Design of Fine Tracking System Based on the PC104

Chenjie Zhang [a], Hanping Hu [b]

Changchun University of Science and Technology, Changchun 130022, China

[a] custzcj@163.com, [b] custhhp@163.com

Abstract. With the development of the free optical communication, the requirements for the performance of optical communication have been improved continuously. The system of fine tracking plays a key role in space laser communication. In this paper, a kind of experimental system is designed and tested based on the working and composition principles of fine tracking system, The experiment results show that it can do the Tracking well.

Keywords: PC104; fine tracking; real time miniaturization.

1. Introduction

Since the free-space laser communication with communication capacity, high transfer rate, concealment, strong anti-jamming ability, etc., which has broad application prospects. APT (Acquisition, Pointing, Tracking) subsystem is an important part of space laser communication systems, Research APT technology has become an interplanetary space link, open space link between an aircraft and a variety of important issues, whether it is directly related to the successful establishment of space optical communication links and communication quality is good or bad, so that for APT technology research is of great significance. APT is divided into coarse and fine tracking two parts, precision tracking mainly to complete the visual axis tracking precision under dynamic conditions task. Precision real-time tracking system, digitization and miniaturization technology is one of the key research APT point.

PC104 hardware architecture and software development are compatible with the IBM PC, for the vast majority of developers are familiar with, so relative to the special structure of the PLC, MCU, PC104 development, maintenance and expansion are very convenient. And it has been widely used in aerospace, smart instrumentation, communications, portable computers, medical equipment, automated production equipment, data acquisition. Using PC104 fine tracking servo system as the main controller, the volume of the entire system, the quality is greatly reduced, in addition to embedded operating systems and real-time optimization software algorithm to improve the control system in order to achieve airborne, space borne optical communications where in space.

2. Fine tracking system components and principles

Fine tracking servo unit spot by the CCD imaging unit, the amount of off-target image processing unit, PC104 digital servo unit and galvanometer servo unit. Its tracking range is 450μrad, tracking accuracy 3μrad, servo bandwidth of 300Hz or more. Composition structure shown in Figure 1.

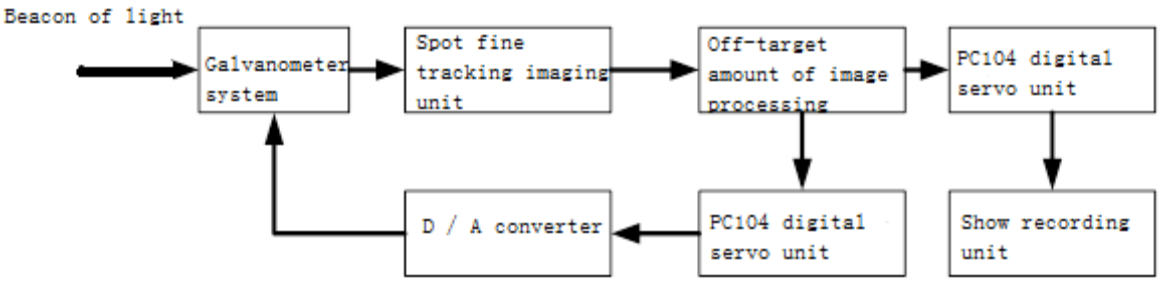

Fig.1 Block diagram of fine tracking system

Fine tracking systems, high-speed CCD used to detect each beacon beam center, the digital signal output from CCD, after A / D conversion via the divider, one signal for display spot and make the necessary records, other signal fed controller, real-time solver miss distance, and then convert the off-target offset compensation is fed into a galvanometer and drive through the DA converter, and finally act on the galvanometer, in addition to the impact of the delay because the system requires the position to spot emerging be predicted in advance.

The main function of the system is the residual error of the coarse tracking loop is further possible to compensate for the correction, in order to meet the desired final alignment of the system and tracking accuracy.

3. Select the important device

3.1 Selection of fine tracking camera

The system requirements for precision tracking camera should have the following features: real-time output frequencies up to 5K per frame; has more than 80 × 80 pixel resolution; has high sensitivity and signal to noise ratio; pixel size of less than 20 m; in near-infrared have a higher response efficiency.

