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Assessment on the potential of Multispectral and Hyperspectral datasets for Land Use/ Land Cover Classification

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ABSTRACT

Land use / Land Cover is a significant factor which plays a vital role in defining an urban ecosystem. Interpretations of LULC are eased in recent times by utilizing hyperspectral and multispectral datasets obtained from various platforms. An attempt is made to comparatively assess the potentiality of AVIRIS NG with Sentinel 2 data through applied classification techniques for Kalaburagi urban sphere. Spectral responses of both datasets were analyzed to derive reflectance spectra. Standard supervised classification algorithm associated with dimensionality reduction techniques is applied. For performance evaluation, results are validated to check which dataset outperforms well and provides better accuracy.

Keywords: AVIRIS NG; Sentinel 2; Kalaburagi; Land cover

INTRODUCTION

- Land Use / Land Cover (LULC) is a salient element used in explication of terrain features.

- Multispectral and hyperspectral datasets obtained from spaceborne and airborne platforms yields possible results when used for numerous geospatial use cases [1, 2].

- The classification task in general requires precise bands exposing apparent land cover features. Though hyperspectral and multispectral datasets provides more detailed information, spectral bands in vicinity remain strongly correlated thus revealing high degree of redundancy [3].

- Selection of appropriate bands is of prime importance in order to reduce irrelevant information. Also, the acquired hyperspectral data have to be transformed like the multispectral dataset for accurate classification [4 -7].

- The aim of this study is achieved using the following objectives that are mentioned below.

1) To focus on using multispectral and hyperspectral dataset for LULC classification through standard dimensionality reduction techniques.

2) To assess the classified results and its corresponding accuracies obtained using supervised algorithm for a benchmark dataset representing a core urban area.

STUDY AREA

The study area chosen is Kalaburagi, a growing urban sphere located at the north eastern part of Karnataka state. It extends between 76°.04’ and 77°.42’ East longitude, and 17°.12’ and 17°.46’ North latitude. A portion of the core urban area is considered for this study covering an area of about 18.9 Sq.Km

