

## VNIR Hyperspectral Camera

## ATH6500

### Feature:

- Spectral Range: 400-5300nm (Customized)
- Max. Spatial Pixels: 2048x2048 (Different by model)
- Max. Spectral Channels: 1088 (Different by model)
- Superior imaging performance;
- The data format is compatible with ENVI
- Built-in auto-scan device, compact size
- Weight: 6.5kg (Different by model)
- A variety of stray light elimination design, high imaging quality
- High-definition visible light camera, capable of image fusion
- High responsibility

### Application:

- **Monitor Agriculture:** plant diseases and insect pest, disaster, categories ID etc.
- **Forestry:** Tree categories identification, Phytomass, nutrient elements, forest health etc.
- **Water Environment:** Water quality parameters, water waste spatial distribution and migration analysis
- City geological substances classification and identification
- **Soil Pollution:** heavy metal waste
- **Minerals:** Mineral mapping, ingredients explore, metallogenic prognosis etc.

### Describe:

ATH6500 is designed spectral imaging system suitable to field operation with a function of auto-scan.

It composes of hyperspectral camera ATH1500 and tripod. The core hyperspectral camera is a complete self-developed, and it employs low cost split light system with a compact size, CMOS image sensor, high frame rate, high-performance-to-price ratio, USB power supply no need extra power, customized high precision scan mirror can sweep target forming image; It employs built-in power supply module, external wire connect is simple can improve integrated and portability.

ATH6500 combines hyperspectral imaging technology with high-definition photography technology, and the collected data has both high spectral resolution and high spatial

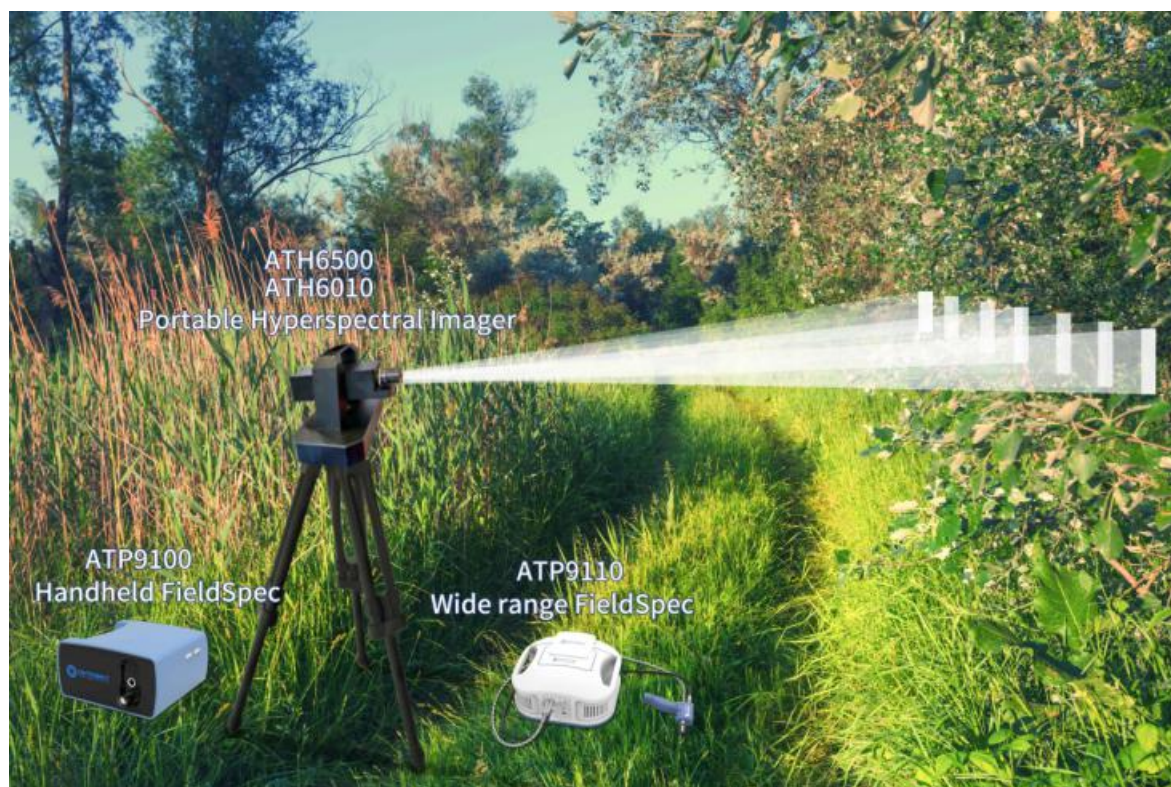
## 1. Performance Parameter

Items	Specification			
	ATH6500	ATH6500-17	ATH6500-25	ATH6500-50
Spectral Range	400-1000nm	1000-1700nm	1.2-2.5um	2.5-5.0um
Detector	CCD	InGaAs SWIR Detector	Deep Cooling IR Detector	Deep Cooling IR Detector
Max. Spatial Channels	2048	640	640	640
Max. Spectra Channels	1088	512	512	512
Data Quantification Class	12bits	14bits	14bits	14bits
Max Frame Rate	330fps	240fps	80fps	80fps
Scan range	0-280mm	0-280mm	0-280mm	0-280mm
Reflectance calibration board	50%	50%	50%	50%
Interface	USB3.0	USB3.0	USB3.0	USB3.0
Power Supply Type	12V±10%, 60W			
Dimension	252 x 365 x 326	252 x 365 x 326	452 x 365 x 421	452 x 365 x 421
Weight	<7kg	<7.5kg	<16kg	<16kg
Working Temp.	-20-50 °C			
Storage Temp.	-30-70 °C			

## Order Guides

ATH1500 Series	Feature	Application
ATH1500	400-1000nm VIS-NIR hyperspectral imaging camera	Precision agriculture, agricultural and forestry diseases and pests, vegetation analysis, planting area evaluation, crop yield evaluation, water quality analysis, artwork scanning, cultural relic identification, pattern scanning, industrial sorting, oil pollution detection, etc.
ATH1500-17	1.0-1.7 um SWIR hyperspectral imaging camera	Semiconductor, industrial sorting, food sorting, construction waste sorting, meat sorting, plastic sorting, geological prospecting, mineral exploration, cultural relic identification, judicial identification, document inspection.

ATH1500-25	1.2-2,5 um SWIR hyperspectral imaging camera	Precision agriculture and food analysis, dark plastic sorting, geological prospecting, mineral exploration, national defense and military industry, cultural relic identification, judicial identification, document inspection, moisture content analysis, medicine and material sorting, mineral mapping, medical identification, waste recycling.
ATH1500-50	2.5-5.0 um MWIR hyperspectral imaging camera	Geological survey, national defense and military industry, gas analysis, VOCs inspection, water temperature detection, land cover type identification, camouflage investigation, mineral sorting.
ATH1500-12-50	1.2-5.0 um SWIR hyperspectral imaging camera	Geological survey, national defense and military industry, gas analysis, VOCs inspection, water temperature detection, land cover type identification, camouflage investigation, mineral sorting.
ATH1500-04-17	0.4-1.7 um VIS-NIR hyperspectral imaging camera	Precision agriculture, agricultural and forestry pests and diseases, vegetation analysis, planting area evaluation, crop yield evaluation, water quality analysis, artwork scanning, cultural relic identification, pattern scanning, industrial sorting, oil pollution detection, etc.

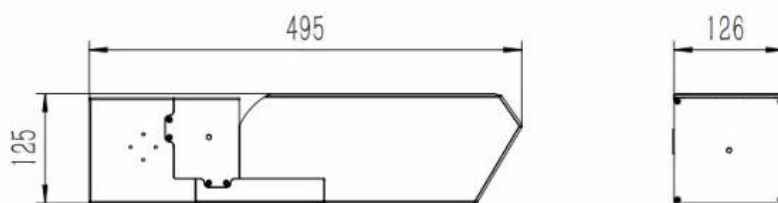
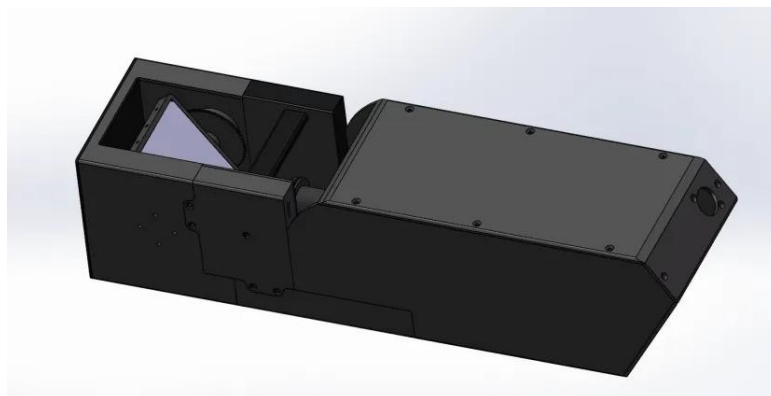




