Optik - International Journal for Light and Electron Optics 200 (2020) 163445

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.com/locate/ijleo

Original research article

Identification of poppy by spectral matching classification

Qing He[a,*], Yang Zhang[b], Lan Liang[a]

[a] Department of Biomedical Engineering, Guangdong Medical University, Dongguan 523808, China
[b] Guangzhou Xingbo Scientific Instruments Co. Ltd., Guangzhou, 510070, China

ARTICLE INFO

Keywords:
Poppy
Hyperspectral imaging
Spectral matching classification

ABSTRACT

In this paper, hyperspectral imaging and spectral matching classification technology are used to identify poppy and distinguish it from other leaves in the surrounding environment, which solves the problem of identification of poppy plantation. In this application, spectral classification chooses waveform and spectral absorption index as classification features, takes the size of the spectral angle between pixels as a similarity measure to make classification judgment, takes minimum error criterion as a classification criterion, and uses spectral angle matching method as classification algorithm to carry out spectral matching classification. Experiments show that this spectral matching classification technology has strong classification ability and good effect, and can be applied to detect illicit poppy cultivation.

1. Introduction

Drug crime has become the most serious social problem in the world, which greatly endangers social stability and people's health. To combat drug crime, we need to start from the source of drug cultivation [1]. There are a large number of illicit poppy plantations secretly planted among the people. They are scattered in mountainous areas, forest areas and places where few people live, or covertly Interplanted in crop fields, which makes it difficult to find and destroy illicit poppy cultivation. In recent years, some countries have used GPS-based image mapping technology to monitor suspicious areas of poppy cultivation and improve the accuracy, safety and effectiveness of poppy eradication operations [2]. The method is to identify potential poppy growing areas according to the spectral and environmental conditions reflected by satellite images. However, the spectral signals of plants are very similar and require high spectral identification ability. At present, for the investigation of illicit cultivation of poppy, anti-narcotics personnel basically adopt the method of inspecting, such as on-the-spot monitoring and inspecting in the Hilltop of key drug-related villages and forest margins during the period of poppy cultivation or growth, with a great investment in manpower and material resources. Benefiting from the continuous development of spectral imaging technology and UAV technology in recent years, the project of detecting the existence of illegal poppy cultivation by using small spectral imager on UAV has been put on the agenda of first-line technical investigators. In this paper, based on the image acquired by hyperspectral imaging technology, we use spectral matching classification technology to distinguish poppy leaves from other leaves in the surrounding environment, so as to identify poppy planting areas [3].

2. Principle of spectral matching classification technology

Spectral classification function is to classify the pixels according to the classification decision rules after the classifier has

* Corresponding author.
E-mail addresses: 442904734@qq.com, jessiehq@163.com (Q. He).

https://doi.org/10.1016/j.ijleo.2019.163445
Received 17 June 2019; Accepted 18 September 2019

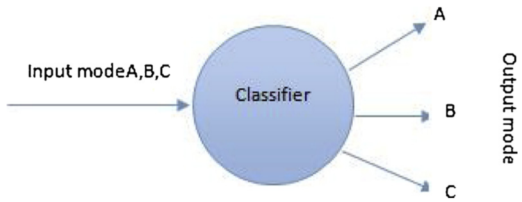

Fig. 1. Classifier.

mastered the characteristics of each category by selecting the feature parameters according to the samples provided by the training area of the category. The specific method of image classification is to first determine the characteristics of each pixel or a relatively homogeneous combination of pixels. These features include the spectral features of the pixels in all bands of the spectral cube and the texture features of the pixels. Then, based on these features, the image is segmented in space according to the classification decision rules.

As shown in Fig. 1, the classifier is a tool for transforming unknown patterns into known patterns. It consists of four parts: classification features, classification judgment, classification criteria and classification algorithm.

Classification features refer to the features that distinguish the types of patterns. The commonly used classification features of hyperspectral images are spectral features, such as waveform, spectral absorption index, spectral reflectance and spectral digital transformation features. Classification judgment refers to the similarity as a measure of classification judgment, such as distance value, probability value, spectral angle, etc. The commonly used classification criteria include least squares method, Fisher criterion and minimum error criterion. Classification algorithm selection is the choice of classifier, commonly used are neural network classification, spectral matching classification, etc. [4–11].

