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"A Framework for crop type recognition based on spectral reflectance through spectral analysis techniques"

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Abstract:

Our overarching goal is to frame an accurate model for crop type and health recognition based on hyperspectral data. The spectral vegetation Indices (SVI) was applied for prediction of precise information for crop type recognition. The literature reveals that, no any significant system is available with combination of ASD and Hyperion sensor. Total 400 spectral signatures were measured using spectroradiometer within wavelength range 350nm to 2500nm along with EO-1 Hyperion dataset. The study area was located at Aurangabad region, Maharashtra, India. The current research contribution discloses crop parameters based on SVI. The five SVI were targeted for analysis of crops namely Cotton, Maize, Vigna Radiata and Bajara. The pre-processing of EO-1 Hyperion was performed using Quick Atmospheric Correction (QUAC) algorithm. The Normalized difference Vegetation Index was identified as a suitable parameter between -1 to +1 The cubic regression method was implemented with 0.9 as a R^2 error for accuracy assessment of system. Hence, we are more confident about the crop prediction of developed model. The experimental analysis was performed using ENVI and python open source software.

Keywords- Hyperspectral remote sensing, Spectral Vegetation Indices, Precision Agriculture,

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I. Introduction

The hyperspectral remote sensing data has provides precise information about vegetation structure and patterns of classes. Hyperspectral imagery insights details about earth surface for mapping and monitoring using electromagnetic spectrum (Vibhute A.D., et. al., 2015). Crop type recognition plays vital role in precision agriculture. The literature reveals that, combined approach had not been yet implemented for crop growth monitoring (Driss et. al., 2008). The growth of the crop components are depends on photosynthetic pigments. The major pigment includes chlorophyll, anthrocyanin, xanthophylls and Cartenoid etc. The spectral vegetation indices (SVI) perform well for analysis of crop health along with disease detection. The prominent information was extracted from rice crop using leaf area index (LAI) (Holecz, et. al., 2013). All the crops have photosynthetic pigments mainly chlorophyll a, chlorophyll b, Cartenoid and anthrocyanin (Jan-Chang, et. al., 2008).

The research contribution explores that; pigment analysis was successfully achieved using remote sensing methods. The paper is divided into four sections including background details in introduction, details about study site come in section second. The third section contains proposed methodology with mathematical description. The fourth section comes with analyzed results of the specified methods and last section signifies conclusion of research work followed by future scope.

II. Study Site

The field experiment was carried out in June 2016 to February 2016 at targeted farm. The study site is elongated strip of Aurangabad region Maharashtra, India shown in Fig. 1. The spectral information was collected using ASD Field Spec 4 spectroradiometer and EO-1 Hyperion Imagery. The major crop types were targeted for research purpose. The ancillary data was collected using My GPS CO-ordinates android application. The total 300 Ground Control Points (GCP) were collected for accuracy assessment. The mapping of Cotton, Maize, Vigna Radiata and Bajara were done using EO-1 Hyperion data downloaded on 25 December 2015 collected from USGS site. Hyperion imagery consists of 220 spectral bands with 30 m resolution. The scene size of EO-1 Hyperion contains 100km x 7.5 km.

