

Soil Image Segmentation and Texture Analysis: A Computer Vision Approach

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ABSTRACT: The objective is to extract soil features of a sample of soil and estimate the soil type using satellite images of soil obtained by remote sensing and using Segmentation technique in Matlab to get the desired results. We employ different segmentation techniques to reveal the minute features of the soils which will help us to classify them based on these features.

KEYWORDS: Computer vision, image segmentation, remote sensing, soil analysis, texture analysis.

I. INTRODUCTION

Soil plays a vital role on sustaining all life-forms. The features of soil decide the diversity of organisms. It influences the distribution of plant species and provides a habitat for a wide range of organisms. It controls the flow of water and chemical substances between the atmosphere and the earth, and acts as both a source and store for gases (like oxygen and carbon dioxide) in the atmosphere. Soils not only reflect natural processes but also record human activities both at present and in the past. They are therefore part of our cultural heritage. Soil feature extraction through image processing therefore becomes essential to understand its content and to reveal the way it influences the existence of various life-forms.

Image processing can be defined as the analysis and manipulation of a digitized image, especially in order to improve or enhance its quality. There are various techniques which we can employ to achieve the required result but here I am concentrating on the segmentation techniques with the help of which I have tested this approach of mine.

Feature identification based on colour focuses on "Spectral Reflectance" properties of different elements of images. The high spectral correlation between red, blue and green limits dimensions to identify these components independently. So, additional image processing techniques are applied. Generally,

BLUE BAND	- identifies water, soil and vegetation mapping.
GREEN BAND	- measures reflectance of vegetation and
RED BAND	- sensitive to chlorophyll, identifies vegetation.
INFRARED BAND	- vegetation and soil moisture mapping

Texture study requires application of certain algorithms for the successful extraction of desired feature.

What is texture?

Everyday texture terms - rough, silky, bumpy - refer to touch.

A texture that is *rough* to touch has:

- a large difference between high and low points, and
- a space between highs and lows approximately the same size as a finger.

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Silky would have

- little difference between high and low points, and
- the differences would be spaced very close together relative to finger size.

Image texture works in the same way, except the highs and lows are brightness values (also called grey levels, GL, or digital numbers, DN) instead of elevation changes. Instead of probing a finger over the surface, a "window" - a (usually square) box defining the size of the probe - is used.

Textures in images quantify:

- *Grey level differences (contrast)*
- *Defined size of area where change occurs (window)*
- *Directionality or lack of it*

Image segmentation can be divided into three different but complementary stages, i.e.

1. Pre-processing
2. Region/feature extraction
3. Segmentation Algorithm Application

II. ALGORITHMS EMPLOYED

➤ K-Means Algorithm:

This is used to determine the natural spectral regions present in the remote sensing data set. It starts with some clusters created by associating each pixel in the image to the given nearest centroid, then mean values of the elements in the clusters are computed and the centroids are replaced by them. These steps are done iteratively until there is no more allocation of pixels available for creating new clusters.

➤ Watershed Segmentation:

- a gradient image of the scene is constructed;
- on each object of interest or homogeneous region a marker (set of feature points inside desired region) is detected; and
- the watershed lines associated to the markers are constructed.

➤ Color Segmentation:

- A process of extracting from the image domain one or more connected regions satisfying uniformity criterion which is based on feature(s) derived from spectral components.

➤ Thresholding Segmentation:

Dealing with techniques for partitioning images into different regions based on intensity values. An image is denoted by $f(x, y)$ and a segmented image is given by :

$$g(x, y) = \begin{cases} 1, & f(x, y) > T \\ 0, & f(x, y) \leq T \end{cases} \quad \text{-----1.1}$$

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T is the threshold that extracts the objects from the background

1. Selecting an initial estimate for the global threshold T.
2. Segmenting the image using Eq-1.1, which will produce two groups of pixels: G_1 with pixels of intensity value $> T$, and G_2 with pixels values $\leq T$.
3. Computing the average intensity values m_1 and m_2 for pixels in G_1 and G_2 .
4. Computing new threshold value :

$$T = k \frac{1}{2} (m_1 + m_2)$$
5. Repeating Steps 2 through 4 until the difference in the value of T in successive iterations is smaller than a predefined parameter ΔT

Texture Vector Preparation Techniques worked on:

1. GLCM (Grey Level Co-occurrence Matrix) : A tabulation of how often different combinations of pixel brightness values occur in an image. GLCM texture considers the relation between two pixels at a time, called the reference and the neighbour pixel.

