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DETECTION OF HYPERSPECTRAL IMAGES

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Abstract— **Hyperspectral imaging is a powerful technique that captures data from a wide range of electromagnetic wavelengths, enabling the detailed analysis of materials and objects. However, processing hyperspectral images posses significant challenges due to their high dimensionality and complex spectral information. In recent years, terse representation and fully connected neural networks have emerged as effective tools for hyperspectral image analysis. This paper proposes Detection of Hyperspectral images using terse representation and Fully connected neural networks. This system uses the advantages of terse representation and fully connected neural networks. At first the hyperspectral images are converted into a compact terse representation reducing its dimensionality and preserving the spectral information and then this is feed to fully connected neural networks. These networks are trained to learn the underlying patterns present in the data. The result obtained by combination of terse representation and fully connected neural networks gives better accuracy than traditional methods.**

Keywords— Hyperspectral images, Terse Representation, Fully Connected Neural Network(FCNN).

I. INTRODUCTION

Hyperspectral imaging collects and processes the information from across the electromagnetic spectrum. Hyperspectral imaging is the technique that is used to capture and analyse the images of objects. Unlike others, here hyperspectral images will capture much wider range of spectral information. Each pixel in this contains a spectral signature which will represent the amount of energy emitted or reflected by the object in each and every spectral band.By analysing this information hyperspectral imaging can provide information about the structure, composition, properties of that particular object. These images (i.e hyperspectral images) sometimes represented as cubes and each pixel corresponds to the spectral signature.

Hyperspectral image detection is the process of finding and analysing particular features or patterns within the images. By detection process we can get the meaningful information from the high-dimensional spectral data. For detection process, there are various techniques like target detection, classification algorithms, unmixing etc. The detection process involves some pre-processing steps which helps in removal of noise, reduces dimensionality, enhance the accuracy, gives efficient data.

The algorithm here we used is Fully Connected Neural Networks (FCNN) (Fully Convoluted Neural Network). This involves pre-processing, Terse representation, Feature extraction, validation, testing, post-processing.

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Terse representation, also known as compressed sensing, is a method for reducing the amount of data required to represent a hyperspectral image while preserving its essential information. Hyperspectral images contain a large amount of spectral information, which can lead to issues of high dimensionality and redundancy. Terse representation aims to exploit the sparsity of the hyperspectral data by representing it as a linear combination of a small number of basis vectors, known as atoms, chosen from a pre-defined dictionary. Terse representation can refer to techniques that reduce the dimensionality of hyperspectral data while preserving the important information. Hyperspectral images typically consist of hundreds of narrow and contiguous spectral bands, which can result in a large amount of data. This high-dimensional data can be challenging to process, analyze, and interpret.

A fully connected neural network, also known as a feedforward neural network, is a type of artificial neural network where all nodes in one layer are connected to every node in the following layer. Each node in a fully connected layer performs a linear combination of its inputs and passes the result through a nonlinear activation function. The output of the previous layer serves as the input for the next layer, and this process continues until the final layer produces the output of the network. In hyperspectral image detection, FCNNs can be trained to classify pixels or image patches into target and non-target classes. The input to the network is typically a vectorized representation of the hyperspectral image data, where each spectral band is treated as a feature. The output of the network is a probability distribution over the target and non-target classes.

The organization of the paper is given as follows: Section I deals with the introduction, section II reviews the existing work for detection of hyperspectral images. Section III describes the methodology. Results are discussed in Section IV. Section V gives a summary of the Detection of hyperspectral images.

II. LITERATURE REVIEW

Hyperspectral image target detection based on deep learning [1] This study proposes a deep learning-based approach for hyperspectral image target detection. It explores the use of convolutional neural networks (CNNs) and recurrent neural networks (RNNs) to extract spatial and spectral features from the hyperspectral data. The experimental results demonstrate the effectiveness of the proposed method in detecting targets accurately.

Recent advances in techniques for hyperspectral image processing [2]. This review paper provides an overview of recent advances in hyperspectral image processing techniques, including target detection. It covers various methodologies such as spectral angle mapper, matched filtering, orthogonal subspace projection, and support vector machines. The paper discusses the strengths, limitations, and applications of each technique.