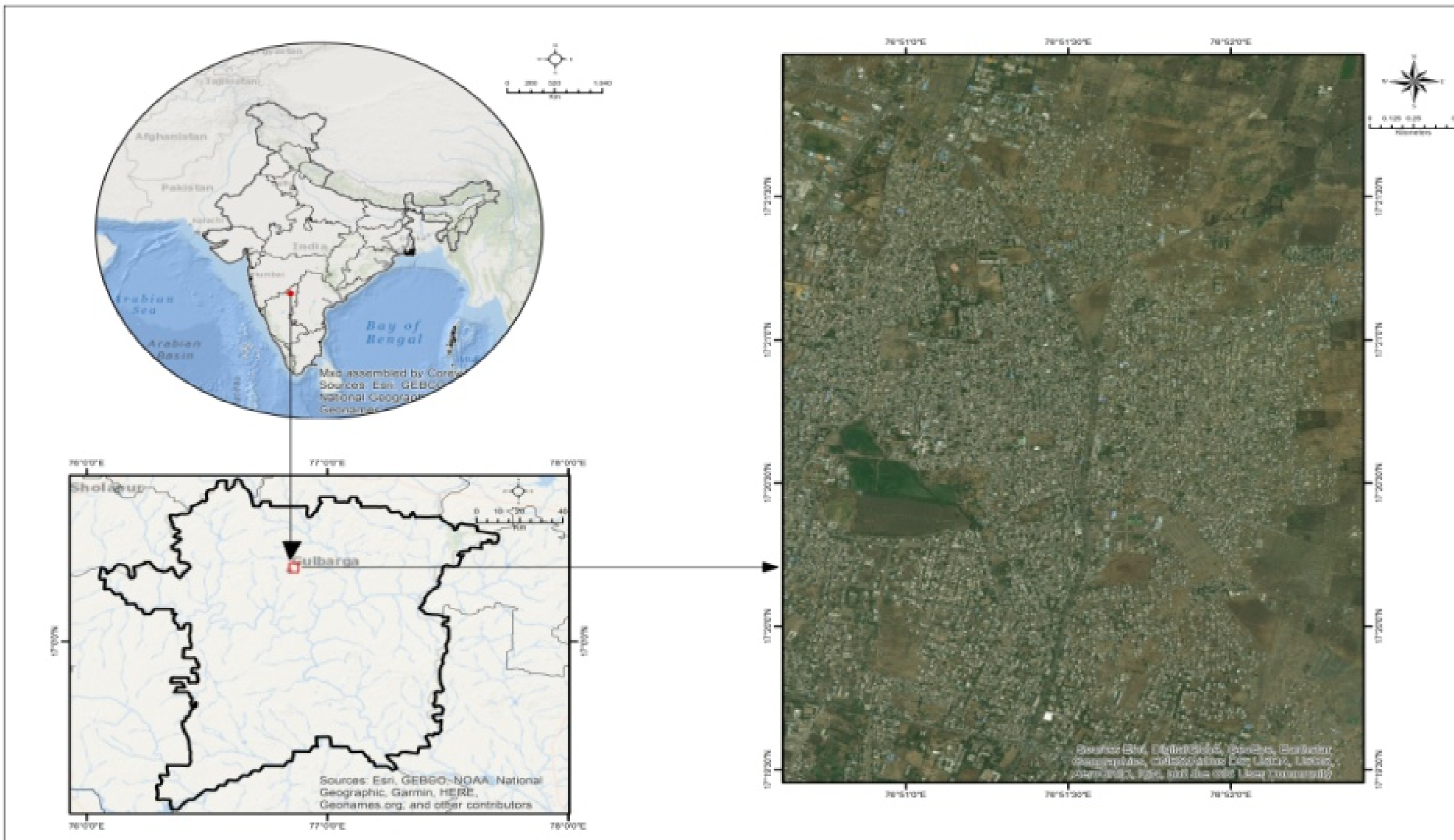


Figure 1. Location of study area

DATASETS

SPECIFICATIONS	MULTISPECTRAL	HYPERSPECTRAL
SENSOR	Sentinel 2 MSI	AVIRIS NG
SPATIAL RESOLUTION	10 m, 20 m, 60 m	4 – 8 m
NO. OF SPECTRAL BANDS	13	425
OPERATING RANGE	443 – 2190 nm	376 – 2500 nm

