A DISTRIBUTED VIDEO ACQUISITION SYSTEM

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ABSTRACT

Camera has been used in telemetry system over decades now. Normally, the video signal outputted from cameras would be acquired by video module(s) located in general data acquisition equipment. In this paper, a distributed video acquisition system is presented. It is a synchronous acquisition system consisted of a record and control unit and several video acquisition units. The synchronous shutter control for cameras and data flow synchronous transportation inside the system is added as well. The accuracy of timing and synchronous acquisition of the system is less than 50ns.

KEY WORDS

Distributed Data Acquirement, Video Acquisition

INTRODUCTION

Cameras are used in variable ways in flight tests, such as eyes for ground or as actual measuring instruments, etc. The common practice for acquiring video and voice signals outputted from cameras is to mount video-acquiring modules in a data acquiring device. However, the video and voice outputted from cameras are usually analog signals which will be attenuated during transmitting from cameras to the data acquiring device. The longer the transmitting distance, the more the signal attenuation would be. Normally, it is difficult to arrange all the cameras near the data acquiring device in a flight test. Therefore, it is not quite satisfactory when the video from cameras are replayed later.

In this paper, a distributed video acquisition system is presented, which is composed by several video acquisition units along with a central control and record unit. In a flight test, each video acquisition unit will be mounted near a camera and connect to it by a cable as short as possible. Thus, the less attenuation of signal would result a better replay of the recorded video data.

Furthermore, a special synchronous mechanism [1] and IEEE 1588 PTP protocol [2] is applied in this system to improve the precision of shutter control for multiple cameras and to achieve a smooth playback when real-time monitor is needed.

SYSTEM OVERALL STRUCTURE

The distributed video acquisition system introduced in this paper is consisted of one central control and record unit and several video acquisition units. Sometimes a radio device might be added into the system to transport video stream to the ground for real-time monitoring. Each video acquisition unit could connect to one or two cameras and is responsible for acquiring video and voice signals. The central control and record unit is used for collect and record the video and voice data streams sent from all the video acquisition units. Figure 1 showed the structure and interconnections between devices inside the system.

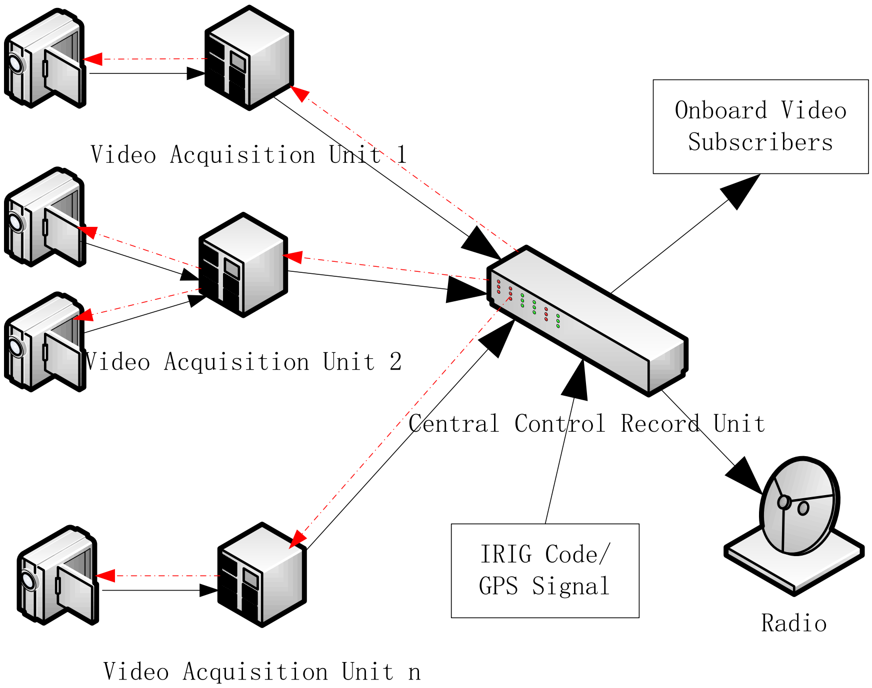

Figure 1 Structure of the Distributed Video Acquisition System

In this system, we have configured five kinds of components in the central control/record unit, including one main control module, several communication module, one record module (with one flash disk inside), one timing module, and one PCM output module. The communication modules will receive all the coded video and voice stream sent from the video acquisition module, and at same time, they will pass timing and controlling signals to the video acquisition unit connected. The record module will write the video data stream into the flash disk, and the GPS timing module will receive IRIG timing signals and resolve standard time from GPS signals, then manage the synchronous time for the whole system.

