The Stellar Spectra Acquisition, Reduction and Archiving Systems at the Ondrejov Observatory 2-meter Telescope

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Abstract

The 2m telescope of the Ondřejov Observatory near Prague is the middle-class instrument fully devoted to high dispersion stellar spectroscopy by which more than 4000 electronic spectra of early type stars were secured. It represents with calibration exposures more than 17000 frames up to date. The data is produced by the two acquisition systems of different generations. The older linear detector Reticon 1872 AF is controlled by the DOS program providing the quick-look display capability as well . The output files of about 4 kB size are in proprietary binary format and their reduction has been done in the home-developed SPEFO package. The second is the Loral CCD (2720x256 pixels) driven by the stand-alone Linux program. The quick-look is provided by SAOImage or XImtool through data pipes. The output is a standard FITS file of about 1.4 MB size. Its reduction is done in IRAF. To provide an easy access to both the raw and reduced data a simple WWW-based archiving system has been recently put into operation. For handling of exposure catalogs a free SQL database PostgreSQL is used and the data is presented by the WDB query interface. We give the basic overview of these systems, the SW methods used for their communication with telescope and spectrograph control systems and their user interface. Finally the necessary design trade-offs are discussed as well as the possibility of future improvements.

1 Ondřejov Observatory 2-m Telescope

The Ondřejov observatory is located 35 km (20 miles) south-east of Prague in the altitude of 534 m.

The 2-m telescope built by Carl Zeiss, Jena, was put into operation in 1967 as a Czechoslovak national instrument and since the beginning it was devoted to high dispersion spectroscopy (17, 8.5 and 4 Å /mm) of early-type (mainly Be) stars in its 64-m coudé focus.

The observing conditions in this low altitude and in the vicinity of Prague as well as the local weather (about 130 partly clear nights in a year with average seeing about 2–4 arcsec) are incomparable with the world largest telescopes in high altitudes. The main advantage of 2-m telescope, however, is the ability of continuous long-term monitoring off a smaller number of stars.

2 Scientific Instruments

The plate archive of the 2m telescope contains almost 6000 spectral plates exposed until the beginning of year 1993.

Then the photographic plates were replaced by Reticon AF1872 detector by use of which more than 4000 stellar spectra were secured, giving with calibrations the total of 16600 frames up to date. In addition to normal observation with Reticon the department had been ocassionaly testing a CCD camera made by the instrument group of the Danish Institute of Astrophysics for last three years. Due to the quite poor quality of its LORAL 2688x512 CCD detector the stellar department had decided to buy a new CCD camera with ISA 2000x800 chip. This device has just been installed last month and now it is undergoing thorough testing.

All detectors are installed in the coudè spectrograph which can operate either with the 700mm camera or the larger 1400mm camera. In summer 1998 the old-fashioned manual control of the hardware devices was replaced by a new automatical system consisting of a number of stepping motors, power switches and single-board computer units. The detailed description of this systems is given in next chapters.

3 The Spectrograph Control System Overview

- Each controlled device in spectrograph has its own driver unit based on single-board microcontroller. All units are connected to common serial line bus.
- One main unit periodically reads status of controlled devices and sends commands to driver units over this line. The main unit is connected to serial port of controlling computer.
- The controlling computer runs a daemon which is used like a server for clients running on an arbitrary computer in the local net.

