Hyperspectral Image Based Soil Classification using Deep Soft Computing Techniques

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KEYWORDS

Hyperspectral Images, Deep Soft Computing, Deep Fuzzy Logic, Deep Regression, Soil Classification, Types of Soils.

ABSTRACT

In India Agriculture is the main employment. The growth of population leads to decrease of cultivation land significantly. To ensure the increase of crop production it is necessary to identify and select the appropriate soil type because different crops need different soil types. In present scenario image processing and chemical analysis are used to determine the soil types. In image processing hyperspectral remote sensing image analysis is the efficient technique for classifying different types of soils. For classifying these soil types deep soft computing methods like deep regression algorithm and deep fuzzy logic algorithms are applied to classify the soil types.

1. Introduction

Food is the main source in the earth to live. These foods are come from cultivation of crops in soil. For cultivation of crop every type of soil is not suitable because soils have different properties [6]. For example, sandy soil uses large amount of water whereas clay soil uses less water because it stores large capacity of water. The identification of soil type is the first step for cultivation crop. Image analysis and chemical analysis are the two ways for identifying the soil types [7]. The chemical analysis is done in lab by mixing different chemicals to know the soil type which is expensive and time consuming method.

Whereas using image processing the soil type is classified based on color, texture of soils. The texture and colors describes the physical, biological, chemical properties of soil [1]. Due to environmental changes soil texture and color may change in different areas. Therefore, for image analysis remote sensing technology is the new possibilities because it takes images in real time environment [8]. Hyperspectral image is a remote sensing technology used to define various domains like biology, precision agriculture, land cover application, chemistry, detecting natural disasters etc.,.

To classify the soil types color properties are mainly used technique in digital image processing [9]. The soil colors are identified by applying deep soft computing techniques like deep regression and deep fuzzy logic algorithm to classify soil types.

2. Hyperspectral Image

A device of remote sensor captures the reply which is built on various features of the surface land, counting artificial and natural cover. A linguist uses the section of site, pattern, tone, shape, shadow, size, texture, and connotation to originate info about cover of land [10]. The group data or images of remotely sensed by several kinds of sensor hovered on-board dissimilar stages at variable heights overhead the topography at dissimilar periods in every

day and years may not to lead a modest classification scheme. It is repeatedly thought that no single cataloguing might be used through all kinds of images and all balances. The effective effort in emerging a general drive classification structure attuned with data of remote sensing that is supported by Anderson at 1976, which is similarly denoted to as USGS (United States Geological Survey classification) structure.

3. Methodology

In this work, Chittoor and Tirupati districts are selected for soil type classification. In Chittoor and Tirupati district four different regions of Hyperspectral image are for the Soil classification due to with one hyperspectral image we cannot find the different types of soil because each region of hyperspectral image may contain one or two type of soil only. Then soft computing techniques like deep regression algorithm and deep fuzzy logic algorithm are applied for soil type classification.

3.1 Deep Regression Algorithm

Regression technique is used widely to solve and predict continuous values in computer vision [2]. The process of getting quantitative knowledge from image fusion and for reconstructing image regression is used. The image reconstruction is a process of changing the signals that are obtained from multiple projections at the phase of data acquisition of image [3]. So the obtaining process contains non-linear and complex image. For this case deep learning method is applied to the regression method for solving the problem. The figure 1 shows the deep regression method

