An open system design of high speed image transmission

SONG Xue-qun[1,2]

1. Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences,Changchun 130033，China

2. Graduate School of Chinese Academy of Sciences, Beijing 10039，China

E-mail: songxuequn1983@sina.com

LI Shi[1,2]

1. Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences,Changchun 130033，China

2. Graduate School of Chinese Academy of Sciences, Beijing 10039，China

E-mail: brightlishi@gmail.com

LIU Xun

Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, Changchun 130033，China；

E-mail: liuxun_ciom@sohu.com

***Abstract*--A high speed image transmission system is designed to compress the aerial image, improve the speed of image transmission. This paper introduces how PTP (Picture Transfer Protocol) can be extended to work over generic USB interfaces, the multi-threaded transfer mode of file stream and the JPEG decoding algorithm, self-developed an open system of aerial digital camera image transmission. Experiments show that image transmission with PTP not only guarantees a good image quality and prevents data loss but also fulfill the requirement of aerial camera large image transmission that ensure the advantage of high frame rate.**

Key Words: Image Transmission; PTP Protocol; High Speed

1. INTRODUCTION

PTP is a transport and platform independent standard [1] that enables communication and data exchange between digital cameras and other devices with USB interfaces [2]. With PTP [3-4], digital cameras can exchange images with host computers, printers, other digital capture，imaging and display devices. PTP is a recent standards effort (PIMA15740) from the Photographic & Imaging Manufacturer's Association for connectivity of digital still photography devices.

As we known that the resolution and the file size of aerial images are big. Take the aerial digital camera with the CMOS resolution of 5616 x 3744 pixels for example: a single uncompressing frame's size is 25 MB with RAW storage format, and when the aerial camera using continuous function (5 frame/s), the image storage size in one second is 125MB and then 7500MB in a minute. The uncompressing data size is huge and the current bandwidth of transmission and storage can not support that (the bandwidth of general hard disk is about 60MB/s). It may block the data path and make the image data loss which is unacceptable in aerial imaging system. Hence, image compression must be taken into account before transmission and storage.

But there still has a problem that the image compression may degrade the image quality and compression itself is not helpful to the aerial image processing [5-6] at all. To deal that, therefore, an open system based on the PTP protocol for high speed image transmission is proposed. The rest of the paper is organized as follows. Section 2.1 describes System Overview. Section 2.2 presents the description of the PTP as a common connection protocol to exchange images between aerial camera and PC. Section 2.3 shows the design of multi-threaded transfer modular used for control the transmission process. Section 2.4 introduces JPEG decoding algorithm which is applied as preprocessing for the following image process. Section 3 and 4 is the experiment and the conclusion.

2. SYSTEM DESIGN

2.1 SYSTEM OVERVIEW

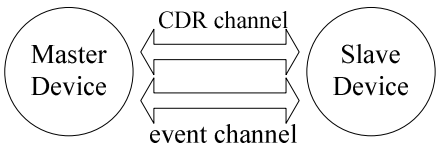

Figure 1. System channel

The possibility to open multiple concurrent channels between the devices would provide a mechanism to separate (i) the command, data & response (CDR) channel and (ii) the event

978-1-4244-5273-6/09/$26.00 ©2009 IEEE

channel in the system. The former carries command, data and responses while the latter carries events related to the CDR channel asynchronously (show in figure 1). The system can be separated into three parts: PTP connection module, multi-threaded transfer of file stream module, JPEG decoding module. The diagram of system is showed in figure 2.

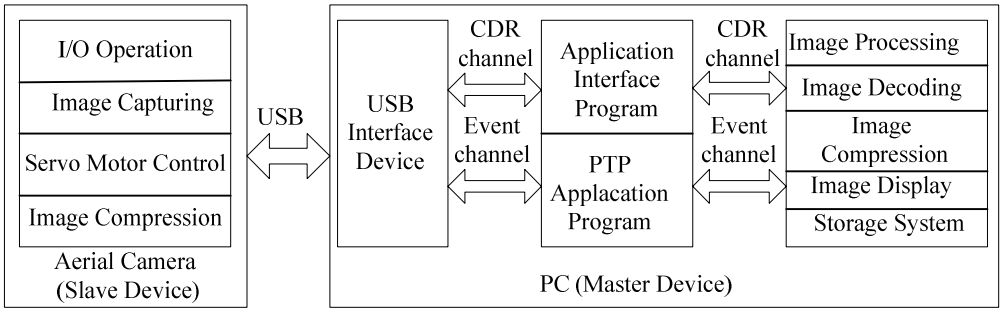

Figure 2. System working principle

When the system is powered on, the communication between the aerial camera and PC is connected under the control of PTP API which provides support for device bonding and transfer mechanisms. The PTP communication must be used master/slave structure via USB that is depended on the characteristics of USB interface. The PTP application program is the realization mode of PTP protocol. When receives the command of packet from PC through USB, the aerial camera will responds the operation requests such as control servo motor, capture image, transfer image and so on. The pitch and azimuth position of aerial camera can be controlled by servo motor to capture omnidirectional images conveniently. The application interface program's main function is to send command, control the image multi-threaded transmission and storage image and so on. In order to make sure the system work regularly, the instruction will be sent to aerial camera for the further work after every image frame is read.

