THE UCSB REMOTE ACCESS TELESCOPE PROJECT

PHILIP LUBIN
Physics Dept., University of California
Santa Barbara, CA 93106, USA

ABSTRACT

The remote access telescope project is a unique computerized optical telescope and data distribution system that can potentially substantively change the way astronomical concepts are taught to undergraduate and high school students. In addition, particularly at the secondary school level, it can be an aid to teachers for curriculum distribution, a forum for teachers to share new ideas and concerns and a method to foster a closer link with universities and professional astronomers. The system is undergoing testing at both the undergraduate level, with several high schools and a local museum.

1. Introduction

The UCSB remote access telescope (RAT) project grew out of some experiences in teaching undergraduate astronomy three years ago. It quickly became clear that most students were less than impressed with the usual roof top observation session with small telescopes. In addition to having to come back to campus when it is cold and dark, the students could see very little more (qualitatively) in the eyepiece than with the unaided eye. This is particularly disappointing when compared to the beautiful pictures presented in the textbook. Clearly, for them, astronomy should be done from the textbook and not with a telescope!

From a modern perspective of photon counting devices, some comparisons of the eye, emulsions and photon integrators (CCD, etc.) are very instructive. The major difficulty with the eye as a light detector is not "read noise", "dark current" or quantum efficiency, but rather integration time. The eye has an effective integration time of only 50-100 ms. Though near single photon sensitivity is possible, typical dark adapted sensitively is 10-100 photons on a receptor in an integration time. Emulsion grain sensitivities are typically of order 100 photons per grain.

Film has excellent spatial resolution but suffers from low quantum efficiency and dynamic range. The UCSB RAT uses a cooled CCD as the photoreceptor. It has an average quantum efficiency of 40% and read noise of 12 electrons and a dark current of about 1 electron per second. Pixel capacity (well depth) is about 150,000 electrons. For a comparison, the UCSB RAT which has a 14 inch aperature with its CCD camera is roughly as sensitive as the Lick 120 inch was with film 40 years ago. A large amount of astronomy was done then and can still be done now at this sensitivity which corresponds to a 10σ detection of a 20th magnitude point source in a few minutes. Figure 1 shows the theoretical signal to noise ratio for m=15, 17.5 and 20 with $1\times$ and $10\times$ "ideal" dark sky conditions, where ideal sky includes airglow, zodiacal light and unresolved stars and galaxies.