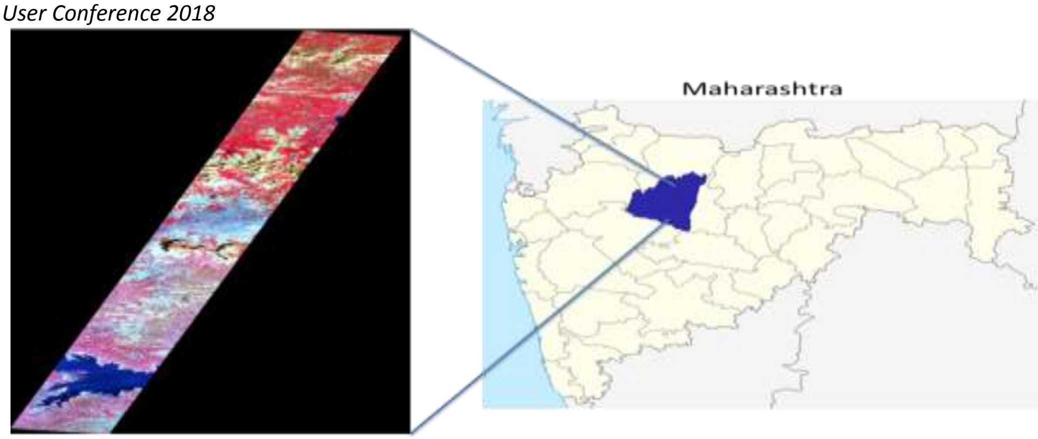


Fig:1- Study Site of Aurangabad region, Maharashtra

III. Proposed Methodology

This section contains details about methodology of proposed research work,

i. Measurements of Hyperspectral Data

The goal of system was achieved by the collection of hyperspectral data in two modalities. The spectral responses were generated by Analytical Spectral Device (ASD) Field Spec 4 spectroradiometer and the base is applied to EO-1 Hyperion spectral responses using round control points. The 400 crop samples were taken by spectroradiometer in standard controlled environment from the range of 350 nm to 2500 nm. The tungsten light was used at 10 cm height from the location of sample and Field Of View (FOV) was set as 8 degree at zenith angle. The reflectance and radiance factor of samples were generated in the form of absorption spectrum. The white reference panel was used for the calibration of device. The details about hyperspectral device are given in Table 1.

Title : 1-Database collection Sensor Specifications

Measuring Device/ Mission	ASD Field Spec 4 Spectroradiometer	EO-1 Hyperion
Spectral Range	350-2500 nm	220
Spectral Resolution	3 nm @ 700 nm 8 nm @ 1400/2100 nm	
Sampling Interval	1.4 nm @ 350-1000 nm 1.1 nm @ 1001-2500 nm	
FOV	8	
Spectral Channels	2151	
Spectral Pixels	1651	
Max Frame Rate	-	
Spatial Channels	-	

ii. Pre-Processing Methods-

The spectroradiometer consists of wavelength range from 350nm to 2500 nm. It comes with three detectors at visible, shortwave Infrared 1 and shortwave Infrared 2, the shifting sensor error comes in every sample after calibration process. To remove that specified sensor noise spice error correction method was applied on every samples using View spec pro software. The EO-1 Hyperion comes with bad band while taking the dataset for analysis. The bad bands were removed using Quick Atmospheric Correction (QUAC) implemented in Environment for Visualizing (ENVI).

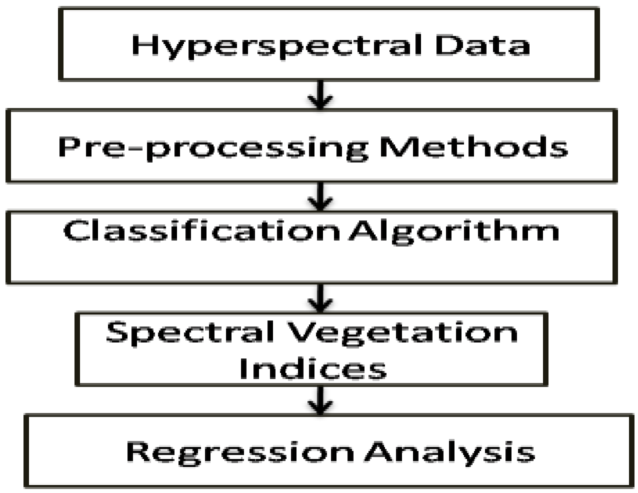


Fig: 2- Proposed Methodology of research work

iii. Classification Algorithm

The classification algorithms were applied for crop recognition on EO-1 data. The narrowband vegetation indices provides good amount of pigment details for crop type recognition. The spectral vegetation indices were implemented for the classification for crop types.