3. Spectrum matching classification adopted in this experiment

In this experiment,spectral classification chooses waveform and spectral absorption index as classification features, takes the size of spectral angle between pixels as similarity measure to make classification judgment, takes minimum error criterion as classification criterion, and uses spectral angle matching method as classification algorithm to carry out spectral matching classification [12,13].

The spectral angle matching method regards the spectrum as a multi-dimensional vector. If a spectral cube has n registered images, the vector form of any pixel i can be expressed as follows:

$$X_i = (x_1, x_2, \ldots\ldots, x_n)^T \tag{1}$$

The similarity between a matched spectrum t_i and a reference spectrum r_i is determined by calculating the "angle" between them.

$$\cos\alpha = \frac{\sum_{i=1}^{n} t_i r_i}{(\sum_{i=1}^{n} t_i^2)^{\frac{1}{2}}(\sum_{i=1}^{n} r_i^2)^{\frac{1}{2}}} \tag{2}$$

The algorithm flow of matching classification is as follows:

Step 1. Select several standard spectra and establish a standard spectral library: Select the regions of known types in the image as standard spectra, and take the geometric mean vectors of the spectra in the regions as class centers.

Step 2. Selecting the first standard sample from the standard spectral data.

Step 3. Taking the gray value of n bands as a multidimensional vector, the angular cosine value of the spectral vector is calculated according to the formula (2) between the spectral data of the standard sample and the spectral data of the pixel to be matched.

Step 4. Selecting other standard samples in turn, calculating the angle cosine between the spectral data of other standard samples and the spectral vector of the pixel to be matched.

Step 5. The bigger the cosine value is, the smaller the vector angle is, and the more matched the spectrum is, so as to judge that the matched pixel belongs to the standard sample with the largest cosine value.

Step 6. By scanning and matching all pixels of the image, the spectral matching classification of the whole image can be completed.

4. Experiment

4.1. Experimental device

Experiments were carried out using a self-designed spectral imaging system [14]. The structure of the system is shown in Fig. 2 (a). The incident light illuminates the sample evenly, and the output light is divided into two-dimensional spatial spectra by an electrically adjustable liquid crystal filter(LCTF). The wavelength of the liquid crystal filter is adjusted by a computer through a controller. The output light is divided into several narrowband spectra, which are received by the receiving device in turn. Consequently, continuous spectral images can be acquired, and single frame spectral images can also be acquired according to the need. The receiving device mainly includes imaging lens, camera and image collector. The optical signal gathered by the imaging lens is

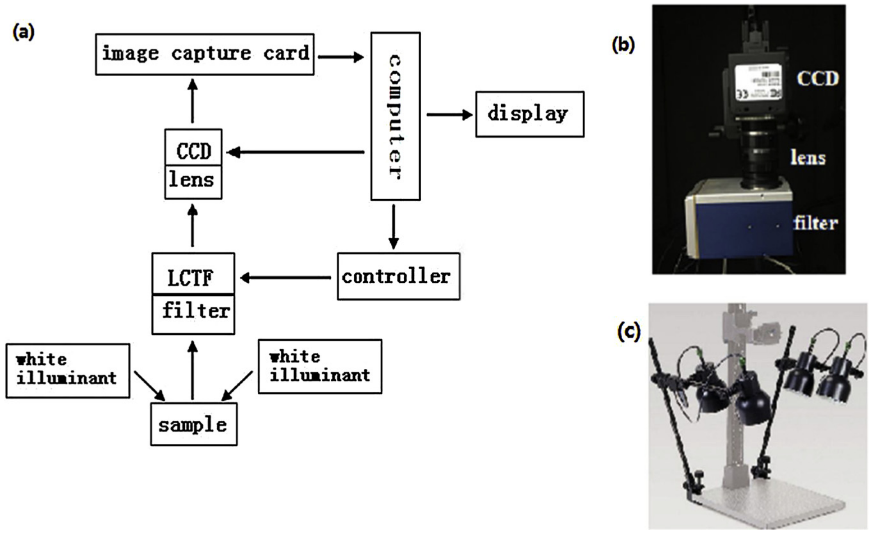

Fig. 2. (a)System principle sketch Map.(b) Connection diagrams of filter, lens and receiver. The filter adopts LCTF VariSpec VIS, which has large aperture, fast scanning speed, no mechanical jitter at scanning wavelength and good filtering quality.The receiver uses Lumenera Lm165.(c)White illuminant. Kaiser 5450 RB 2 remake light is chosen as the excitation light source. This remake lamp is a professional reflection lamp. When it is used for object illumination, the speed of illumination attenuation is much slower than that when it is illuminated by a spotlight. It looks like a light source without shadows.

converted to electrical signal by the CMOS array. After digitization of the image collector, it is stored in the computer. The obtained spectral cube is processed and the processing results are displayed on the display.