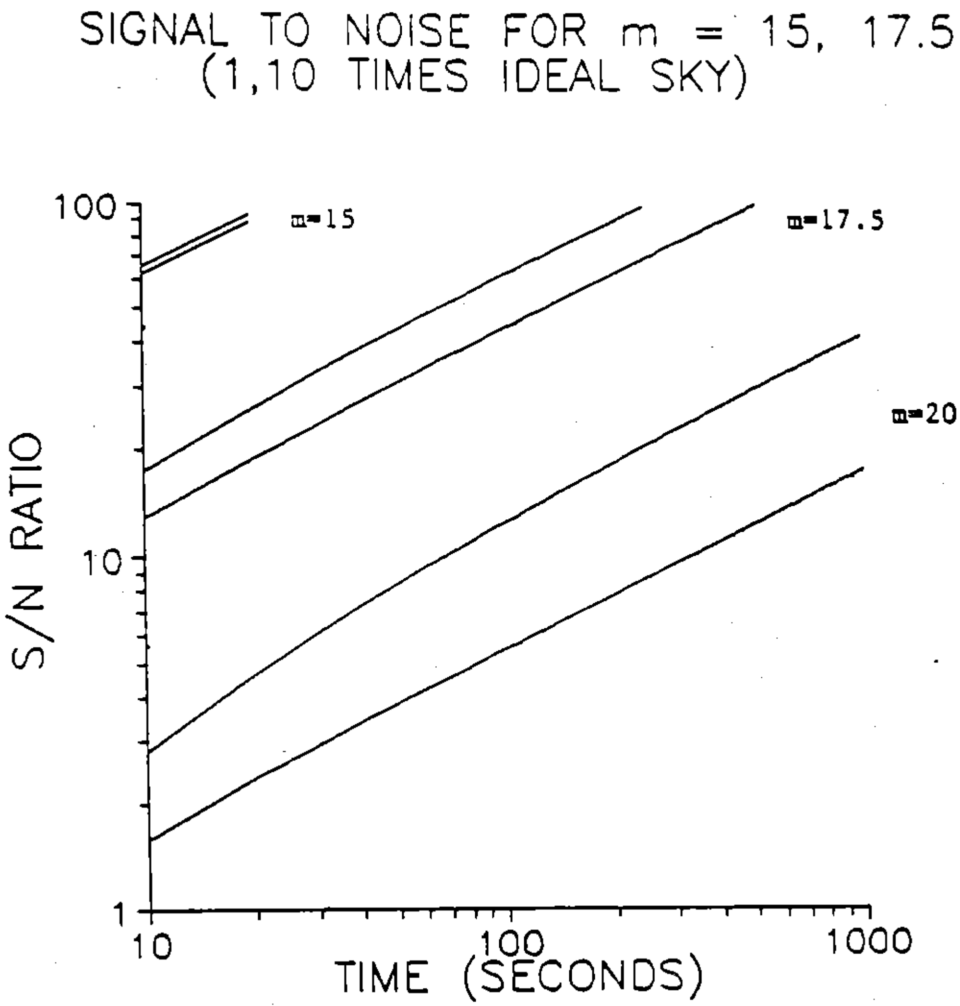

Figure 1: Signal to Noise Ratio vs. Integration Time

2. Current System

The system consists of a 14 inch diameter aperature Celestron telescope computer controlled with a micro step driven stepper motor, a thermoelectric cooled CCD camera, 16 position filter wheel (dual 8 position wheels), servoed focus and a computer controlled weatherized enclosure. A computerized weather station and infrared sky monitor determines meteorological conditions before opening the "dome".

This part of the system communicates via a microwave link to the base of the system which consists of an ethernet connected network of workstations for undergraduate use and a high speed modem interface for high school and other colleges. The dial in interface uses V.32/V.42 modem technology for effective throughput of 1-1.5 KBs (Kilo Bytes per second) for compressed image files, 2 KBs for binary executable files and 3-4 KBs for ASCII text files. Our current Thomson CCD has a format of 576×384 pixels, and after image compression, yields image sizes of 90-300 KB depending on the image complexity. Typical image transfer times are 1-4 minutes per image. Figure 2 shows the current system.