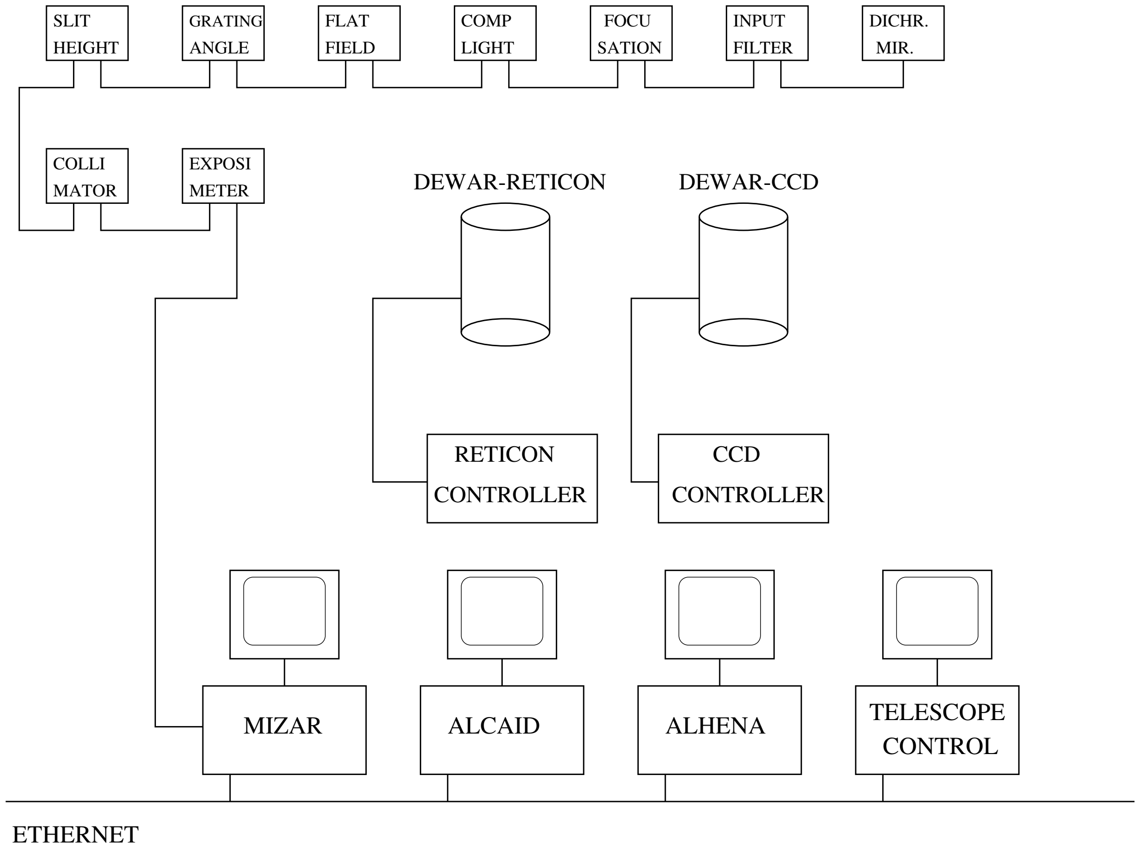

Figure 1: The controlled devices in the coudé spectrograph

3.1 Controlled Devices in the Coudé Spectrograph

Flat field lamp - to switch on the projector flat

Flat field mirror - to tilt the mirror into the lightpath

Comparison arc lamp - to switch on the ThAr lamp

Comparison arc mirror - to tilt the ThAr lamp mirror into the lightpath

Grating - to set desired angle by AC motor, measuring by incremental angle encoder, two limit sensors

Slit - to set desired slit height by stepping motor, two limit sensors, the position must be reset by driving to the limit sensor.

Collimator mask - to set desired mask (open, close, open-left, open-right) by rotating mask wheel by AC motor, optical encoders are used to recognize masks

Dichroic mirrors - to set desired dichroic mirror by rotating wheel with mirrors by stepping motor, optical encoders are used to recognize actual position

Spectral filters - to set desired filter by rotating filter wheel by stepping motor, optical encoders are used to recognize actual position

Focusing the 700mm camera - to set desired position by stepping motor, two limit sensors

Focusing the 1400mm camera - to set desired position by stepping motor, two limit sensors

Correction plate 700 read-only signal to distinguish the plate position (in beam, out of beam, intermediate)

Correction plate 1400 read-only signal to distinguish the plate position (in beam, out of beam, intermediate)

Exposure-meter - to start/stop counting pulses from photo-multiplier, to measure frequency (per second) and sum of pulses during exposure, to zero this sum

3.2 Server for communication with driver units in spectrograph

The server runs as a daemon on controlling computer and is started by first program, which needs it. After start the server forks into two processes:

Process-1 - waits on port xxxx for UDP connection from a client and replays by status data from controlled spectrograph devices on the same port

- waits on port yyyy for UDP connection from a client, reads a command from this port, converts it to a special format and sends it to serial port of local host (to main control unit)

Process-2 - periodically reads serial port of local host and the data saves to shared memory which shares with Process-1

This configuration has several advantages:

- the server itself knows in every moment about the status of controlled devices and can answer immediately to a client
- the spectrograph can be controlled from any computer which is connected to Ethernet and is allowed to do
- the client can be linked to various programs and so extend their functions
- several clients can run at the same time, some of them can only monitor the status of spectrograph

Disadvantage:

- doesn't work for DOS machines

3.3 Client-1 - monitor and control program of spectrograph

This program shows the status of all controlled spectrograph devices and allows user to control them.

The program is written in Tcl/Tk. The client part for communication with server is written in C and as a set of functions compiled to shared libraries by swig. (swig generates wrapper code needed to integrate C,C++, and Objective-C functions and variables with Tcl, Perl, Python, and Guile and produces documentation. This organization radically simplifies design of new monitor and control programs since whole boring work with making TCP/IP connection to a computer, reading data from it, sending data to it or canceling connection is reduced to only four TCL-like functions. Using these functions is enabled by comand `load my_library.so` at the beginning of the TCL program.

