URBAN MATERIAL IDENTIFICATION & CLASSIFICATION FROM HYPERSPECTRAL USING AMEE TECHNIQUE

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Abstract: Most of the multispectral sensors acquire data in several broad wavelength bands and are capable of extracting different Land Cover features while hyperspectral sensors contain sample spectral data in narrow bandwidth (1020nm). The spectrally rich data enable the extraction of useful quantitative information from earth surface features. Endmembers are the pure spectral components extracted from the remote sensing datasets. Most approaches for end member extraction (EME) are manual and have been designed from a spectroscopic viewpoint, thus neglecting the spatial arrangement of the pixels. Therefore, EME techniques which can consider both spectral and spatial aspects are required to find more accurate Endmembers for Sub pixel classification.

Airborne Visible/Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG) datasets of Ahmadabad is used in this study. The above mentioned datasets are preprocessed and converted to surface reflectance using Fast Line-of-sight Atmospheric Analysis of Spectral Hypercube (FLAASH). Further Automated Endmember extraction and Sub pixel classification is carried out using Multiple Endmember Spectral Mixture Analysis (MESMA). Endmembers are selected from spectral libraries to be given as input to MESMA. To optimize these spectral libraries one technique has been deployed i.e. Iterative Endmember Selection (IES). Further identified end members are used for classifying hyperspectral data using MESMA, SAM, LSU and MTMF. It was observed from the obtained classified results that different classification techniques can classify different targets which can be very clearly seen from results obtained and MTMF outperformed the other classified results in terms of overall accuracy since we have used Minimum Noise Fraction (MNF).

Keywords: Hyperspectral, Automated Endmember Extraction, MESMA, SAM, LSU and MTMF.

Introduction: Hyperspectral imaging (HSI) sensors collect discrete images in a series of narrow and contiguous wavelength bands. In 1980, Airborne Visible Infra-Red Imaging Spectrometer (AVIRIS) was developed by A. F. H. Goetz and his team at NASA's Jet Propulsion Laboratory. It can cover the wavelength region from 0.38 to 2.5 micrometer using two hundred and twenty four spectral channels, at nominal spectral resolution of 10 nm. Applications of Hyperspectral Remote Sensing Projects utilizing hyperspectral imagery usually have one of the objectives: Target detection, Material mapping, Material identification, Mapping details of surface properties.

Objectives: The primary objective of the work will be to distinctively separate out urban features from a given hyperspectral dataset (AVIRIS-NG). Since the dataset is a hyperspectral image, it will be possible to differentiate out minute components in a specific region based upon their spectral signatures.

Study Area: The study area chosen is a portion of eastern part of Ahmedabad in the state of Gujarat.

The study area of about 4.85 sq.km is bounded by Kasturba Gandhi Marg in the north and the walled city adjoining it, industrial area of Rajpur- Gomtipur in the east, Gita Mandir Road in the west and area of Mani nagar in the south. The location extent is as under:

- Latitude : 22.998952592N to 23.01874265N
- Longitude : 72.58969011E to 72.61159437E

The area falls under the jurisdiction of Ahmedabad Municipal Corporation (AMC) and encompasses parts of five wards under three zones of the corporation. Details of wards and zones are as follows:

- Khadia ward(part) : Central zone
- Kankaria ward(full): South zone
- Maninagar ward(part): South zone
- Rajpur ward(full): East zone
- Gomtipur ward(part): East zone

The mixed environment centered on Kankaria Lake, an artificial lake built in 1451 by Sultan Qutubudin Ahmed Shah II, contains maximum possible distinct features like roads, railway lines, water body, different types of vegetation and building rooftop materials.

Software Used: Environment for visualizing images (ENVI) is image analysis software meant for remotely-sensed data and provides the users with a host of algorithm contained in an automated, wizard-based approach for execution of complex image processing tasks.

The VIPER Tools software package is an ENVI add-on that provides a suite of processing tools for multiband passive optical remote sensing data including hyperspectral and multispectral imagery. The major components of the software are tools for creating and managing spectral libraries, for selection of optimal end members for Spectral Mixture Analysis (SMA) and for calculating and interpreting SMA and Multiple Endmember Spectral Mixture Analysis (MESMA).

Extracting Automated End Members: ENVI helps us define "Regions of Interest" (ROIs) in our images. ROIs are typically used to extract statistics for classification, masking, and other operations. Later using ROIs we can create Spectral Library Creation, Metadata and also Spectral Library Optimization which helps us create a Square Array.

