Scheme of Hyperspectral Curve of Growing Soybean

TieLi Yang

University of science and technology Liaoning, ANSHAN, 114051, Liaoning, China

ABSTRACT. *When the typical hyperspectral image classification method is used for vegetation classification and extraction, its extraction accuracy and precision classification degree are difficult to meet the practical application requirements. Hyperspectral data acquisition is mainly accomplished by two kinds of sensors: non-imaging spectrometer and imaging spectrometer. This paper combines SCVHR 1024i portable hyperspectral instrument and ubert UHD185 UAV imaging spectrometer to collect spectral reflectance curve of soybean, through data processing to achieve the purpose of analysis of its growth, and has a strong guiding significance for large-scale monitoring of soybean nutrition, pests, pesticide residues and so on.*

1. INTRODUCTION

Accurate analysis of green cup elements using remote sensing data analysis has been a hot topic in the field of remote sensing application research, and hyperspectral is one of the active directions after the rapid development of many basic scientific research in recent years. Soybean is the main food crop in China. It is very important to use hyperspectral equipment to collect spectral curves of its growth in different nutritional status and growth potential for soybean yield estimation, pest control, pesticide residues and other research.

Hyperspectral data acquisition is mainly accomplished by two kinds of sensors: non-imaging spectrometer and imaging spectrometer. Non-imaging spectrometer can measure the reflectance spectrum of the target in the field or indoor, and generate spectral reflectance curve. Users can directly see the spectral characteristics of the target, and use hyperspectral analysis method to process the data to achieve qualitative or quantitative monitoring. The imaging spectrometer integrates spectral technology and imaging technology to achieve "atlas integration", which can not only acquire the shape and position information of the target object in the image, but also record the spectral information of the object. Each pixel in hyperspectral image contains a continuous reflectance spectrum curve, which achieves the collection of spectral information from point to surface. It has more abundant spectral information and is an upgraded version of non-imaging spectrometer.

Hyperspectral remote sensing is a new method of remote sensing data

ISSN 2616-7433 Vol. 1, Issue 1: 75-83, DOI: 10.25236/FSST.070111

acquisition developed at the end of last century. Hyperspectral remote sensing refers to the acquisition of many very narrow spectral continuous image data in the visible, near infrared and thermal infrared bands of electromagnetic spectrum. It has hundreds of scanning bands of imaging spectrometers. To study it reflects the reflection characteristics of the target to the specific wavelength of electromagnetic wave, and is also the "fingerprint" of the object's reflection to the specific hyperspectral electromagnetic wave. The research features can directly obtain the structural characteristics of the object of study, that is, the observation channels of small changes in the internal structure of the object of study. It has been widely used in vegetation growth research, map updating and mapping, marine resources remote sensing, crop remote sensing, meteorological change research and environmental change monitoring as important technical means.

Traditional methods of crop growth research are mainly field sampling, laboratory analysis and simulation. Their growth range is obtained by large-scale aerial image interpretation, which requires high technical requirements and strong subjectivity of operators, and requires destructive sampling, so it is difficult to achieve large-scale monitoring.

Hyperspectral remote sensing technology has the unique advantages of high spectral resolution and integration of atlas. Spectral resolution hyper-resolution refers to the fact that each pixel in hyperspectral image can be approximately continuous spectral curve to delicately represent land objects, and the number of bands is very large, the range of wavelength variation is very small (spectral resolution is high), and actually can reach several nanometers, showing the fingerprint recognition effect on the research object, showing that the small differences of objects can also form different spectral curves, which is precisely quantitative analysis. The theoretical basis of fine classification and recognition. The combination of atlas realizes the integration and unification of the space geometric information and spectral physical information of the observed objects. Macroscopically speaking, hyperspectral remote sensing technology obtains the geometric and physical characteristics of the observed objects at the same time, which can be interpreted as the spatial geometric attributes (texture, shape, size, etc.) of the objects are contained in the spatial dimension, while the spectral physical characteristics (reflection intensity, absorption depth, absorption width, etc.) of the objects are reflected in the spectral dimension, which is a method for classification and recognition of hyperspectral remote sensing images and target detection. The construction provides theoretical guidance.

Hyperspectral remote sensing is a technology that uses very narrow and continuous spectral channels for continuous remote sensing imaging of objects. It is developed on the basis of imaging and spectroscopy. Compared with ground spectral radiometer, hyperspectral remote sensing spectral measurement is carried out in continuous space, so the target image information and spectral information can be obtained at the same time. Compared with traditional remote sensing, hyperspectral resolution imaging spectrometer provides a very narrow imaging band for each imaging pixel, its resolution is up to nanometer order of magnitude, and the number of spectral channels is as large as the number of spectral channels.