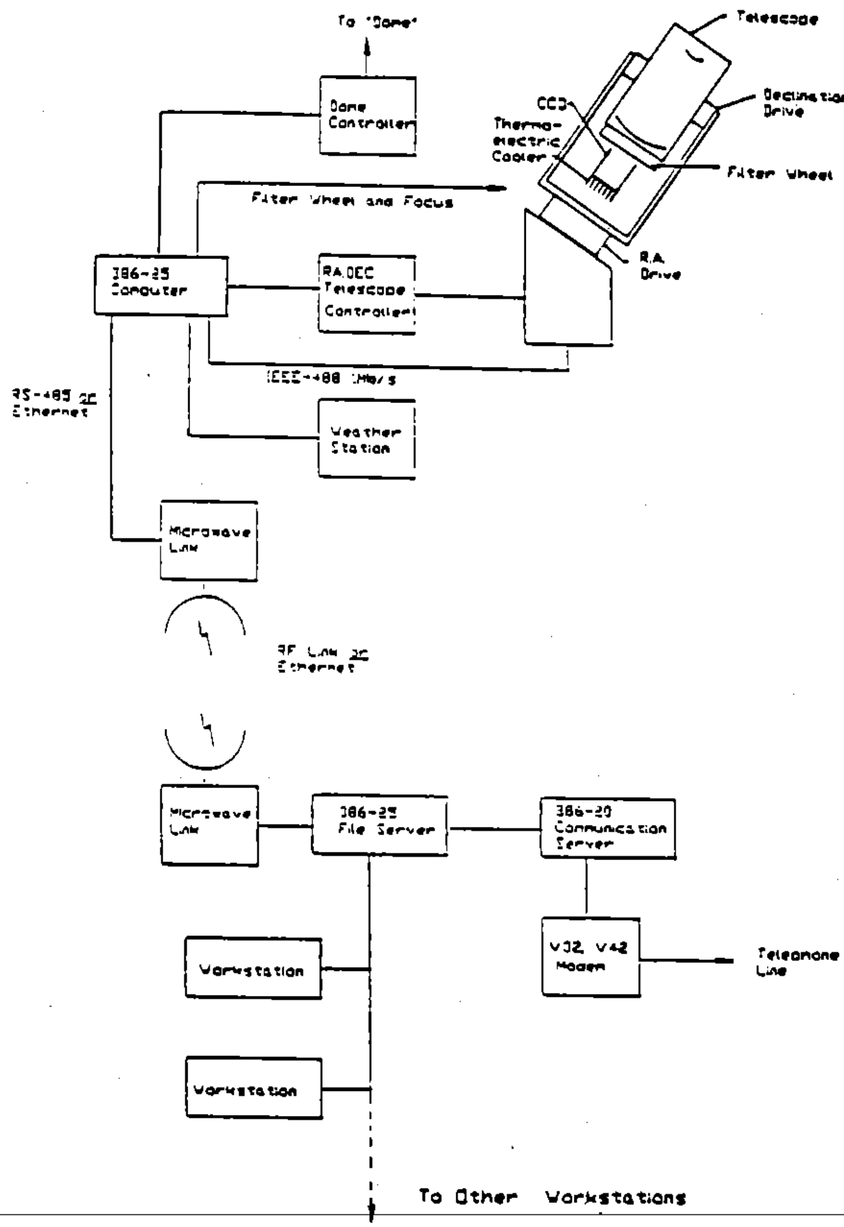

Figure 2: System Diagram

Undergraduate and high school users can submit target requests to the system during the day or have their computer automatically call in at night when costs are lower. The next day (or night), they would download the requested images and analyze them during normal class hours. This eliminates the need for evening classes which for the majority of students and teachers is not practical on a daily basis.

Additionally, news, bulletins and organized curricular can also be distributed as well as e-mail between high schools and between high schools and us. We also have selected Keck images and some Hubble Space Telescope images online for truly front line astronomy. In particular, as events occur, supernova, nova, eclipses, etc., can be made available along with study guides. Numerous other sources are possible such as Voyager images, radio and infrared sky maps, x-ray survey maps and so on.

Typical costs for night-time image transfer is 10-40 cents per image. Eventually, the system may be put on one of the university networks (internet, etc.), but at present, very few high schools have access to such a network. Currently, we are operating on a commercial telephone number, but may go to an 800 number to centralize costs.

The workstation for image analysis can vary considerably though presently, we are targeting 32 bit IBM-PC class machines (80386 or 80484 CPU). This class of machine currently has from 1.5 MIPS (16 MHz 386 SX) to 17 MIPS (33 MHz 486) and has enough power to handle the image manipulation. Cost for our current minimum recommended workstation is about $2,000 including display. A V.32/V.42 modem adds about $500. All these costs are dropping, so it is anticipated that within a few years the costs will drop another factor of 2. Additionally, other computers could be used for display purposes, in particular, Apple Color Macintosh's will work.

In the longer term, once our initial test with high schools are finished, we may be able to support a considerable number of schools. Since we have the capability to add multiple phone lines, one hundred or more schools is feasible. Curriculum development is one area of ongoing work. A common curriculum may be advantageous, since this would allow a larger number of teachers to participate. Our system provides a very natural way to distribute curricula and images together.