Hyperspectral target detection: An overview of current and future challenges [3]. This comprehensive review article presents an overview of hyperspectral target detection methods, including both conventional and advanced techniques. It discusses the challenges associated with target detection in hyperspectral images, such as spectral variability, limited training samples, and high-dimensional data. The paper also highlights emerging trends and future directions in the field.

Hyperspectral target detection using sparse representation A comprehensive review [4]. This review paper focuses on target detection in hyperspectral images using sparse representation techniques. It discusses various

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sparse representation-based methods, such as orthogonal matching pursuit, sparse Bayesian learning, and collaborative representation-based classification. The paper provides insights into the advantages and limitations of sparse representation for hyperspectral target detection.

A survey on deep learning-based hyperspectral image classification and its future trends [5]. Although this paper primarily focuses on hyperspectral image classification, it provides valuable insights into deep learning techniques that can also be applied to hyperspectral target detection. It reviews various deep learning models, including CNNs, recurrent neural networks, and generative adversarial networks, and discusses their applications and potential future trends in hyperspectral image analysis.

III. METHODOLOGY

In this section we are going to discuss the methodology used in detection of hyperspectral images. The flow of the detection process is shown in figure 1.

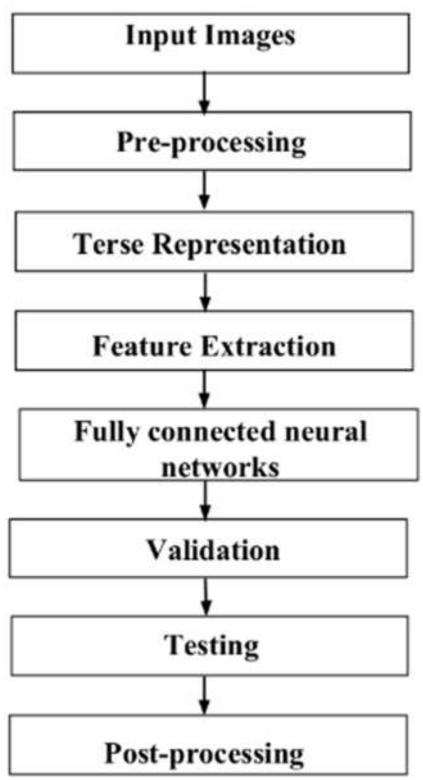

Fig.1. Flowchart

In the proposed system detection of hyperspectral images is done by using Fully Connected Neural Networks (FCNN) and terse representation. Initially the hyperspectral images are pre-processed, Pre-processing of hyperspectral images will reduce the noise. These images are then made to reduce dimensionality by using Terse representation, As we know that hyperspectral images contain large spectral bands. In Terse representation we use Principal Component Analysis transformation (PCA) is a mathematical technology transforms a large set of

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variables into a smaller set of uncorrelated variables. These Principal Components are sorted in decreasing order of their corresponding eigen values, which represent the variance of the data captured by each Principle Component (PC).To choose PC we start computing covariance matrix of dataset, eigen values & values are computed. Terse representation removes the spectral bands which contain noise. It is used to overcome data redundancy and improve computational efficiency, discards less relevant information.

From the low compressed image, we will extract features which are used for detection and then there, features are made into a vector form. These features are made indo one dimensional vectors in order to feed data set to Fully Convoluted Neural Network(FCNN). It consists of several layers of interconnected neurons that are trained to classify and identify the relationship among the images in data set.

Trained neural network is then validated. In validation process, we use a subset of dataset that is randomly selected is used to validate the dataset.then a testing dataset is given to the model to determine the accuracy of the trained model. Final output is post processed such as filtering, removing noise.Then we get the final result.We used Matlab to implement the model.