Problems associated with the co-occurrence matrix methods:

- they require a lot of computation (many matrices to be computed)
- features are not invariant to rotation or scale changes in the texture

But they provide with satisfactory results.

2. Invariant Moments:

Simple properties of the image which are found *via* invariant moments include area (or total intensity), its centroid, and information about its orientation. Moment invariants have been frequently used as features for image processing, remote sensing, shape recognition and classification. Moments can provide characteristics of an object that uniquely represent its shape. Invariant shape recognition is performed by classification in the multidimensional moment invariant feature space. Several techniques have been developed that derive invariant features from moments for object recognition and representation. These techniques are distinguished by their moment definition, such as the type of data exploited and the method for deriving invariant values from the image moments.

3. Auto-Correlation:

Auto-Correlation between pixels in digital images of sediment is used to measure average grain size, its distribution and vertical profiles of sediment on a bed. An important property of many textures is the repetitive nature of the placement of texture elements in the image. The autocorrelation function of an image can be used to assess the amount of regularity as well as the fineness/coarseness of the texture present in the image. Formally, the autocorrelation function of an image is defined as follows

$$f(x, y) = \frac{\sum_{u=0}^N \sum_{v=0}^N (I(u, v) I(u + x, v + y) n)}{\sum_{u=0}^N (I(u, v) I(u + x, v + y) m) \sum_{v=0}^N (I^2(u, v) m)}$$

The image boundaries must be handled with special care but we omit the details here. This function is related to the size of the texture primitive (i.e., the fineness of the texture). If the texture is coarse, then the autocorrelation function will drop off slowly; otherwise, it will drop off very rapidly. For regular textures, the autocorrelation function will exhibit peaks and valleys.

4. Gabor Transformation:

These functions have optimal localization property in the joint time or frequency domains helping in optimal extraction of texture information. The Gabor transform, named after Dennis Gabor, is a special case of the short-time

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Fourier transform. It is used to determine the sinusoidal frequency and phase content of local sections of a signal as it changes over time.

III. RESULTS

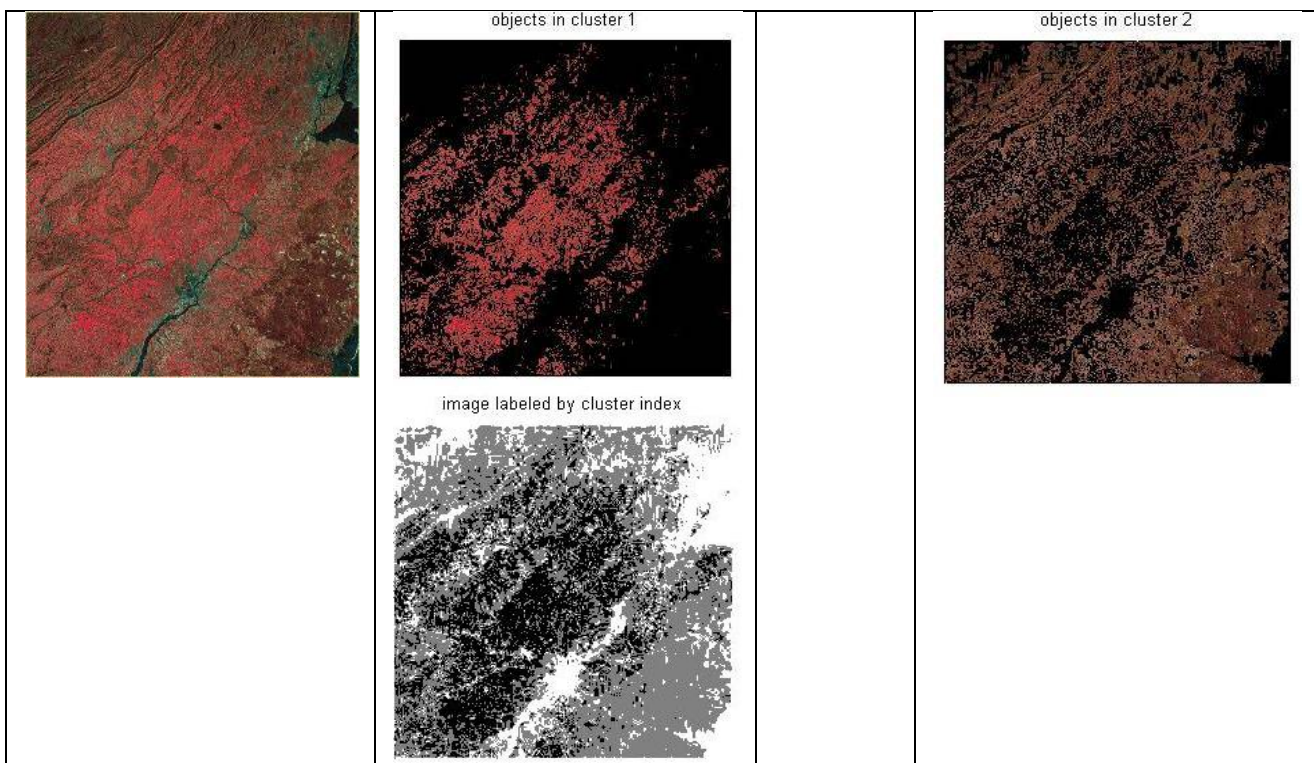
After applying the above mentioned algorithms we were successful in getting satisfactory results. The obtained results provided me with results better than expected. This approach can be of vital importance to us if we want to study the features of the soil of any remote area where human access is difficult. With the help of satellite imaging we can get pictures of the areas of interest, processing the images of which one can declare the soil type and its features which can be used to study the type of vegetation supported there.