3.4 Client part of a program controlling CCD

Client for communication with server is included in a large program which controls CCD. The original CCD driving program BIAS (delivered with CCD) was modified to be able to control the spectrograph and to communicate with telescope driving computers).

A function which establishes UDP connection to the server is called at start of the program and at the end, after quit another function closes connection. During execution of the program is periodically called function for getting data from the server in a loop which displays status of CCD. The function for sending commands to spectrograph is called whenever CCD needs change a stage of a spectrograph device. At this moment a waiting loop must be made which reads data from server and waits for finish of the change. It is sometimes unpleasantly time demanding.

Function for reading data from server must be designed with reference to possible failure in UDP connection. Waiting for replay after sending requirement for data must be limited and after a timeout finished, else sometimes happened that client waited "for ever" for answer. The timeout is made by using system call of function `alarm()`.

3.5 Spectrograph DOS driver

The reticon 1872 AF detector is controlled by the home-made ISA card (containing PIO 8255 and timer 8253) and driven by the program `creticon` which was written in Turbo Pascal 5.5 and contains time-critical part for the synchronous Reticon readout. This was achived by disabling interupts, including waiting loops and direct reading I/O port with embedded assembler commands. Most critical and time-consuming was the tuning of the loops to fit the particular computer *Alcaid* speed and compiler options.

As this program cannot be easy replaced due to its complexity (it is also taking care of the target star catalogues, maintains the observing logs, provides the simple debiasing and flat-fielding as well as the quick-look display and many more services) we decided to change only several small routines that make the very calls to hardware. As the new spectrograph controlling computer *Mizar* is the stand-alone Linux machine connected to the ethernet network, we needed the easy way of reading status of devices and sending them commands through TCP/IP network without need of principal changes in the code. The solution we have developped is quite tricky :

- We have installed the TCP/IP stack called PCTCP by FTP Inc. on the DOS machine *Alcaid*
- At the top of this stack was installed the NFS client called Interdrive
- The small partition `/home/coude` on the Linux computer *Mizar* is NFS exported using the `pcnfsd` and mounted as the logical drive `Q:` on *Alcaid*
- When the `creticon` program is run the special daemon `expcd` is fired on *Mizar* through `rsh` command. The daemon periodically reads the status of the devices from the serial bus and writes the results in the short ASCII file `/home/coude/data1` each second (see the example of the file below).
- The daemon waits 200 msec to give the client enough time to read the data by simple `readln` from `Q:data1` into an memory array. After that the file is deleted and new one written with updated status.
- Each status file also includes unique counter which is incremented after new data from the serial bus units is read. So the client only chacks this number and when the same it does nothing.
- At the same time the presence of the file `command` is checked by the daemon on the *mizar*. When the DOS program sends a command to the particular device it will create the file `Q:command` with simple commands like `FF=1 exit`.

- If the file `/home/coude/command` exists, it is opened by `expc` and the commands for the driving units sent through the serial line. After finishing all HW movements the file `command` is deleted by the daemon..

- Before the opening of files on the client side the existence of them should by checked by the IOResult routine in loop.

The quite interesting result of this setup is the speed of status updates though NFS - more than 250 readouts per second. The uniqe counter is very good for the timeout control for case the communication is somehow disabled.

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4 Data Reduction and Analysis Software

At present the most important for the current research at The Ondřejov is the Reticon electronic spectra. They are small (about 4kB) and quite simple to handle. For the basic reduction and analysis of these data a proprietary program SPEFO written by J. Horn has been used for years in the stellar department.

The new spectra from CCD detector (about 1.4MB per image) is processed by standard packages `CCDproc` and `doslit` in IRAF. All the necessary FITS headers are provided by the modified BIAS data acquisition software.

5 Data archiving

In order to be able quickly find the detailed information about exposure of particular spectrum (plate or Reticon file) a SQL-based archive of observing logs has been under development in the Stellar department. Its preliminary version based on free RDBMS Postgresql and HTML presentaton and query interface WDBI is accesible on the 2m telescope homepage `http://stelweb.asu.cas.cz/archive.html`. The raw data will not be available on-line (due to its specific nature as a xresults of long-term monitoring observation) but those interested may ask the staff of stellar department by e-mail `stelveda@sunstel.asu.cas.cz`.

The archive will include in the near future the catalog of CCD exposures as wellonce the reduction of them is finished.

This work was partially supported with the subvention by the Ministry of Education, Youth and Sports of the Czech Republic (grant LB98251)