High frame rate to achieve CCD camera There are three main ways: One is the use of small multi-output port for high-resolution CCD camera frame rate, this solution requires the use of special CCD sensor, the price is very expensive and poor purchase channels, such as Tom Johnson's company has 5kHz of 16 × 16 CCD camera; the second is the use of small resolution mode BINNING camera work in this method a plurality of adjacent pixels to be synthesized, thereby reducing the spatial resolution, frame rate, but the rate of increase, as UNIQ's UF1000, full-frame reading when the frame frequency is 200Hz, resolution of 640 × 480, when implementing the 4 × 6 BIN-NING work, the resolution becomes 120 × 80, a frame rate of up to 1000, although this method improves the frame rate, but not suitable for reducing the fine tracking resolution requirements; the third mode is used PROGROM-MING local region of interest on the CCD is read out, the outstanding advantages of this method is the angular resolution without sacrificing spatial conditions, the rate of the frame rate has been greatly improved and refined according to the tracking field of view, the size of the window to read arbitrary. In addition, the communication link for the future stars, you can use this technique to achieve the completion of coarse and fine bipolar monolithic CCD detection system, can greatly reduce the complexity of the APT system size, weight, cost and systems.

APT system subsystem spot detection unit based on a partial region of interest readout mode for high frame rate camera, this camera system has the following specific requirements: the field of fine tracking receiver: 300μ rad; spot detection accuracy: than 4μ rad; choose TI's TC237B area array CCD camera to achieve high frame rates.

3.2 Fine tracking galvanometer

Precision tracking systems for precision servo tracking specific requirements. Dynamic control accuracy of better than 2 rad; control range greater than 8mrad; resonant frequency greater than 2000Hz; adjustment dimension: two-dimensional orthogonal; load capacity: Band diameter 25mm, 8mm thick of optical mirrors.

System used by the fast galvanometer Germany PY company's products PHS 10-dimensional tilt platform. PY company provides ultra-fast piezoelectric ceramic tilting platform a large range, it is designed for active optics and adaptive optics design. It provides in mill radians tilt range, fast response (sub-millisecond) and submicron resolution of curvature, the dynamic operation of the system (e.g., track, scan, and vibration to eliminate drift and jitter) is ideal static positioning.

3.3 Memory

Data storage devices on the PC104 bus devices are usually used in hard drives and flash-based SSD technology. As embedded systems tend to be harsher working environment, the hard disk will not work under harsh conditions of normal vibrations while working SSD range is very wide, and the small size, suitable for embedded applications. CE companies such as CF card.

4. The main measures to achieve fine tracking system

4.1 Embedded operating system

Embedded operating system and the operating system on the PC is very different, different roots from the embedded resource limitations, the use of embedded operating systems XPE can be much smaller than the PC's CPU speed, memory, Flash's embedded hardware environment to complete multi-tasking, real-time, memory access, hardware operation so complex tasks, thus improving the real-time digital servo system.

4.2 Improve the accuracy of CCD spot centroid image

In space optical communication, image noise directly affects the spot centroid accuracy to meet real-time requirements, the program uses real plane filtering method, using median filter to suppress noise in the image. Traditional median filtering algorithm cannot make use of relevant information between the adjacent windows, in order to sort the values of the pixels within each window, a very large amount of computation. For this reason the introduction of a fast algorithm. The algorithm is shifted by one column of pixels out and retain their left and the sort of information within the boundaries of the window, only one new pixel shift sorting method, median filter processing is completed. Thus greatly improving the computing speed. In graphics programming process also uses bitmap and palette techniques to improve the speed and quality of the image displayed.

4.3 Using a distributed system

During the experiment, fine tracking servo system on the one hand to the real-time speed camera massive data collection, real-time off-target volume solvers for real-time control galvanometer drives, on the other hand, fine tracking servo system should keep up with APT total communication control system, display and record the image spot experimental data, which will inevitably reduce the bandwidth of the servo system. In order to ease the contradiction between these two requirements, the use of distributed systems, with CAMLINK divider output signal is divided into two high-speed cameras, were sent to the two PC104, PC104 dedicated to a real-time control, with another PC104 the display of data, records and total control of communication with APT.