VI. RESULTS AND DISCUSSION

We are trying detection process on both black & white image and coloured image. Coming to the black and white image as shown in the fig.2 is input image

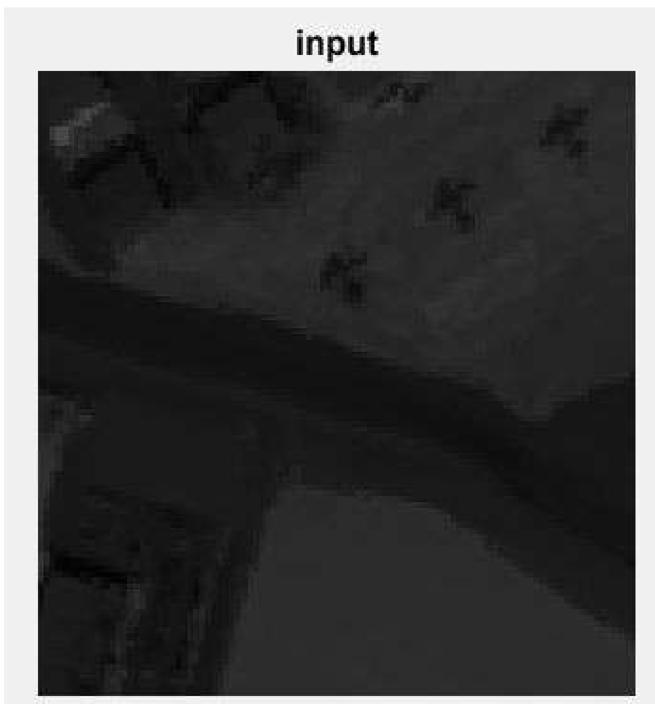

Fig.2 Input Image of black and white

The input image is pre-processed. Now, the pre-processed input is compressed by using terse representation, we are doing high compression and low compression.

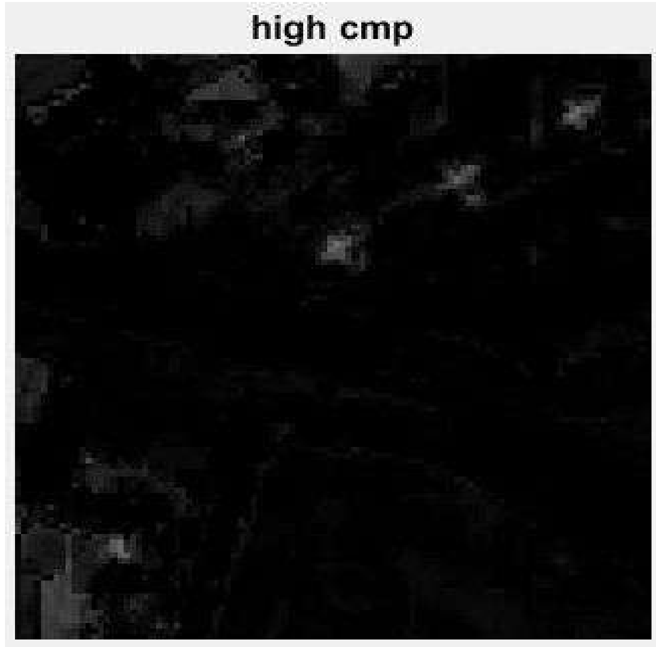

Fig.3 High Compressed Image

The above image is a highly compressed image. Which is compressed using terse representation.