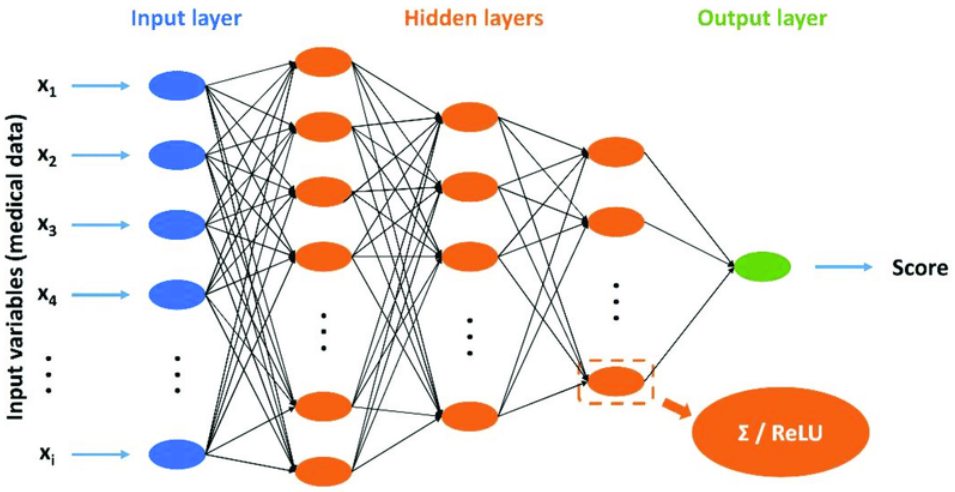


Figure 1: Deep regression method

The network contains three layers like input layer, hidden layer and output layer. The network output layer is derived as

$$F(x;\theta) = (f_{L\ 0.....0}\ f_1)(x) \quad ----------(1)$$

Where f_i is depends on parameter $\theta_i\ \epsilon\ H_i$ in that θ represents the parameter set (θ_i, ……., θ_L. The important parameters in optimization are loss of function. The loss of function is designed for prediction of performance in the deep regression model. In deep regression the loss function is mostly considered as square loss and these is described as

$$J_n(x, y{:}\theta) = 0.5\{y - F(X;\theta), y - F(X;\theta)\} ----------(2)$$

The new parameters like weights (w), biases (b) and to minimize the errors in deep regression process a gradeient descent is applied and the equation is given as

$$V_{\theta L}J(x,y;\theta) = \nabla^*_{\theta L} f_L(X_L) * D^*_{WL+1}(X_{L+1}) * e_L = \nabla^*_{\theta L} f_L(X_L) * e_L \text{ ---------- (3)}$$

For image prediction, pixels are used to predict the image represents in matrix pixel which as x and y positions. The training process in deep learning model [4], array pixels converted for dimensionality reduction with color values are normalised in the rage from 0 to 1.

The input vectors for applying the deep regression method for predicting measurement cases with a unique value as equation 4

$$I = [X_1, X_2, X_3, X_4, X_5, \ldots\ldots, X_{48}] - - - - - - - - - - - (4)$$

The vector output contains the pixel values as equation 5

$$\emptyset = [y_1, y_2, y_3, \ldots\ldots, y_{16}] \text{ ---------- (5)}$$

The output vector image prediction with input pixels, hidden neurons and other hidden layers are reflected in linear regression is transferred the function for classifying the hyperpsectral image to know the soil types.

3.2 Deep Fuzzy Logic Algorithm

To classify the each pixel in image to find the soil types. For identifying soil types soil color like white (w), gray (g), red (r), brown (b1), black (b) yellow (y) and blue (b2). The classification of soil colors is difficult in an image to overcome this problem fuzzy logic approach is applied to each pixel for classification [5].

The fuzzy logic rule is in IF-THEN rules. These rules are applied to each pixel in a hyperspectral image in order to decide whether the pixel represents which type of soil.

The fuzzy logic rules applied to find the type of soil

1. If pixel is b and pixel is b1 THEN the pixel =1
2. If pixel is w and pixel is b1 THEN the pixel =1
3. If pixel is w and pixel is b THEN the pixel =1
4. If pixel is g and pixel is r THEN the pixel = 1
5. If pixel is r and pixel is b THEN the pixel =1
6. If pixel is r and pixel is b1 THEN the pixel =1
7. If pixel is g and pixel is y THEN the pixel =1
8. If pixel is w and pixel is b2 THEN the pixel =0
9. If pixel is g and pixel is b THEN the pixel =1
10. If pixel is y and pixel is r THEN the pixel =1
11. If pixel is w and pixel is g THEN the pixel =0
12. If pixel is g and pixel is b2 THEN the pixel =0
13. If pixel is r and pixel is y THEN the pixel =0
14. If pixel is w and pixel is r THEN the pixel =0

The standardized classification of image using deep fuzzy logic is concerns IF-THEN rules along with logical operators like logical connectives such as OR(∨), AND(∧), NOT (¬), and implication (→) that implicates several values in a pixel to single pixel. Quantifiers all (∀) and exists (∃) gives the domain values of each pixel positions for classification.