The video acquisition units in the system are responsible for capturing pictures from the cameras connected and coding the pictures into compressed data stream. At same time, the units are also responsible for passing the synchronous shutter control signal to the cameras as well.

Usually, Ethernet could be used for the interconnection between central control/record unit and each video acquisition unit. However, due to following reasons we decide to adopt direct Ethernet connection combining time division multiplexing technique [1] (DEC-TDM in short) plus improved IEEE 1588 PTP protocol instead.

a) Uncertainty of temporal latency in Ethernet transportation
The uncertainty of time delay in Ethernet transportation is caused by the CSMA/CD mechanics in Ethernet switch, which means that much time is needed for caching a full frame of video picture.

b) Precision of clock synchronization assured
IEEE 1588 PTP protocol is commonly used for clock synchronization for Ethernet. The latency of the timing signal transferred over Ethernet could be estimated by using this protocol. For a connection using DEC-TDM, this latency could be actually calculated precisely.

c) Precise control for shutters of multiple cameras
As a virtual channel for synchronous acquiring control signal is enabled in DEC-TDM, it easy for synchronous sampling control and synchronous shuttle control for multiple cameras. The precision of the control signals in the system is less than 50nm.

d) Transportation efficiency improved
Parallel process has been implemented in central control/record unit, so that the total data rate of video streams outputted from all the video acquisition units might reach nearly 10Gbps.

Finally, there are two output channels in the system, which are PCM output channel at the PCM output module and Ethernet output channel at the main control module. The PCM output module will code the video data and output to a radio device for ground real-time monitoring. Ethernet compatible output could be enabled by the configuration setup file stored at the flash disk for distributing videos to airborne subscribers.

VIDEO ACQUISITION UNIT

The video acquisition unit is made up of three modules, including one image acquisition and compression module, one main control module and one power supply module. Figure 2 shows the structure design of the video acquisition unit.

Among all three modules of the video acquisition unit, the power supply module is only a single function module, just in charge of supplying electricity for other modules. The acquisition/compression module plays the leading role, which will capture pictures from the output signals of the camera connected and then code the acquired data into compressed video data stream by using traditional H.264 coding algorithm, and then pass them to the main control module, which is actually a combine of communication, timing and management. A timestamp will be added in the user defined field in each video frame. The video data flow will then be sent to the central control and record unit.

The shutter control signal is also sent via the acquisition/compression module. System management information, including timing code and synchronous acquiring control signal, is received by the main control module. Following the instruction from the central/record unit, the synchronous acquiring control signal could be converted to shutter control signals and transmitted to the cameras through the acquisition/compression module.