## 2. ATH6500 Physical







Outlook dimension, 3D drawing

## 3. ATH6500 Images Quality

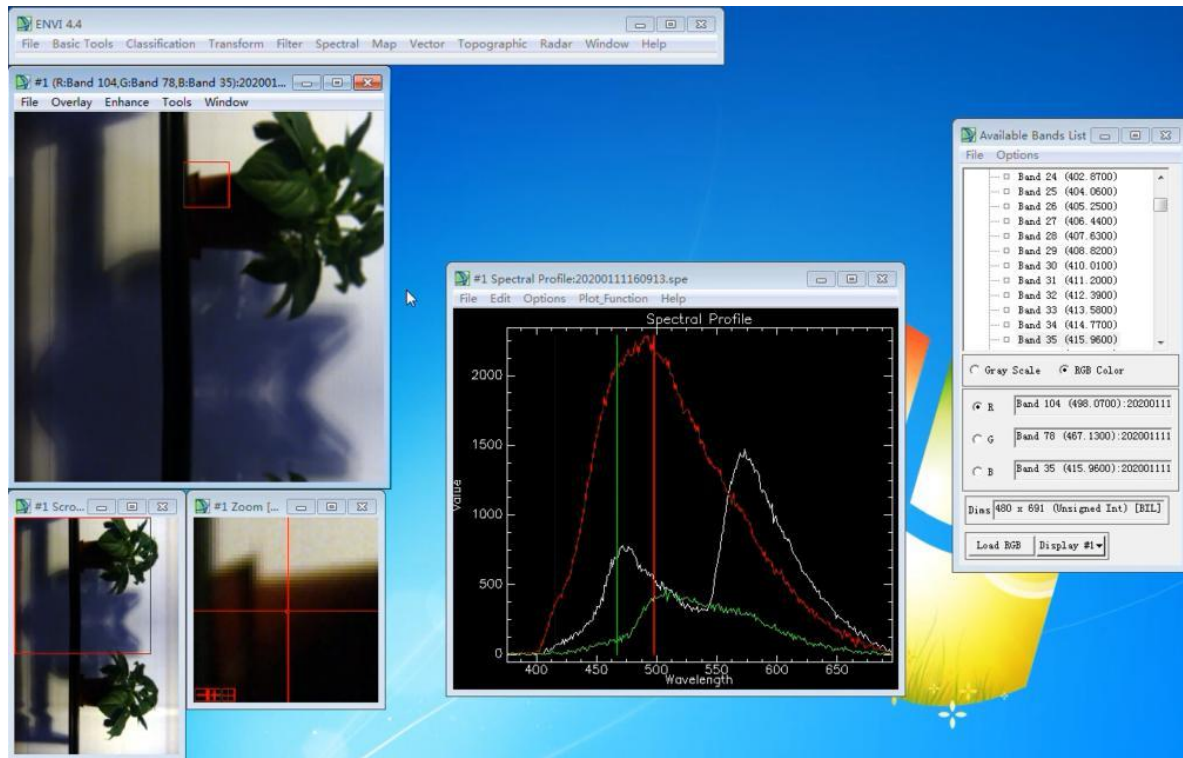


Fig 1 ATH6500 scan hyperspectral database

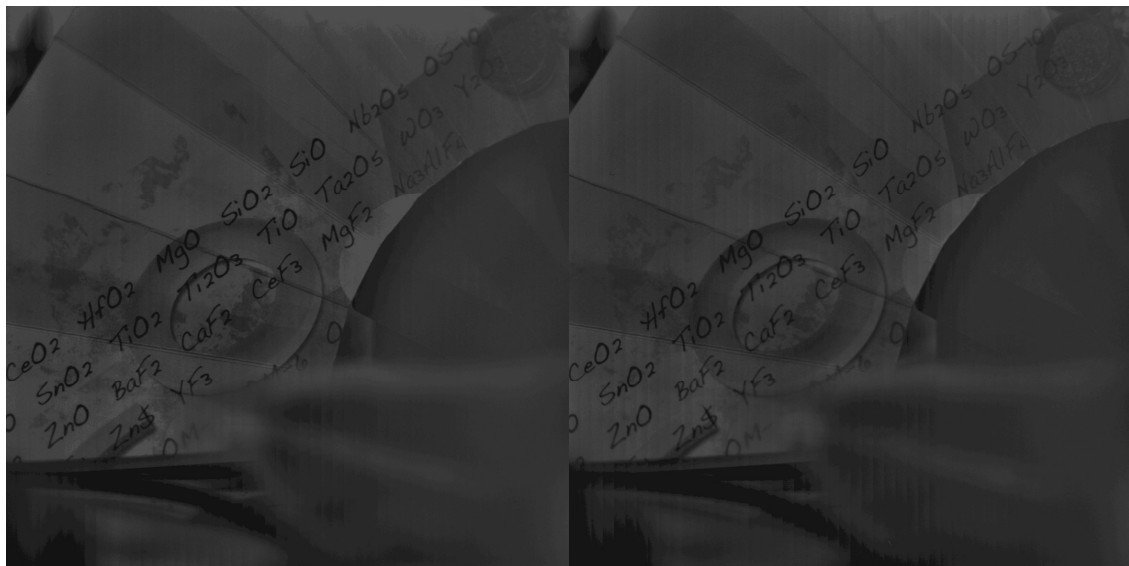


Fig 2 ATH1500 scan the 493nm band image

Fig 3 ATH1500 scan the 653nm band image

## 4. ATH6500 Hyperspectral Camera Series

ATH1500 Models	Feature	Application
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Product data information is current as of publication data. Products conform to specifications per the terms of Optosky Standard warranty.

ATH6500	400-1000nm VIS-NIR Hyperspectral Camera	a, Agriculture & Forestry: precision farming, pests and diseases, vegetation analysis, planting area evaluation, crop yield evaluation, b, Environmental Industry: water quality analysis, oil pollution monitoring c, Industrial sorting: fruit sorting, d, Archaeology: artwork scanning, cultural relic identification, pattern scanning
ATH6500-17	1.0~1.7μm SWIR Hyperspectral Camera	a, Semiconductor, Industrial sorting, food sorting, construction waste sorting, meat sorting, plastic sorting c, Geological survey, mineral survey d, Cultural relic identification, judicial identification, document inspection
ATH6500-25	1.2~2.5μm SWIR Hyperspectral Camera	a, precision agriculture and food analysis, moisture content analysis b, dark plastic sorting, medicine and material sorting, waste recycling c, geological survey, mineral survey, national defense and military industry, mineral mapping c, cultural relic identification, d, judicial identification, document inspection, medical identification
ATH6500-50	2.5~5.0μm MWIR Hyperspectral Camera	Geological survey, mineral sorting, land cover type identification national defense and military industry, camouflage investigation gas analysis, VOCs inspection water temperature detection
ATH6500-12-50	1.2~5.0μm SWIR Hyperspectral Camera	Geological survey national defense and military industry, camouflage investigation gas analysis, VOCs inspection, water temperature detection, land cover type identification, mineral sorting
ATH6500-04-17	0.4~1.7μm VIS-NIR Hyperspectral Camera	Precision agriculture, agricultural and forestry pests and diseases, vegetation analysis, planting area evaluation, crop yield evaluation, water quality analysis, oil pollution detection artwork scanning, cultural relic identification, pattern scanning, industrial sorting



## 5. Application

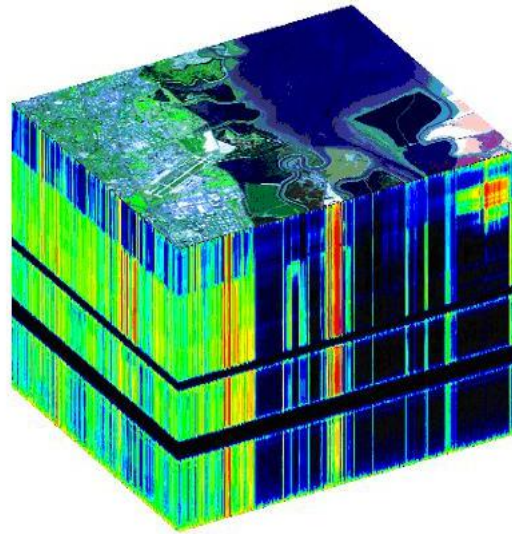


Figure 2 Data cube captured



Figure 3 Drone experiment



Figure 4 Outdoor experiment sceneI



Figure 5 Outdoor experiment sceneII





Figure 6 Outdoor experiment scene III



Figure 7 Outdoor experiment scene IV



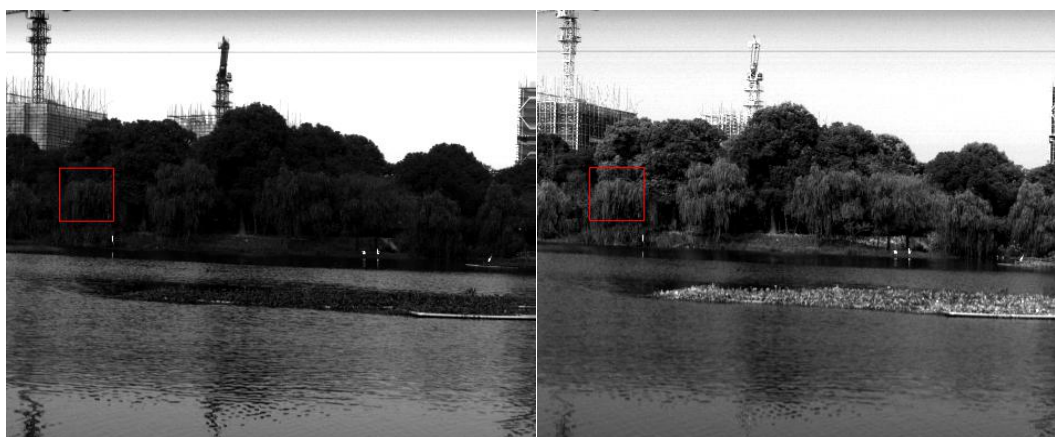


Figure 8 Outdoor experiment sceneV

## 5.1 Case Study by Portable Ground Hyperspectral Imaging System

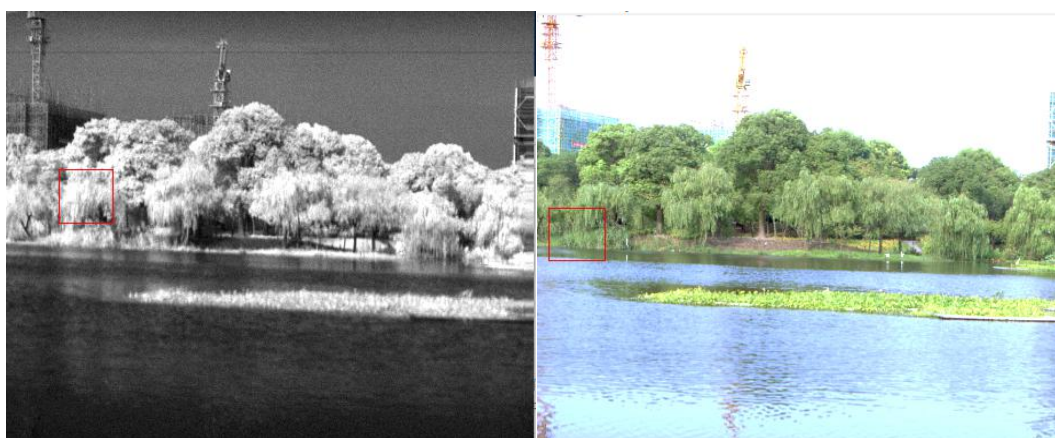
### Plant Measurement

ATH6500 portable hyperspectral imaging system is used to acquire spectral data of field plants, tower crane, and soil etc. Based on single wave band image and color images to display, compare and analyze spectrum. Seen through single wave band image, different ground materials have obvious differences reflected in the different wave bands to differentiate different materials.



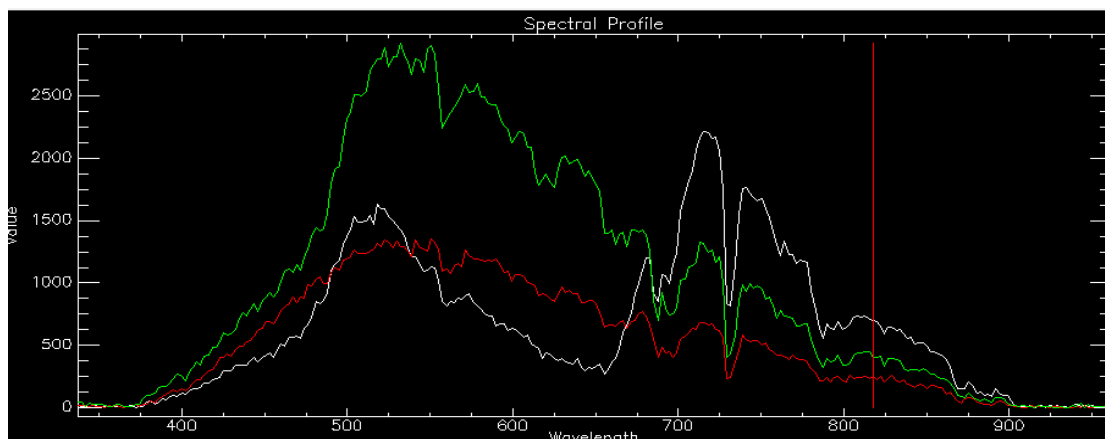
The 50th Wave Band

The 100th Wave Band



The 200th Wave Band

RGB composit image



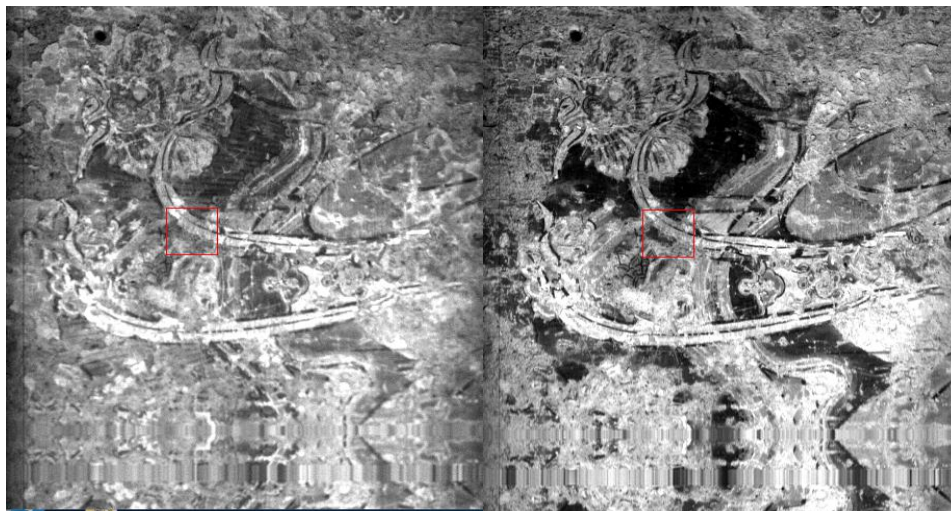
## 5.2 Archeological Mural Measurement

At present, hyperspectral camera has a unique feature of obtaining materials of “fingerprint spectra”, especially fit for archeology, mural, oil painting, and archaeological site spectral image data. Here exhibiting a temple mural measurement spectral image data, we depends on spectral image analysis can vividly restore color and mural condition, provide a solution to solve fades, covered places, damages. Hyperspectral technology is confirmed to provide new clues to analyze cultural relic repairs, identification and protection.