2.2 PTP CONNECTION

A PTP connection should be fully established before any event and data communication take place. Be sure to execute initialization and termination of the aerial camera once each within the application process. Opening a session means connecting to a camera at the application level so that it is possible to control aerial camera using the application and get associated properties and events. A session is considered to open after the aerial camera returns a valid response to the OpenSession operation requested by the PC. The session will be closed after the CloseSession operation is completed or the transport closes the communication channel, whichever occurs first. An event handler capable of the specific processing required for a particular event must be registered in order to receive such an event (notification). An event handler is a user function called when an event is received. Event handlers are also referred to as "callback functions". Figure 3 illustrates the aerial camera access.

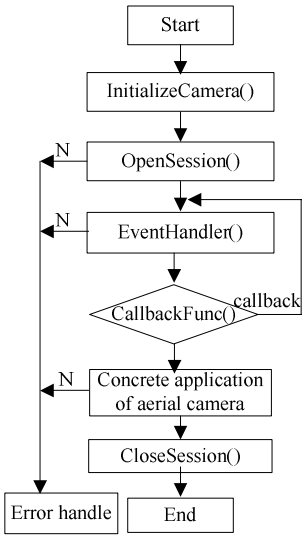

Figure 3. PTP connection and camera access

2.3 MULTI-THREADED TRANSPORT CONFIGURATION

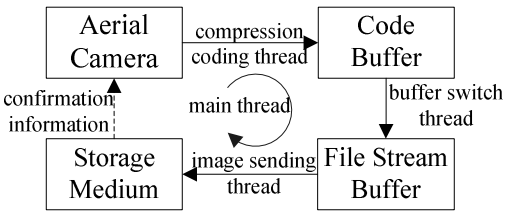

Figure 4. Flowchart of multithread transmission

The image transmission mode of double-buffer and multi-thread (DBMT) is given in this section. The DBMT synchronizes image compression and image transmission. The

double-buffer is code buffer and file stream buffer. There are four threads in the whole transmission process: compression coding thread whose main function is complete image compression coding and send compressed image data to code buffer; buffer switch thread which transfers image data from code buffer to file stream buffer; image sending thread can download image data from file stream, then save to the storage medium in PC; main thread is coordinate simultaneous operation of three above-mention threads and receive the confirmation information of storage medium. Figure 4 shows the flowchart of multi-thread transmission. Compression coding thread, buffer switch thread and image sending thread have a relationship of precedence order as well as a parallel relationship. When a frame image data transferred to the storage medium, aerial camera's image keep compression coding synchronously. In this way image data continue write to the code buffer, and then transfer to the file stream buffer. It is ensure that the image data I/O operation is synchronously.

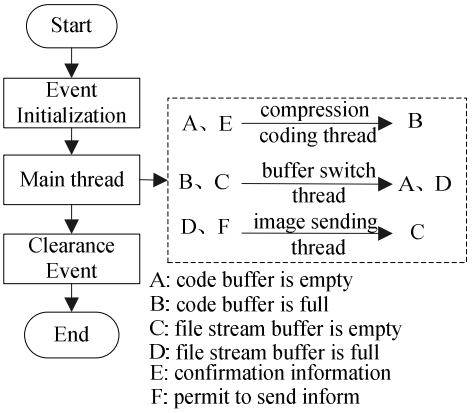

Figure 5. Operation of multi-thread transmission

The multi-thread transmission implies six different kinds of event: code buffer empty event, code buffer full event, file stream empty event, file stream full event, confirmation information event, and permit to send inform event. Figure 5 describes the operation of multi-thread transmission. The relationship between the thread and event as follow:

- If the code buffer empty event is valid, the aerial camera will receive a confirmation information, and the compression coding thread will be activated. Then the code buffer empty event will change to be invalid and code buffer full event will be valid after image compression completed.
- If the code buffer full event and the file stream buffer empty event are valid, the buffer switch thread will be activated. After image data switched, the code buffer full event and the file stream buffer empty event will change to be invalid.
- If the file stream buffer full event and permit to send inform event are valid, the image sending thread will be activated. The file stream buffer full event will be invalid after download image data completely. At the same time, the application program sends another confirmation information event to inform aerial camera to continue capturing and compressing image.
- The main thread's job is ensuring the other threads run steadily and orderly.