To classify the soil types in image with deep fuzzy logic rule can be calculated with performing the above if then rules are mixed with these rules of our classification. The predicted logic formalised as

$$F(P) = Iscolor\ (p) \rightarrow Is\ type\ of\ soil\ (p) \text{ ---------- (6)}$$

$$\text{With } Is\ type\ of\ soil(p) = (\exists q\ \in p: Is_{soil}(q) \wedge \text{pixel (p, q)}) \text{ ------- (6)}$$

$$\text{And } Iscolor\ (p) = \vee_{b \in soilcolor} Is_b(p) \text{ ---------- (7)}$$

Where p belongs to pixel position in an image, color is predefined to predict the soil types with Is_b for b ∈ soil color.

The equation 6 formulation allows us to model the image pixel-wise with connectives, quantifier, predicted, verifying the image each and every corner to monitor where the soils are located in the image.

4. Experimental analysis

Hyperspectral images are collected from Chittoor and Tirupati districts shape files by linking python programing with QGIS. Here in this work four different Landsat images of each district are collected for the classification of different types of soils.

The collected hyperspectral images are pre-processed using data cleaning technique that removes cloud covering in the satellite image, data integration, data transformation and data reduction are also applied for pre-processing. Then the images are segmented into cubes by taking region of interest (ROI) which is measured in the form of polygon, circle and rectangle. Next segmented images are trained and the deep regression algorithm and deep fuzzy logic algorithm are applied for different soil type classification.

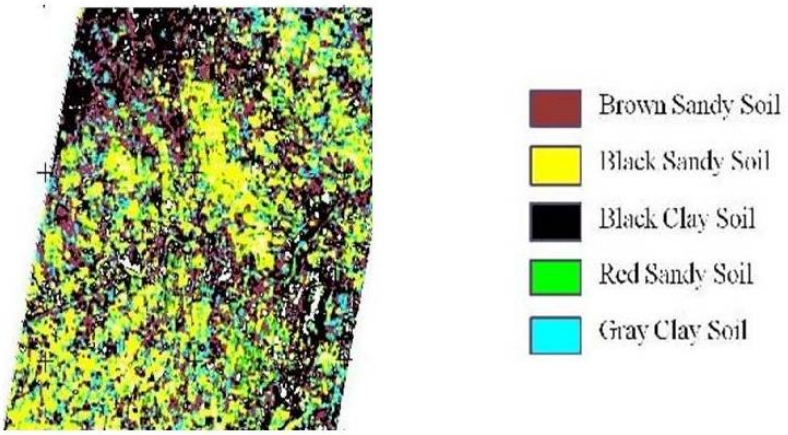
The soil type classified hyperspectral images of four Chittoor district regions are show in figure 2 as figure 2 (a), figure 2 (b), figure 2 (c), figure 2 (d). Here each figure describes the classified areas that are represented in different colors and each color classification represents different area of that region like:

In the figure 2 (a), brown colour represents brown sandy soil, yellow color indicates black sandy soil, black color represents black clay soil, green color represents red sandy soil and sky blue represents gray clay soil.

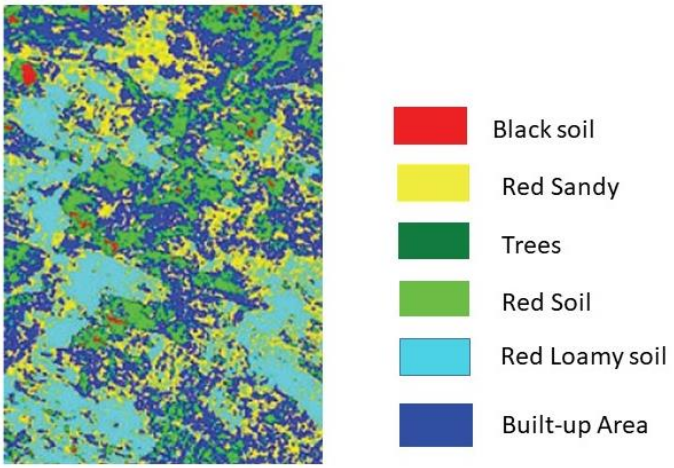
In the Figure 2 (b) red color represents black soils, yellow color represents red sandy soil, dark green represents trees, light green represents red soils, sky blue color represents red loamy soil, blue represents built-up area.

In the figure 2 (c) red color represents red clay soil, dark green represents red sandy soil, light green represents black clay soil, yellow color represents forest area with red soil, blue represents built-up area.