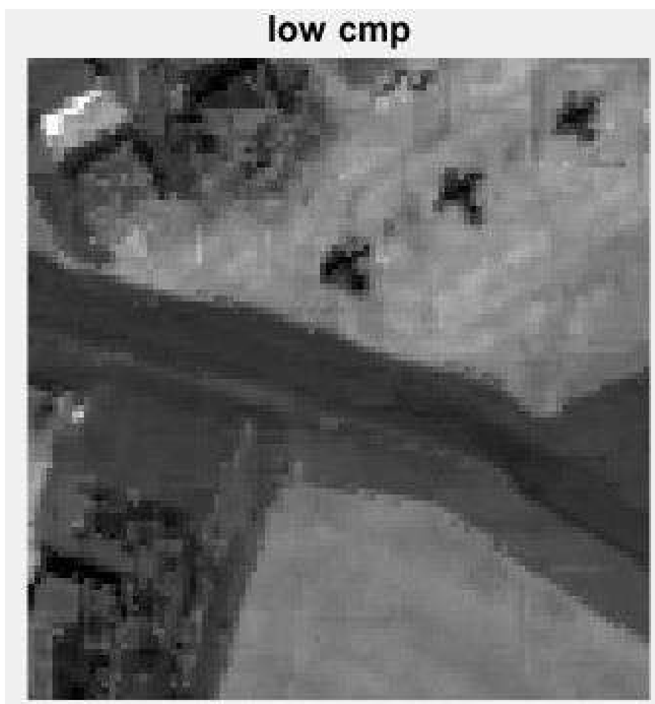

Fig.4 Low Compressed Image

The above image is a less compressed image. Which is compressed using terse representation.

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As we are doing high compression, the image is not clear. By doing low compression, the image will be somewhat clear and also hyperspectral image contains large dimentionality. So, we are using that image for detection, After training the model using fully connected neural networks. These are the outputs obtained, which are shown in the fig.5,Fig 6.

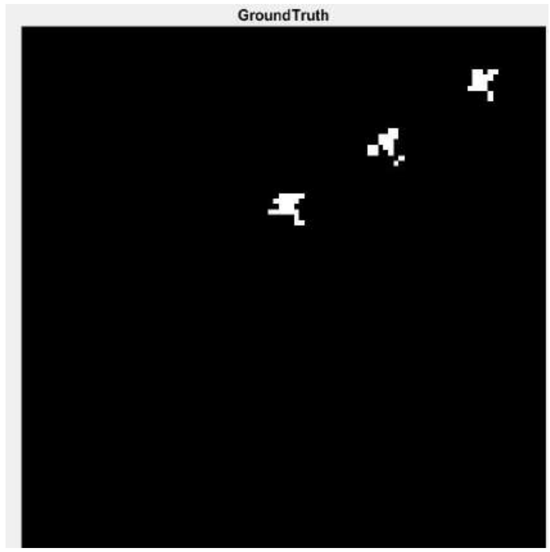

Fig.5 Ground Truth Image

The above fig.5 is the detection of ground truth image. In the detection process, at 50% we get the ground truth image.

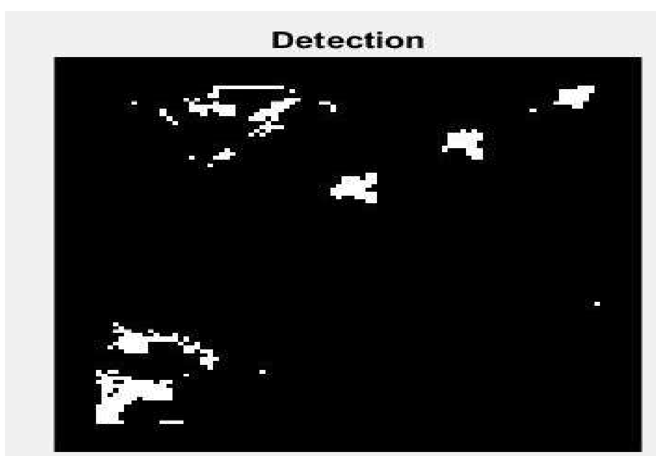

Fig.6 Output Image

The above fig.6 gives us the final detected image. And this is the output for black and white image.

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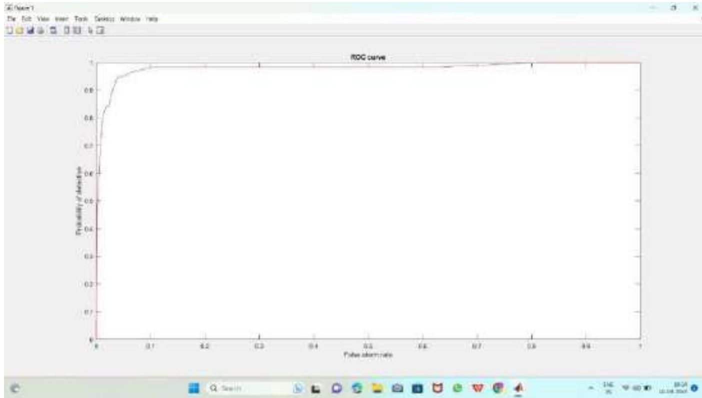