The system has synchronization control software, which controls the LCTF filter and the CCD camera to work together to synchronize the shooting time with the spectrum scanning time of the LCTF filter. After taking a set of spectral image cubes, according to the design of the software, the default display result is the synthetic RGB image, which is convenient to preview the experimental results. After shooting, if you need to look at the gray image of each channel, you can preview the gray image of each channel by choosing the gray mode again.

4.2. Preparation of experimental samples

Samples were made by picking the leaves of the poppy and some leaves of five different plants growing in the environment around the poppy. As shown in Fig. 3, the first column contains four leaves of poppy. In the second column, the leaves of plant 1 are marked as leaf 1, with three leaves in total. In the same way, the leaves of plant 2 in the third column are marked as leaf 2, with four leaves in total. The leaves of plant 3 in the fourth column are marked as leaf 3, with four leaves in total. The leaves of plant 4 in the fifth column are marked as leaf 4, with four leaves in total. The leaves of plant 5 in the sixth column are marked as leaf 5, with four leaves in total. Leaf 1, 2, 3, 4 and 5 were harvested from five other plants growing in the environment around poppy. The leaves are fixed on the foam board with double-sided adhesive.

4.3. Experimental method

The experiment uses the reflection spectrum imaging mode to perform spectral imaging. The exposure time of CCD is set to

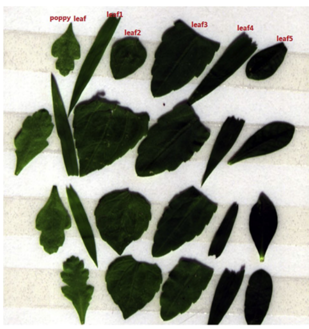

Fig. 3. Sample.

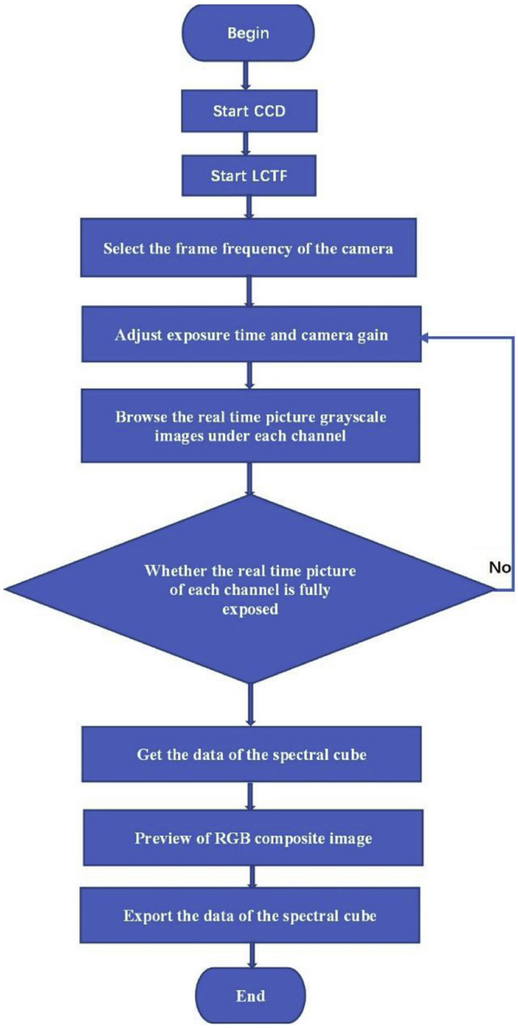

Fig. 4. Operational flow chart.

automatic exposure, and the gain is set to 2. The spectral response range of the system is selected in the 400–720 nm band. The scanning step is 10 nm. The images are saved in the form of gray images, and the spectral data are saved in the spectral library files. The specific operation flow is shown in Fig. 4.

4.4. Experimental data processing

Open the spectral image data, display the sample hyperspectral RGB reconstructed image on the display, and sample different

Fig. 5. Hyperspectral RGB reconstruction image of Sample (using polygon vector selection tool for sampling).

Fig. 6. Spectral matching classification. Results in the pseudo color display after spectral matching classification according to standard sample.

plant leaves by polygon vector selection tool. The selected ROI (region of interest) is shown in Fig. 5.

