MODERNIZATION OF THE TELESCOPE CONTROL SYSTEM

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Abstract: *The modernization of the mirror telescope control system is a complex multi-factor and multistage process, which demands a thorough, structural engineering analysis. The software information approach is the basis on which the functional control algorithms executed by multi-board constructions of the telescope transform to multilevel integrated software. The state-of-the-art, structure and software of a modernized telescope control system are described in this paper.*

Keywords: *telescopes, controlled systems, reconstruction.*

INTRODUCTION AND STATE-OF-THE-ART

The telescope is a complex system for astronomical observations, determinations of astronomic conceptions and for accumulation of the astronomic knowledge consisting of strategic, tactical operative and executive layers. The Telescope Control System (TCS) is a relatively separated part in the executive layer.

An example of PC based amateur telescope control is presented in www.astro.ku.dk/~jacob/bao/tcs.html by Bjarne Lassen. The PC of the TCS would integrate a science CCD camera, a guide camera and two custom-made controllers of step motors. The 80286 processor-based PC drives the automatically guided telescope. The PC runs the controller cards of two 4-phase step motors. On every input data portion PC is driving the stepper controllers by sending pulse series to them via two 8255 I/O cards. This process is highly critical in the time, so the software on this PC has to be designed carefully with a respect to the execution time. The software calculates polar angle, eliminates the gaps in the engines in accordance to the settings. Because of the limited speed capabilities the step motor is effective in a narrow area of direction of the telescope.

A large reconstructed TCS of optic infrared 2.2m telescope of the University of Hawaii is based on Linux OS and on the experience of upgrade the TCS in the Michigan University. The system: 1) improves existing performance for noise depressing, setting, pointing, tracking and offsetting; (2) provides reliable software operation with remote oversight, diagnostic and future remote operation capabilities; (3) utilizes existing hardware where appropriate; and (4) provides a user friendly and easily refined system to enable efficient interaction between telescope and multi-instrument control.

A Pentium II single-board CPU and the 3-axis motion control together with interface cards are assembled in a 19-inch industrial rack-mount chassis with ISA/PCI passive back-plane. Whole this construction is mounted in a separate rack with optic isolators and with other interface components. This rack is interfaced to the existing 24-volt relays, telescope encoder and drive system. The motors of the telescope and of the dome run under DC amplifiers and hydraulic servo valves.

The developed on C++ software contains operational part of 22 independent processes – loops that cover all control functions of the TCS. Each process is called with a frequency of 10 to 200 Hz in accordance to its participation in the common control sequence. Their corresponding procedures utilize information through a "share everything" memory where the addresses of the modules are located and the scheme "semaphores" control the access for data writing.

The implementation of the PC based TCS in the data acquisition loop process and in the control loop process confirms the grown computer power and capabilities. On the other hand, the DC motion control could not provide high resolution in a narrow area of the telescope orientation.

A modernized TCS for a complex motion control of DC and step motors could consolidate their individual capabilities and could create conditions for fast, versatile and adjust orientation of the telescope. These conditions are available in the NAO "Rozhen".

The purpose of this paper is functional structural analysis of TCS, description and integration of the basic project schemes of the modernized TCS for the 2m mirror telescope in NAO "Rozhen".

CONTROLLED OBJECT AND ITS FUNCTIONS

The mirror telescope Ritchey-Chretien-Coude is shown on the fig. 1. It represents a combined mirror optical system with steady high temperature properties of the mirror glass. The telescope is equatorial installed, with fairly large accessories for access, adjustment and observation at a secure degree of device and motor redundant. Thus, the telescope provides optimal conditions for preliminary preparation and work through night and for the operation during the observations.

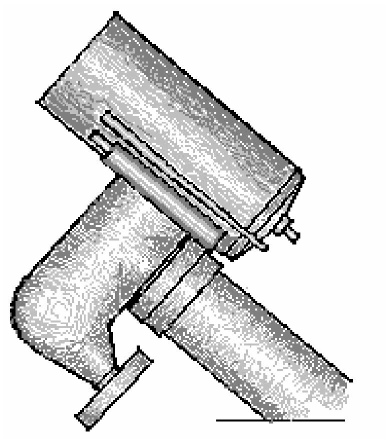

Figure 1. A common view of the mirror telescope.