Fig.7 ROC curve

The ROC curve (Receiver Operating Characteristic curve) is a graphical representation of the performance of a binary classifier. In this case, the curve is specifically drawn between probability of detection (sensitivity) and false alarm rate (1-specificity).

The ROC curve shows the trade-off between the true positive rate (sensitivity) and false positive rate (1-specificity) for different classification thresholds. As the classification threshold is lowered, the sensitivity and false positive rate both increase. This is because more positive cases are correctly identified, but also more negative cases are incorrectly identified as positive.

The curve is typically increasing at the beginning, where an increase in sensitivity is accompanied by a larger increase in the false positive rate. Then, it becomes more horizontal as the sensitivity increases while the false positive rate remains relatively stable. Now, coming to the colour image detection. The coloured input image is shown in below fig.7

Fig.8 Input Image

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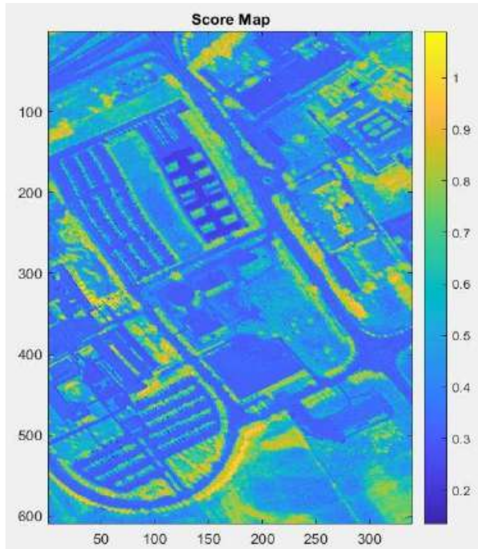

Fig.9 Score map

By using the score map, we are masking the input image in order to detect particular area.

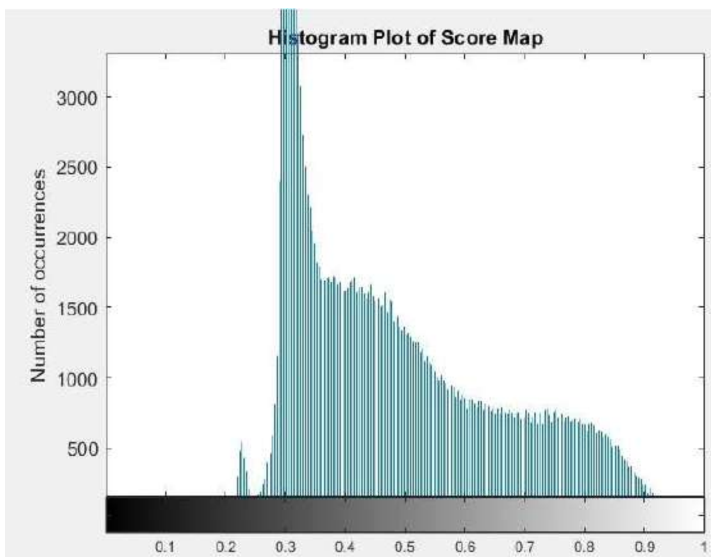

Fig.10 Histogram plot of the score map

The above figure is the Histogram plot of the score map. It says about the dark and bright regions in the image.