IV. EXPERIMENTAL RESULTS

Using K means segmentation soil analysis:

RED SOIL:

Here we can observe that the results are very much satisfactory giving us the perfect distinguished image of red soil areas



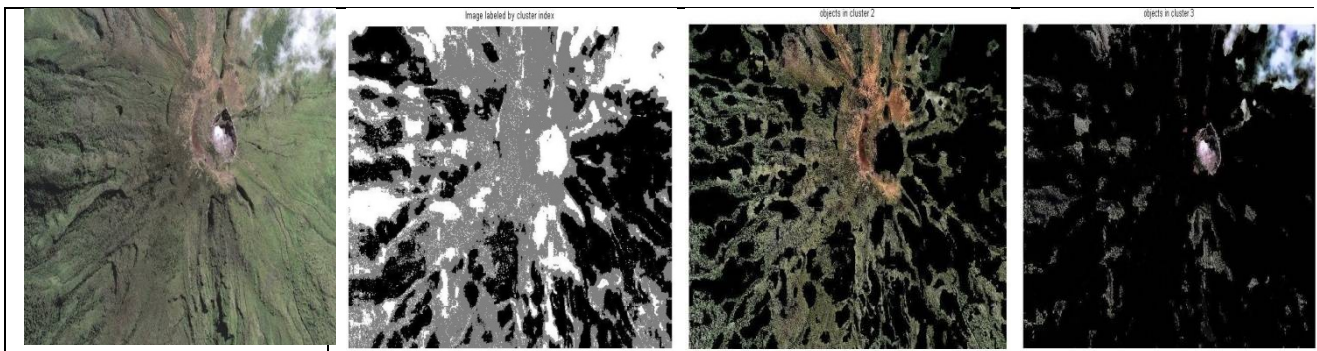
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BLACK SOIL:

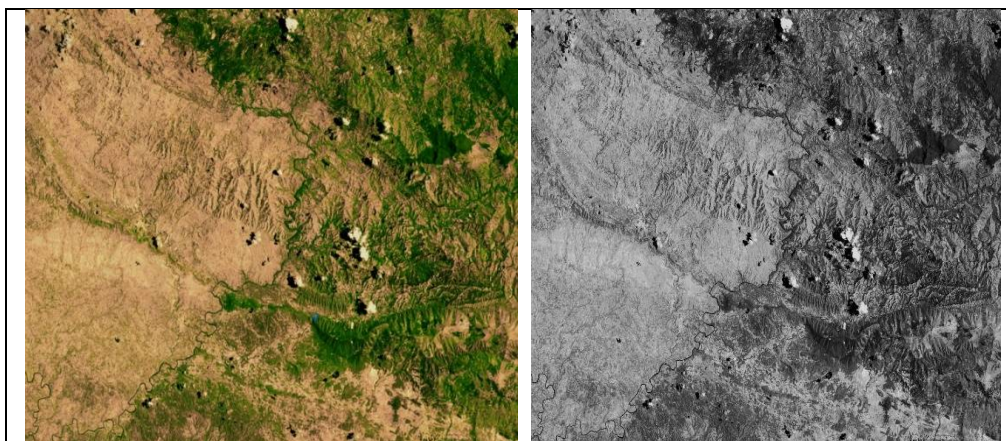
The same can be observed for th black soil areas as well. The results show the detected black soil areas very well distinguished.