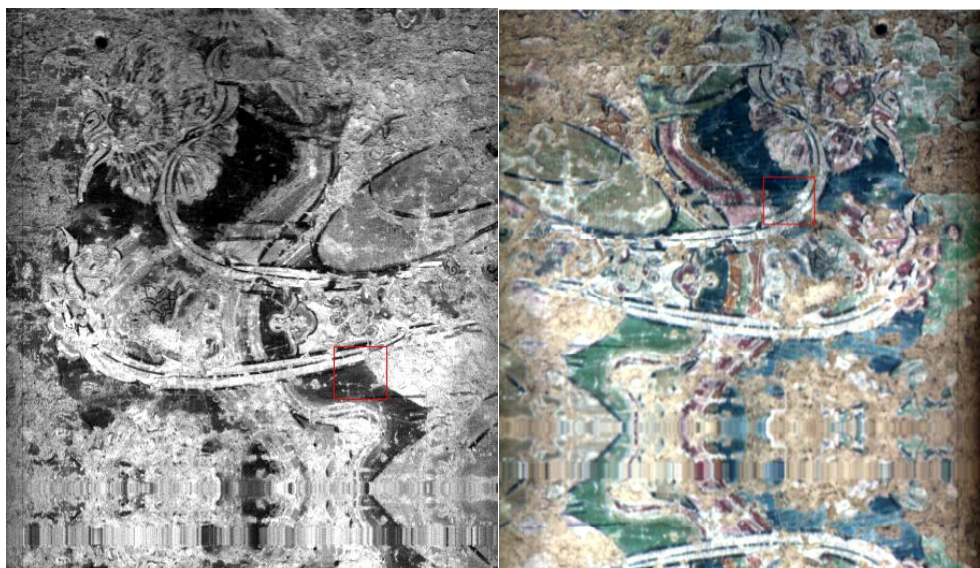
On site picture





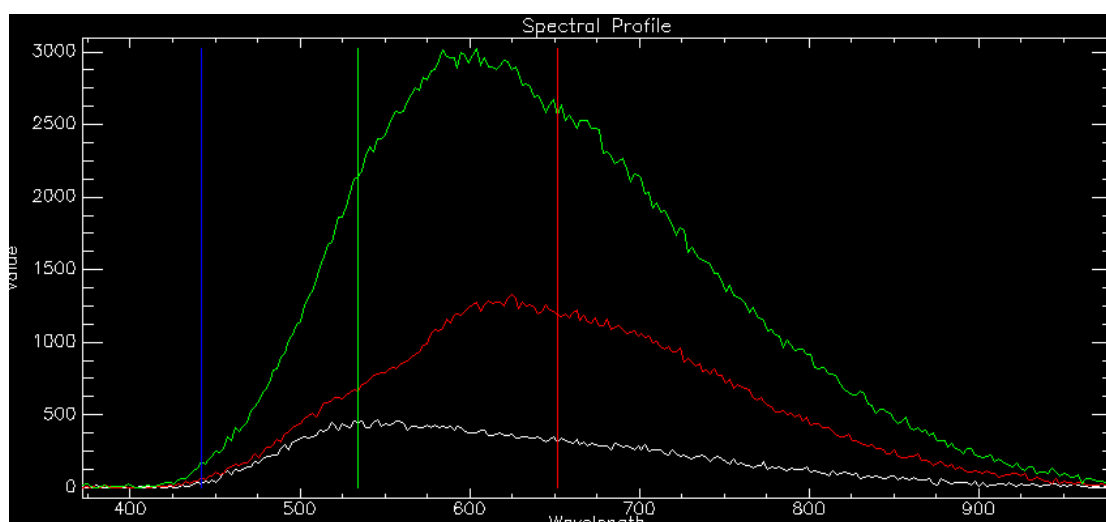
The 50th Wave Band

The 150th Wave Band



The 200th Wave Band

RGB composit image

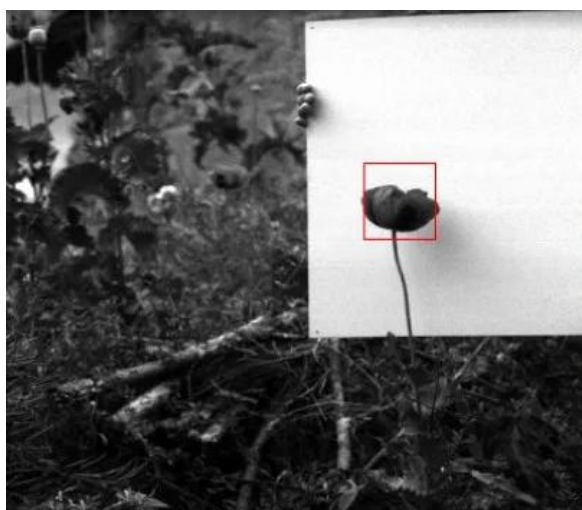


Spectral Curves Comparison

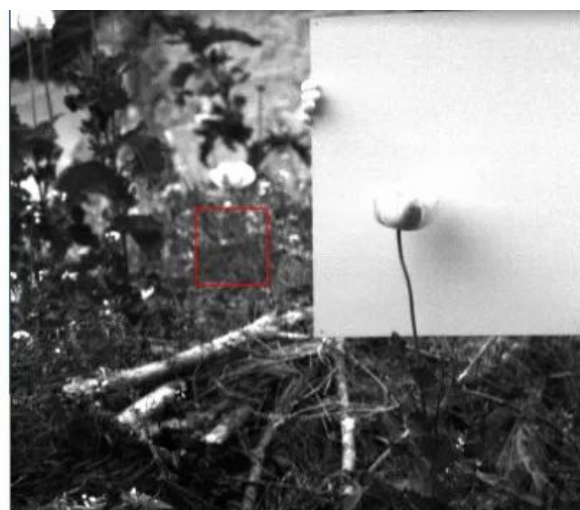


## 5.3 Opium Poppy Measurement

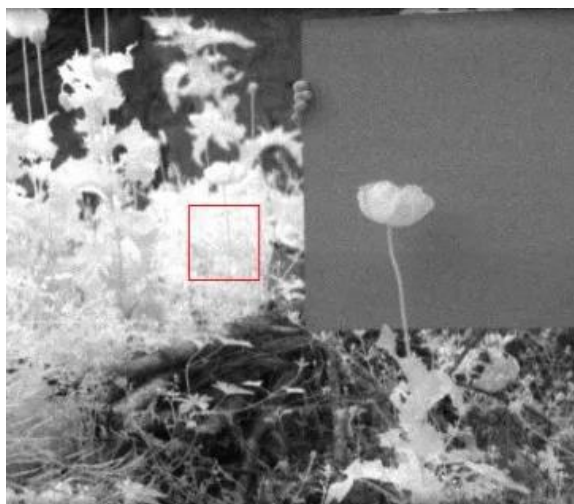
Papaver Somniferum, the Opium Poppy has certain medicinal value, but they are also raw materials to produce drugs. China has strict law to prohibit any person or community from planting opium poppy plant, but there are still a large number of illegal opium poppy garden distributing in mountain & forest areas, and even hided in crop land, which bring difficulties to positioning and monitoring illegal plantation. Many countries take advantage of satellite imagery reflecting spectrum and eye seeing explaining suspect area, but plant spectral signal has a high similarity, so that hyperspectral imaging possessing higher identification. After cooperation with relative departments, Optosky performed a field measurement on opium poppy by hyperspectral imaging system, and it provide a fast and efficient solution to investigate illegal plantation and result a positive result. You can refer to opium poppy spectral image as shown below:



The 50<sup>th</sup> Wave Band



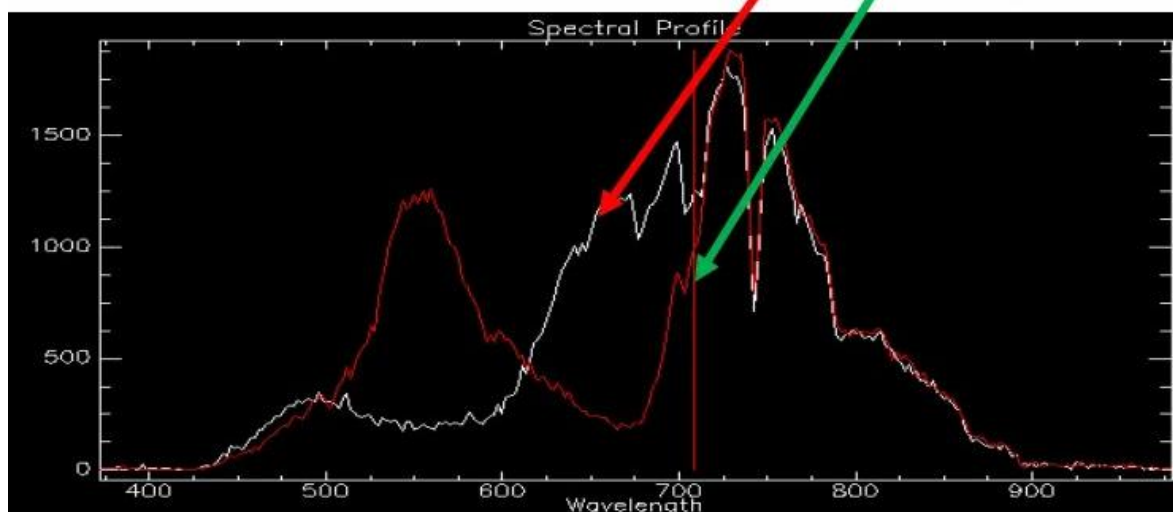
The 130<sup>th</sup> Wave Band



The 200<sup>th</sup> Wave Band



RGB Composite Image



Opium poppy spectral curve

## 5.4 Industrial Sorting Application

With the development of NIR hyperspectral technology, such as Jiang tried to use near-infrared hyperspectral technology to detect impurities in cotton, especially the application of SWIR hyperspectral technology, which significantly improved the detection rate of plastic films compared with conventional methods.

Hyperspectral imaging technology is based on a very large number of narrow-band image data technology, which can obtain image information and spectral information of the sample while imaging the sample. Commonly used hyperspectral data processing methods include partial least squares (PLS), support vector machine (SVM) and artificial neural network (ANN).