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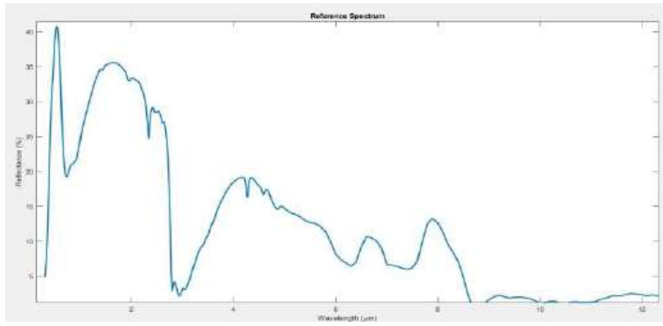

Fig.11 Reference Spectrum

The above image is reference spectrum. It says about the range of the input image.

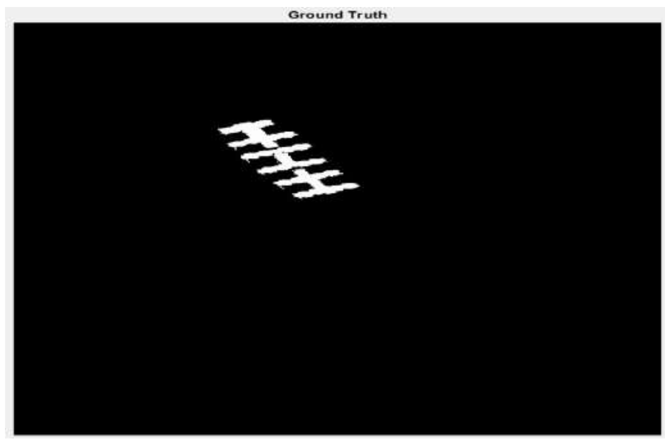

Fig.12 Ground truth image

In the detection process at 50%, we get this ground truth image as shown in the above fig.11.

Fig.13 Results Obtained

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The above fig.13 gives us the final result obtained in the detection process of coloured image.

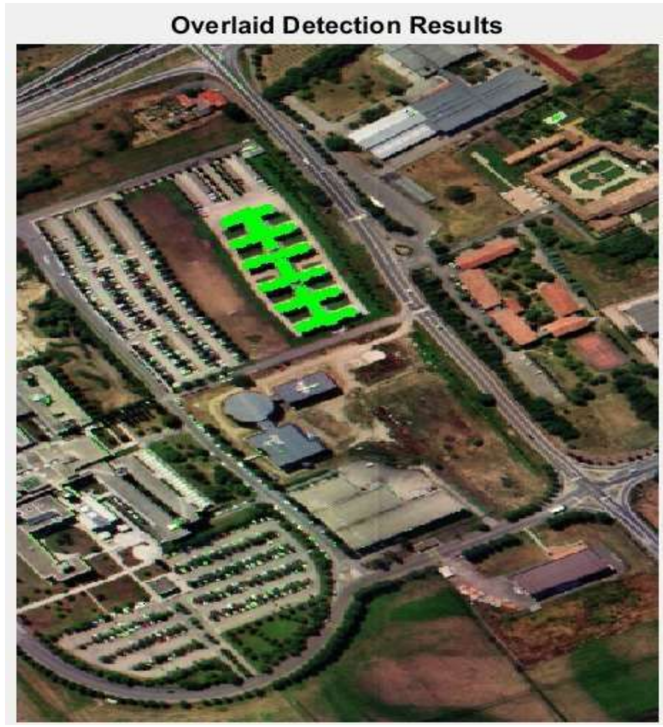

Fig.14 Overlaid Detection results

We are overlaied the obtained results on the input image. We highlighted with the light green colour that is the output in the detection process.

VII. CONCLUSION

Hyperspectral image detection is a complex task which involves analysing large amount of data with high level of accuracy. In our paper we used terse repersentation and Fully Connected Neural Network(FCNN) to detect the hyperspectral images. Terse representation involves compressing the hyperspectral image into a low-dimensional space by exploiting sparsity and redundancy in the data. This method has shown promising results in detecting hyperspectral images, particularly in applications such as target detection and classification.

Fully connected neural networks, on the other hand, involve training a deep neural network with multiple layers to learn features from the hyperspectral image. This method has also shown promising results in detecting hyperspectral images, particularly in applications such as land use classification and anomaly detection..We observed a good accuracy in the detection process by using the combined technique.

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