Optics Derotator Servo Control System for SONG Telescope

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ABSTRACT

The Stellar Oscillations Network Group (SONG) is an initiative which aims at designing and building a ground-based network of 1m telescopes dedicated to the study of phenomena occurring in the time domain. Chinese standard node of SONG is an Alt-Az Telescope of F/37 with 1m diameter. Optics derotator control system of SONG telescope adopts the development model of "Industrial Computer + UMAC Motion Controller + Servo Motor".[1] Industrial computer is the core processing part of the motion control, motion control card(UMAC) is in charge of the details on the motion control, Servo amplifier accepts the control commands from UMAC, and drives the servo motor. The position feedback information comes from the encoder, to form a closed loop control system. This paper describes in detail hardware design and software design for the optics derotator servo control system. In terms of hardware design, the principle, structure, and control algorithm of servo system based on optics derotator are analyzed and explored. In terms of software design, the paper proposes the architecture of the system software based on Object-Oriented Programming.

Keywords: Astronomical Telescope, SONG, Servo Control System, Linux Qt

1. INTRODUCTION

The telescope network will have eight identical nodes distributed in longitude to give continuous time coverage that allow observations over long time scales with high duty-cycle(85%) for stars within 30 degrees of the celestial equator to be obtained. An example of a possible site distribution is shown in Figure1. To ensure full sky coverage there will be four nodes in each hemisphere. The telescopes will be robotic and operated from a single central operations center. For daily operations there will be no, or very little, demand on local staff-presently, local staff work is mainly foreseen for emergencies and maintenance tasks.[2]

Due to Chinese Standard Node of SONG is an Alt-Az Telescope, The field of view which is relative to vertical circle is fixed for the alt-az telescope, When the telescope is tracking, vertical circle is constantly changing which is relative to circle of right ascension, so in the process of tracking it will cause the rotation of image field . In the same field of view , the tracked star and other reference stars are rotating around the center of the field. In order to obtain the real image of the target , Compensation must be done for the rotation of alt-az telescope 's field of view. There are many ways to compensate for the rotation of the field of view , optical methods which eliminates the rotation of the field of view is adopted. A servo motor which drives a device of three mirror is adopted so that eliminating the rotation of the field of view.

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Ground-based and Airborne Telescopes IV, edited by Larry M. Stepp, Roberto Gilmozzi, Helen J. Hall,
Proc. of SPIE Vol. 8444, 84444T · © 2012 SPIE · CCC code: 0277-786/12/$18 · doi: 10.1117/12.924943