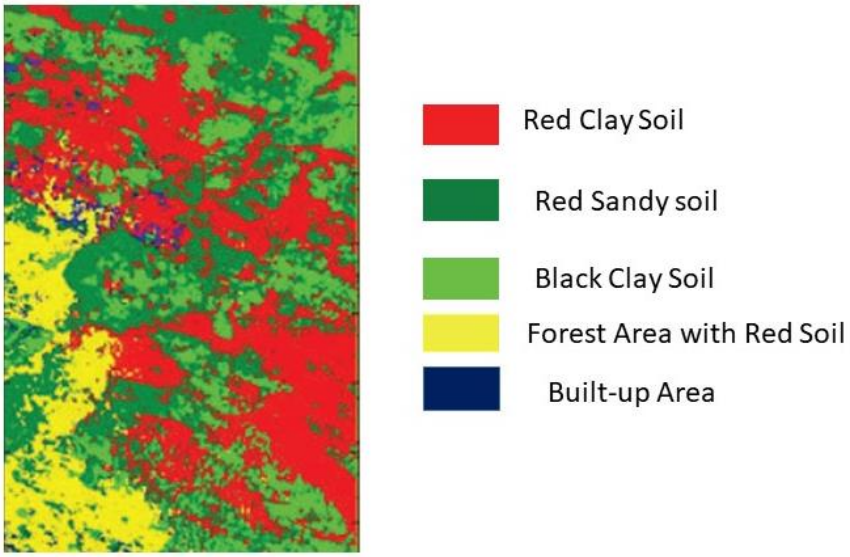
In the Figure 2 (d) shows the classified Chittoor district hyperspectral image and figure describes pink color represents red soil, blue colour indicates water Bodies, green colour represents red sandy soil, sky blue represents grey clay soil and black represents unclassified area.


Brown Sandy Soil
Black Sandy Soil
Black Clay Soil
Red Sandy Soil
Gray Clay Soil

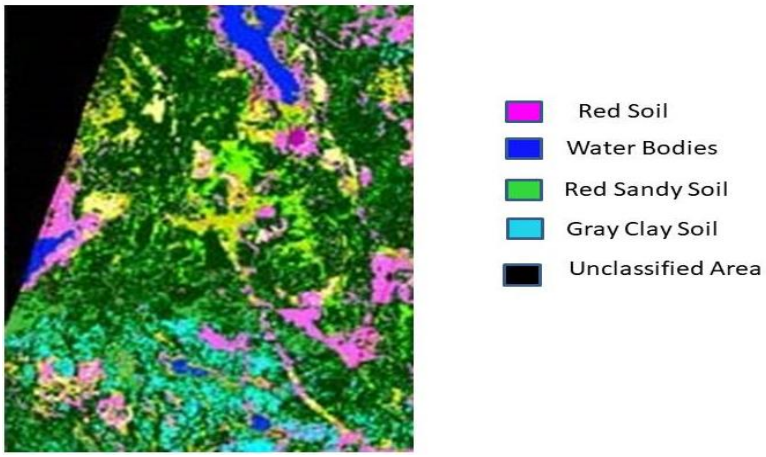
(a)


Black soil
Red Sandy
Trees
Red Soil
Red Loamy soil
Built-up Area

(b)


Red Clay Soil
Red Sandy soil
Black Clay Soil
Forest Area with Red Soil
Built-up Area

(c)



(d)

Figure 2: Chittoor District Regions Hyperspectral Image Classification using deep regression and deep fuzzy logic