ISSN 2616-7433 Vol. 1, Issue 1: 75-83, DOI: 10.25236/FSST.070111

There are more than ten or hundreds of channels, and the spectral channels are often continuous. Compared with traditional remote sensing, more spectral spatial information can be obtained, which can be reflected in the following aspects: the ability of distinguishing and recognizing ground objects has been greatly improved, and the number of imaging channels has been greatly increased. It is the main data source for quantitative remote sensing research.

2. Current status of application in Crop Research

The popularization of hyperspectral remote sensing has raised the research of crops to a new height. Hyperspectral has a unique spectral resolution advantage. It can describe as much as possible the subtle differences between crops in the spectral space, which greatly improves the accuracy of vegetation classification and extraction. At present, the application in crop field is mainly embodied in the species composition, fine classification, physical parameter estimation, chemical parameter estimation, vegetation nutrition status, vegetation pest monitoring and so on.

Classification methods from the initial manual visual interpretation to the widely used computer automatic classification research, the latter mainly includes supervised classification and unsupervised classification. Unsupervised classification is also known as clustering analysis. Computer software will automatically cluster remote sensing images according to the basic parameters and rules of classification, and then compare the automatically generated cluster group and reference data, and divide them into a certain category by iteration. In the whole process, there is no need to provide category feature information. Common unsupervised classification methods include spectral clustering, K-means clustering and ISODATA clustering. However, the attribute information of the category can not be obtained from the classification results. Before supervised classification, through existing experience or conclusion, a typical region is selected as training sample in the image to be classified to compose the corresponding ROI file. The software system calculates the relevant parameters through the sample area provided by the ROI file, and then classifies other pixels according to specific rules, such as maximum likelihood classification. Method, Minimum Distance Classification, Parallel Hexahedron Classification, Mahalanobis Distance Classification, etc. However, since the classification effect of this method is serious, the selection of training area will be seriously distorted if the spectral characteristics of sample area are not typical enough. There are also two ways to integrate them for classification. First, unsupervised classification is carried out, and the results of unsupervised classification are compared with real data on the ground. On this basis, more reliable training areas are selected and ROI files are established. Then, images are supervised and classified. Combining with the latest research results of pattern recognition and artificial intelligence, it can improve the reliability and efficiency of classification. Extraordinary significance.

3. Scheme Design of Hyperspectral Remote Sensing for Soybean Growth

According to the different effects of plants on electromagnetic waves, according to the table below, choices can be made.

ISSN 2616-7433 Vol. 1, Issue 1: 75-83, DOI: 10.25236/FSST.070111

Table 1 spectral range and Resolution

Spectral range	Resolution of spectral
0.49~0.53 μm、0.55~0.58 μm、0.67~0.74 μm	0.5nm
0.40~0.51 μm、0.53~0.56 μm、0.58~0.67 μm、0.78~0.90 μm	10nm
0.90~2.50 μm	20nm

The main soybean producing areas in Northeast China will be selected in the test area. Field observation and sample collection were carried out at seedling stage, flowering stage, podding stage and harvesting stage of soybean. Observation items include: outdoor canopy spectrum, indoor single leaf spectrum and hyperspectral image of winter wheat UAV in Milky period; leaf nitrogen content, chlorophyll, plant height, leaf area index, aboveground biomass, leaf water content, leaf dry weight, etc. 40 outdoor samples can be collected at each growth stage, totaling 200 sets of field data; 40 sets of indoor single leaf spectra and corresponding leaves at flowering and potting stages, totaling 80 sets of indoor data.

3.1 Imaging Spectrometer Selection

3.1.1 The canopy and leaf spectra were measured by SCVHR 1024i portable hyperspectral instrument.

Figure 1. SCVHR 1024i hyperspectral instrument

The basic parameters and settings are as follow tab 1:

Table 2 SCVHR 1024i hyperspectral instrument

Item	parameters
routes	1024
Spectral range (FWHM)	resolution and internal
350~2500 nm	3.5 nm, 1.5 nm
1000~1850 nm	9.5 nm, 3.6 nm,
1850~2500 nm	6.5 nm, 2.5 nm

ISSN 2616-7433 Vol. 1, Issue 1: 75-83, DOI: 10.25236/FSST.070111

3.1.2 Airborne Imaging Spectrometer

Cubert UHD185 UAV on-board imaging spectrometer is a non-scanning, full-frame, real-time imaging spectrometer, which acquires hyperspectral image data by aerial photography. The product uses push-broom imaging technology. Full-frame imaging technology does not need high-precision inertial navigation and GPS equipment support. Data processing is less difficult, image data quality is high and usability is strong. At present, it is the lightest version of high-speed imaging spectrometer. It combines the ease of use of high-speed camera and high spectral accuracy. Its equipment parameters, performance and other indicators can meet the needs.