5. Experiments and conclusions

After the rough track to achieve stable tracking, tracing it's tracking residual visual field of less than fine. Then, start fine tracking detector unit, do not control, you can record coarse tracking residuals. Then start the fine tracking servo system. Visual axis is aligned in the center immediately fine tracking field of view, a very small amount of off-target spot to obtain high tracking accuracy.

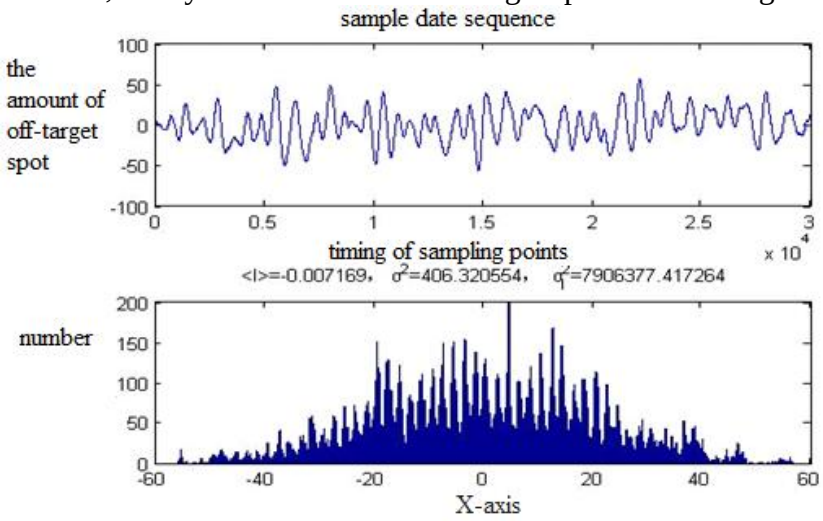

Fig.2 CCD detect residual crude sample tracking curve and histogram (X-axis)

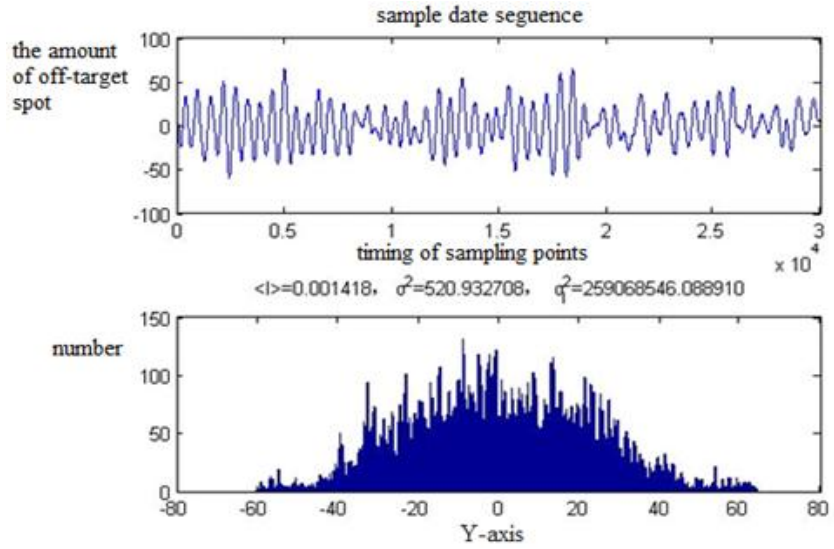

Fig.3 CCD detect residual crude sample tracking curve and histogram (Y-axis)