According to the way of Fig. 5, the characteristic spectral curves of different kinds of leaves were obtained by sampling different kinds of leaves, and the standard spectral library was established.

By using the spectral matching classification technology adopted in this experiment, the spectral matching classification of the whole sample target is processed by the characteristics of the sampled spectral curve (standard spectral library). The results of the classification are displayed in pseudo-color as shown in Fig. 6:

5. Discussion and conclusion

We repeated the experiment five times and sampled arbitrarily different kinds of leaves using polygon vector selection tool. In each experiment, the leaves of "poppy" plants were marked with "red". After spectral classification, the results of the five experiments can be shown as shown in Fig. 6. The leaves of all "poppy" plants can be displayed in "red" pseudo-color.

The leaves of poppy plants marked by red color, which can be clearly seen from Fig. 6, can be marked by spectral classification algorithm through known spectral characteristics of poppy leaves, which display in red pseudo-color. The experimental results show that the spectral matching classification technology used in this experiment has strong classification ability and good effect. Poppy leaves can be identified by the spectral matching classification technology of hyperspectral imaging technology and can be distinguished from the leaves in the surrounding environment.

In practical applications, anti-narcotics personnel can identify potential poppy growing areas by using hyperspectral imaging technology with a small spectral imager mounted by UAV to monitor suspicious areas of poppy cultivation and improve the accuracy, safety and effectiveness of poppy eradication action.

But in the actual scene, poppies are usually planted in hilly areas with weeds or Interplanted in crop fields. How to effectively identify poppies in complex growing environments needs to explore further improvements in technology.

Acknowledgments

This work is partially supported by Natural National Science Foundation of China (NSFC) (No. 81571724).

References

[1] United Nations. World Drug Report, (2008).
[2] Y.S. Liu, 3S technology to monitor poppy planting, Surv. Mapp. China 6 (2007) 68–69 (in Chinese).
[3] Q. He, Development and Application of a Multi Type Hyperspectral Imaging Integrated System, Jinan University, Guangzhou, 2015, pp. 20–27 (in Chinese).
[4] H. Wu, Research on Hyperspectral Remote Sensing Image Data Classification Technology, National Defense University of Science and Technology, Changsha, 2004 (in Chinese).
[5] S. Costa, S. Fiori, Image compression using principal component neural networks, Image Vis. Comput. 19 (8) (2001) 649–668.
[6] P.E. Dennison, D.A. Roberts, Endmember selection for multiple endmember spectral mixture analysis using endmember average RMSE, Remote Sens. Environ. 87 (2003) 123–135.
[7] A.S. Lewis, G. Knowles, Image compression using the 2-D wavelet transform, IEEE Trans. Image Process. 1 (2) (1992) 244–250.
[8] X. Jia, J. Richards, Segmented principal components transformation for efficient hyperspectral remote-sensing image display and classification, IEEE Trans. Geosci. Remote. Sens. 37 (1) (1999) 538–542.
[9] A. Soltani-Farani, H. Rabiee, When pixels team up: spatially weighted sparse coding for hyperspectral image classification, IEEE Geosci. Remote. Sens. Lett. 21 (1) (2015) 107–111.
[10] S.Q. Zhu, K. Su, Y.M. Liu, H. Yin, Z.H. Li, F.R. Huang, Z.H.Q. Chen, W.D. Chen, G. Zhang, Y.H. Chen, Identification of cancerous gastric cells based on common features extracted from hyperspectral microscopic images, Biomed. Opt. Express 6 (4) (2015) 1135–1145.
[11] G.L. Lu, L.M. Halig, D.S. Wang, X.L. Qin, Z. Chen, B. Fei, Spectral-spatial classification for noninvasive cancer detection using hyperspectral imaging, J. Biomed. Opt. 19 (2014).
[12] W.X. Chen, A.S. Chen, Z.H.H. Cai, Classification study based on hyperspectral absorption characteristic parameters, Comput. Eng. Appl. 44 (28) (2008) 230–241 (in Chinese).
[13] H.J. Su, P.J. Du, Y.H. Sheng, Spectral feature extraction and classification of hyperspectral remote sensing data, Comput. Appl. Res. 25 (2) (2008) 390–394 (in Chinese).
[14] Q. He, L. Liang, Multi-type hyperspectral imaging integrated system, Proc. SPIE 10815 (2018) 1–8.