The basic parameters and settings are as follows: UHD185 has a net weight of 470 g. It can obtain 137 channels of hyperspectral image data in the range of 450-950 nm with a spectral resolution of 8 nm and a sampling interval of 4 nm.

Figure 2. Cubert UHD185 UAV

3.2 Data Acquisition

3.2.1 Canopy Spectrum Acquisition

Soybean fields with uniform growth and no pest damage were selected. On sunny, cloudless and windless days, the time ranged from 11:00 to 14:00. The reference board (whiteboard) was calibrated before each acquisition. The probe was downward, about 1 m from the crown top. Four spectral curves were measured each time, and the average value was obtained. At the same time, location parameter information is recorded for geographic registration of large-scale images.

The measurement of single leaf spectroscopy is carried out in the laboratory. According to the rules of indoor spectral acquisition, the instrument must be calibrated before each measurement and the blade surface must be cleaned. In the measurements, the upper, middle and lower positions of the leaves were taken to measure the spectra in turn, and the measurements were repeated twice. Mean values were taken and recorded without exceeding the time limit.

3.2.2 Acquisition of hyperspectral image data by aerial photography

At the same time of ground data acquisition, hyperspectral image data are acquired by aerial photography of UAV imaging spectrometer.

The data acquisition system of low altitude light UAV imaging spectrometer is an important means to acquire hyperspectral image data at present. The platform is an eight-rotor UAV with a takeoff weight of 18 kg and a net load of no less than 8 kg. The flight distance is more than 3 km, the flight time is 30 min and the flight speed is less than 10 m/s. The flight altitude is 100 m, the speed is 6 m/s, the focal length of hyperspectral imager lens is 25 m m, the field of view angle is 13 degrees, the ground resolution of hyperspectral image is about 0.32 m, and the coverage area of each scene image is about 16 m*16 M. In flight measurement of Airborne Hyperspectral imager, the data can be transmitted to the ground station in real time and the hyperspectral image can be analyzed on site.

3.3 Hyperspectral Data Processing

Because the sampling interval of hyperspectral data is different, before data processing, the measured spectral data are re-sampled with the random processing software ViewSpec Pro 6.0, which is provided by the spectrometer. The sampling interval is set to 1 nm.

Considering that the canopy reflectance spectrum acquired by the spectrometer contains not only the information of the target object soybean, but also the pop noise of other objects in the field environment, as well as the factors such as the error of the instrument itself, weather conditions and the stability of personnel operation, it is necessary to reduce the noise of the spectral file. Savitzky-Golay (SG) smoothing filter is used to denoise the spectral data. Setting the number of smoothing points to 9, the noise can be eliminated, and the data can not be distorted and the signal-to-noise ratio can be improved.

Vegetation index normalization, first derivative spectra and trilateral parameters can be used to process spectral data. For example, derivative spectroscopy is a commonly used change method in hyperspectral analysis. This method can reduce or eliminate the influence of background noise, improve the ability of identifying target information and the accuracy of monitoring model. At the same time, the effective decomposition of canopy mixing spectrum can significantly improve the relationship with the pigment density and improve the extraction efficiency.

The corresponding "three-sided" parameters are extracted from the first derivative spectrum of the original spectrum. These parameters are closely related to various physical and chemical parameters of plants, especially in the transition band from "red valley" formed by strong absorption in red light to platform formed by strong reflection in near infrared band, forming the most prominent feature of green plant spectrum "red edge", which can be cited in chlorophyll content, nitrogen content, vegetation coverage, canopy structure, leaf area index, biomass and other factors. Change of position and amplitude of red edge.

The "three-sided" parameter algorithm is shown in the following table.

Table 3 algorithm of trilateral parameter

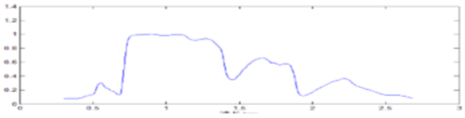
Type	Trilateral parameter	Algorithm
Red edge parameter	red edge position red edge Amplitude red edge area Kurtosis coefficient coefficient of skewness	λ_{red} $REA = \max\left[R'(\lambda)_{\lambda=680\text{-}760nm}\right]$ $SD_R = \int_{680}^{760} R'(\lambda)d\lambda$ $Kur = \frac{E(X-\mu)^4}{\sigma^4}$ $Ske = \frac{E(X-\mu)^3}{\sigma^3}$
Yellow edge parameter	Yellow edge position Yellow edge Amplitude Yellow edge area	λ_{yellow} $YEA = \max\left[R'(\lambda)_{\lambda=560\text{-}640nm}\right]$ $SD_Y = \int_{560}^{640} R'(\lambda)d\lambda$
Blue edge parameter	Blue edge position Blue edge Amplitude Blue edge area	λ_{blue} $BEA = \max\left[R'(\lambda)_{\lambda=490\text{-}530nm}\right]$ $SD_B = \int_{490}^{530} R'(\lambda)d\lambda$

R( ) is the spectral reflectance of any wavelength, R( ) is the corresponding first derivative spectra. E(X) is the expected value of vector X , is the average value of vector X , is the standard deviation of vector X .

