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2010 China-Ireland International Conference on Information and Communications Technologies

High Resolution Technology in Digital Imaging and its Remote Sensing Applications

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ABSTRACT

Remote Sensing is a markable achievement in-last century. High resolution is a vital technology to digital image characteristics. Especially, in recent 20 years, digital technology promotes the development of spatial information field. As the increasing requirement of people, achieving high resolution images is urgent. For this target, we work from four parts: spatial resolution, radiant resolution, spectral resolution, temporal resolution and proposed schemes for each of them with different imaging manners, designed several prototype systems and carried out many experiments to verify their feasibilities.

Keywords: High resolution; Digital Imaging; Remote Sensing

1. INTRODUCTION

Spatial Information technology is one of the best known mark of technical and scientific achievements in 20th century. Among them, remote sensing plays a significant role in the fields of resource environment, hydrology, meteorology, geography, geology, military and so on.

Remote sensing image is the carrier of the objects information. And spatial resolution, radiant one, spectral one, temporal one are the four important parameters for remote sensing image. Spatial resolution is defined as the corresponding distance on the ground for a pixel. Radiant resolution means minimum radiance contrast that can be distinguished by receiver. Spectral resolution is the minimum wavelength interval which can be distinguished. And temporal resolution is the time interval between sampling for the same place. If they are high resolution, we can obtain more accurate information and stronger resolving power for tiny objects.

Recent 20 years, digital technology promoted the development of spatial information field, and the four kinds of resolution are focuses. We obtained more and more information from the high resolution images. However, demands of higher resolution is still urgent, even the resolution restricts the researches on global change and sustainable social. Whatever, the four resolutions interrelated, influence each other. For developing high resolution technology, first of all, each kind of resolution should be deeply improved.

Therefore, several solutions based on digital imaging technology are proposed for each resolution as follows.

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2. HIGH SPATIAL RESOLUTION

New scheme of high spatial resolution remote sensing imaging system aims at integrating digital imaging modules based on the traditional film camera's lenses and stabilized platform, achieving high aerial base-line-to-height ratio [1]-[3].

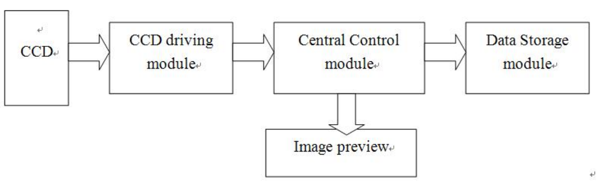

Figure 1. Structure diagram of high-precision CCD imaging system.

General idea of multi-CCD large format digital sensors with the twice-imaging principle is: a special optical intermediate imaging plane to image towards ground objects, and execute digital acquisition to images on the plane with multi high-resolution CCD chips in back-end[3][4]. This scheme not only effectively uses components of high-quality lens cone etc in the original film aerial cameras, but also forms strict central projection which is lacked in external mosaic program of digital aerial camera[4]. The system structure is shown in Fig.1.

In the structure of film aerial cameras, photosensitive film is placed on the imaging surface (approximately

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equivalent to the location of focal plane) of the lens end through the adsorption of pressure plate. A special intermediate device (fine-grained or doped glass devices) is placed on the imaging surface in this program.Here scenery light projects to the side A of the material through the lens cone, and a real show appears on side B. The four lenses on the back-end of special intermediate device collect the image on side B. Then the four area CCD chips output four digital images.

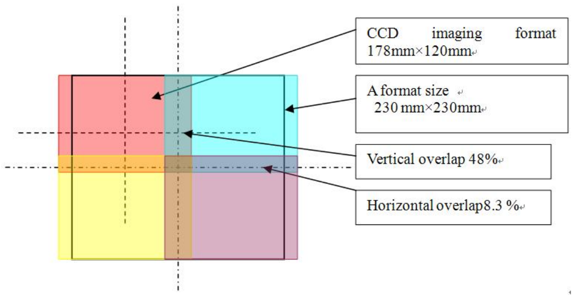

Figure 2. CCD Schematic diagram of imaging format.

The twice-imaging system includes the image mosaic fast real-time dynamic and original high-precision image mosaic (shown in Fig.2). This novel scheme for high-resolution remote sensing imaging is based on film aerial camera, and forms a design to new aerial photography digital camera. Based on key technologies of the original optics structure, the digital imaging scheme uses large diameter light field to acquire ground targets, and produce a large breadth, baseline-to-height ratio and high-resolution remote sensing image.

3. HIGH RADIANT RESOLUTION

Polarization is a part of radiant resolution. Compared with traditional optical remote sensing, polarized remote sensing is able to utilize the polarization light intensity, polarization degree, polarization angle and object emissivity to solve some problems. It has higher precision than the radiation measurements, and can provide measurements of radiation levels while obtaining high-precision polarization measurements[5]-[7].

