

Atmospheric Seeing and Transparency Robotic Observatory



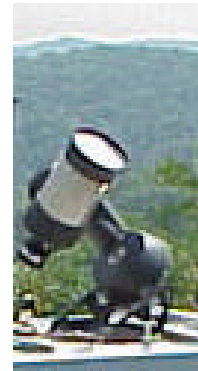
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Pisgah Astronomical Research Institute

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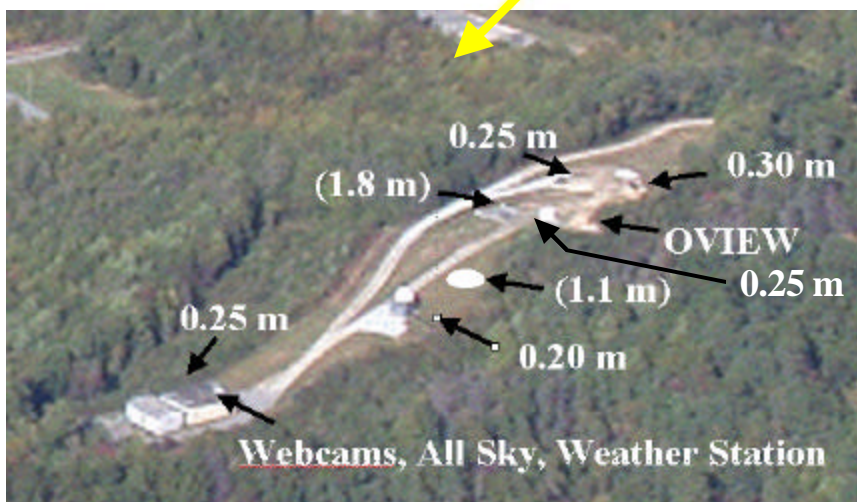
Introduction



- Robotic research observatories are common (e.g. Bode 1995, *Robotic Observatories*).
- Part of a robotic observatory's strategy for opening up is a check on weather.
- At present, however, robotic observatories have no mechanism to estimate, a priori, seeing and astronomical sky conditions built into the observing strategy. Seeing and sky conditions are not known until data has been taken and reduced.

- A priori measurement of seeing and transparency conditions increases the efficiency of a robotic observatory's operation strategy, and is useful in interpreting the accuracy of the data that is acquired.
- We have built **OVIEW** - a robotic atmospheric seeing and transparency observatory to serve as a source of information for research robotic observatories.
- OVIEW is meant to serve all telescopes at the PARI Observatories.
- With the PARI weather station, a 180° FOV sky camera, OVIEW, all observers (on-site, remote, robotic) will have access to a complete view of atmospheric conditions.

PARI CAMPUS AND OBSERVATORIES



**OPTICAL
RIDGE**

OVIEW is located in Western North Carolina in the Pisgah National Forest, on the PARI Optical Ridge.

Description of the Observatory



Image of OVIEW

The telescope shown on the left is called *BrightStar*, and the other telescope is called *Solar/Lunar*. *BrightStar* measures seeing/transparency. *Solar/Lunar* is for Education/Public Outreach.

OVIEW is powered by solar panels and batteries.

BrightStar Telescope and Camera Configuration

- The telescope is a Celestron NextStar 5 (12.7 cm, f/10, 162 arcsec/mm) computer controlled by RS232.
- Telescope Altitude-Azimuth mounted in an enclosure with transparent acrylic dome for continuous observing.
- Telescope points at altitudes $> 30^{\circ}$ (limited by dome diameter and telescope tube length).
- Camera on the telescopes is a 656x480 (7.4 μm square) pixel SBIG STV
- Camera is attached directly at Cassegrain focus.
- Scale on camera = 1.2 arcsec/pixel.
- FOV = 13.1 arcmin x 9.6 arcmin