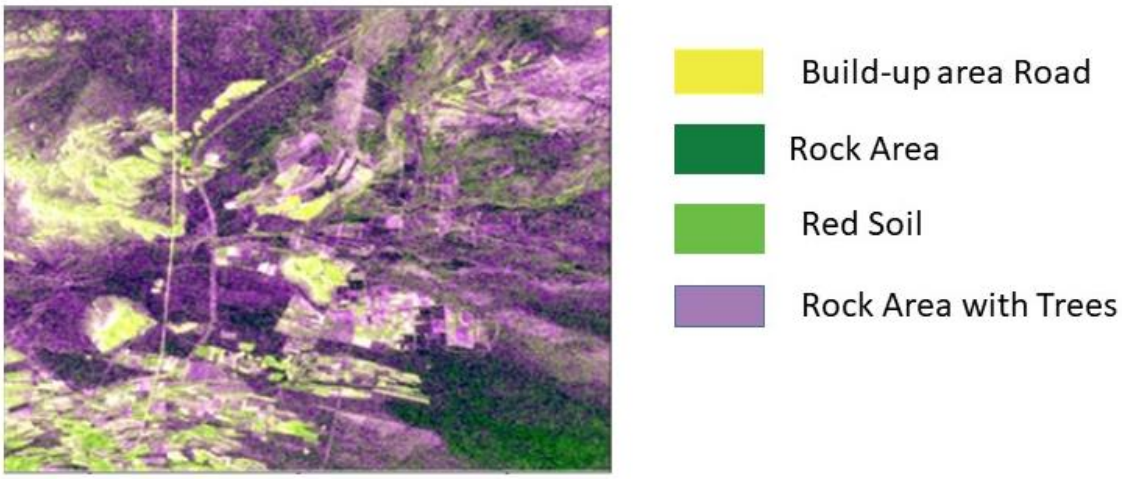
The soil type classified hyperspectral images of four Tirupati district regions are show in figure 3 as figure 3 (a), figure 3 (b), figure 3 (c), figure 3 (d). Here each figure describes the classified areas that are represented in different colors and each color classification represents different area of that region like:

In the figure 3 (a) yellow color represents built-up area and road, dark green color represents Rock area, light green color represents red soils, violet color represents rock area with trees.

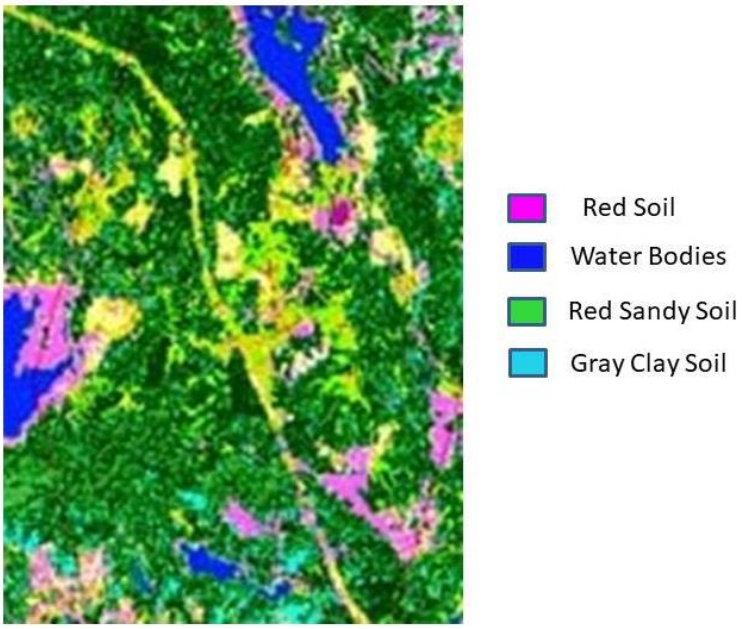
In the figure 3 (b) pink colour represents red soil, blue colour indicates water Bodies, green colour represents red sandy soil and sky blue represents gray clay soil.

In the figure 3 (c) red color represents red clay soil, yellow color represents forest area with red soil, dark green color represents red sandy soil, light green color represents red loamy soil, blue represents built-up area.

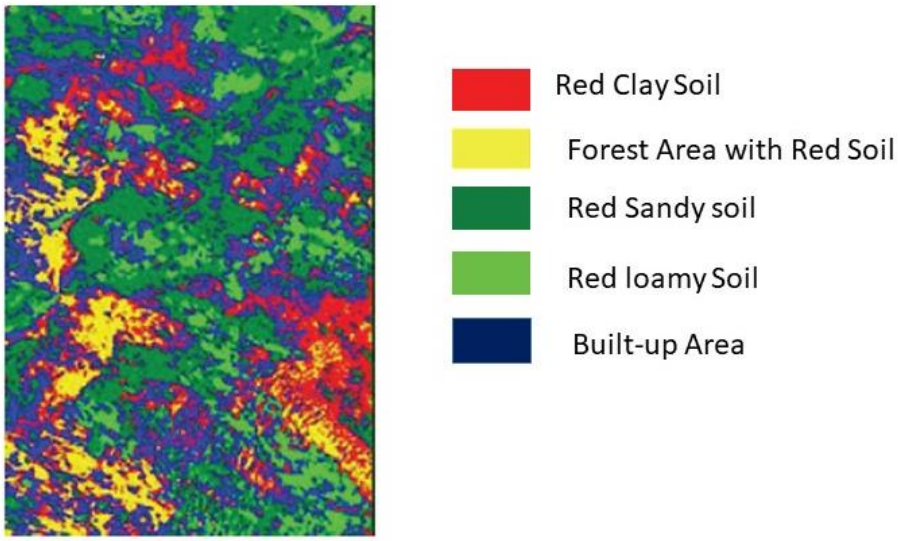
In the figure 3 (d) red color represents red clay soil, dark green color represents red sandy soil, blue represents built-up area, yellow color represents forest area with red soil, light green color represents red loamy soil.