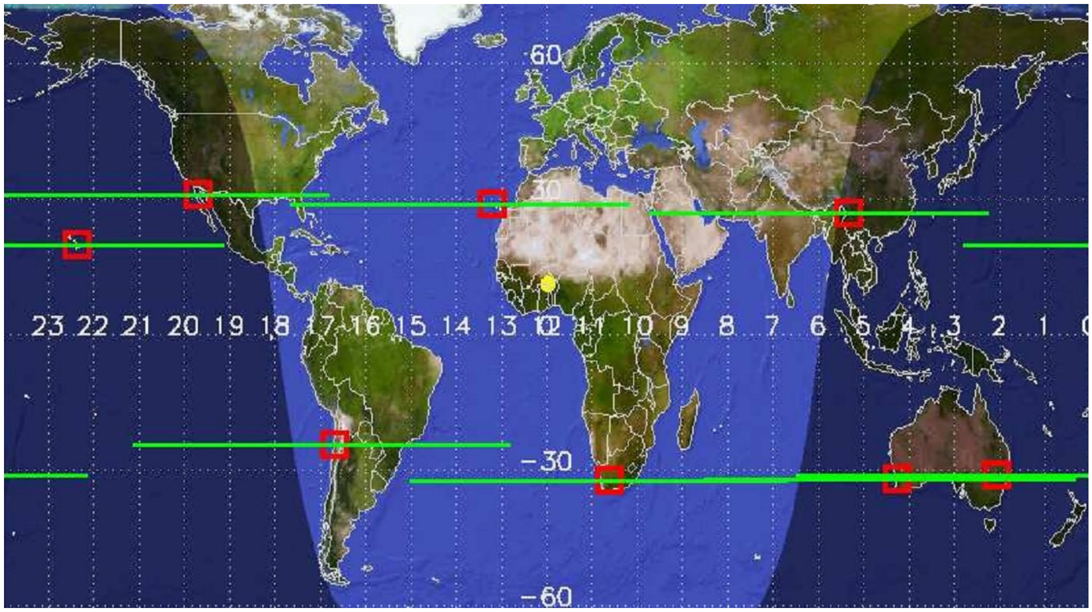

Figure 1. A Possible Site Distribution

2. THE STRUCTURE OF HARDWARE

2.1 ARCHITECTURE OF CONTROL SYSTEM

Host computer is composed of Advantech Industrial Computer, it is used to handle background tasks, realize the non-real-time features which include the I/O and display of program and parameters, and realize the man-machine dialogue and management capabilities for system. Guest computer is composed of UMAC and UMAC accessory boards that achieve real-time capabilities, such as the position control, speed control, multi-axis motion control, processing the motion state of the input and output and movement logic functions.[3] This system is a standard dual semi - closed loop system. Figure2 is a schematic of servo control system. The speed feedback and position feedback come from the motor encoder. The inner loop is speed loop. The outer loop is the position loop. Speed loop is composed of speed control unit, speed detection device, speed feedback circuit and motor encoder. They can achieve the control of constant speed. Speed control is mainly done by the driver. Position loop is composed of position control module, speed control unit, position detection circuit and position feedback circuit of UMAC. Position control is mainly done by guest computer.

2.2 CONTROL ALGORITHM

UMAC controller supports users to develop their own control algorithms. UMAC also provides the PID servo control algorithm. Compared with conventional PID control algorithm the servo control algorithm adds to speed/acceleration feed-forward so that reducing the following error. Meanwhile, UMAC also provides a trap/dead zone filter so that limiting the maximum error for each servo cycle and compensating dead zone, and adds a notch filter to improve servo performance of the system. The servo control principle of UMAC is shown in Figure3.[4]

2.3 TECHNOLOGICAL REQUIREMENT

Technical requirements for optical derotator control system are shown in Table1.

2.4 COMPONENT SELECT

2.4.1 UMAC CONTROLLER

The PMAC (Programmable Motion and Automation Controller) which comes from American Delta Tau Company is one of the most powerful motion controllers in the world. PMAC uses Motorola's DSP digital signal