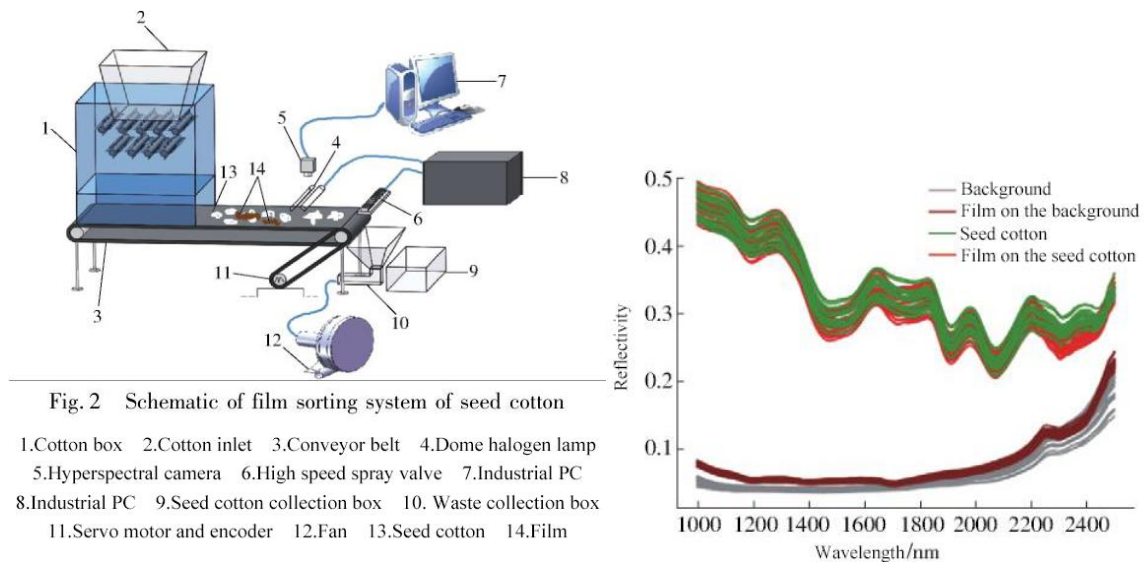


Figure 9 Seed cotton sorting application; (a) System functional composition; (b) Different substances reflectance spectrum

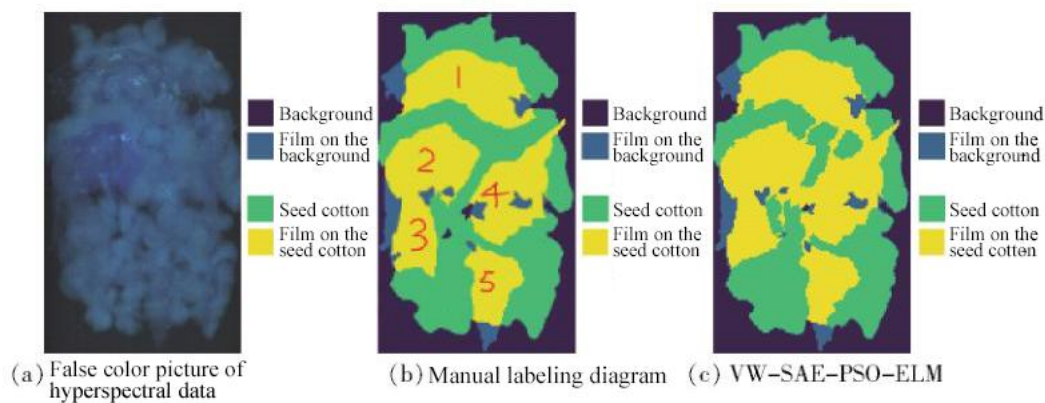


Figure 10 Seed cotton sorting application; (a) Artificial marking; (b) Recognition result

Apple's external quality is the most intuitive quality feature of Apple, which directly affects Apple's price and consumer preference. Aiming at the difficulties and key points of external inspection of apples, based on machine vision technology, hyperspectral imaging technology and multispectral imaging technology, integrated image processing technology, pattern recognition method, chemometric method and spectral analysis technology, the external physical quality of apple (shape and size) and detection methods for common defects on the surface.

The detection system and algorithm developed on the basis of the above research laid the foundation for my country's research and development of rapid online inspection and grading equipment for Apple's external quality based on machine vision technology and multi-spectral machine vision technology.



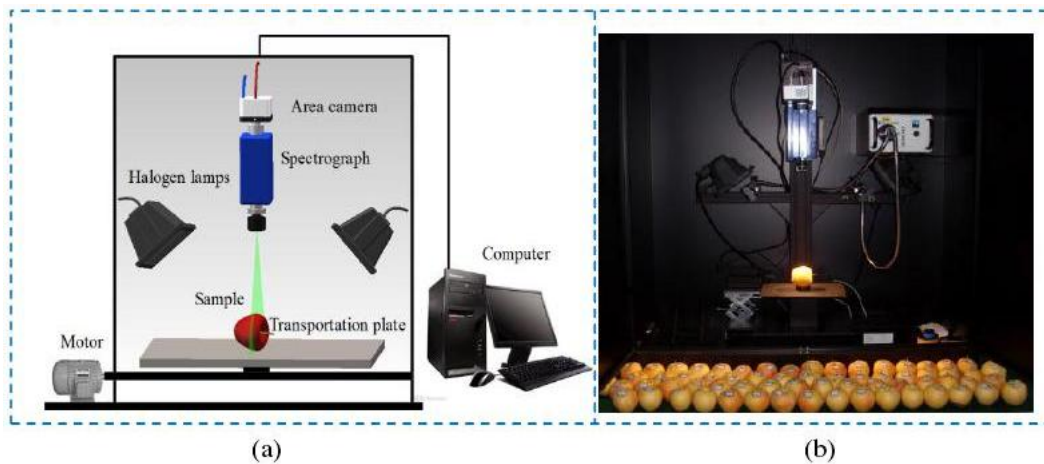


Figure 11 Schematic diagram and physical diagram developed by Dr. Zhang Baohua of Shanghai Jiaotong University; (a) Schematic diagram; (b) Physical diagram

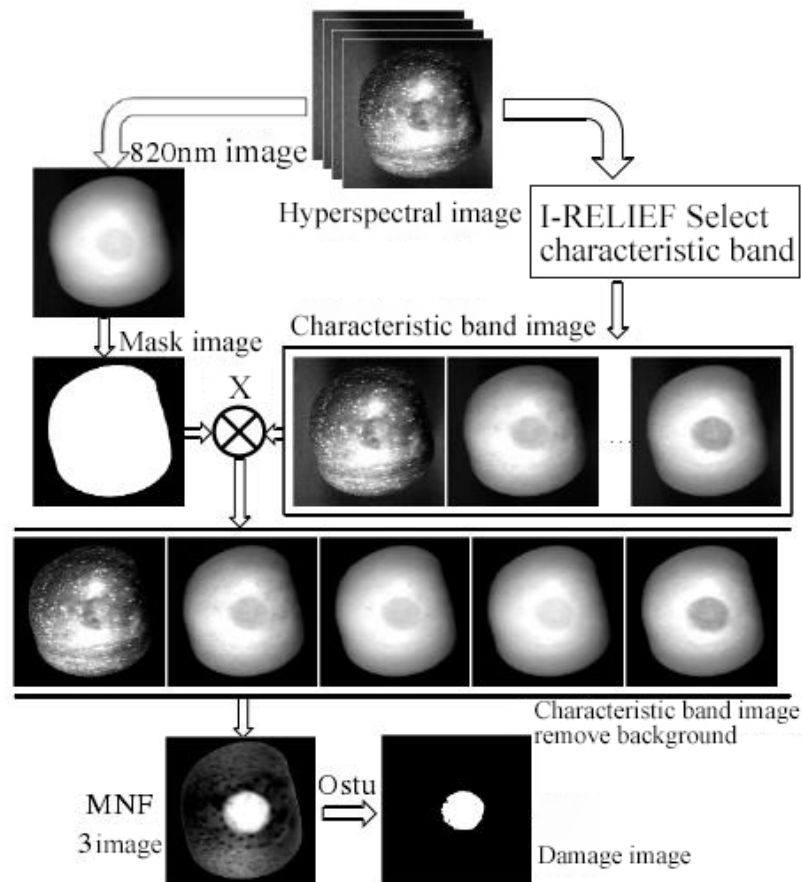


Figure 12: Flow chart of early damage detection algorithm for apple surface

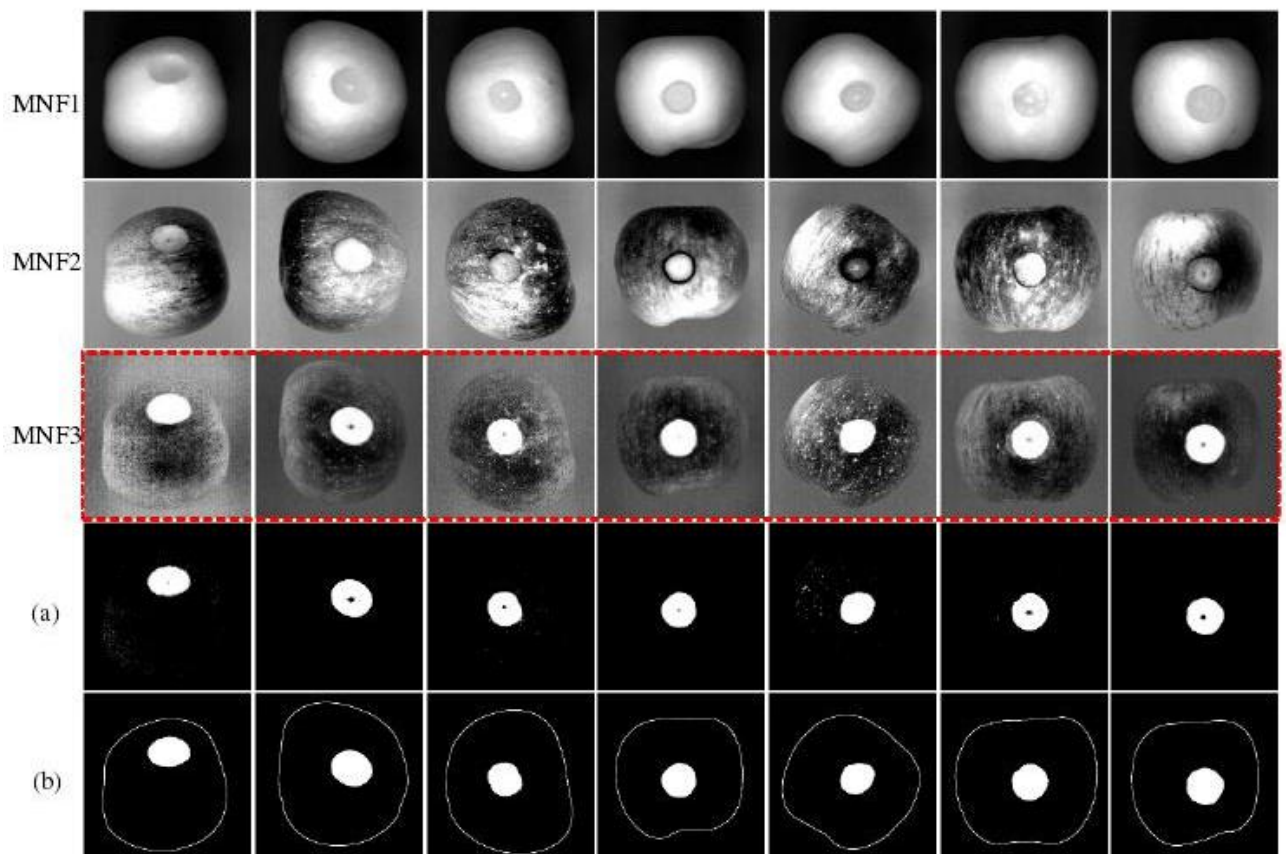


Figure 13 Recognition results of early decay of some apples and intermediate processing (a) rot segmentation results (b) final results