Texture Analysis Using Thresholding and Watershed Segmentation:

SANDY SOIL:

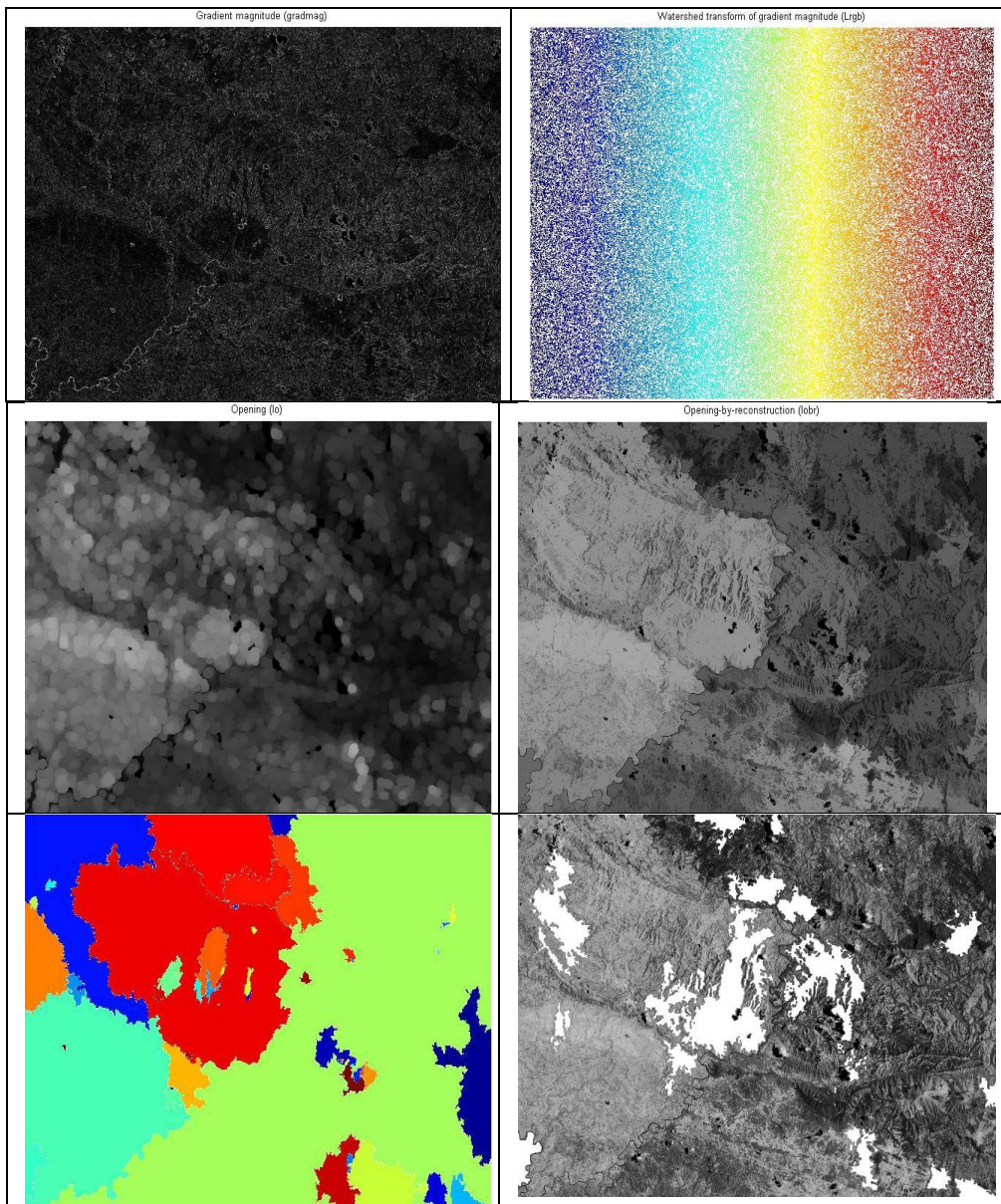
The rough area with scattered sand particles for sandy areas was detected and distinguished from the rest of the environment successfully