iv. Spectral Vegetation Indices-

Our study included five spectral vegetation indices for the analysis of crops health. This study experienced the indices those were good indicator of photosynthetic pigments including chlorophyll a. chlorophyll b, Cartenoid and biomass of the crops. The normalized Difference Vegetation Index provides the pigment information of biomass with its leaf area in the reflectance spectral range of 800 nm and 670 nm. The NDVI specifies significance level from -1 to +1 range, -1 indicates less amount of pigments and +1 indicated highest amount of pigments available in vegetation sample. The pigment specific normalized difference chlorophyll a describes about, amount of chlorophyll contents available in crops. The presence of chlorophyll a and chlorophyll b represents healthy crops. The pigment specific normalized difference chlorophyll c and Cartenoid represents about infected level of crops.

Title: 2- Spectral Vegetation Indices for crop analysis

Sr. No.	***Vegetation Indices***	***Equations***	***Indicator***	***References***
1	Normalized Difference Vegetation Index	$NDVI = \frac{R800 - R670}{R800 + R670}$	Biomass, leaf area	Rouse et al. (1974)
2	Pigment Specific Normalized Difference chl a	$(PSSRa = R800) \,/\, R680$	Chlorophyll a	Blackburn (1998a)
3	Pigment Specific Normalized Difference chl b	$PSSR\ b = R800/R635$	Chlorophyll b	Blackburn (1998 a)
4	Pigment Specific Normalized Difference C	$PSSR\ c = R800/R470$	Cartenoid	Blackburn (1998a)
5	Cartenoid Reflectance Index 2	$CRI2 = \frac{1}{R510} - \frac{1}{R700}$	Cartenoid	Gitelson., (2002)

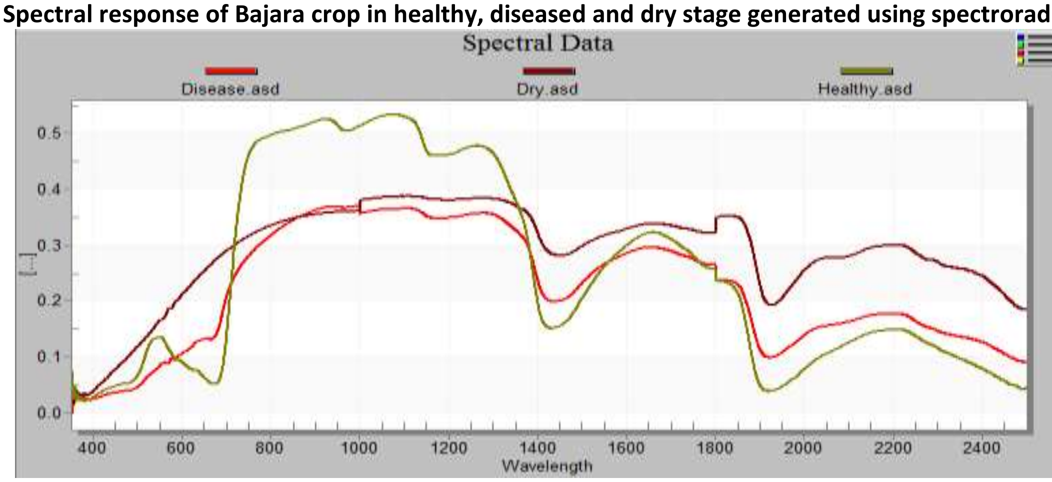
v. Regression Analysis

The regression analysis was performed for the purpose to check performance of developed system. The cubic regression techniques provide positive accuracy as compare to polynomial and linear regression.

