

# Crop Discrimination using Non-Imaging Hyperspectral Data



Pooja Vinod Janse, Ratnadeep R. Deshmukh

**Abstract:** Crop type discrimination is still very challenging task for researchers using non-imaging hyperspectral data. It is because of spectral reflectance similarity between crops. In this research work we have discriminated between four crops wheat, jowar, bajara and maize. We have tried to overcome the problems which have been faced my researchers. Initially by visual analysis we have selected 22 reflectance band which shows the absorption property of particular molecules and classification techniques applied, but it has given us very poor result of classification. We observed only 24% classification accuracy. So we considered nine vegetation indices along with spectral bands and achieved better classification accuracy. ASD FieldSpec 4 Spectroradiometer device is used for capturing spectral reflectance data. We calculated nine different vegetation indices and some selective reflectance bands are used for crop classification. We have used Support Vector Machine (SVM) for classification.

**Keywords:** Crop Discrimination, ASD FieldSpec 4 Spectroradiometer, Support Vector Machine, Vegetation Indices

## I. INTRODUCTION

Remote sensing is being increasingly used in different agricultural applications. Hyper spectral remote sensing in large continuous narrow wavebands provides significant advancement in understanding the subtle changes in biochemical and biophysical attributes of the crop plants and their different physiological processes, which otherwise are indistinct in multispectral remote sensing [1].

Hyper spectral remote sensing has been applied to many agriculture applications such as crop stress and diseases, however, the potential use of this technique for disease detection under field conditions is unknown. Hyper spectral remote sensing, also known as imaging and non-imagingspectroscopy is useful for various applications such as the detection and identification of minerals from crops, terrestrial vegetation, and man-made materials [2].

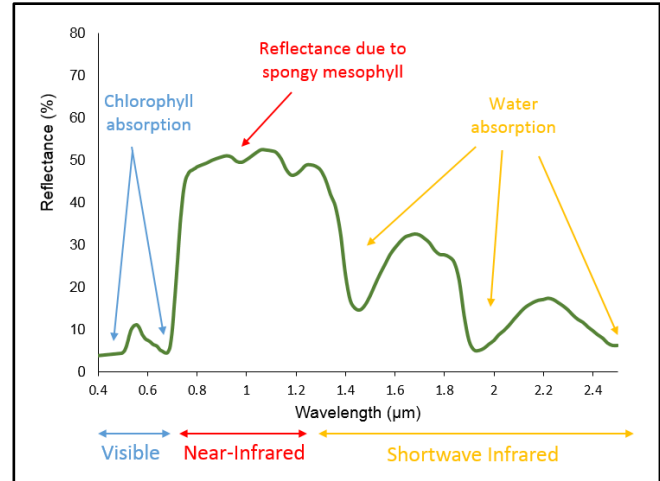


Fig. 1: Spectral Signature of Vegetation

Here in figure 1 we can see spectral signature of vegetation. The general reflectance shape and transmission curves for green vegetation is similar for all types of crop species. It is featured by absorption of specific molecules and the cellular arrangement of the leaf tissue. In the visible region (400 -700nm), chlorophyll a and b (Chl a and b), xanthophyll, carotenoids and polyphenols shows absorption. Chl a shows maximum absorption in 410-430nm and 600-690nm region. Chl b shows absorption in 450-470nm.

In near-infrared (NIR-700-1300nm) region cellulose and other leaf pigments are transparent in nature so they shows very low absorption and higher reflectance and transmittance value.

In shortwave infrared (SWIR-1300-2500nm) region, water and other foliar constituents affects leaf optical properties. The major absorption bands of water are 1450nm and 1940nm.

We have used these spectral reflectance properties and some vegetation indices for crop classification purpose which given us satisfactory result.

## II. MATERIAL AND METHODS

### A. Study Area

Leaf samples of Bajara, Cotton, Jowar, Maize and Wheat from Paithan Road, Chikalthana and Harsool road Area of Aurangabad region were collected. The latitude value of Aurangabad, Maharashtra is 19.8762° N and longitude value is 75.3433° E. The mentioned study area is consist of both man made material and agricultural fields.

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Fig. 2: Satellite image of the study area (a) Paithan road, (b) Harsool road, and (c) Chikalthana

### B. Leaf Sample Preparation and Laboratory Setup

Leaf samples of Bajara, Cotton, Jowar, Maize and Wheat were cut from plant and immediately kept in air tight plastic bag so that there will be no or very less loss of its biological properties. These samples then brought to laboratory in Department of Computer Science and IT, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra for spectral signature generation.