Automated Endmember Extraction:
Iterative Endmember Selection (IES): Iterative Endmember Selection (IES) is a semi-automated approach for selecting optimal endmember subsets. The basic concept of IES is to identify the subset of spectra within a spectral library that provide the best class separability when MESMA is used as a two-endmember classifier. IES operates by first identifying the spectrum within a library that provides the highest classification accuracy as quantified using the kappa coefficient. This endmember would belong to the most commonly represented class in the library. Next, it identifies the endmember which, in combination with the first choice, generates the highest kappa. In the next iteration, it repeats, adding a third endmember. As it continues to iterate, it also tests all previous endmember selections to determine whether removing an endmember increases kappa. IES continues to iteratively add, and subtract spectra until the kappa coefficient no longer improves.

MESMA: MESMA is typically implemented by developing a spectral library, then unmixing an image using every possible combination of two, three, four or more end members applied to each pixel. Using this approach, significantly more than four materials can be mapped across an image, while minimizing pixel-scale fraction errors by selecting the best-fit model for each pixel.

Classification:
Spectral Angle Mapper Classification: The Spectral Angle Mapper (SAM) measures the similarity of unknown and reference spectra in n-dimensions. The angle between the spectra treated as vectors in n-space is the "spectral angle",

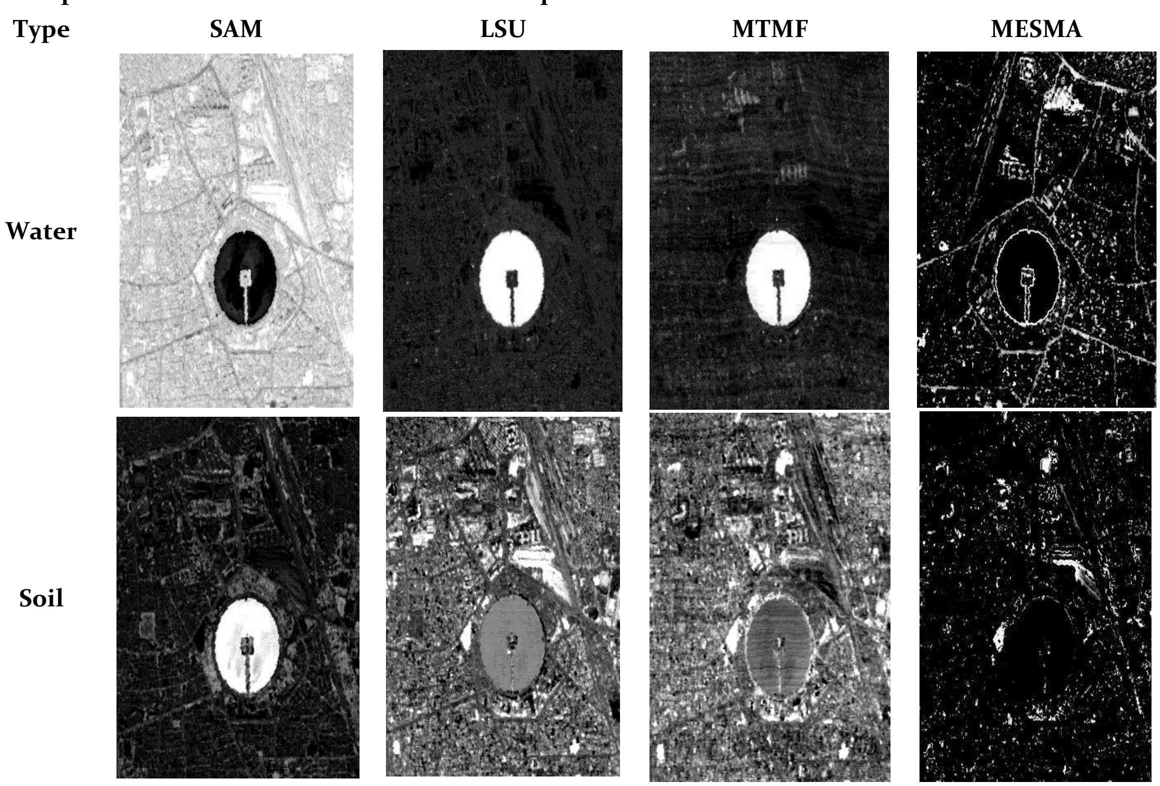
Linear spectral Unmixing Classification: It aims to identify a set of reference signatures (end members) that can be used to model the reflectance spectrum at each pixel of the original image. These end members are extracted from the images using techniques such as PPI or scatter plots. Thus, the modeling is carried out as a linear combination of a finite number of ground components and their reflectance spectra.
Bright values in the abundance images represent high abundances; the Cursor Value/Location function can be used to examine the actual values.