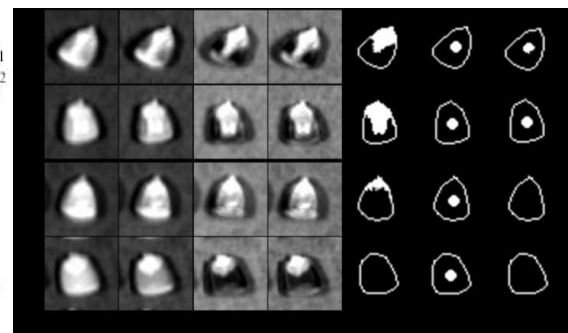
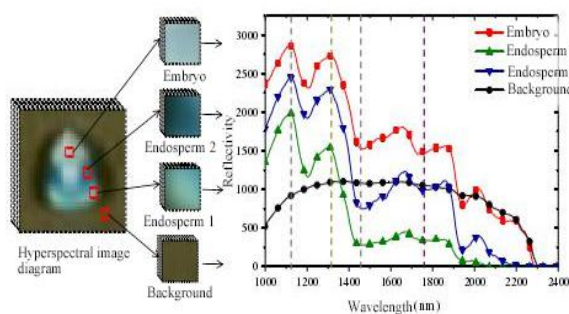


Figure 14 Corn seed sorting application (Dr. Chaopeng Wang, Northwest A&F University)

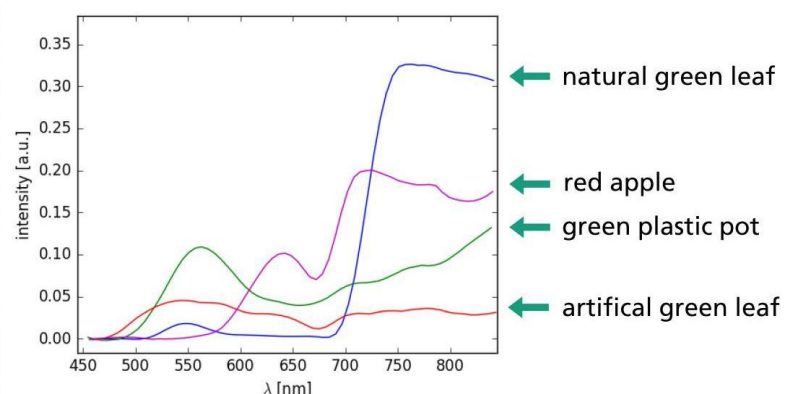
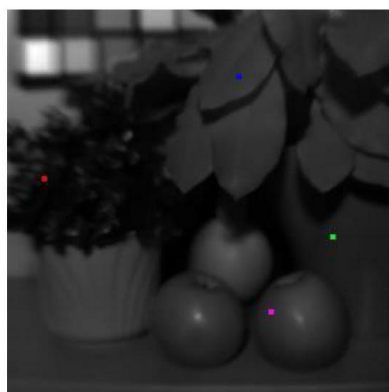


Figure 15 The spectrum of natural green plants, artificial green leaves, green plastic, and red apples

## 5.5 Precision Agriculture Application



Figure 16 Drone-borne hyperspectral imaging camera

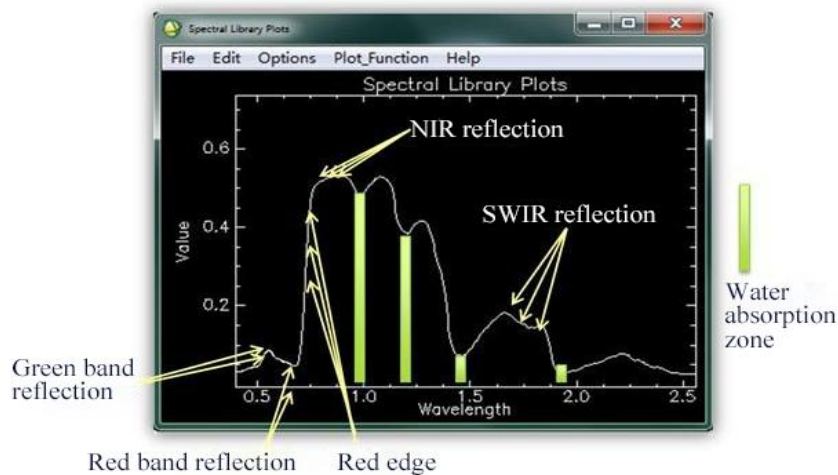


Figure 17 Green plants measured spectrum

- 1) **Crop growth monitoring and yield estimation:** Due to the different external factors of crops at each stage of their growth and development, there will be certain differences in their internal composition and external morphology. The most important difference is the leaf area index. Leaf area index is a comprehensive index reflecting the individual characteristics and group characteristics of crops.
- 2) **Crop pest control:** Remote sensing technology can monitor the effects of pests and diseases on the growth and development of crops, track the growth and development of crops, analyze and estimate disaster losses, and can monitor the distribution and activity of pests, thereby preventing the occurrence of pests.
- 3) **Drought monitoring of crops:** Remote sensing technology monitors crop drought conditions



through crop vegetation index and canopy parameters.

- 4) **Monitoring of soil moisture content and distribution:** In the case of different thermal inertia conditions, the difference between remote sensing spectra is very obvious, so a mathematical model between thermal inertia and soil moisture content can be established, and remote sensing technology uses this model to analyze soil moisture content and distribution.
- 5) **Crop nutrient monitoring:** The accuracy of remote sensing technology to monitor the nitrogen content of crops is higher than that of other nutrient elements.

Normalized difference spectral index (NDSI), ratio spectral index (RSI) and simple spectral index (SSI) were constructed by using single band and any two bands in the range of 450 ~ 882 nm to calculate the correlation between CGI and spectral index and screen out spectral index with good correlation. Combined with partial least squares regression (PLSR), the inversion model was established.

Using CGI as the index, Airborne hyperspectral image was used to monitor the growth status of wheat in the multi-growth period in 2015. Unmanned aerial vehicle hyperspectral image inversion CGI has high precision, which can judge the difference of wheat overall growth, and can provide reference for wheat growth monitoring.

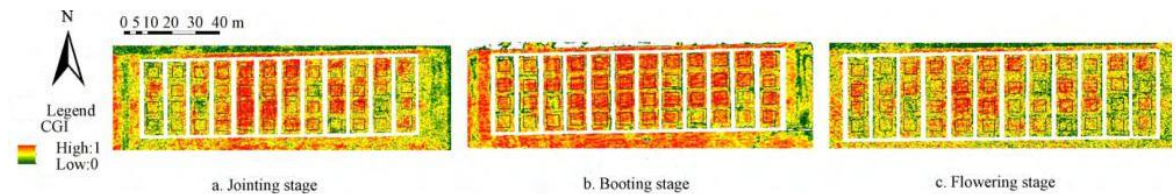


Figure 18 CGI inversion of wheat growth index

## 5.6 Forest Health Application

Used for pest monitoring and forest resource assessment.

Principle: The health of vegetation is related to greenness index, leaf area index, leaf moisture content and light use efficiency;

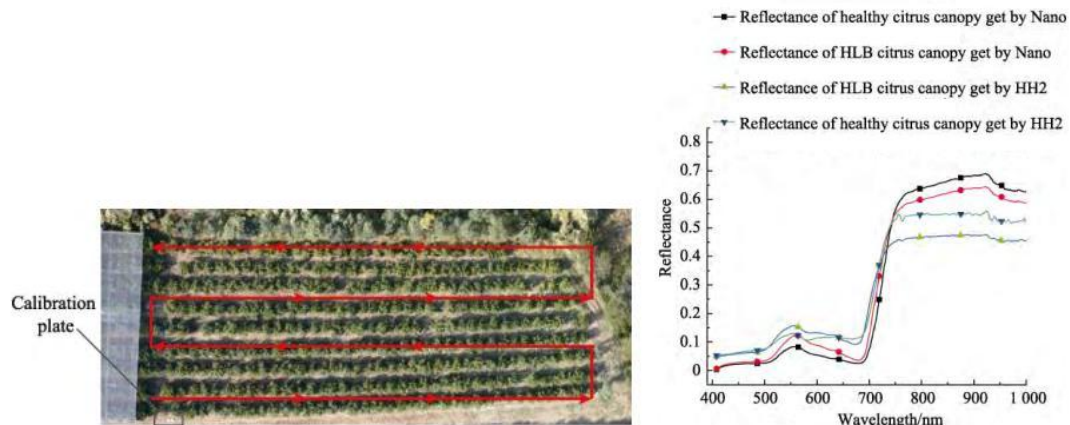


Figure 19 Monitoring and classification of citrus yellow dragon disease plants based on drone-borne hyperspectral imaging camera (designed by Lan Yubin et al., South China Agricultural University)

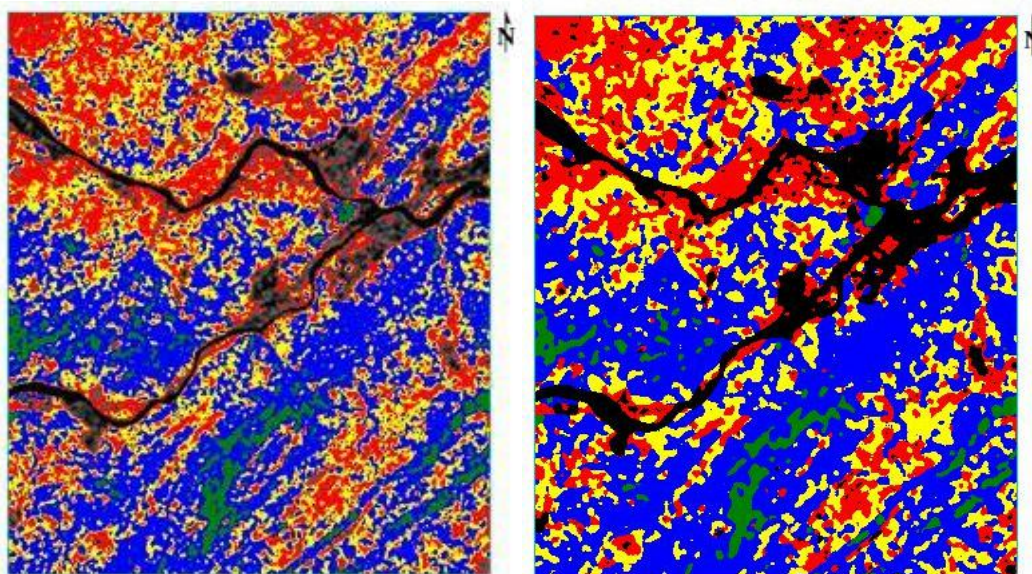
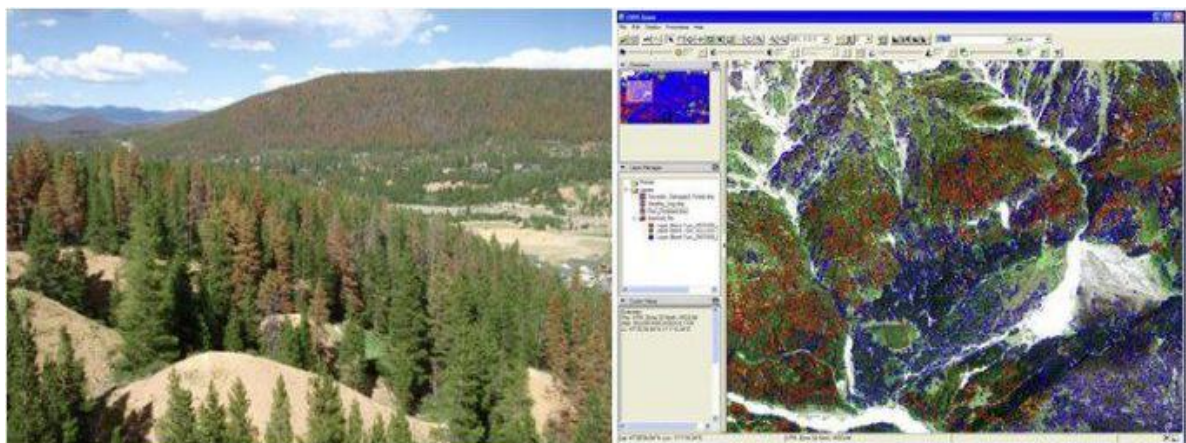


Figure 20 Distribution map of masson pine health degree studied by Wang Shuang of the University of Electronic Science and Technology of China with a hyperspectral camera



## 5.7 Geological Survey Application

Spectral remote sensing technology evolved from the multi-spectral remote sensing technology represented by Landsat and took initial shape in the mid-1980s (Goets et al., 1985, Tong Qingxi et al., 2006).