We have collected spectral signature of leaf samples by using ASD FieldSpec4 spectroradiometer and RS3 software. We collected database in laboratory in controlled condition, it was a dark room specially created for spectral data collection because other colors and light sources will affect the spectral signature. The spectrometer setup is shown in figure 3.

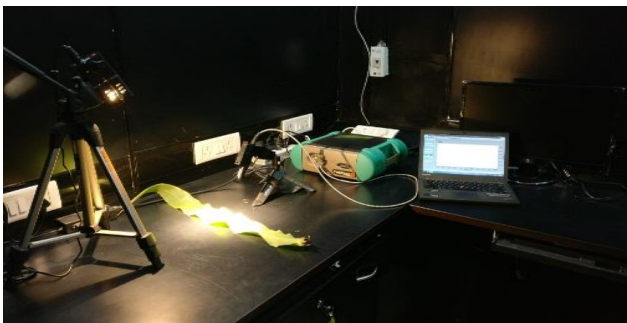


Fig. 3: Spectrometer Setup in data collection process

### C. Instrumentation and Software

Analytical Spectral Device (ASD) FieldSpec 4 Spectroradiometer is a primary tool used for generating hyperspectral signature data. It is general-purpose instrument which has proven effectiveness of application in several areas which require measurement of reflectance, transmittance, radiance, or irradiance. FieldSpec 4 Spectroradiometer is a compact and field portable device of incredible precision, with a spectral range of 350 nm to 2500 nm.

RS3, ViewSpec Pro, Microsoft Excel are essential software's which are used in this study. RS3 software states to the version of the Analytical Spectral Devices application. Its purpose is to receive and store the spectral signature data transmitted from ASD Spectroradiometer. ViewSpec pro software is used for converting .asd file into ASCII file of .txt format. ENVI is useful for analysis, visualization and presentation of data.

We have warmed up ASD Fieldspec4 Spectroradiometer for 30 minutes before data collection. Distance between spectral gun and light source was kept 50 cm. Distance between spectral gun and sample was set to 8 cm. and

80Field of View (FOV) was used. Then we used RS3 Software for capturing spectral signature. The splash screen of RS3 is shown in figure 4.

Then Spectroradiometer have been optimized first to set the appropriate light source settings. Then white reference panel reading have been measured. Then spectral signature of leaf samples have been collected. Leaf spectral measurement provides reflectance values from 350nm-2500nm.

### D. Spectral Data Processing for analysis

The spectral data which is captured using ASD Spectroradiometer were received and stored using RS3 software in .asd format. The spectral data then be viewed with ViewSpec Pro after necessary conversion from .asd format to ASCII in .txt format. The ViewSpec Pro software was used for the data conversion process. All the spectral data saved in .asd format were transferred to ASCII and later saved as .txt format. Furthermore, the data arrangement process was carried out using Microsoft Excel to average all the spectra data obtained from ASD Spectroradiometer device [3,4,5].

The reflectance band showing absorption characteristics of particular molecule are taken into consideration for statistical analysis. Table I shows spectral band and its absorption properties.

Table-I: Vegetative characteristics and their centered spectral band[2]

Reflectance Band	Vegetative Characteristics
370	Phototropism
420	a - Carotene
425	b - Carotene
430	Chlorophyll a
440	a - Carotene
445	Xanthophyll and synthesis of chlorophyll
450	b - Carotene
453	Chlorophyll b
470	a - Carotene
475	Xanthophyll
480	b - Carotene
650	Synthesis of Chlorophyll
960	Chlorophyll absorption
1100	Chlorophyll absorption
1400	Water absorption
1930	Water absorption
2200	Peak Al - OH, Mg - OH, CO <sub>3</sub>



**E. Vegetation indices**

Vegetation indices are used as potential variables for crop type discrimination. Some of those are used in this research work for getting more clear result of classification. Table II shows vegetation indices used in crop discrimination process.