SOFTWARES USED

METHODOLOGY

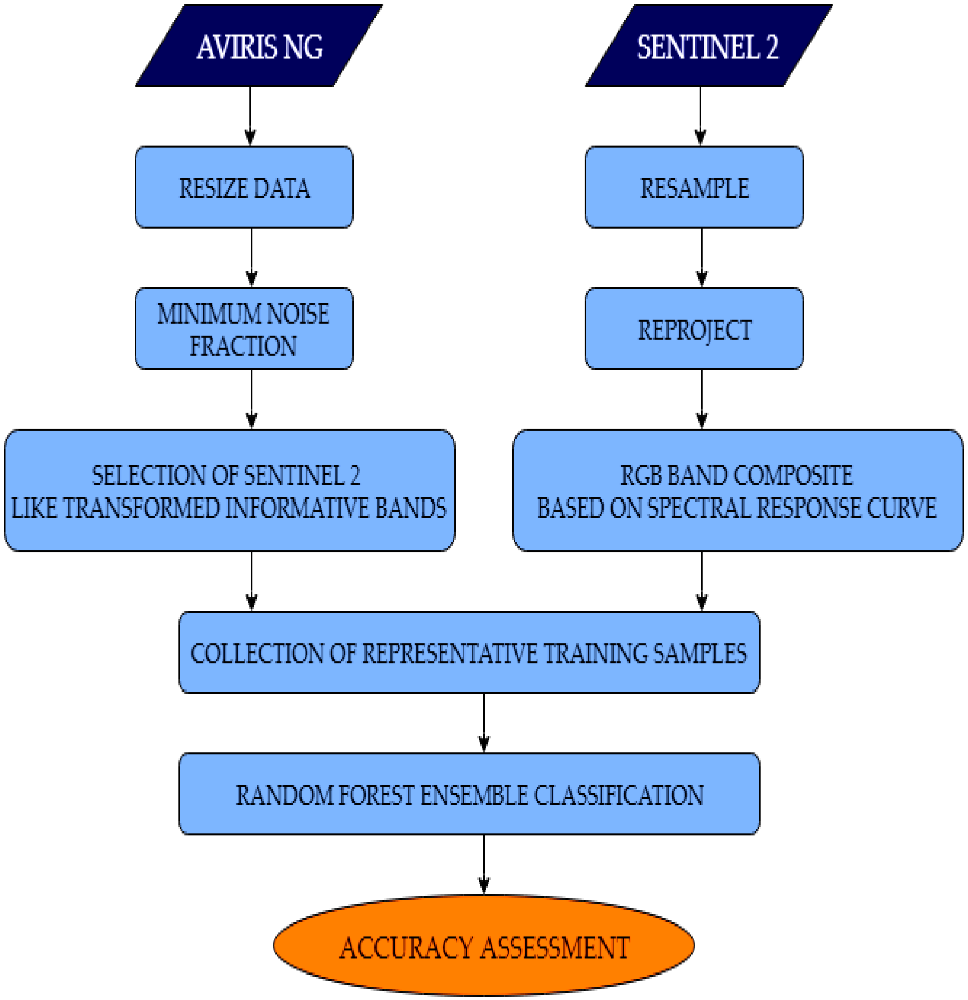


Figure 2. Formalized workflow

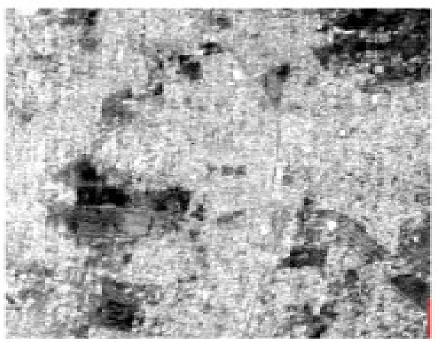
DIMENSIONALITY REDUCTION

- As the numbers of bands are contiguous and narrow in AVIRIS NG, discrete set of bands are chose for performing classification.
- The characteristic dimensionality in the data is investigated through the associated eigenvalues.
- MNF transform, an unsupervised dimensionality reduction technique [8], is incorporated for AVIRIS NG reflectance corrected imagery containing a total of 425 bands. Covariance matrix computation followed by eigenvalue decomposition is the first phase of MNF transform.
- This phase continues to reduce the decorrelation thus normalizing the linear noise from the image by the process called “noise whitening”. The results will define high signal to noise ratio that decreases towards lower order which are noise dominated.
- Bands ranging from λ_{20} = 471 nm to λ_{194} = 1358 nm, λ_{218} = 1463 nm to λ_{283} = 1788 nm and λ_{330} = 2024 nm to λ_{411} = 2500 nm where λ_k is k^{th} spectral band with its corresponding wavelength and a total of 323 bands from 425 are chosen thus eliminating water absorption and redundant bands.
- Eigenvector matrixes with corresponding eigenvalues for the selected MNF components are displayed, from which eigenvalues (>3) containing almost 6 bands are selected as the benchmark study region for Kalaburagi.

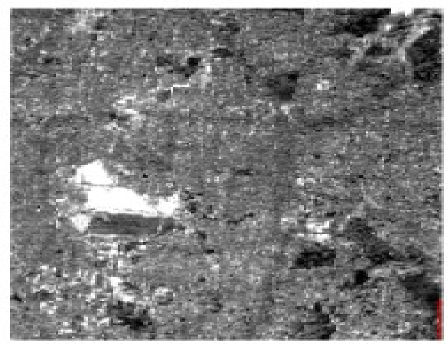
MNF TRANSFORM

MNF	EIGEN VALUES
1	9.5014
2	6.5218
3	4.7629
4	4.3128
5	3.7146
6	3.4232

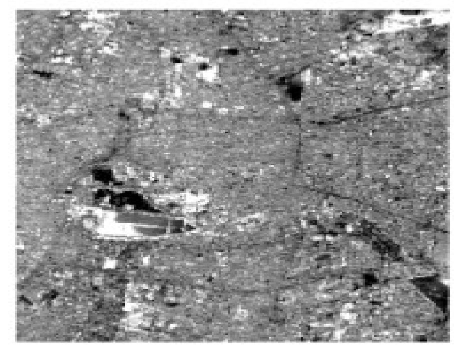
BAND 1



BAND 2



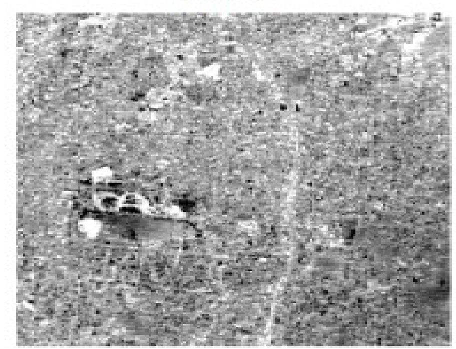
BAND 3



BAND 4

BAND 5

BAND 6



SNAP PROCESSING

- Sentinel 2 multispectral dataset having varied spatial resolutions needs to be equalized and hence resampled, reprojected for further processing.