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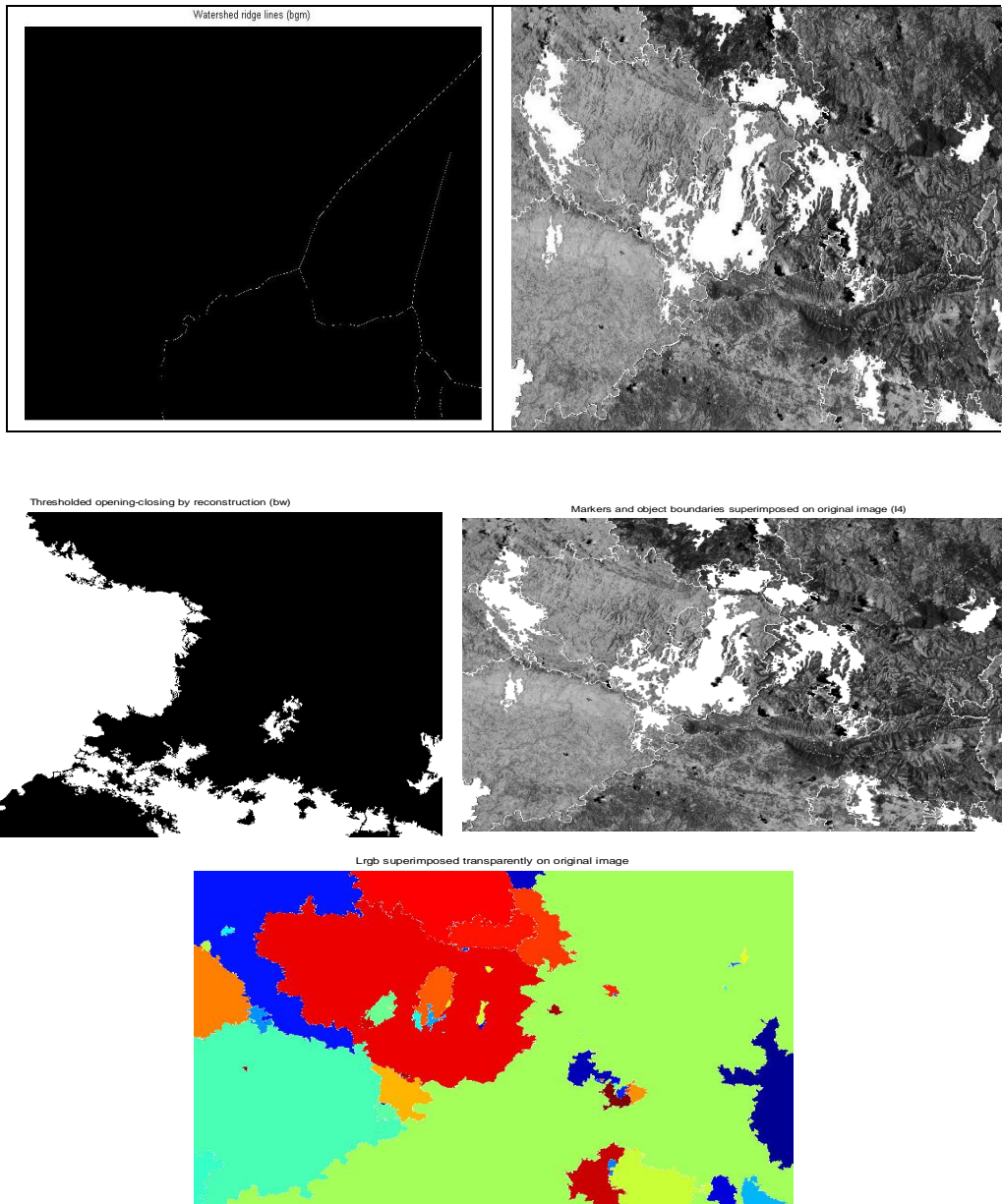
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These results were quite impressive as most of them displayed the required minute features almost correctly

V. CONCLUSION

We have implemented various algorithms for the detection of soil features basically colour and texture. Our algorithm successfully detects the soil region from the image which consists of distinguished colours and identifiable texture. We have applied our algorithm on many images and found that it successfully detects the features quite well.



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- [3] Image Analysis of Soil Micromorphology: Feature Extraction, Segmentation and Quality Inference *Petros Maragos¹, Anastasia Sofou¹, Giorgos B. Stamou¹, Vassilis Tzouvaras¹,Efimia Papatheodorou² and Giorgos P. Stamou²