- **Telescope and Camera are computer controlled through RS232 ports.**
- **In the telescope housing, the RS232 ports are routed through a PortServer II.**
- **PortServer II has 15 RS232 Ports that can be controlled from any computer on the PARI LAN.**
- **BrighStar is controlled by a computer in PARI Control Center on the Main Campus.**
- **PARI Data Protocol (PDP) was developed so seeing and transparency data from BrightStar can be requested by any robotic observatory computer.**



BrightStar Telescope

Robotic Observing and Software

Observing Method

- Operates in robotic mode: pointing, imaging, and data analysis are automatic
- Fifty stars with V magnitudes brighter than 2.5 and visible from PARI were compiled into a catalog ordered by RA.
- The telescope software reads the position of a star in the catalog and calculates the star's Alt and Az.

- If Alt $>30^{\circ}$, then the telescope slews to the star.
- Sun avoidance is set at 30° and Moon avoidance is set at 15° .
- When pointed at the star, a 60 second snapshot is taken.
- Images are filtered through the STV green (488-574 nm bandpass) color glass filter .
- The image is saved and downloaded for analysis.
- When the analysis is complete, the telescope goes to the next available star in the list and the process repeats.

BrightStar Software



BrightStar Control Panel.

For each star, the panel displays

- Current and Next Horizon and Equatorial Coordinates
- Atmospheric Transparency
- Seeing
- Current Image

- Software is written in Visual Basic 6.0.
- Software controls the telescope using the NextStar 5 command set.
- Point telescope either by manually entering coordinates, or operate in automatic mode accessing the catalog of bright stars.
- Software controls all camera functions including imaging, saving, and downloading the image
- Software automatically does the data analysis.
- The analysis of the image data is saved to a file.
- The control panel is screen captured and sent to a web page once a minute so anyone can see the results.

BrightStar Data Analysis

Seeing and Transparency from an image is derived in real time calculations by:

1. Calculating the mean and standard deviation of the pixel values from the entire image.
2. Scanning the image for a bright pixel value greater than 3 standard deviations above the mean.
3. Reading the pixels adjacent to the bright pixel to determine if their values also are greater than 3σ .
4. Counting the bright pixel with the number of adjacent pixels with values $> 3\sigma$.

6. If number of pixels > 4 , then assume this is the bright star.
7. The number of pixels with values $> 3\sigma$ is proportional to the seeing.
8. The proportionality constant will be derived from a history of data over the next several months.
9. Total intensity is calculated by adding the values from the bright ($>3\sigma$) pixels
10. Total intensity is a measure of transparency.
11. Transparency is derived from comparison of observed total intensity to best observed in photometric weather and given as a percentage.

Making the Seeing and Transparency Accessible to Robotic Observatories at PARI

**Use the PARI Data Protocol (PDP) to
access seeing and transparency data**

How PDP works:

- **PDP server listens to a set port (usually 7200) for requests to connect.**
- **PDP client connects to a server's ip and sends a KEYWORD as a string**
- **When given a request that matches a PDP KEYWORD, the PDP server sends back a string of data elements joined with the "|" character. PDP server disconnects after one second.**
- **Any program that needs information from another program can be set up as a PDP CLIENT.**

Solar/Lunar Telescope

and Camera Configuration

- **The telescope is a Celestron NextStar 5 (12.7 cm, f/10, 162 arcsec/mm) computer controlled by RS232.**
- **Telescope is polar mounted on a pier inside of a tilt-off enclosure cover.**
- **Telescope has a permanently mounted solar filter.**
- **Camera on the telescope is a 656x480 (7.4 μm square) pixel SBIG STV**
- **Camera is attached to an f/3.3 focal reducer at Cassegrain focus.**
- **Scale on camera = 5.0 arcsec/pixel.**
- **FOV = 57.3 arcmin x 36.5 arcmin to observe the entire solar or lunar disk.**