The module system consists of central control unit, motion regulator, power electronics unit and power supply unit. The modernized TCS commits with an substitution and/or upgrade of the control units, where it is expedient, with innovation of the primary unit components, with development of a relatively independent communication system for data transmission and direction through addressing and switching, and with implementation of functions for remote oversight.

The large- and the middle-sized rotations of the telescope accomplish through multi-velocity DC motors. A separated 5-phase stepper motor completes photoelectric trace and the manual adjustments. Another step motor positions the telescope secondary mirrors. A frequency-ruled independent motor keeps the time-compensation rotation of the telescope in the minimal range of deviation. Four new installed frequency inverters regulate the velocity of the asynchronous motors for the dome positioning. This large motor interoperability is among the main dignities of the telescope. Besides, it imposes specific requirements to the modernized TCS and individual approaches for regulation and control during the different modes of motion.

The modernized TCS would complete the following main functions: automatic and indirect manual positioning; multi-parameter compensation including automatic time-compensation rotation; automatic corrections in dependence of the Sun system orientation, star time and calendar and of the atmosphere refraction; automatic tracing of object with an individual velocity toward static sky objects; automatic guidance of the telescope at long-time observation of static or of light movable sky objects; automatic synchronization of the telescope and the dome area positions at graceful start-stopping.

The basic functions are impossible without fine adjustments of the secondary mirrors, gap compensation engines, continuous background diagnostics of the executive engines, indication and/or visualization of their positions and state conditions. Simultaniously, local instrumental interfaces allowing maintenance, measure and tuning of local accessories – spectrograph, refractors, lenses and supported by research toolkit would be usefull. The preliminary and the essential astronomic activities accomplish through micro-controller functional command support of the available control panels and of the alternative indirect manual control trough a virtual panel. On this basis, the remote control can be provided with different details.

Thus the modernized TCS can be interpreted as a multifunctional superstructure incorporating the existing modules of the telescope. New electronics, relays and other hardware components would replace the old electric parts, where it is necessary.

On the other hand, the TCS would provide data supply into a number of additional functions bounded with the essential astronomic activity, for example the image transmission. But this is a subject of attention for the higher layers of the astronomic knowledge.

MODULE STRUCTURE OF THE MODERNIZED TCS

Similarly to the structure of the modernized TCS of the University of Hawaii, and for to meet the defined function support, the modernized TCS decomposes on multi-layer module architecture, shown on the fig. 2. It contains basic sense-motor system (BSS), communication system (CS), user-control interface (UCI) and astronomic observation interface (AOI).

The BSS is the kernel of the operational control and the motion activity. It consists of inside and outside sensors, panels with end input-output manual components for operator maintenance, light indication and or visualization components, time support system, digital convert units and microprocessor controllers for intermediate processing and machine program control. Every unit of the BSS is defined as a class object with list of properties and their ranges of values. The unit functions represent by linked code modules that are installed in PC for local telescope control. The module software of BSS is expandable, adjustable, time variable and provides a variety of observation and help instruments. Innovative microprocessor controllers support the panel scanning, indications, data exchange through fast communication lines and the new outside sensor system.

In reasons of hardware incompatibility and data encoding the CS is a separate module so that different PCs can be connected at a time and replaced when is need.

The UCI incorporates menu interface with pop-up functions, operational maintenance and automatic control, start-stop of a variety of secondary motion drivers. This tool is installed on the PC for local control. This PC also orders the remote requests and compresses the image data from AOI for automatic guidance of the telescope.