- Spectral consistency is examined for Sentinel 2 bands that are capable to suit for urban applications and it is perceived that bands ranging from λ_3 = 550 to 580 nm, λ_4 = 640 to 670 nm and λ_8 = 780 to 900 nm are ideal for classification.

- Rest of the bands from the spectrum is discarded as they strongly affect the atmospheric transmissivity at certain wavelength.

TRANSFORMATION OF DIMENSIONALLY REDUCED AVIRIS NG TO SENTINEL 2 – LIKE DATASET

- The reflectance corresponding to the spectral bands of AVIRIS NG are used to derive alike reflectance values from Sentinel 2 by analyzing the spectral response functions [3].

- Reflectance spectra are compared and concatenated through weighted mean of the reflectance values determined using linear interpolation that is dependent upon spectral response function normalized to 1.

- Spectral bands that are dimensionally reduced having distinct and perceptible land cover features from both the datasets are examined for representative training sample collection.

- It is observed that, MNF transformed bands 1, 3 and 4 of AVIRIS NG of range λ_k > 1900 nm are considered equivalent to bands 8, 4 and 3 of Sentinel 2 where λ_k > 850 nm are with specified analogy revealing urban information.

- Thus the bands associated with similar reflectance properties of reliable urban information are equated and chose as input for further classification process.

RANDOM FOREST CLASSIFIER

•The supervised algorithm Random Forest uses bagging / bootstrap, an ensemble aggregation method for estimating statistical quantities from samples and creates multiple models from single training dataset.

•Representative training samples are assigned for desired LULC classes that are structurally similar and works better for accurate predictions.

•For each of the five given bootstrap sample taken from training dataset, some samples remain and are left out of the bag that are averaged to estimate accuracy.