Due to its advantages of high spectral resolution and atlas integration, hyperspectral remote sensing technology has the ability of fine detection and analysis of surface rock mineral composition on a large scale. It can not only provide a macro image of the ground, but also determine the type and abundance of minerals in the geological body, and even the chemical composition of some minerals at pixel level details (Wang Runsheng et al., 2010).

In recent years, with the continuous development of hardware, data processing methods and software related to imaging spectrometer, the application of hyperspectral remote sensing technology in the field of geological survey has been accelerated.

Hyperspectral remote sensing technology has played an important role in geological mapping, the

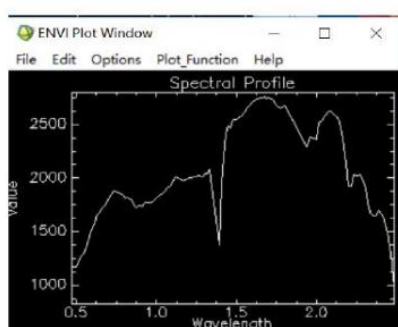


definition and division of hydrothermal alteration zones, and the delineation and discrimination of mineralization anomalies from large metallogenic areas to medium-scale ore fields (e.g. Bierwirth et al., 2002; Company Changyun et al., 2005; Kruse et al., 2006; Cudahy et al., 2007; Wang Runsheng et al., 2010; Liu Dechang et al., 2011; Yan Baikun et al., 2014; Yang Zian et al., 2015; Graham et al., 2017).

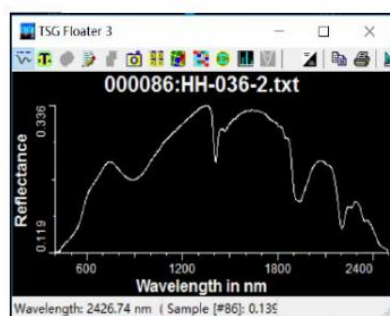
With the theory of metallogenic system (Wyborn et al., 1994) becoming the guiding principle of prospecting practice, thematic mineral mapping on the scale of large ore concentration areas and metallogenic belts will provide key regional material composition information for predictive prospecting and exploration.

The spectral wavelength ranges used for mineral mapping include visible light (400-700nm), NIR (700-1000nm), SWIR (1000-2500nm), and thermal IR (7000-15000nm). At present, the most widely used in mining is the short-wave infrared region (1000-2500nm).

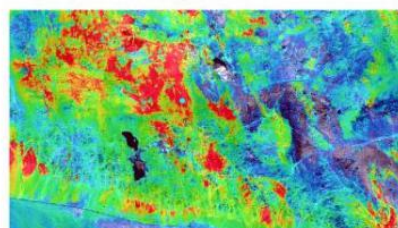
Because the frequency is close to the cofrequency and combined frequency of the chemical bond vibration in the mineral lattice, the mineral containing water or OH- (mainly layered silicate and clay) as well as some sulfate and carbonate minerals can be observed in the range of short-wave infrared wavelength.



HH036 point image spectrum

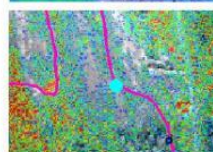


HH036 point measured spectrum

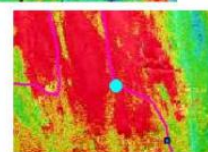


Sericate Filling Results

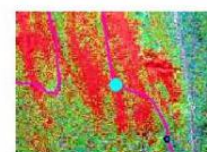
Comparison of known deposit points between HH036 and measured



Chlorite extraction results



Sericate extraction results



Feb3+ extraction result

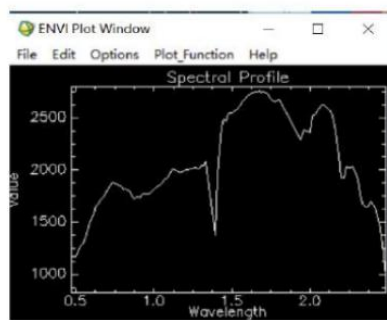


Sampling point photos

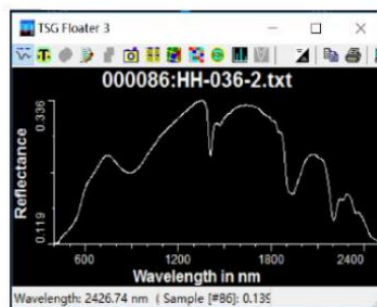


Long-range photos of sampling points

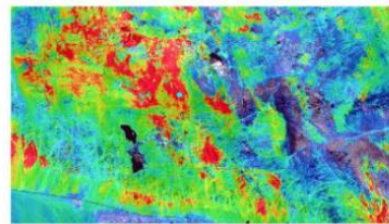




HH052 point image spectrum

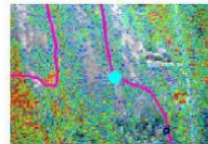


HH052 point measured spectrum

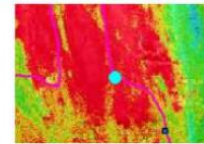


Sericite Filling Results

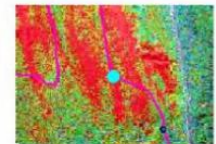
Comparison of known deposit points between HH052 and measured



Chlorite extraction results



Sericite extraction results



Feb3+ extraction result



Sampling point photos



Long-range photos of sampling points

Figure 21 Application of hyperspectral imager in prospecting

Soil salinization is one of the important ecological and environmental problems in arid and semi-arid areas. Soil salinization causes soil hardening, fertility decline, acid-base imbalance, land degradation and other consequences, which seriously restricts agricultural development in China and affects the strategic situation of sustainable development in China at present. Remote sensing technology, with its characteristics of large scale, wide range, strong timeliness and economy, makes up for the deficiency of traditional methods for monitoring salinization phenomenon, and provides a new way for quantitative monitoring of soil salinization phenomenon.

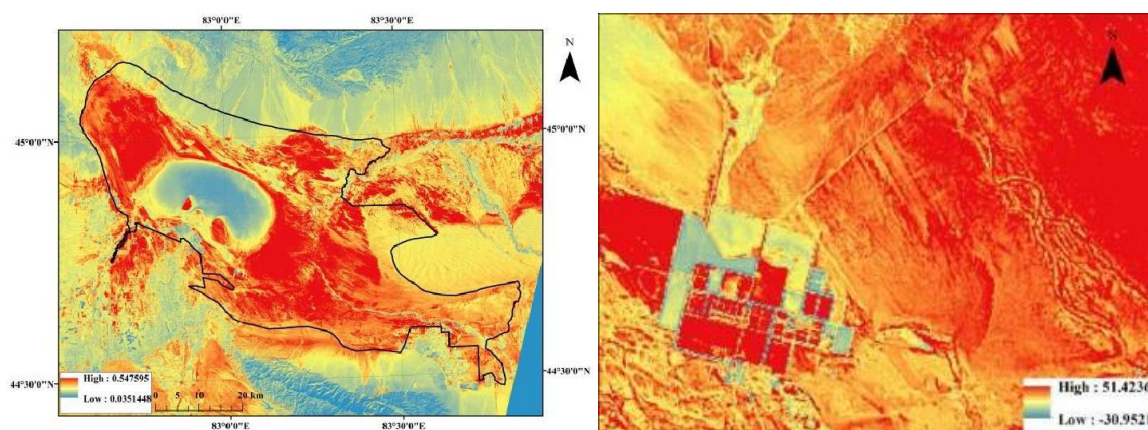
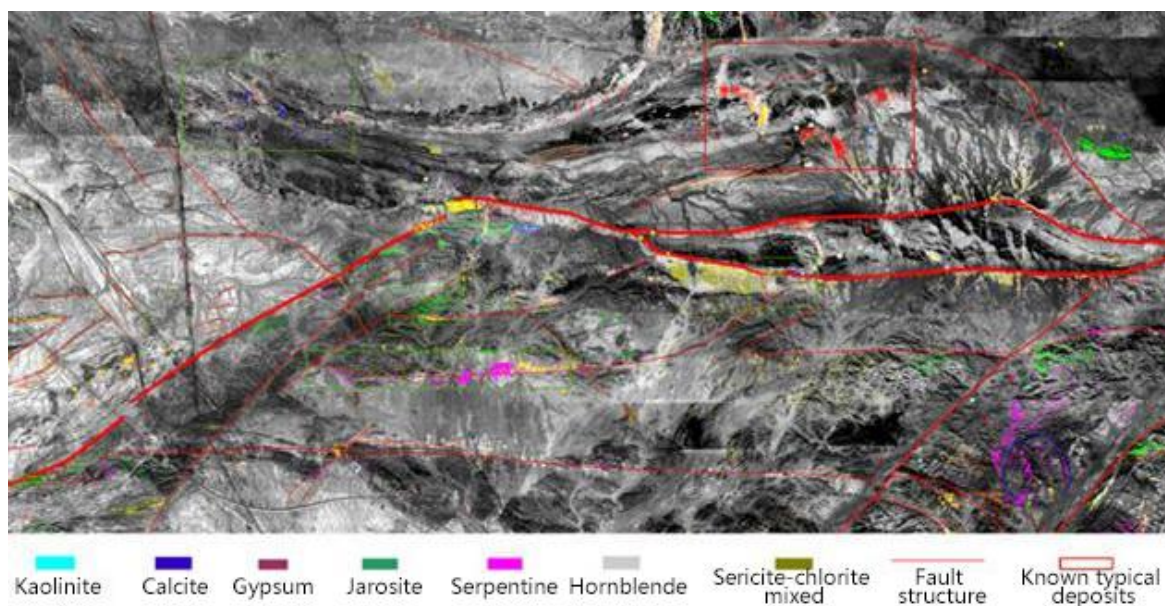