Bionic polarized navigation is one of the new type navigation methods, which is commonly used by many animals with polarization vision system in nature[5]-[7]. They are navigated by the polarization characteristics caused by the scattering of sunlight in the sky. We apply the knowledge of celestial navigation, utilizing the sun azimuth to revise the angle between solar meridian and the system moving direction, then to determine the angle between moving direction and the geographic north-south for navigation task.

Clear-sky polarimetric measurements were performed from 11:00h to 16:00h on 1st Sept. 2008 at the top of the Remote Sensing Building, Peking University, China. The polarization pattern images of the entire clear sky were obtained hourly. The distributions of polarized light in the sky we observed in early days at different times, under different weather conditions are shown in Fig.3 and Fig.4. From the distribution of the polarization degree and polarization angle, polarization angle is affected less by atmosphere; and at different solar elevation angle, the distribution of the polarization angle is determined.

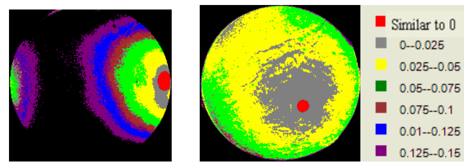

Figure 3. The distribution of polarization degree.

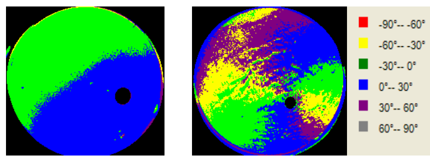

Figure 4. The distribution of polarization angle.

The basic unit of polarization-sensitive compass is polarization-opponent one that is functionally similar to the polarization-sensitive neuron in insects[6]. Each polarization-opponent unit consists of a pair of polarized-light sensors with a log-ratio amplifier, as shown in Fig.5. Polarization sensor consists of photodiode with linear polarizer and blue filter. In each polarization-opponent unit, the polarization axis of one polarization sensor is adjusted 90° to the polarizing axis of the other sensor to imitate cross-vertical structure of rhabdome in the compound eyes of insects.

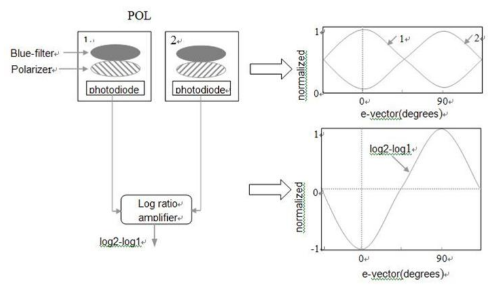

Figure 5. The model of polarization-opponent unit.

As a new kind of navigation, polarization one is based on polarized light with strong anti-interference. The study illuminates a new navigation method in the aircraft and kinetic carrier, which enriches the scope of navigation theory and technology for the bionic imaging application. In addition, the polarization navigation technology can also provide new ideas for the underwater navigation.

4. HIGH SPECTRAL RESOLUTION

As a hyperspectral imaging system, image data of hundreds of wave bands can be obtained at the same time. It can provide more information than multispectral remote sensing images. However, the original hyperspectral image is restrained by various factors to meet all kinds of needs. To solve the problem, remote sensing scientists propose a solution based on existing image simulation technology. It refers to use the multispectral images with low spectral resolution to simulate hyperspectral remote sensing images, which are acquired more easily and cheaply[8][9].

In this part, we propose a new method to simulate hyperspectral remote sensing data, which is called as spectral reconstruction. This method is widely used in the design of new types of sensors, which is able to get the simulated images before satellites are launched or airborne experiments are made. It not only can increase the decision-makers' perceptual cognition, but also can be applied in scale-effect analysis in some research fields and new algorithm verification [9].

We select one band and adjust its bandwidth to build a chain of multispectral dataset, while other bandwidths are fixed. Then reconstruction errors are calculated and fitting curves are also drawn. The similar process is applied to the whole six bands and we get their fitting curves[9]. When the reconstruction process is applied to all pixels in multispectral images, the simulated hyperspectral imagery cube will be achieved. Vegetation spectrum is simulated from 400 nm to 900 nm by spectral reconstruction model. Fig.6 is the comparisons between the reconstruction spectral reflectance value and the original measurements data.

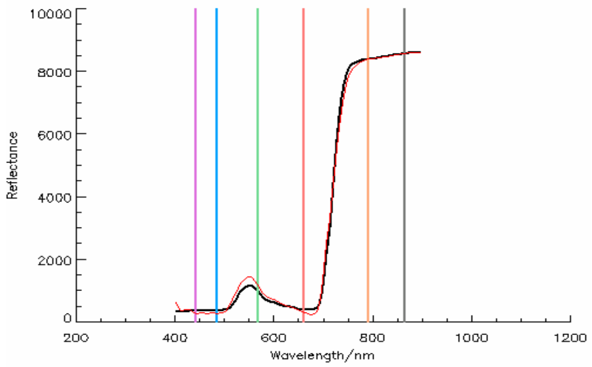

Figure 6. Comparison between the reconstructed spectrum and the measured one.