	(RENDVI)		
9	Vogelman Red Edge Index- I (VOG-I)	$R_{742} / R_{722}$	

**Table-II: Vegetation indices calculated from hyperspectral data[2]**

Sr. No.	Vegetation Indices	Equation	Use
1	Lipidium Index (LI)	$R_{630}/R_{586}$	Sensitive to bright reflectance displayed by Lipidium in visible range
2	Normalized Difference Vegetation Index (NDVI)	$(R_{864}+R_{671}) / (R_{864} + R_{671})$	Respond to change in amount of green biomass and more efficiently in vegetation
3	Simple Ratio (SR)	$R_{864}/R_{671}$	Same as NDVI
4	Pigment Specific Normalized Difference (PSND)	$(R_{800} - R_{470}) / (R_{800} + R_{470})$	Estimates LAI and Carotenoids
5	(RVI)	$R_{1088}/ R_{1148}$	Quantify LAI and water content at canopy Level
6	Water Index (WI)	$R_{900} / R_{970}$	Quantify relative water content at leaf level
7	SGI (Sum Green Index)	$(R_{508}+R_{518} +R_{528}+R_{538}+R_{549}+ R_{559}+R_{569}+R_{579}+R_{590}+R_{600}) / 10$	
8	Red Edge NDVI	$(R_{752} - R_{701}) / (R_{752} + R_{701})$	

**III. METHODOLOGY**

For crop type classification support vector machine (SVM) [6,7] classifier is used which has given satisfactory results. Steps of SVM is as follows.

- Import the dataset
- Pre-process the data
- Split the data into attributes and labels
- Divide the data into training and testing sets
- Train the SVM algorithm
- Make some predictions
- Evaluate the results of the algorithm

SVMs is dissimilar than other algorithms of classification because of the way they choosing the decision boundary that exploits the distance from the nearest data points of all the classes.

**IV. RESULT AND DISCUSSION**

By making visual analysis we identified and analyzed difference between spectral signatures of four crops wheat, Jowar, Bajara and Maize. This severability is verified by SVM classification algorithm. We prepared dataset using vegetation indices. Some of the samples vegetation indices are listed in table III.

We have also taken reflectance value into consideration where particular molecule shows its reflectance property. Some of those sample values are also listed in table IV.

**Table-III: Vegetation Indices performed on Wheat, Bajara, Jowar and Maize leaf spectral signature**

LI	NDVI	SR	PSND	RVI	WI	RENDVI	VOG	SGI	CLASS
0.8532	0.5991	3.9898	0.604	1.0518	1.0233	0.381	1.2222	0.1565	Bajara
0.849	0.6782	5.2155	0.6593	1.0524	1.0308	0.5332	1.4293	0.1732	Bajara
0.8729	0.5866	3.8384	0.5741	1.0598	1.0353	0.41	1.2975	0.1933	Bajara
0.8926	0.5249	3.2096	0.525	1.0398	1.0153	0.3333	1.2602	0.1813	Jowar
0.8784	0.4527	2.6546	0.426	1.0515	1.0255	0.2627	1.1499	0.457	Jowar
0.7475	0.8226	10.28	0.8243	1.0551	1.028	0.5863	1.4647	0.1085	Maize
0.7731	0.6592	4.8702	0.6546	1.05	1.0308	0.3958	1.1901	0.2605	Maize
0.8358	0.7188	6.1136	0.7434	1.0798	1.0344	0.4782	1.3444	0.0707	Wheat
0.8539	0.7692	7.6666	0.7344	1.0481	1.0232	0.6248	1.5222	0.1	Wheat

**Table -IV: Reflectance values of Wheat, Bajara, Jowar and Maize leaf spectral signature at specific band**

370	420	425	430	440	445	450	453	470	475	480	650	960	1100	1400	1930	2200	CLASS
0.074	0.081	0.084	0.086	0.089	0.091	0.093	0.094	0.097	0.097	0.098	0.114	0.387	0.406	0.209	0.079	0.205	Bajara
0.114	0.112	0.115	0.117	0.119	0.121	0.122	0.123	0.124	0.124	0.124	0.125	0.586	0.601	0.303	0.116	0.273	Bajara
0.107	0.113	0.118	0.121	0.126	0.129	0.131	0.133	0.135	0.135	0.136	0.144	0.483	0.495	0.258	0.097	0.222	Bajara
0.087	0.101	0.104	0.107	0.111	0.114	0.117	0.119	0.123	0.125	0.126	0.148	0.393	0.391	0.235	0.084	0.198	Jowar



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0.217	0.284	0.293	0.3	0.307	0.313	0.318	0.321	0.326	0.326	0.328	0.346	0.786	0.773	0.451	0.184	0.359	Jowar
0.038	0.043	0.044	0.046	0.046	0.047	0.048	0.048	0.049	0.049	0.049	0.065	0.502	0.517	0.229	0.048	0.205	Maize
0.138	0.127	0.128	0.129	0.129	0.13	0.132	0.133	0.134	0.135	0.135	0.158	0.618	0.628	0.313	0.104	0.274	Maize
0.033	0.034	0.035	0.036	0.037	0.037	0.038	0.038	0.039	0.04	0.04	0.049	0.262	0.283	0.115	0.022	0.099	Wheat
0.058	0.07	0.074	0.077	0.08	0.081	0.082	0.082	0.081	0.081	0.08	0.071	0.517	0.521	0.254	0.046	0.202	Wheat