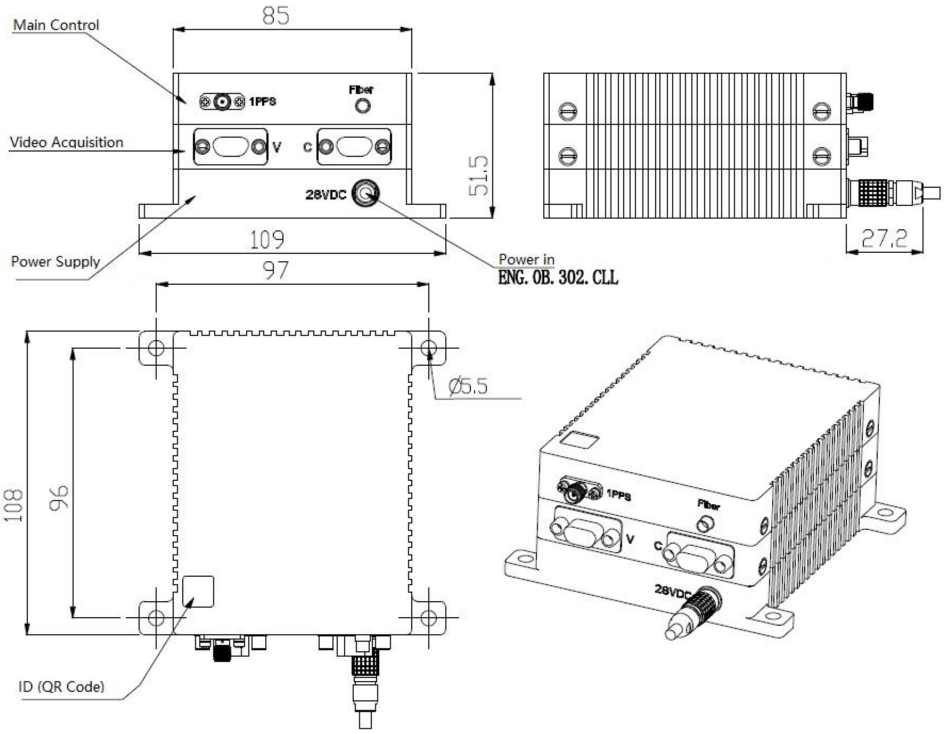

Figure 2. Video Acquisition Unit Structure Design

For the purpose of compatibility, in addition to ordinary video stream dispatch by Ethernet, there is an option that the outputted video data stream could comply with the iNET conventions.

If the original video source should be kept for later usage, the video acquisition unit should be capable of outputting the source to the central control/record unit. The GigE could be utilized for transporting the video source.

SYSTEM OPERATION MECHANISM

During an actual video acquisition task, one or two nearby camera(s) will be connected to one video acquisition unit, which will be connected to the central control/record unit with Ethernet cable. A radio device will be connected if real-time monitor needed on the ground.

A system clock is used for synchronization of video capture and control for multiple cameras, and this clock will be corrected periodically by IRIGB connection or standard time resolved from GPS signals. The timing module in the main control/record unit will use system clock to issue timing signals (codes) and synchronous acquisition control signals (codes) for synchronizing the local clocks in all video acquisition units and for controlling the shutters of the cameras connected. As direct Ethernet connection has been employed, the timing code and control code will not be delayed while these codes are transported from the central control/record unit to all the video acquisition units.

Cameras will start to take pictures as soon as the synchronous control signal was received, and then each camera will output video flow to connected video acquisition unit which will capture every frame of video and compress it with timestamp in each frame. All the fames compressed will be coded into a data flow which will be sent to the central control/record unit through the Ethernet connection interface.

The central control/record unit will receive all the data flow (video stream) from different video acquisition units and then record them into the flash disk. In the case some video sources are needed for measurement, the data rate for writing to the flash disk may exceed the writing speed of a single disk. So we had also tried a parallel recording structure in which multiple flash disk were used and the whole data flow needed to be recorded were divided into multiple data stream, and each disk could easily record one of the steams.

According to video acquisition task configuration, the central control/record unit will select one or more video stream to the onboard video subscribers through Ethernet interface located in its communication module, or send selected video stream by the PCM module to the ground via a radio set.

CONCLUSION

Distributed video acquisition system is better if multiple cameras had been used in a flight test, because the video acquisition unit could be mounted as close to the camera as possible and signal attenuation would be less correspondingly. In addition, for a video acquisition system, it is better to have synchronous control for all cameras connected to the system. It is very useful to get same moment pictures from different cameras if the pictures taken will be used as measuring resources.

As DEC-TDM has been implemented for transporting, both the timing and the synchronous acquisition control have been improved greatly. The laboratory experiments showed that the precision of timing synchronization and shutters synchronized control reached up to 50ns.

Parallel recording would be a solution for fast recording (data rate over 2Gb/s) when high-definition video cameras used in the system and the video source needed for further usage.

Furthermore, the video acquisition unit mentioned above could also be used as the front end for other iNet universal acquisition devices or recorders.

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