Lunar/Solar Telescope

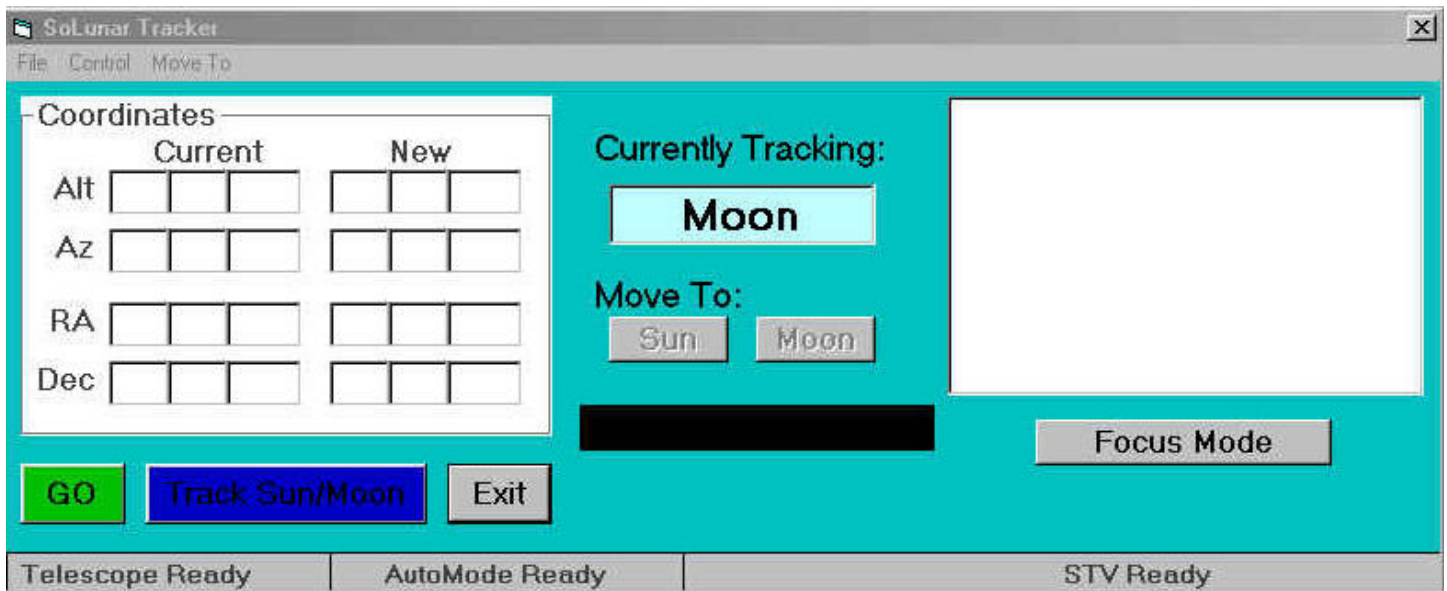


Robotic Observing and Software

Observing Method

- Telescope and Camera are computer controlled through RS232 ports.
- In the telescope housing, the RS232 ports are routed through a PortServer II – same method that used with BrightStar.
- Operates in robotic mode: pointing, imaging, and publishing the image to a web page is automatic and realtime.

- Images are filtered through the STV green (488-574 nm bandpass) color glass filter .
 - The image is saved and downloaded
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Solar/Lunar Control Panel.