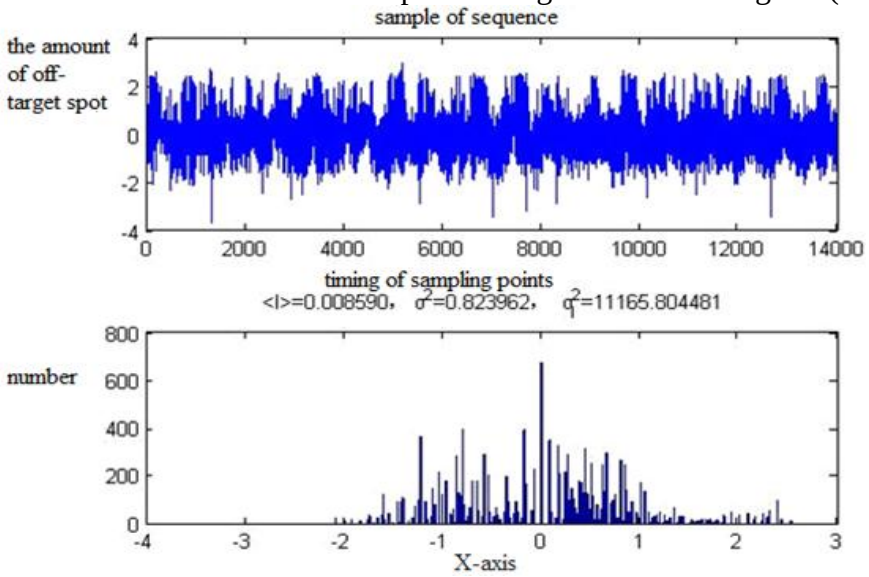

Fig.4 Fine tracking residual inhibition curve and histogram time-domain (X-axis)

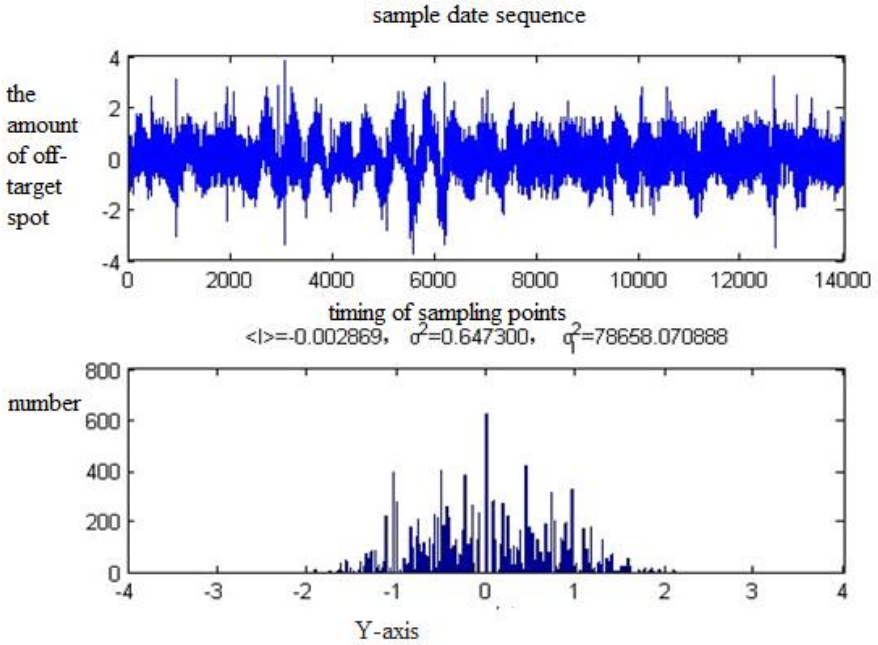

Fig.5 Fine tracking residual inhibition curve and histogram time-domain (Y-axis)

After laboratory tests, Figure 2, Figure 3, before the track after finishing suppression, coarse tracking residuals about 10 pixels, after the fine tracking control system, jitter amplitude spot in less than two pixels . Tracking accuracy of the x-axis and y-axis are 3 rad. the bandwidth of the x and y axes is 300Hz, meet system requirements. Figure 4, Figure 5 is a fine tracking x and y axes of vibration suppression of the inhibition curves.

The system realizes the fine tracking servo system miniaturization and digitization. And in the field of laser communication experiments verified that the system can meet the requirements of real-time processing, while the experimental data obtained were analyzed to verify the accuracy of the intended targets and tracking servo bandwidth.

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