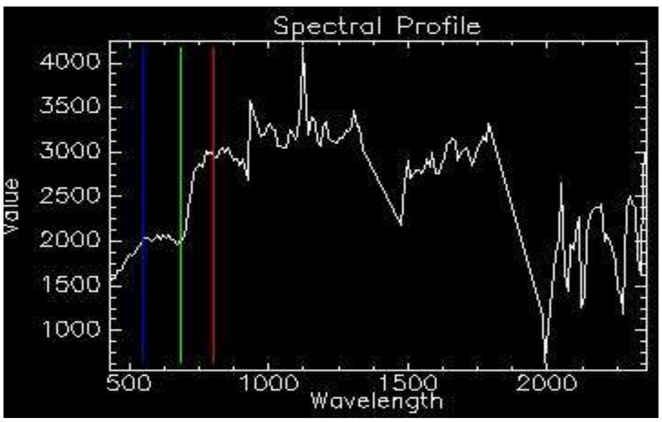
IV. Result and Discussion

In this paper, experiments were performed on an EO-1 Hyperion spectral data set assimilated on 2015 with targeted area Aurangabad region agricultural site. Several land cover types were also discriminated based on latitude and longitude of the classes. The spectral responses of crops were measured in three different stages including healthy, diseased and dry shown in Fig 1.

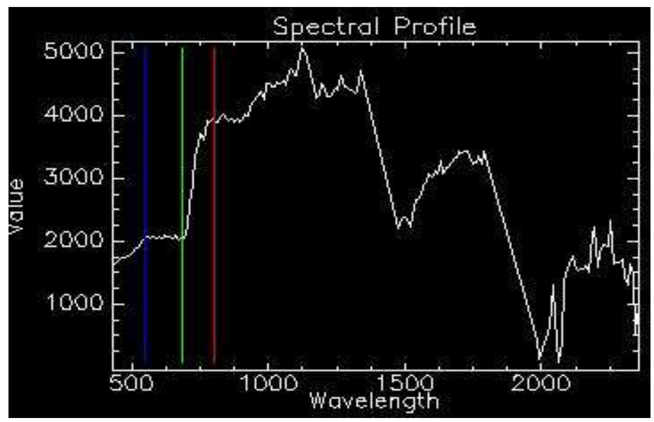
Fig: 3- Spectral response of Bajara crop in healthy, diseased and dry stage generated using spectroradiometer



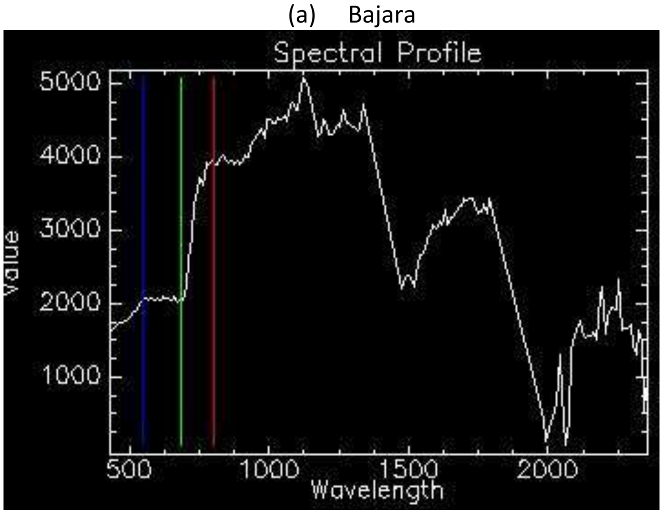
The QUAC algorithm was implemented to remove bad bands from EO-1 Hyperion imagery. After bad band removal the spectral responses of crops were stored in format given in Fig 4, the (a) represents spectral information of Bajara crop, (b) represents spectral information of Cotton crop, (c) represents spectral information about Maize crop and (d) describes about the Vigna Radiata crop along with pigments information. The spectral Indices represent that crop types were easily discriminated using hyperspectral indices. The pigment specific normalized difference generates significant results for crop health recognition and classification.