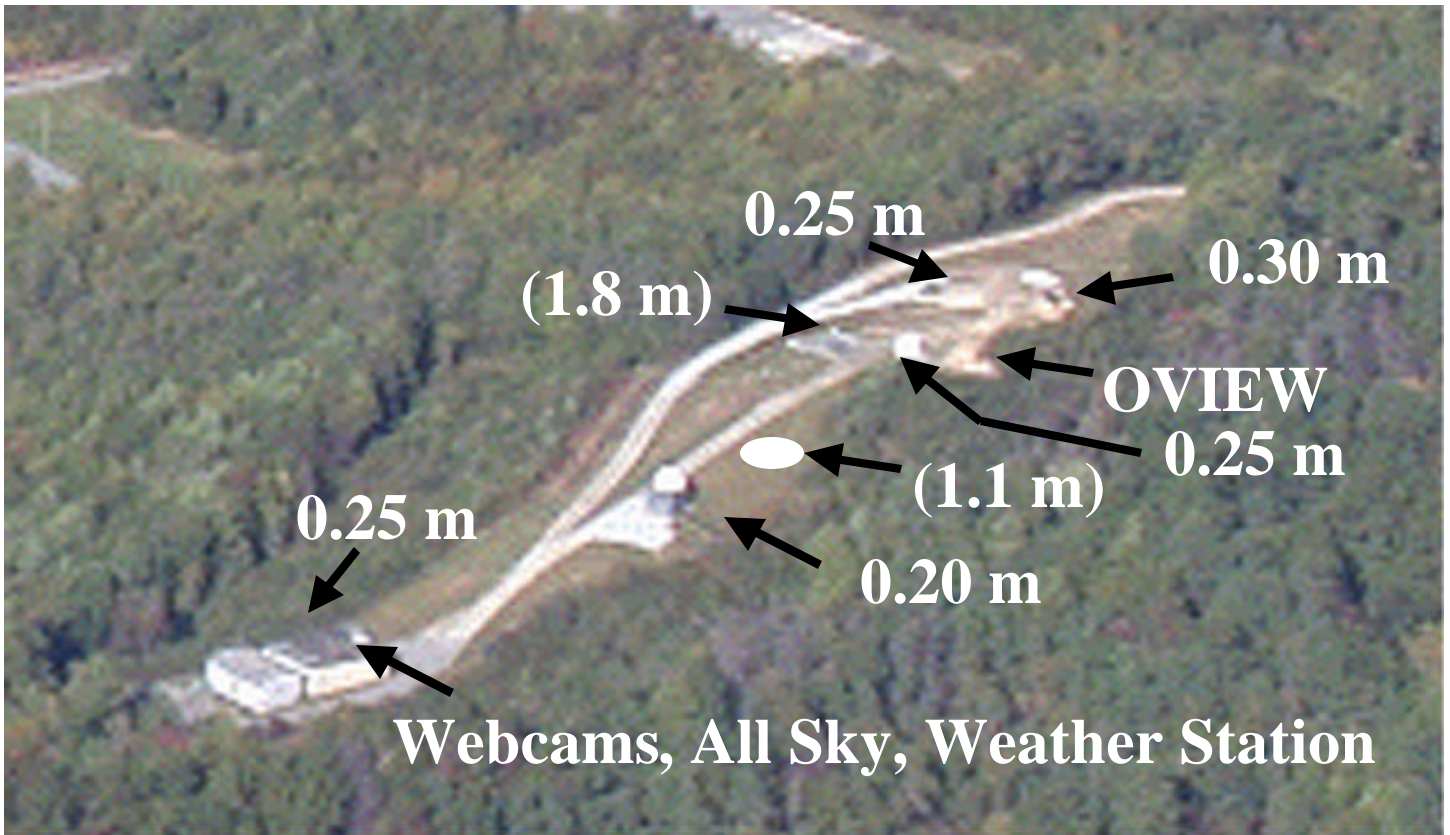
The panel displays

- Current and Next Horizon and Equatorial Coordinates
- Current Image

Lunar/Solar Software

- Software is written in Visual Basic 6.0.
- Software controls the telescope using the NextStar 5 command set.
- Software controls all camera functions including imaging, saving, and downloading the image
- The image is saved to a file.
- The control panel is screen captured and sent to a web page once a minute so anyone can see the results.
- Results are for education/public outreach

PARI Optical Ridge Telescopes



Currently

Three 0.25 m Telescopes and cameras

Two 0.20 m Telescopes and cameras

One 0.30 m Telescope and camera

All Sky camera

Webcams

Weather Station

Future:

1.1 m Telescope

1.8 m Telescope

CONTACTS

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