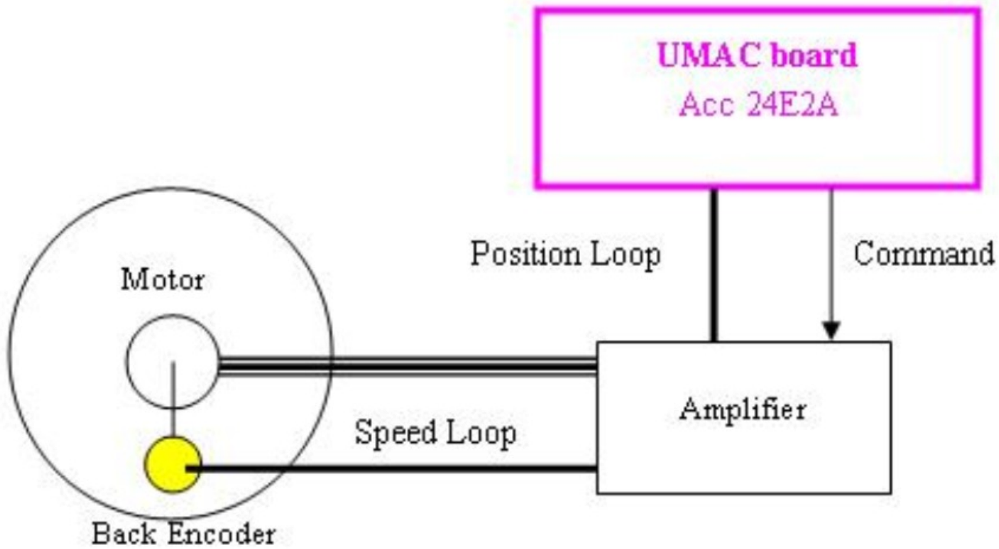

Figure 2. The Schematic of Control System

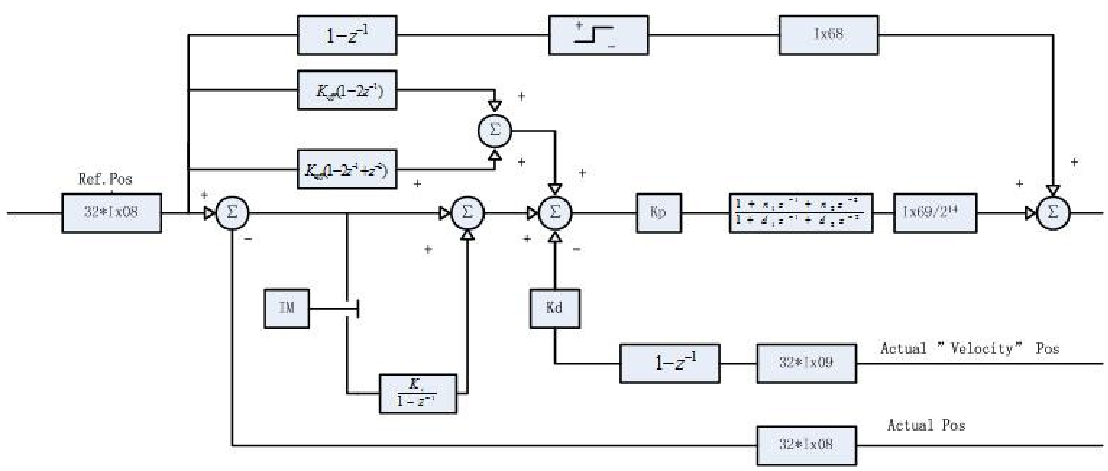

Figure 3. The Schematic of Servor Control

Table 1. TECHNOLOGICAL REQUIREMENT

Item	Requirement
Rotation Error	60 arcsec
Torque(The Axis of Motor)	0.01 Nm
Scale of K Mirror	-90deg —– +90deg
Speed of K Mirror	Depend on the Altitude

processor as CPU. PMAC can control 32 axes at the same time. PMAC can also automatically discriminate the priority so that processing the real-time multitasks, that reduces the burden for host computer and programmer when processing the time and task switching, and improves the operational speed and control accuracy for the entire control system. PMAC has an open platform. PMAC can use the programming language of G code, C or BASIC, it also can individually operate the internal program which is saved, run motion program and PLC program, update the servo loop and communicate with host computer through TCP/IP protocol.[5]

This system uses the UMAC (Universal Motion and Automation Controller) whose core component is PMAC. Compared with PMAC board, UMAC is a stand-alone controller which has a 3U rack backplane. The backplane can be extended many modules from Delta Tau, including the CPU module, power module, the servo module, the I/O modules and so on. UMAC can work independently. the modular design can meet the request of the open system, and improve the reliability of the system.

The base board of UMAC provides 3U board, and its features include as followed:[5]

80 MHz DSP56303 CPU

2 RS-232 serial communication

The application to the servo system and I/O accessory boards stack connection

Applicable to the servo system and I/O accessory board UBUS bus backplane connection

Using PID trap wave/feed-forward servo algorithms

Expand the servo algorithm of "pole-placement"

Current consumption 850mA @ 5V

Applicable to PC/104 connection

High-speed communication is built into the board

Ethernet interface for TCP or UDP protocol

USB 2.0 ports (485Mb/sec transfer rate)

2.4.2 SERVOR AMPLIFIER

This system uses ADP series servo driver which is produced by Copley Controls Company. Accelnet is a high-performance, DC powered drive for position, velocity (using encoder, resolver, Halls, or BEMF), and torque control of brushless and brush motors. It can operate as a distributed drive using the CANopen, or as a stand-alone drive accepting analog or digital commands from an external motion controller. In stand-alone mode, current and velocity modes accept digital 50% PWM or PWM/polarity inputs as well as 10V analog. Drive commissioning is fast and simple using CME2 software operating under Windows and communicating with Accelnet via CAN or an RS-232 link. CAN address selection is by a 16-position rotary switch. If there are more than sixteen devices on the CAN bus, the additional address bits needed can come from programmable inputs, or can be set in flash memory.

Main parameters:[6]

Input Voltage HV: 20-180 Vdc

Input Peak Current: 10 A

Input Continuous Current: 3.3 A

Output Peak Current: 9 (6.4)A 1 seconds

Output Continuous Current :3 (2.1)A

Output Impedance Rout: 0.075R

Maximum Output Voltage Vout: Vout = HV * 0.97 - Rout * Iout

2.4.3 SERVOR MOTOR

This system uses FP series servo motor which is produced by INFRANOR Company.

