Astronomical Data Analysis Software and Systems VI
ASP Conference Series, Vol. 125, 1997
Gareth Hunt and H. E. Payne, eds.

A Graphical Field Extension for sky

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Abstract. At Keck we use the graphical tool *sky* to plan observations and to control the telescope. Since 1992, *sky* has provided all status via alphanumerics and control via buttons. We recently extended *sky* to provide status via a graphical star field. The user controls the telescope by clicking on stars and an overlayed view of the instrument detectors. Geometrical operations, painful to convey in the alphanumeric *sky*, become trivial using the graphical approach. In this paper we discuss the advantages of the new display.

1. Introduction

Acquisition and guide star selection for the Keck telescope is accomplished via the *sky* program. *Sky* presents two distinct panels, the *main display* for direct control and the *graphical field* for staging an observation.

We developed the main display during early 1992 and have since been using it to control the Keck telescopes. The graphical field is a recent addition motivated by

1. the need for more intuitive pointing and rotation control,
2. the need for a more general method to find suitable guide stars, and
3. AO requirements.

2. The Graphical Field Display

Typically a *sky* user begins by specifying a group of objects, either by reading in a predefined object list or by searching an area of the sky. The group of objects is displayed as a tabular list in *sky*'s main display and as a star chart in *sky*'s graphical field. The *sky* user can overlay an instrument view onto the star chart and use the middle mouse button to drag it and rotate it among the objects in the field.

As the instrument field is dragged with the middle mouse button, its right ascension and declination are displayed next to the cross hair that moves along with it. As the instrument view is rotated with the middle mouse button, its position angle on the sky reads out as ψ in the lower left portion of the display.

These three position values, right ascension (`RA`), declination (`Dec`), and position angle (`PA`), taken together with the pointing origin (`PO`), completely specify an instrument orientation. To point the telescope, the *sky* user selects a pointing origin with the mouse and then drags and rotates the instrument

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field until the desired orientation appears on the display. At this point, the `RA/Dec/PA/PO` quadruple can be transferred to the main display by clicking on the button labeled "Transfer setup to main display."

The *sky* user can also interact with the graphical display to measure distances, measure angles, and display a particular object's name, visual magnitude, and color. A right mouse button click anywhere in the field positions a red cursor at that point. Rough astrometry data is then displayed for that point, including

1. offset polar coordinates in arcseconds and degrees,
2. offset Cartesian coordinates in arcseconds, and
3. absolute Cartesian coordinates in hours and degrees.

If the right mouse button is clicked on an object, then the object's name, visual magnitude, and color are also displayed. In this case, the astrometry data listed above are taken from the catalog and are therefore more precise.

In summary, the middle mouse button is used to drag the field, the right mouse button is used to interrogate the field, and the left mouse button is reserved for selecting stars, selecting pointing origins, and button clicks.

3. Pointing Origins

To point the telescope, the *sky* user specifies two points: a *sky location* and a *detector location*. After the telescope has been pointed, and an image has been read out from the instrument, the specified sky location will appear at the specified detector location in that image. Moreover, any field rotation that takes place during the exposure will be centered about these two coincident points. The sky location and detector location can be thought of as a pair of points which are pinned together by the act of pointing.

The *sky* program has always provided features, such as catalog search tools, telescope limit displays, and predefined star lists, that help the user specify a sky location. Until recently, however, *sky* had no features to help the user specify a *detector* location. This shortcoming introduced unnecessary confusion into the pointing process. In the new *sky*, the detector location name occupies equal real estate with the target name.

A detector location name, such as "slit" or "center_pixel" serves the same purpose in the instrument coordinate frame as does a target name, such as "Vega" or "NGC1234," in the sky coordinate frame. That is, it provides a named key for referencing a set of precise coordinates. While a target name references the right ascension and declination of a given object, a detector location name references the (x, y) coordinates of a given pixel.

In the previous section we described how the user can drag a cross hair pinned to the instrument's view to adjust the intended right ascension and declination. The point in the instrument view to which the cross hair has been pinned is called the currently selected *detector location*, or, equivalently, the currently selected *pointing origin* (Wallace 1987). The red circles displayed at specific positions in the instrument view indicate the predefined detector locations for the instrument. When the *sky* user clicks on a red circle, the displayed

instrument view is shifted to align the specified detector location with the cross hair.

Note that when the user changes pointing origins by clicking on a red circle, the instrument view is shifted to align with the cross hair. Because the cross hair does not move, the intended right ascension and declination do not move either. The notion of a telescope move that does not alter right ascension or declination can be confusing if the display offers only an alphanumeric representation, but is readily apparent with the graphical view.

4. Catalogs (and Other Sources of Objects for sky)

As described in section 2, the objects displayed in the graphical field are either read from a predefined star list or extracted from an online catalog. Many of the features available from *sky*'s graphical field would also be useful with a real time guider display, with images read from `DSS` (Morrison 1994) or with images read from image archives.

Our success in integrating better catalogs, in particular the degree to which we can go faint, will strongly influence our decisions about the alternate sources listed above. In particular, if we can provide catalog coordinates with reasonable coverage down to 18th visual magnitude, the urgency to integrate `DSS` images recedes.

Processed image data from `DSS` is now readily obtained via the Internet. With current Internet bandwidth to Hawaii, these images are barely useful for daytime planning. Even with planned improvements for Hawaii's Internet access, `DSS` images could not be used for night time decision making unless either a complete set is available on a juke box or a subset is available on a conventional disk.

Similarly, the turn around time for accessing past Keck images is sufficiently slow that using these images for planning from within the *sky* graphical field would barely be useful for daytime planning and could only be used for night time work if an appropriate subset of images were loaded onto a conventional magnetic disk before the night's observing.

For both `DSS` and archive images, the level zero method for integrating images into the sky graphical field is straightforward: simply add a button for loading an arbitrary `FITS` image. The question of what do to with that `FITS` image is more subtle. There are three choices:

1. read raw pixel data directly into the sky graphical field,
2. use centroiding and background flattening to generate a stylized version of the `FITS` image, or
3. produce a stylized image as above and, in addition, scale and translate the object locations to match the results of a catalog search from the same area (Mink 1997).

5. Star Lists

While still at their home institutions, visiting observers prepare a list of objects for their run at Keck. In past versions of *sky*, this list contained only the object

name, right ascension, declination, and equinox, and, optionally, keyword-value pairs for proper motion or differential tracking rates. In the new version of *sky*, the user can optionally include

1. rotator position angle,
2. detector location name (also known as, pointing origin name), and
3. the positional coordinates of any movable instrument detectors.

Past star lists only described sky objects, and provided no information specific to the telescope or the instrument. With the addition of the above information, each line in a predefined star list can now specify all of the information needed to set up the telescope completely.

6. Conclusion

The graphical field display makes pointing and rotating more intuitive. The display provides point-and-click mechanisms both for setting up an observation and for measuring distances and angles. *Sky* now provides methods for selecting the detector location as well as the sky location; both are needed to set up an observation. The best method for incorporating non-catalog sources requires further study and is influenced by the availability of faint guide star catalogs.

Acknowledgments. We thank Julie Barreto, Tom Bida, Randy Campbell, John Gathright, Tony Gleckler, Bob Goodrich, Wendy Harrison, Hilton Lewis, William Lupton, Jerry Nelson, Gerry Neugebauer, and Pat Wallace.

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