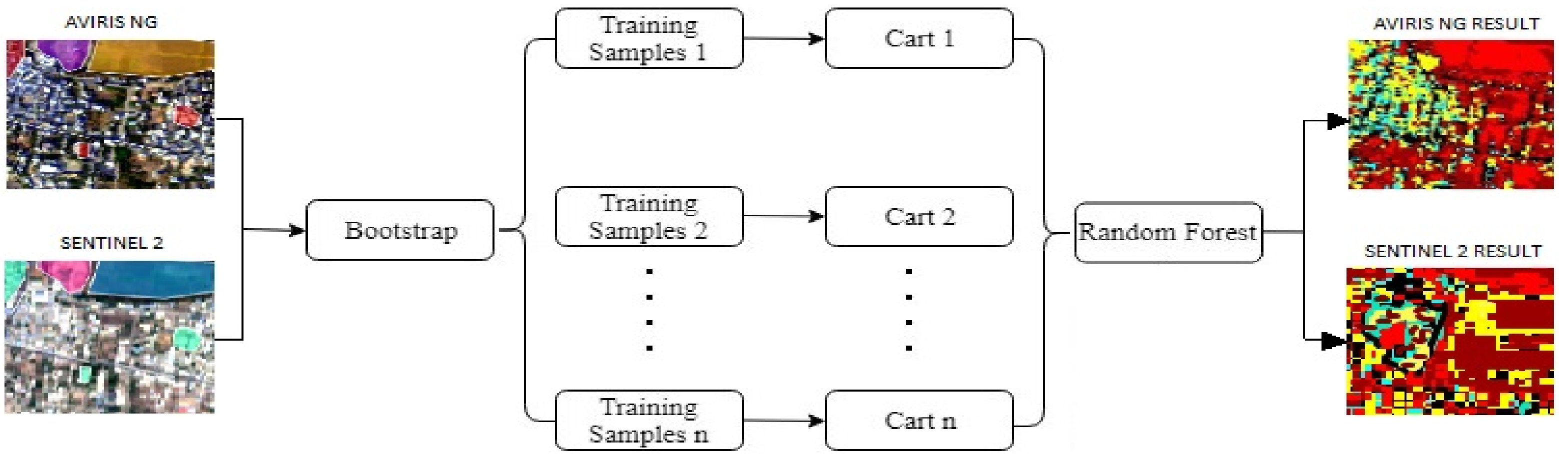


Figure 4. Framework of Random Forest classifier

CLASSIFIED RESULTS AND ACCURACY ASSESSMENT

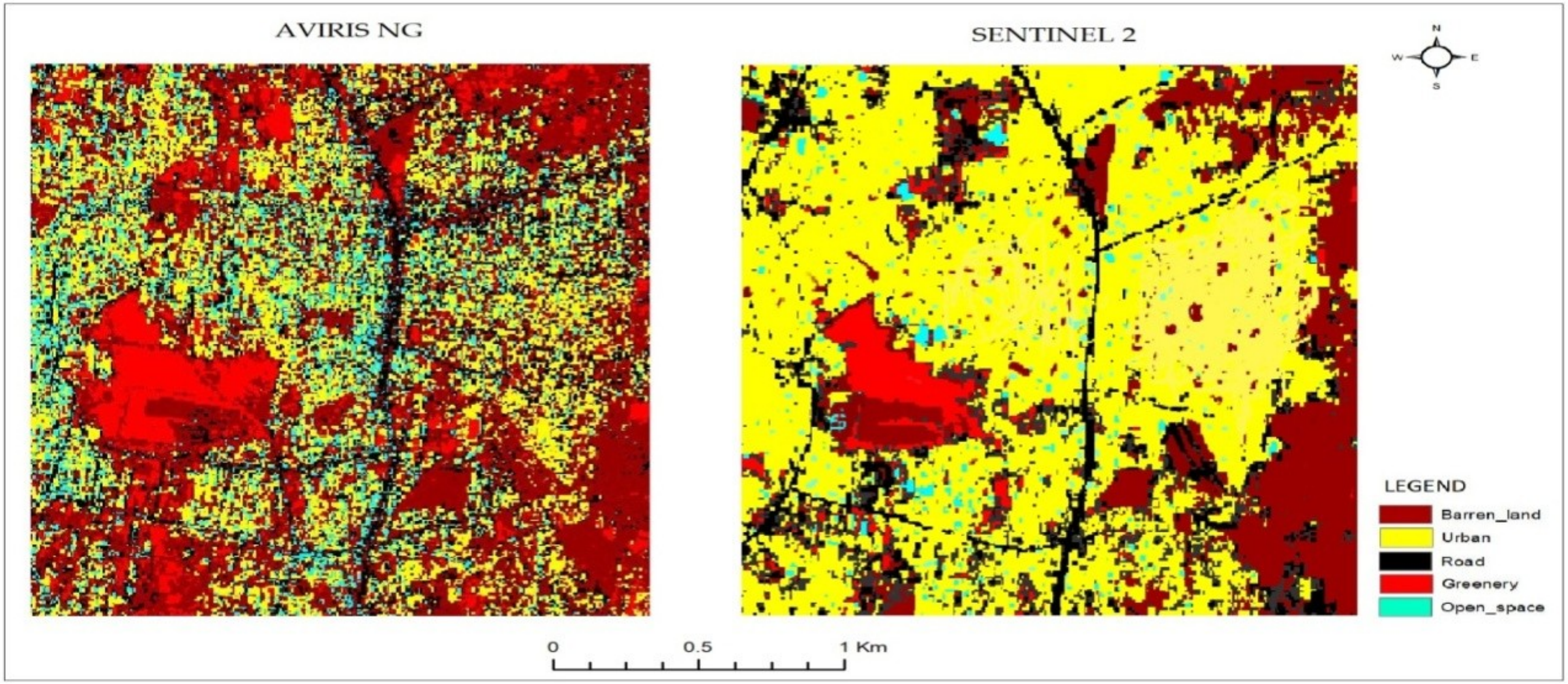


Figure 5. Classified result of using RF algorithm

Classes	AVIRIS NG			Sentinel 2		
	Accuracy	Precision	Correlation	Accuracy	Precision	Correlation
Road	93.9	82.3	82.6	84.6	60.1	61.1
Greenery	97.7	94	92.9	94.3	85.2	83.3
Open Space	91.6	78.4	76.1	90.8	76.7	73.9
Barren land	91.8	79.5	75.7	92.8	81.3	79.2
Urban	96	93.4	87.6	80.5	51.5	47.4

Accuracy results for Random Forest classifier

CONCLUSION

- Features of Sentinel 2 that ends up with low scores might have been strongly biased towards variables with many categories.

- The mean of individual class wise accuracy for AVIRIS NG and Sentinel 2 are 94.2 % and 88.6 % respectively.

- Hyperspectral airborne AVIRIS NG with highest ground sampling distance yielded better classified output as like original data.

- Significant dimensionality reduction by applying MNF has improved the quality of bands by rendering minute details of the original sensor imagery.

- Since MSI data has a lower resolution, pixel associated with samples was misclassified thus slackening accuracy.

- The scope of this paper clearly fulfils that hyperspectral data AVIRIS NG outperforms well when incorporating ensemble Random Forest supervised classification when compared with multispectral Sentinel 2.

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