On the above spectral reconstruction method, a new multi-spectral imager is designed and developed. The system consists of narrow band filters and a frame CCD sensor, which can capture multi-spectral images of one target in the whole view field simultaneously. Multi-spectral images are fed into the model of spectral reconstruction to achieve hyperspectral imagery cube. The advantage of the imager is to acquire a full-frame image at one shoot. It is helpful to capture information of moving target. Besides, it is no need of enormous dispersion devices to acquire more light flux and a simple optical instrument is achieved.

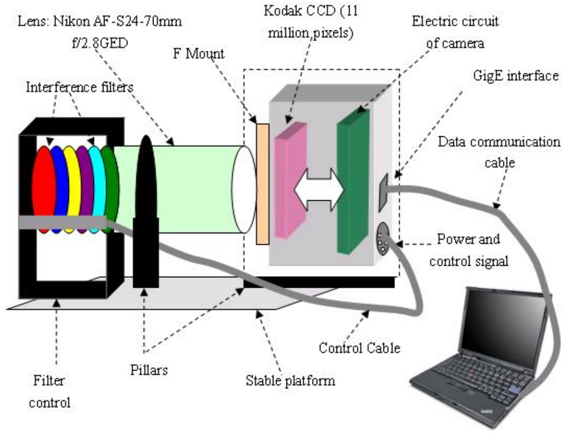

Figure 7. CCD multispectral imager.

The software is built on the hardware. It faces to users for showing the capability of the hardware which determines the practicability of the whole system[10]. The software provides all users interfaces to operate multi-spectral imager.

The architecture of the novel multi-spectral imager is shown in Fig.6. It can provide the technical support for the hyperspectral resolution imaging.

5. HIGH TEMPORAL RESOLUTION

Insect compound eye system has the unique superiority to find moving target. It can detect moving goal with little information by extracting outline characteristic of object. And it avoids the visual dimension transformation problem with large computation, low real time and bad precision [11]-[18].

Based on electrophysiological principle and anatomy of insect compound eye, the experimental imitated apparatus is achieved. By comparing insect compound eye with experimental data acquired from the apparatus, the mechanism of moving target detection is revealed in theory to establish the corresponding mathematical model. Finally, the new algorithm of moving target detection is modeled to improve temporal resolution of remote sensing imaging[12]-[14]. The flow is shown in Fig.8.

Moving target detection by compound eye is imitated at the two levels of function and principle. A bionic detection algorithm is proposed [12][13]. The algorithm can detect one movable target in a single window. It also makes the target detection more integrated[12][13].

We imitate dragonfly eye structure to set up bionic compound eye equipment. The equipment is used to test moving target detection algorithm, and its sche-

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matic drawing is shown in Fig.9. As a detection from coarse to fine, high temporal efficiency is achieved. We developed the software for electronic image stabilization and moving target detection.

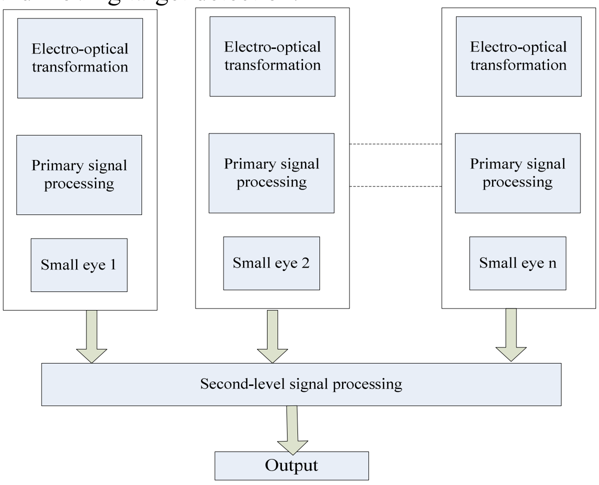

Figure 8. Compound eye two levels of signal processing schematic drawing.

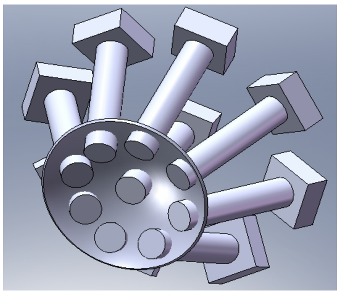

Figure 9. Compound eye equipment spatial structure.

With the breakthrough in the research, it will lead to some revolution in methods for the intelligence vision system.

6. CONCLUSION

High resolution is the hot issue in imaging field, especially in remote sensing one. We try to solve these problems from a peculiar view: the imaging methods. In this paper, we proposed some solutions for each kind of resolution. Twice-imaging for spatial resolution, bionics compound eye for temporal resolution, imagery reconstruction for spectral resolution and bionic polarized navigation for radiant resolution. We designed prototype system for each of them, then carried out a series of systemic confirmation and got satisfied results to prove our ideas.

7. ACKNOWLEDGEMENT

This paper is sponsored by Beijing Key Lab. of Spatial Information Integration & Its Applications. Thanks to all the experts from whom we are inspired and thanks to our team.

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