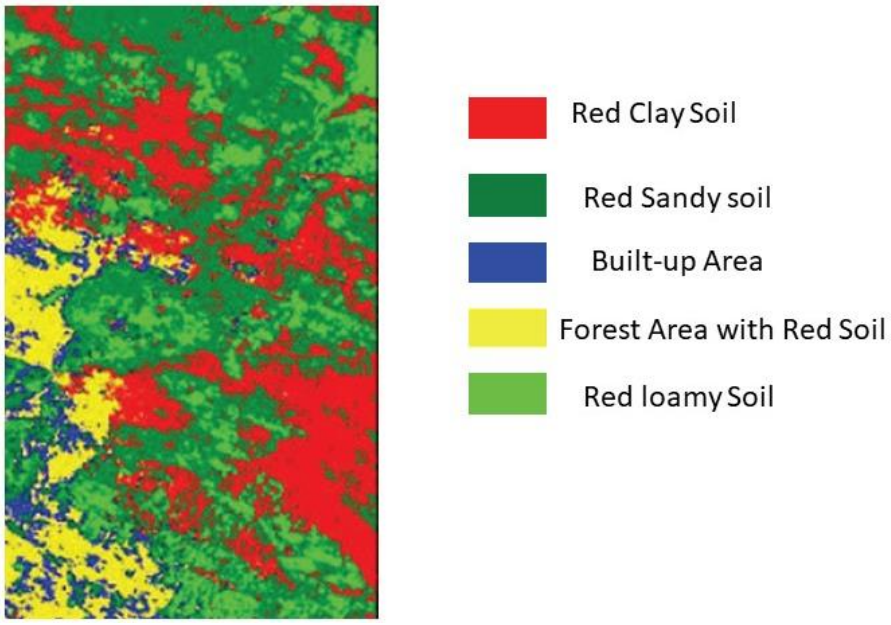
(a)


Red Soil
Water Bodies
Red Sandy Soil
Gray Clay Soil

(b)


Red Clay Soil
Forest Area with Red Soil
Red Sandy soil
Red loamy Soil
Built-up Area

(c)



(d)

Figure 3: Tirupati District Regions Hyperspectral Image Classification using deep regression and deep fuzzy logic

The classification accuracies of deep regression algorithm and deep fuzzy logic algorithm are shown in table 1. By observing the accuracies deep fuzzy logic algorithm is the best algorithm with 99.2% for classification of various types of soils in Chittoor and Tirupati regions soil.

Table 1: Comparison of accuracies

S.No.	Model	Accuracies (%)
1.	Deep Regression Algorithm	98.9
2.	Deep fuzzy logic algorithm	99.2

By observing the soil classified hyperspectral images most of the Chittoor and Tirupati district regions are covered with red soils and then black soils, clay soils. These soils are helpful to cultivate the crops like sugarcane, tobacco, wheat, millets, oil seeds, potatoes, fruits.

5. Conclusion

Soils are identified and classified based on their properties which help the geotechnical Engineer in predicting the suitable soils as foundation or construction materials. They see problems at different scales, need to measure different characteristics, and use different techniques. The identification of soil type is the first step in cultivation of crop. For easy identification of soil remote sensing images are taken. The soil types classifications are done by applying deep regression and deep fuzzy logic algorithms on HSI. Then, the experimental results along with accuracies of deep regression (98.9%) and deep fuzzy logic (99.2%) are compared. Here, deep fuzzy logic algorithm is the best algorithm to classify different soil types.

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