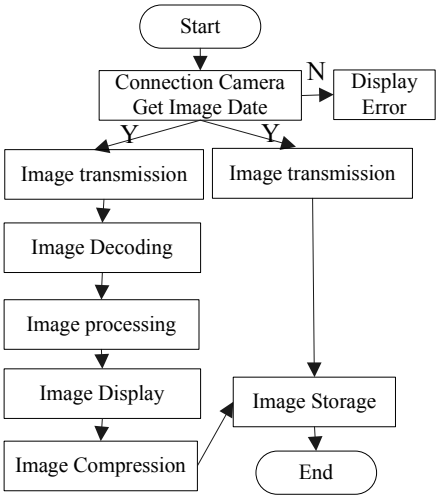

Figure 6. Application program when the image processing

After the image transmission, image processing can be introduced into the open system. As is shown in figure 6, there are two ways to storage image: one is directly storage image after image transmission completely; the other includes the function of image decoding, image processing, image display, and image compression before image storage.

2.4 JPEG DECODING

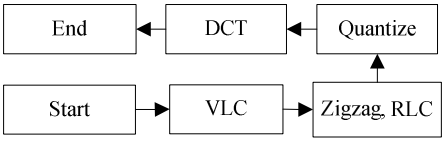

Figure 7. JPEG decoding process

The JPEG standard supports both encoding and decoding after image transmission completed. The composing of JPEG standard using the 8×8 discrete cosine transform (DCT) followed by quantize, zigzag converter & run-level coding

(RLC) and a variable-length coding (VLC), where DCT, zigzag converter &RLC, VLC is reversible and quantize is irreversible in the JPEG algorithm[7]. The loss of image information occurs in the Quantize. DCT coefficients, four quantization tables and two Huffman tables can be downloaded into memory for the fast processing. Figure 7 show that JPEG decoding process.

Notice that the higher compression ratio, which first affects the high-frequency textures in the upper-left corner of the image, the fuzzier contours are. The very high compression ratio severely affects the quality of the image, although the overall colors and image form are still recognizable. However, the precision of colors suffer less (for a human eye) than the precision of contours (based on luminance). This justifies the fact that images decoding should be first balanced the image quality and compression ratio that ensure have a good effect image.

3. TESTING RESULT

In the experiment, we estimate the performance of our system in terms of compression quality and transmission rate. Before the estimation beginning, we found that reading an uncompressed frame (5616*3744) from the aerial camera will take nearly 3 second. The time cost is too expensive to active aerial camera using continuous function (5 frame/s). That is not acceptable for aerial reconnaissance application, so the compression of the aerial image is very necessary.

Figure 8. Aerial image (4992*3328) fetched by the proposed system

The compressed image captured by the proposed system is shown in Fig.8. Visual inspection reveals that the picture is clear and the details are keeping well. The transmission rate test result shows the transmission rate is affected by the image size. The transmission rate would be faster with the larger image size transmission. From Table 1, we can found that the transmission speed is quick enough to support the multi-camera's simultaneous image capture and transmission, and that will be our next research interests. Through analyses the result of experiments result, the open high speed image transmission system can well meet requirement of practical application.

TABLE 1 THE TRANSMISSION RATE OF DIFFERENT IMAGE SIZE

Image Size	Compression Ratio	Transmission Speed
5616*3744	32:1	32 frame/s
4992*3328	32:1	41 frame/s
4080*2720	32:1	54 frame/s
2784*1856	32:1	93 frame/s

4. CONCLUSIONS

This paper designs an open high speed image transmission system which possesses the advantage of high quality and high data transfer rate. By the influence of the bandwidth limitation of storage medium and USB, the ultimate transmission rate of the system has not been estimated. But the experiment result implied that the proposed system can fulfill the requirement of aerial camera large image transmission. The experiment results prove that the proposed system design is reasonable and it is practical in the aerial reconnaissance application.

REFERENCE

1. ISO 15740, Picture transfer protocol (PTP) for digital still photography devices, Photography - Electronic still picture imaging, 2005
2. USB Implementer's Forum. Universal Serial Bus Still Image Capture Device Definition Revision 1.0. http://www.usb.org, July 2000
3. P Bigioi, G. Susanu, P Corcoran, and I. Mocanu, Digital camera connectivity solutions using the picture transfer protocol (PTP), Consumer Electronics, IEEE Transactions vol. 48, Issue 3, pp. 417 - 427, Aug. 2002.
4. P Bigioi, P Corcoran, and G. Susanu, Digital imaging services using PTP (Picture Transfer Protocol), Consumer Electronics, 2002. ICCE. 2002 Digest of Technical Papers, pp. 54-55, June 2002.
5. S. Li, B. Zhang, H. Sun "Restoration of aerial multiple blurred images" Optics and Precision Engineering，2009，17 (5) ： 1161-1170 (in Chinese)
6. G. Wu, C. F. Wu, Q. Y. Hou, and W. Zhang, "Target location method based on invariable moment feature matching". Optics and Precision Engineering ,2009, 17(2): 460-468 (in Chinese)
7. S. Li, B. Zhang, H. Sun "Optimized design of real-time encode for aerial-video image". Optics and Precision Engineering，2009，17(2)：426-432 (in Chinese)