Figure 22 The surrounding area of a salt field



## 5.8 Public Safety Application

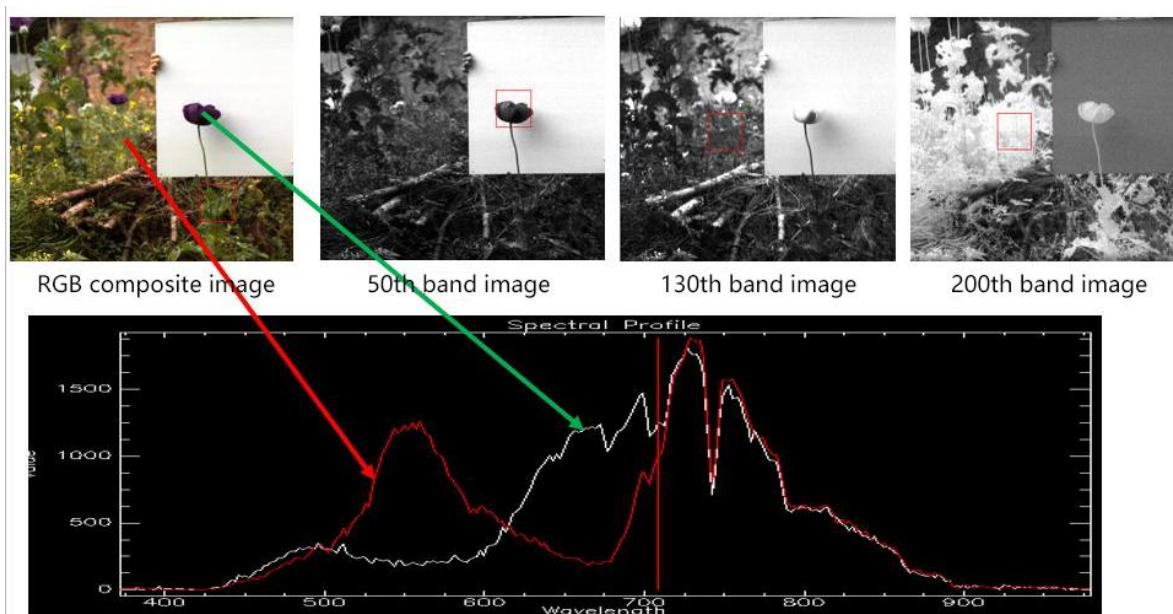


Figure 23 The searching for illegal poppy cultivation application



Figure 24 Document inspection application



## 5.9 Medical Microscopic Imaging Application

Objective: online detection and navigation positioning during tumor surgery

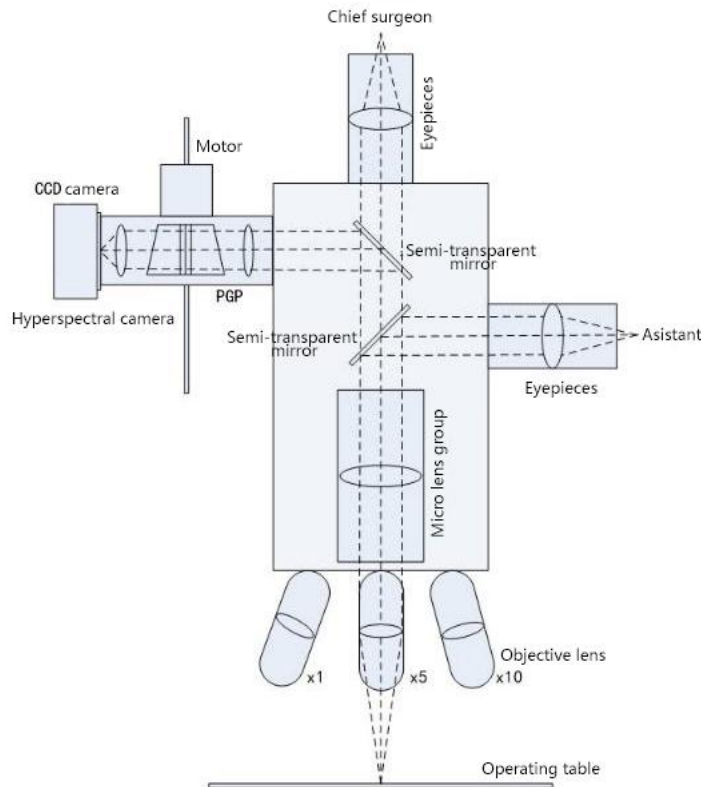


Figure 25 Medical microscope imager optical path schematic diagram

Is shown in the figure of medical microscopic imaging spectrometer principle diagram, the operating table for the target after the objective lens, microscope lens group is divided into three road, visual observation for the surgeon, all the way all the way for the assistant auxiliary visual observation, a routing imaging spectrometer detection, driven by a motor to imaging spectrometer measuring target space d scanning, imaging spectral information of the target under test, then through data analysis, image processing, through the display to the doctor.





Figure 26 Medical microscope imager figure

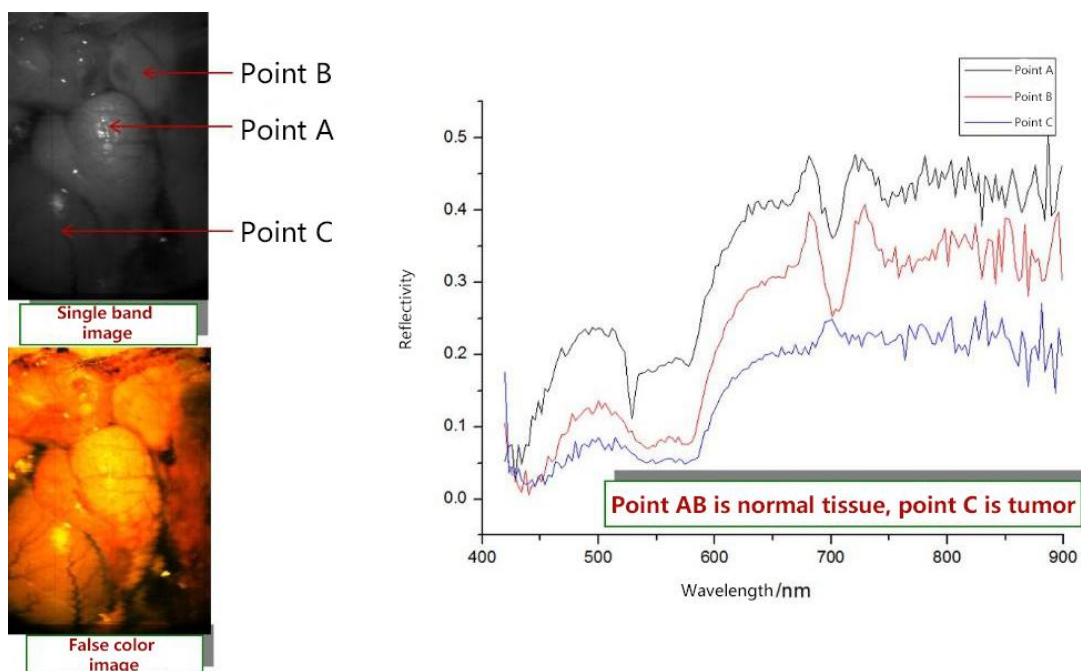


Figure 27 Data collect by medical microscopic imager

## 6.0 Airborne Hyperspectral Imaging System Application



Figure 28 Optosky Airborne Imaging Camera

Objective: Airborne remote sensing

Application: Figure shows airborne imager consists of SpecVIEW-VIS, stable platform and POS modules. Figure 30 and Figure 31 show data was collected. Figure 7 shows pseudo color image processed through geometric correction, flight strip splice and radiation correction. Figure 31 shows typical geology spectral curve.

