = \bigcup_{X \in U/D} \underline{C}(X),$$

Table 2: Spectral Signature in Digital Numbers

K182 fx

	A	B	C	D	E	F	G	H	I
1		RED	GREEN	NIR	MIR	RS1	RS2	DEM	DECISION
155		127	96	184	131	17	32	29	Barren
156		132	104	182	142	13	28	29	Barren
157		103	83	160	135	18	20	29	Barren
158		132	104	190	146	18	39	29	Barren
159									
160	Stdev	18.0886	16.6277	15.8201	14.415	16.0566	16.8598	39.5913	
161	Avg	133.911	106.331	196.841	136.166	28.0318	34.3439	55.1083	
162									
163		62	49	135	91	44	40	94	Rocky
164		84	64	160	102	20	25	165	Rocky
165		52	45	129	85	15	29	107	Rocky
166		91	69	171	106	10	46	123	Rocky
167		87	67	168	104	8	21	157	Rocky
168		76	59	157	95	9	47	114	Rocky
169		70	51	159	95	11	46	127	Rocky
170		82	59	159	100	7	9	173	Rocky

4. Result Analysis

We have calculated the lower approximations for every conflicting classes (Open area-Vegetation, Water body-Vegetation, Rocky area - Vegetation, and Urban –Open area) calculated the cardinality of positive region and then plotted the graphs to see which spectral bands are causing the conflict in experts opinions.

The graphs plotted are for the pixels where the conflict was arising regarding their spectral signature and it can be seen from the graphs what all spectral bands are responsible for these conflicts. The graph ordinate *represents the dependency*, k, and *abscissa represents the bands.*

The calculations of lower approximations & cardinality ratios for identifying the role of bands in the conflict is carried out using the ROSSETTA software

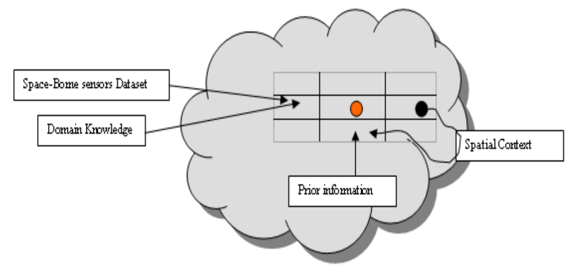

Figure 4: Expert's perception and deriving most appropriate label for a pixel.

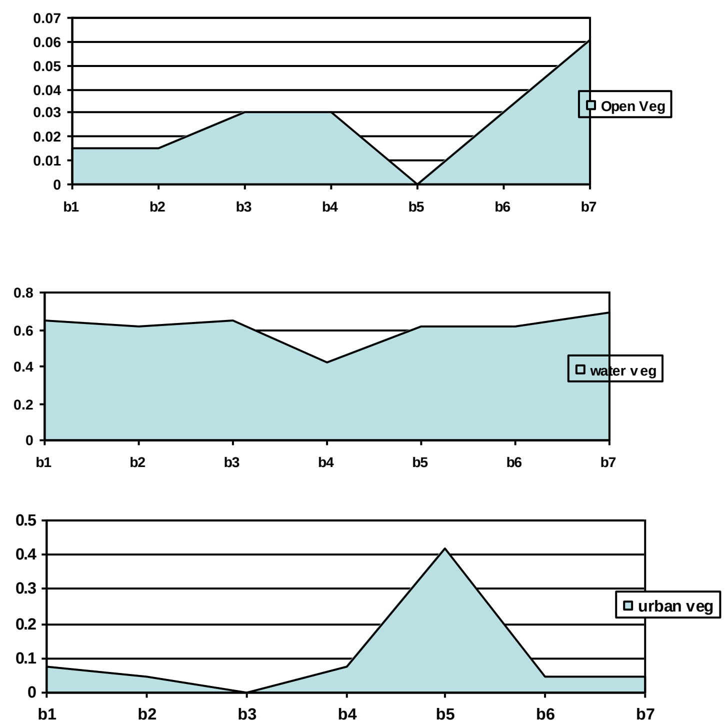

Figure 5: Open Veg, Water Veg, and Urban veg

As a representive case, refer to graph (urban-vegetation), b3 (NIR band) & b5 (RS1) plays very crucial role. Band b3 is good for delineating vegetation Landover whereas b5 is good for identification of urban area. & these are the band responsible for creating class tag conflicts in the experts' opinion.

5. Conclusion & Future Directions

From the study carried out in this study, we derive following inferences:

i. The calculation of dependency of spectral bands based on the prime constructs like lower approximation space of the Rough Set theory provides an instrument to get an insight of the cause of the conflict in assigning mixed pixels a definite class tag/ label.

ii. The class lebel assignments to these mixed pixels may be resolved further using the granular computing paradigm by finding associations between granules composed of these pixels.

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