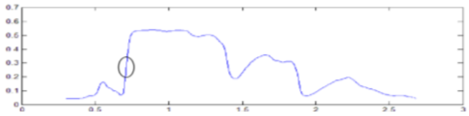
Table 4 algorithm of spectral index

Hyperspectral Parameter	Algorithm	
Normalized Difference Spectral Index(NDSI)	$\frac{R_{\lambda1}-R_{\lambda2}}{R_{\lambda1}+R_{\lambda2}}$	$\frac{D_{\lambda1}-D_{\lambda2}}{D_{\lambda1}+D_{\lambda2}}$
Ratio Spectral Index(RSI)	$\frac{R_{\lambda1}}{R_{\lambda2}}$	$\frac{D_{\lambda1}}{D_{\lambda2}}$
Difference Spectral Index(RSI)	$R_{\lambda1}-R_{\lambda2}$	$D_{\lambda1}-D_{\lambda2}$
Soil Adjust Spectral Index(SASI)	$\frac{R_{\lambda1}-R_{\lambda2}}{R_{\lambda1}+R_{\lambda2}+L}(1+L)$	$\frac{D_{\lambda1}-D_{\lambda2}}{D_{\lambda1}+D_{\lambda2}+L}(1+L)$

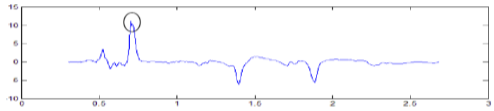
Rλ1 and Rλ2 are the spectral reflectance of any wavelength, Dλ1 and Dλ2 are the corresponding first derivative spectral



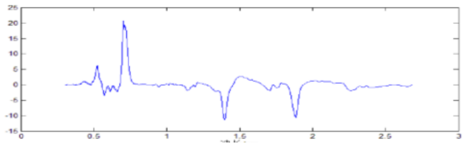
(a) original



(b) Linear



(c) first derivative spectral



(d) Exponential

Figure 3. some typical spectral curve

4. CONCLUSIONS

At present, the detection band covers the range from visible light to thermal infrared, the spectral resolution reaches nanometer level, the number of bands increases to hundreds, which greatly enhances the ability of remote sensing information acquisition, and can accurately analyze the solid and liquid chemical components of the earth surface. With the advent of the era of artificial intelligence, the integrated acquisition of multi-information of image, spectrum and polarization combines the technology of neural network, machine learning and hyperspectral remote sensing.

Cubert UHD 185 imaging spectrometer has great advantages over the traditional push-broom imaging spectrometer, and has the characteristics of real-time imaging. Because the parameters of the model are influenced by many factors, such as region, crop variety, season, weather condition, etc., once the spatial and temporal changes occur, the original model is no longer applicable to the new data, resulting in poor universality and stability of the model. Therefore, it is necessary to explore more accurate models to adapt to the crop structure and hidden spectral information on large-scale hyperspectral images. Based on canopy structure, the crop growth information inversion model based on canopy spectrum is applied to large-scale hyperspectral images, and the spatial resolution of hyperspectral images is relatively small. Therefore, the inversion accuracy can be improved by improving the spatial resolution of hyperspectral images, and the spatial resolution of images can be improved by reducing flight altitude. But at the same time, the relationship between spectral resolution, spatial resolution and

ISSN 2616-7433 Vol. 1, Issue 1: 75-83, DOI: 10.25236/FSST.070111

coverage should be weighed. Otherwise, the scale of image acquired based on UAV platform will lose its practical significance, so it is necessary to make reasonable trade-offs in practical application. In the future, with the continuous development of sensor technology, the spatial resolution of hyperspectral images will be improved, and the accuracy of crop growth information retrieval from large-scale remote sensing images will be higher and higher.

REFERENCES

[1] Luo Dan(2017). STUDY ON MONITORINF NITROGEN STATUS BASED ON HYPERSPECTRAL REMOTE SENSING IN WINTER WHEAT, Northwest A &F University..

[2] Li Jia zhen(2012). Applications of Hyperspectral remote sensing on finding uranium enrichment plants, EAST CHINA INSTITUTE OF TECHNOLOGY, no. 9, pp. 64- 73.

[3] Qin Jinchun(2014).Research on Vegetation Classification and Extraction Technology of Hyperspectral Image. PLA Information Engineering University.