From the above table we can see preprocess data taken for classification purpose. We have collected total 145 leaf samples and tenspectral signature of each leaf have been recorded. Mean of ten spectral signature of each leaf calculated and mean spectral signature id considered for classification. Vegetation indices are also calculated on mean spectral signature. As spectral data of leaf was recorded in controlled condition and in dark room, environmental factors like clouds, humidity, temperature, wind speed and direction, cloud cover, smoke and haze does not effects on spectral data collected.

We have defined dependent and independent variables first and divided data into training and testing samples. We used 80% data for training and rest 20% data for testing.

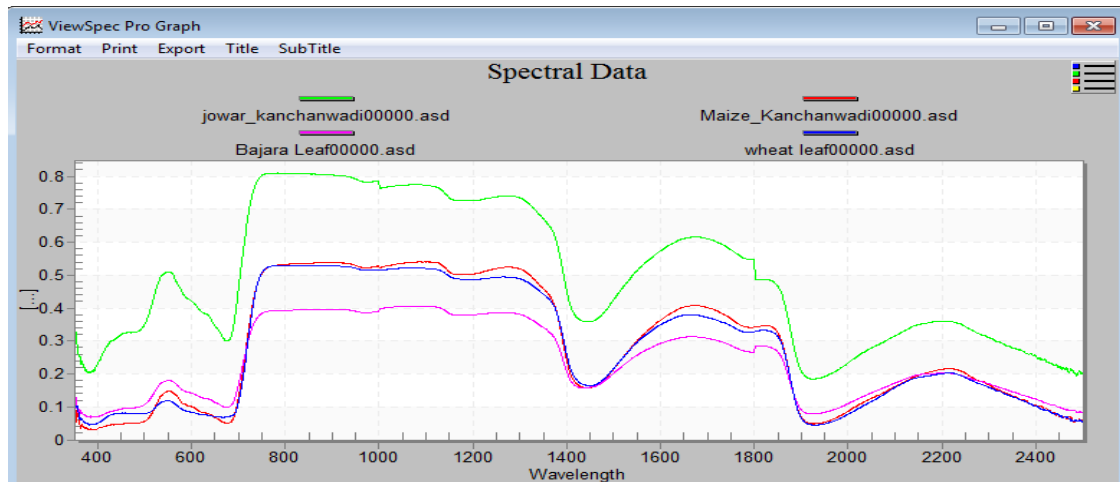
We built SVM classifier model on data and provided some prediction.

SVM classifier provided 100% result of classification.

Confusion matrix is as shown below.

$$\text{Confusion Matrix} = \begin{bmatrix} 30 & 0 & 0 & 0 \\ 0 & 40 & 0 & 0 \\ 0 & 0 & 40 & 0 \\ 0 & 0 & 0 & 35 \end{bmatrix}$$

Above confusion matrix shows that 30 sample of Bajara, 40 samples of Jowar and Maize, 35 samples of Wheat are correctly classified. Precision, recall and f1-score values are shown in table-V. It means that all samples are correctly classified and 100% accuracy achieved by SVM algorithm.



**Fig. 4: Spectral Signature of Wheat, Bajara, Jowar and Maize leaf**

**Table-V: Precision, recall and f1-score values**

	Precision	Recall	F1-Score
<b>Bajara</b>	1	1	1
<b>Jowar</b>	1	1	1
<b>Maize</b>	1	1	1
<b>Wheat</b>	1	1	1

### V. CONCLUSION

Spectral signature analysis of four crops shows their characterization based on reflectance on particular band. Initially we considered only reflectance values for classification using SVM but it has given very poor result. As we seen spectral reflectance of four crops that shows reflectance value of maize and wheat are nearly similar. So we decided to consider some more features like vegetation indices for classification which has given 100% classification result. It has also been observed that NDVI, RVI, SR and RENDVI vegetation indices plays very important role in classification. Also red-edge position in

spectral signature is also feasible spectral region for crop classification. In this research work we have used SVM for classification but many other methods like Principle Component Analysis (PCA), Linear Discriminant Analysis (LDA), and PLSR Regression can also be used for getting better result.

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Intelligence, Computational Auditory Scene Analysis (CASA), Neural Networks etc.

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