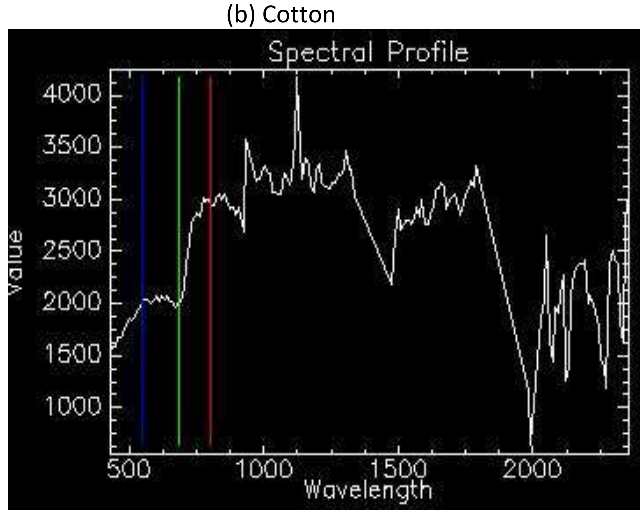
(a) Bajara



(b) Cotton



© Maize



(d) Vigna Radiata

Fig: 4- Spectral Responses of four crops computed after pre-processing technique

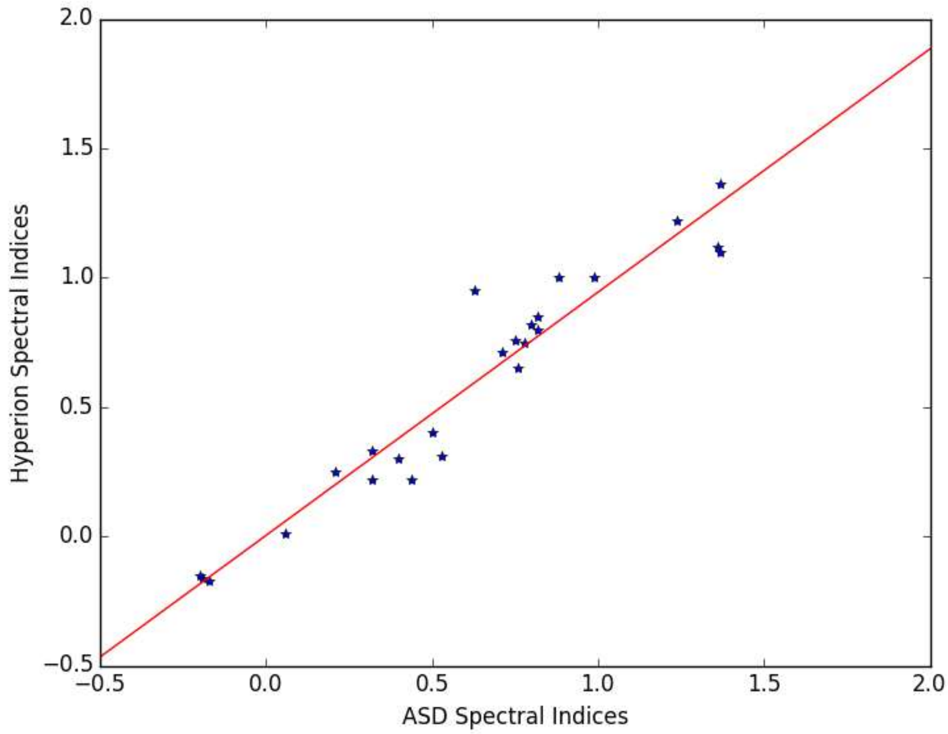


Fig : 5- Cubic Regression analysis of crops compared with spectroradiometer and EO-1 Hyperion sensor based on spectral Indices

The cubic convolution approach was performed using ENVI Excelis 5.3 with 0.9 as a Root Mean Square Error (RMSE) shown in Fig 5. The RMSE represents that, there is good amount of correlation found in ASD data and EO-1 Hyperion data.

V. Conclusion

The current research explores crop type recognition based on spectroradiometer and Hyperion data based on spectral vegetation Indices (SVI). The spectral positive correlation was found using cubic regression. The R Square shows 0.9 as a spectral matching accuracy, it signifies high correlation among crops spectral responses. The diseases of crops were detected using pigment related spectral index for the Cartenoid content identification. The complete investigational investigation was implemented using ENVI and python software. Finally, the crop types were effectively classified based on spectral and spatial parameters with varying band combinations which will be useful for crop growth monitoring and precision farming. The further perspective of research work will be future directions using various regression analysis methods along with more crops patterns discrimination.

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