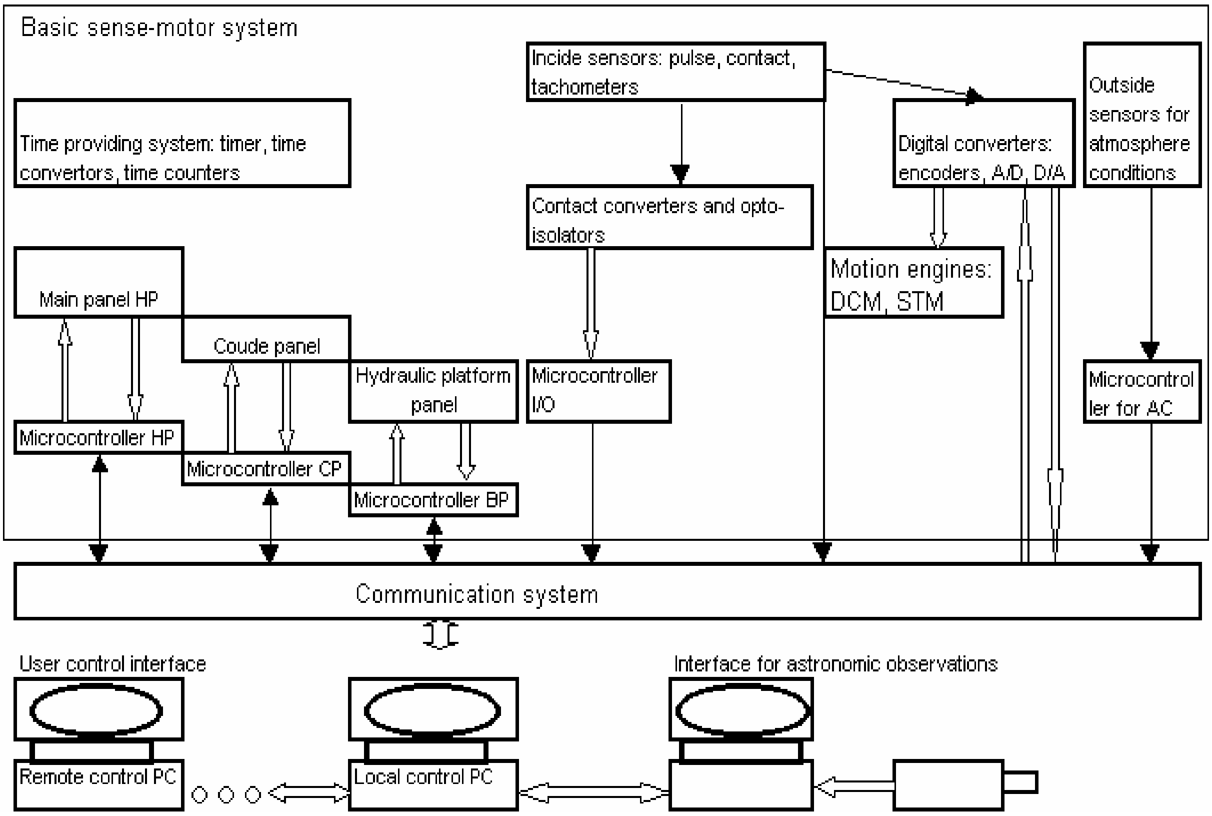

Figure 2. Module structure of the TCS

SOFTWARE STRUCTURE

The software contains layers for handle and function support.

The handle support layer accomplishes the indirect manual control from the main panel, Coude-panel and hydraulic platform panel during the preliminary supporting, learning and extraordinary operations. It disables the incorrect operator command events. This software layer is tested on a virtual panel – a prototype of the main panel that is shown on the fig. 3 together with the virtual indication lamps. This layer includes classes of the basic and secondary engines, lists of identifier variables, settings and software modules of the independent operations. These software modules supports the executive engines during the work modes, the modes of automatic process control belonging to the layer for function support.

The function support layer includes lists of own identifiers, program procedures of both automatic regimes and automatic functions. The structure and relationships of the software layers are shown on the tab. 1.

The telescope object classes in the first column of the tab. 1 have own code local functions. On the other hand, some of these classes could be invoked from the layer of function support in time they could be activated automatically. The modes of the handle support layer represent code procedures, start-stop boolean mode identifiers. Some of these identifiers set regime conditions. They are noted in the merged cells of the second and third columns of tab. 1. Besides, the sub-layer of the automatic regimes, shown in third column of tab. 1 works not only in handle support, but also at execution of some independent automatic functions. Actually, the algorithm binds between automatic functions and the automatic modes is stronger. Thus, they form the function support layer of tab. 1.