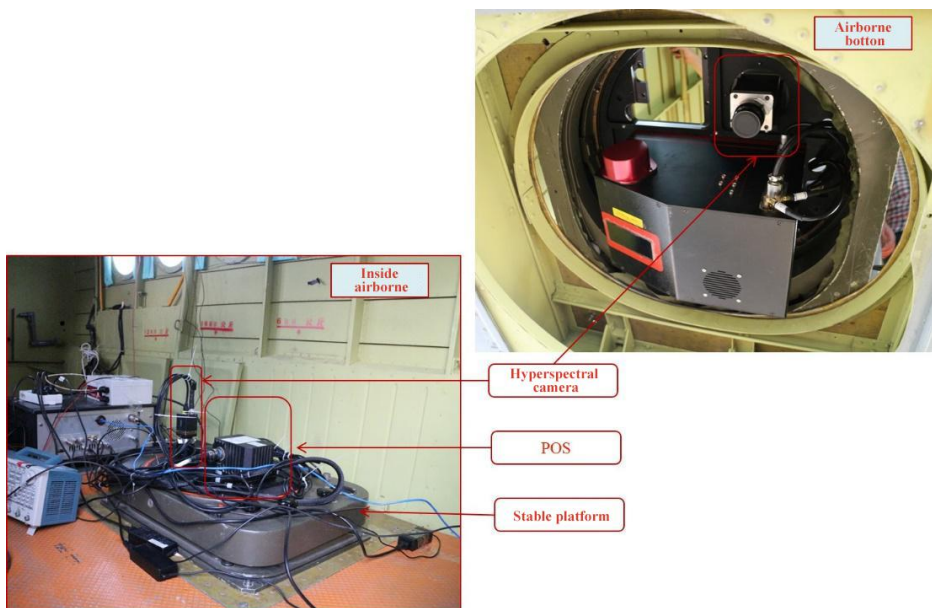




Figure 29 Airborne remote sensing application

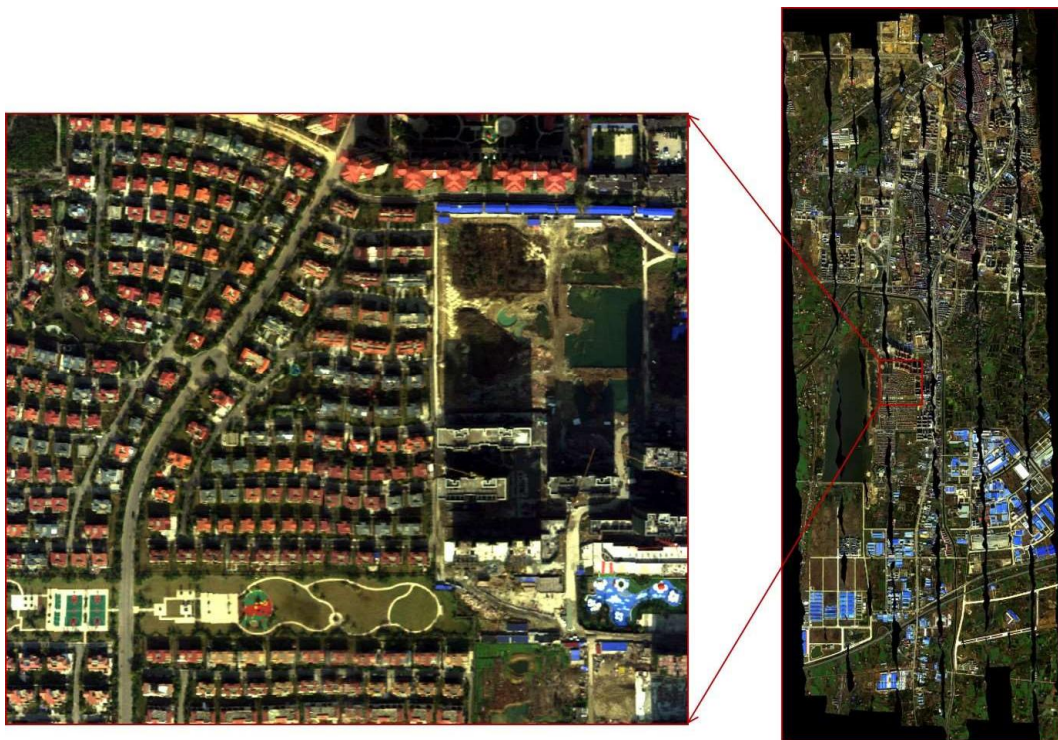


Figure 30 Airborne application data-pseudocolor image

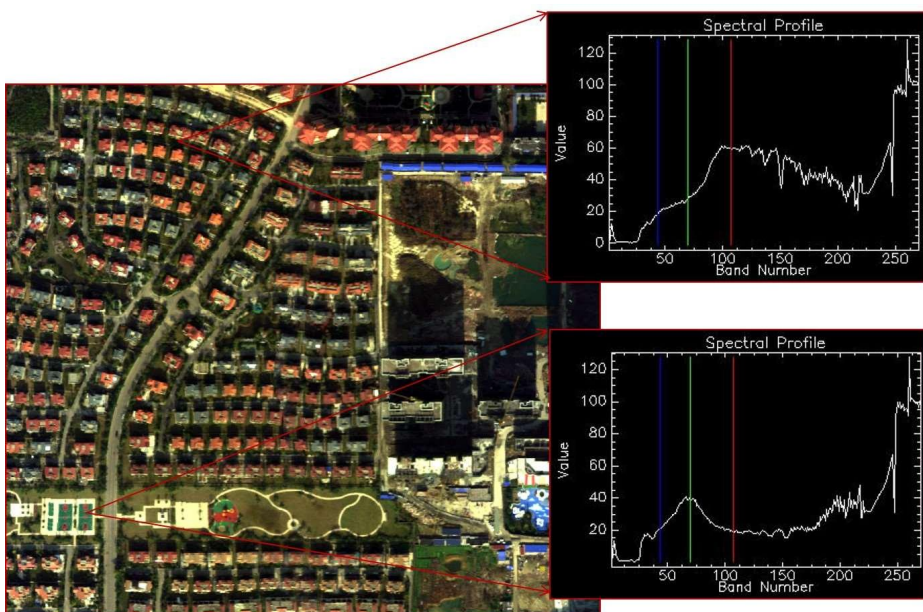


Figure 31 Airborne application data-spectral curve



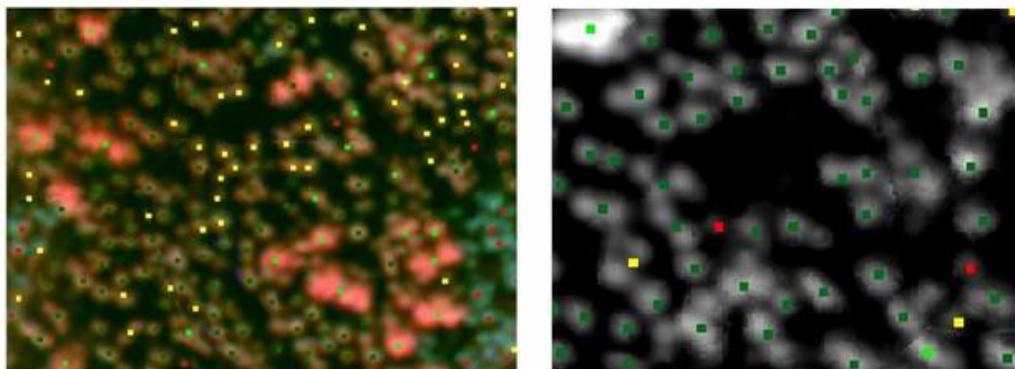


Figure 32 Forest remote sensing, Airborne hyperspectral monitor forest disease and pest

## 6.1 Water Quality and Environmental Protection Application

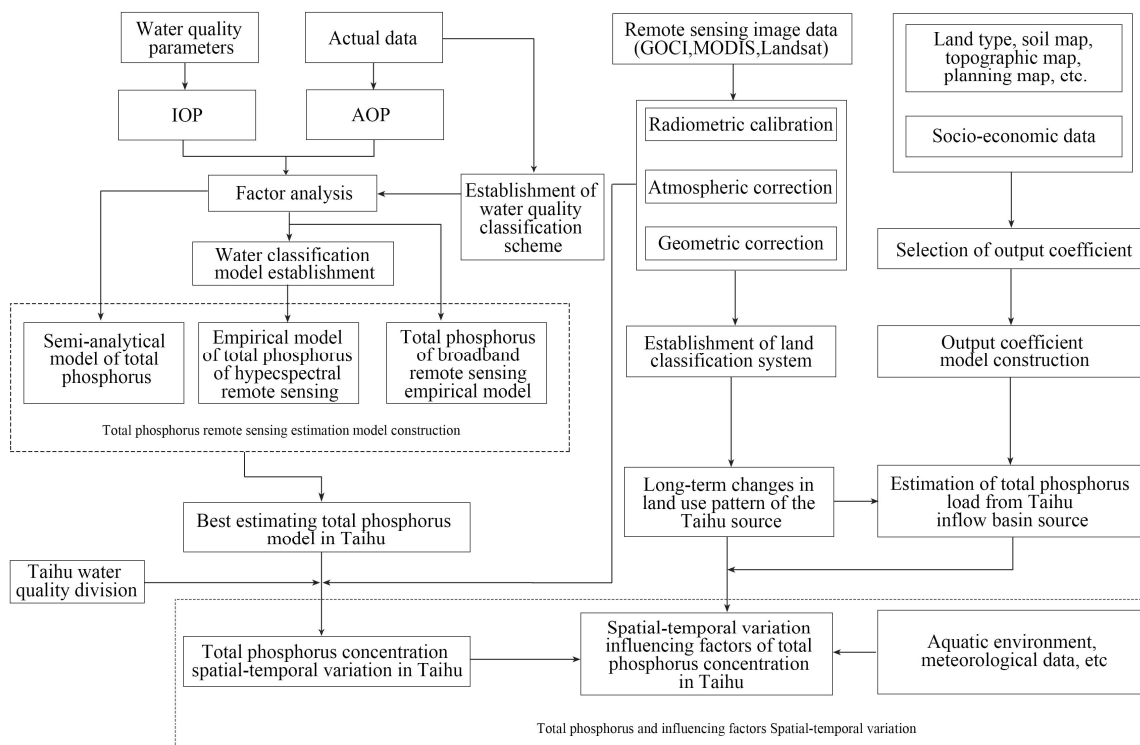


Figure 33 Inversion algorithm flow of hyperspectral data

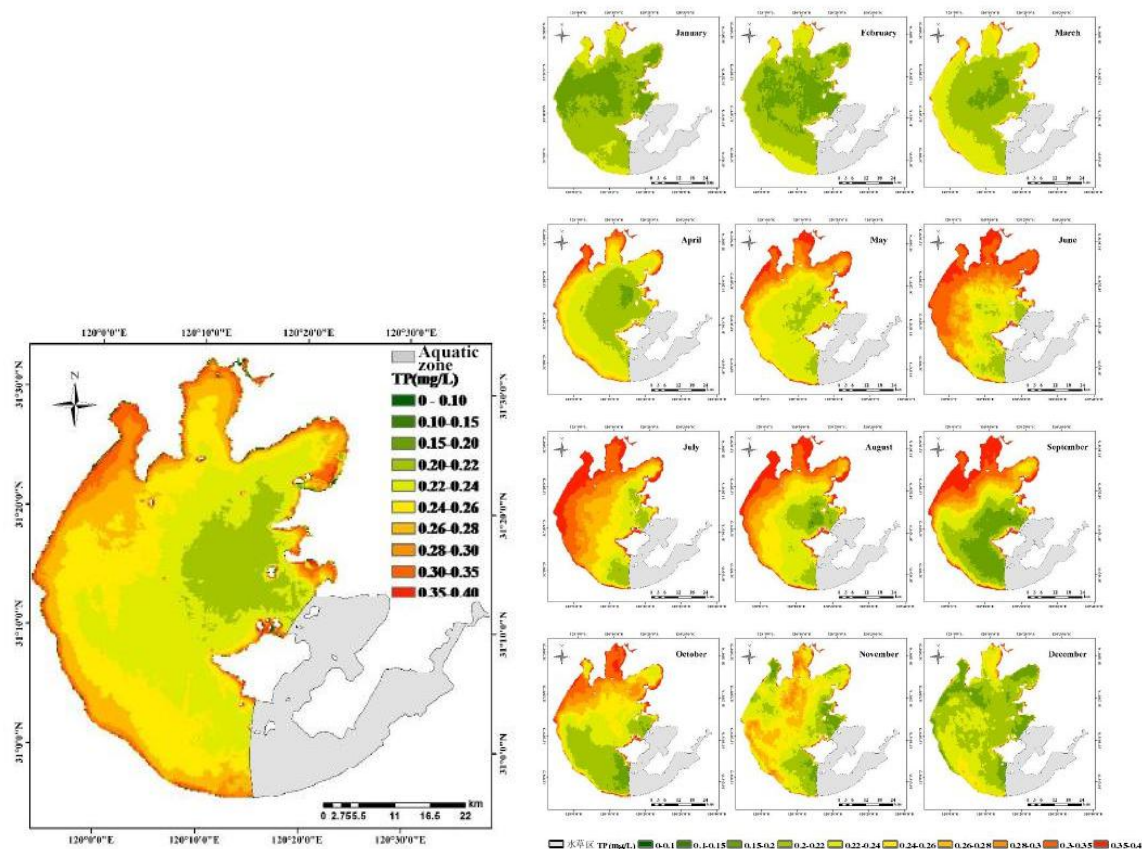


Fig. 34 (a) Spatial distribution of total phosphorus concentration in Taihu Lake. The spatial difference of total phosphorus concentration was obvious, with the highest value of 0.38mg/L and the lowest value of 0.06mg/L. (b) Monthly variation of total phosphorus concentration in different lakes.

The lake area also generally reaches its maximum phosphorus concentration between June and September. The total phosphorus concentration in Zhushan Bay, Meiliang Bay and the west bank of Taihu Lake was higher than the mean value of the whole lake from March to October of the year, and was significantly higher than that in the rest of Taihu Lake. The total phosphorus concentration in Gonghu Bay was higher than that in the whole lake only in June, and the total phosphorus concentration in the south bank of Taihu Lake and Great Taihu Lake was relatively low throughout the year.

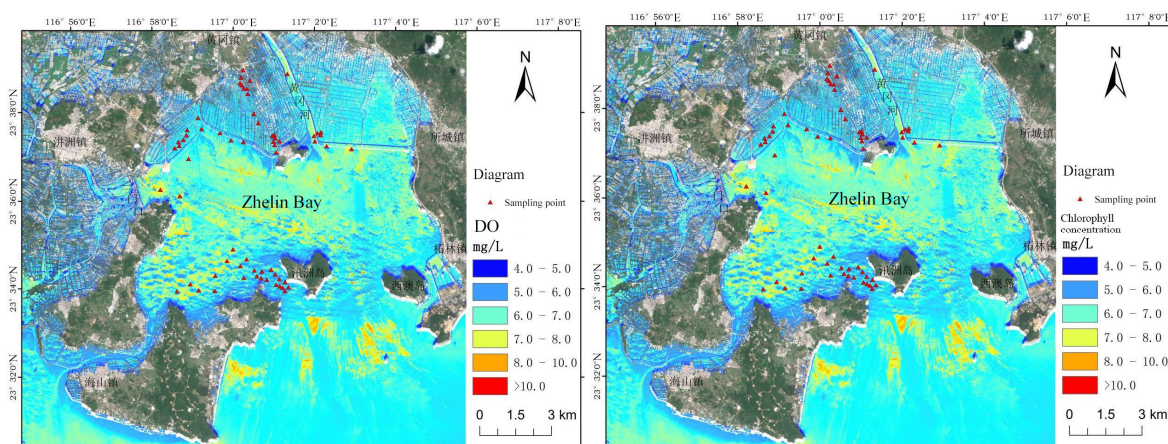


Figure 35 The distribution of dissolved oxygen and chlorophyll concentration in Zhelin Bay, eastern Guangdong, taken by hyperspectral