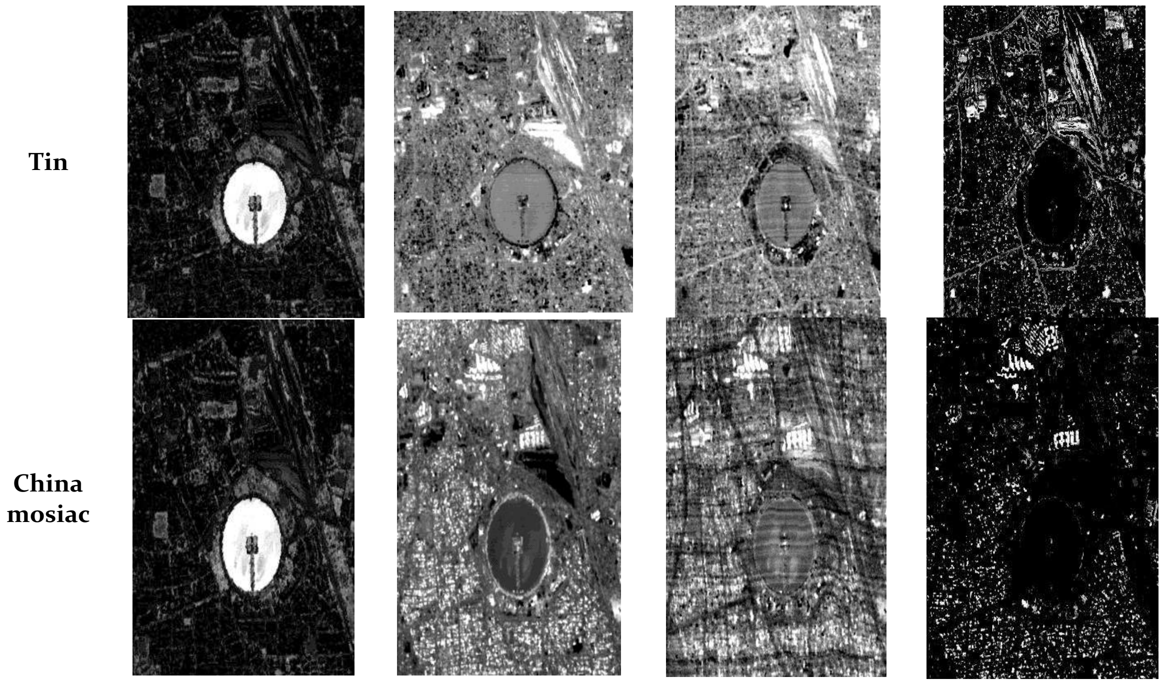
Mixture Tuned Matched Filtering: To perform Matched Filtering (MF) and to add an infeasibility image to the results. The infeasibility image is used to reduce the number of false positives that are sometimes found when using MF. Pixels with a high infeasibility are likely to be MF false positives. Correctly mapped pixels will have an MF score above the background distribution around zero and a low infeasibility value. The infeasibility values are in noise sigma units that vary in DN scale with an MF score.

Results:

Input AVIRIS-NG Image

Comparison of Various Classification Techniques:





Conclusion: After carrying out the work, it was found that different techniques have different classification targets which can be very clearly seen from results obtained. Road features could be very clearly highlighted in SAM and LSU classified images while soil and grassland features could be clearly differentiated in MTMF classified image. It was found that water was properly classified in all techniques except MESMA. The reason for the same is being explored currently and work can be carried out to enhance these results.

It has to be considered that while creating rule classified images, the threshold levels play a very important role in generation of final classified images. We found out that even though abundance images are proper in classification and differentiation of features, still the final classified image won't be visually appealing unless those threshold levels are taken care of.
On an ending note, we can say that different techniques classify different features based upon the parameters that a user sets. And those thresholds can be different for different datasets, locations and users based upon the requirements. ROIs play a major role in classification so it is advisable to select precise and relatively less number of pixels for effective classification in an optimized manner with reduced processing time (for hyperspectral images).

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