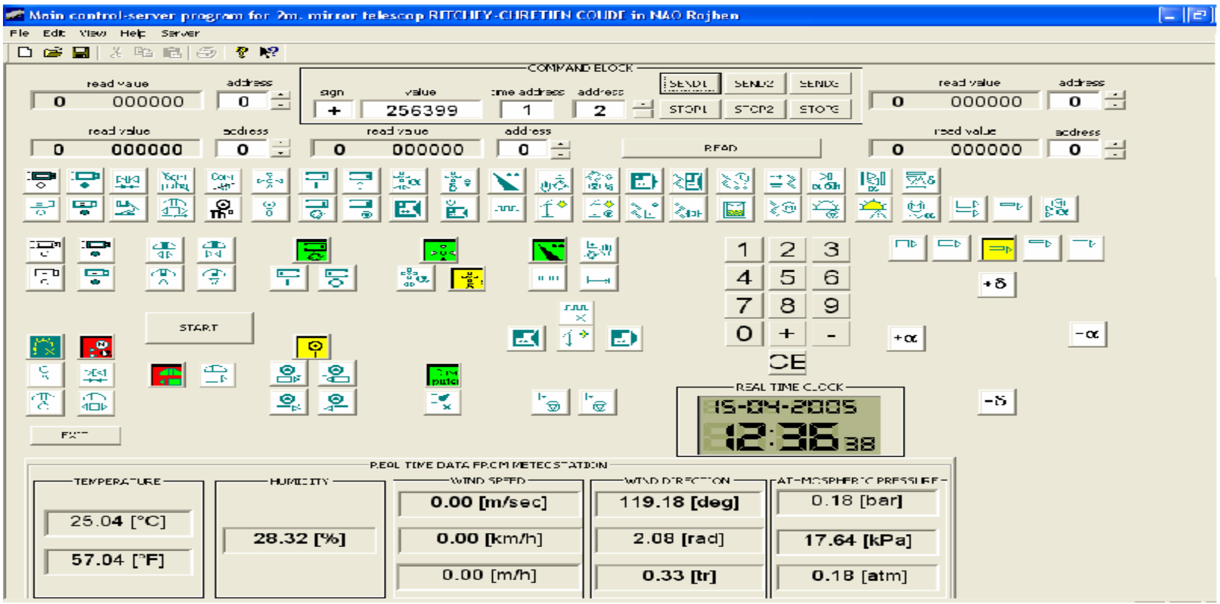

Figure 3. Virtual panel for handle support of the telescope.

Similarly to the independent object classes, the independent automatic functions exist. They are active in background automatic mode. A number of them are supported by information arrays. Thus the software could support data archives and databases.

Table 1. Software layer structure

Handle support software layer		**Function support software layer**	
Independent operations	**Settled regimes**	**Automatic regimes**	**Independent automatic functions**
Tubus flaps: open/close	Automatic / semi-automatic positioning	Automatic positioning in a point	Automatic diagnostics
Coude – flaps: open/close	Position measure	Semi-automatic positioning in a number of points	Automatic diagnostic indication
Wind curtain: up/down	Photoelectric trace	Leading of a random sky object	Automatic guidance
Main window open/close	Synchronous time compensation		Automatic prompts, alerts messages,recommendations, warnings
Dome: right/left	Dome and telescope area synchronization		Automatic corrections: epoch rectasc, refraction
Electric light: on/off	Telescope parking		
Secondary mirror: up/down	Photo exposure		
Sphere spindle: centered	Dome light		
Tubus rotation along the time co-ordinate	Focus adjustment		
Tubus rotation along the decline co-ordinate			

CONCLUSION AND FUTURE WORK

A brief overview of comprehensive TCS is given. The controlled object is described. The new trends and means for TCS modernization are pointed. The integration of module electric and mechanic structures together with module software support is emphasized in this paper. The software integration together with relationship between modules is shown. A multi-layer project scheme containing the existing, modernized and new components of TCS is implemented at explanation of the entire telescope operation. A table incorporating branches of handle and function support layers joint the software project.

The future work cover detailed technological sequence of the modernization. The predominated part of the software is created but not really tested.

The current paper is prepared as a part of the project for modernization of the TCS addressed to the mirror telescope in NAO "Rozhen", Bulgaria.

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