Main parameters:[7]

Nominal torque (continuous) 0.24Nm

Speed at nom. Torque 3000rpm

Max. continuous current 1.4 A

Diam*Length 38*125

Encoder Resolver

2.4.4 REDUCER

This system uses harmonic reducer which is produced in HARMONIC company. the parameters of the reducer are as follows:[8]

Reduction: 100:1

Rated Torque When Input 2000r/min: 2.4 Nm

Maximum Allowable Torque When Start and Stop: 4.8N.m

Maximum Allowable Torque for Average Load Torque: 3.3Nm

Instantaneous Maximum Torque: 9Nm

The Maximum Allowable Input Speed: 8500rpm

3. THE STRUCTURE OF SOFTWARE

3.1 ARCHITECTURE OF SOFTWARE

IPC using the Linux operating system. IPC is host computer which uses the Qt programming environment. UMAC is guest computer which operates the servo program with PMAC language. The software block diagram is shown in Figure4.

3.2 ARCHITECTURE OF COMMUNICATION

TCP/IP protocol is used between IPC and UMAC to communication with each other.

Communication structure picture is shown in Figure5.

4. CONSIDERATIONS

Currently, the system is at the stage of designing. It needs further considerate that how to operate for the derotator institutions when the telescope is in the tracking mode.

5. ACKNOWLEDGEMENT

The autor would like to thank Dr.Shihai Yang. The discussion with him is beneficial and interesting. Many thanks also to prof.Bozhong Gu and Dr.Guomin Wang for their help.

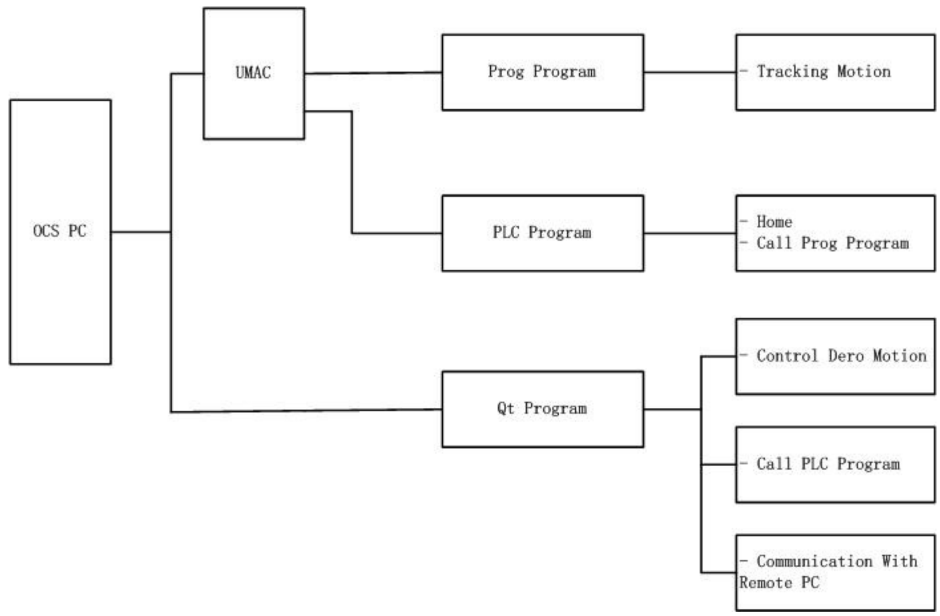

Figure 4. Architecture of Software

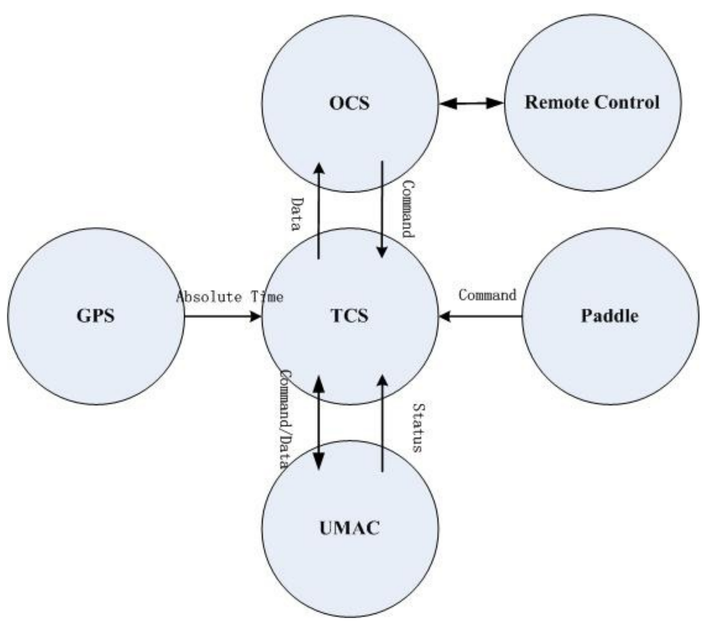

Figure 5. Architecture of Communication

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