SUNGRABBER - SOFTWARE FOR MEASUREMENTS ON SOLAR SYNOPTIC IMAGES

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Abstract. Measurement of positions of the tracers on synoptic solar images and conversion to heliographic coordinates is a time-consuming procedure with different sources of errors. To make measurements faster and easier, the application "Sungrabber" was developed. The data of the measured heliographic coordinates are stored in text files which are linked to the related solar images, which allows a fast and simple comparison of the measurements from different sources. Extension of the software is possible and therefore Sungrabber can be used for different purposes (e.g. determining the solar rotation rate, proper motions of the tracers on the Sun, etc.).

Key words: heliographic coordinates - solar images - software

1. Introduction

The "Sungrabber" is a convenient application for measurements on solar synoptic images (Roša et al., 2000). The images can be stored in a computer in several graphical formats (e.g. jpg, gif, bmp) and can be used for different purposes, e.g. measurements of the solar rotation rate (Brajša et al., 2000; Brajša et al., 2003), measurements of dimensions of solar features (Roša, 1996), etc. The application is written in Microsoft Visual Basic 6.0, and can be run on PC-s under Microsoft Windows OS (98, XP, 2000), and VBrun library 6.0. The work with the application is rather simple. With a few mouse clicks it is possible to define the heliographic coordinate system on a particular image. The ephemeris for physical observations of the Sun are calculated by using formulae with sufficient accuracy (Meeus, 1992). In the next step the Sungrabber offers the possibility for measurements on solar synoptic images. Coordinates of the tracers are stored directly in the heliographic coordinate system (according to Carrington), with no need for
any further conversion. The data are saved by default in the same directory as the image, but it is also possible to store the data under a different name and in a different directory. Additionally, we built-in the option for quick comparison of the data from different sources, which can be stored in separate files and easily changed. All work performed can be saved any time and the data can be used and changed when necessary.

2. Work with Sungrabber

After starting the Sungrabber the user opens the image from the file menu. If the image is loaded for the first time a new dialog is shown. One can enter the number 0 (scan - for any type of image - default), 1 (SOHO - only for the specific type of images), or 2 (other type of image). The option for selecting one of the several coordinate systems is included, because the application is developed not only for measurements on solar synoptic images, but also for measurements on other types of images. The selection must be done from the menu Settings – Coor. system (Figure 1). When the key + is pressed a rectangular grid will be shown on the screen (Figure 2), a higher density of the mesh is received by pressing the key again. The key – has the opposite function. A zero point (menu Settings – Zero point) must be set also. The position of the zero point is arbitrary, but for the correct determination of the Sun’s disc centre it must be located inside the solar disc. If the name of the image is in the format kanz_drawx_fd_yyyymmd_hhmm (where yyyy is the year, mm is the month, dd is the day, hh is the hour and mm is the minute of observation expressed in UT, i.e. according to the SOHO standard), the Sungrabber recognizes the time of the observation and the ephemeris for physical observations of the Sun will be calculated automatically. For other formats of the name of the images, the time of the observation must be entered (Settings – Date and Time). Defining the Sun’s limb (Input – Sun’s limb) is a sensitive process with a high influence on data accuracy. So, it must be done very carefully. Points of the solar limb are marked by a left mouse button click. In the case of a mistake, a point can be unmarked by clicking on the right mouse button. Of course the accuracy depends on the number of marked points, but marking too many points may take too much time with only little improvement of accuracy. Theoretically, three points are enough, but ten to fifteen points are advisable. For the precise alignment of the heliographic coordinate system to the
Figure 1: Selection of the coordinate system

Figure 2: A rectangular net over the image. Indicated lines represent coordinate axes.
image (pixel) axes a track of the daily motion of the Sun - which represents the celestial E-W direction - can be used. The line, which represents the Sun’s daily motion, can be retrieved from the menu Input – daily parallel. For a good accuracy, this line has to be marked by five to ten points. After determination of the daily parallel it is suitable to save the work. Next time when the image will be re-opened, Sungrabber will load the parameters automatically and the work can be continued without repetition of the described procedure. From that moment the heliographic coordinates grid will appear on the screen (the net can be switched on and off from the menu View – Heliographic coordinates), and coordinates on the status line will be displayed as the mouse is moved across the image. If the mouse pointer leaves the solar disk then L₀ is shown. In that case the heliographic coordinates B and CMD will be 0 (Figure 3). For starting position measurements of particular solar features on the images, the option Input – Object from the menu has to be chosen. After entering the object’s number, every left mouse button click will write the coordinates to a temporary file (every click on the right mouse button will delete the last recorded coordinates) and with the option File – Save the coordinates will be saved to a file.
Figure 4: Marks related to measurements on the comparison image are shown on the left in the area where sunspots are drawn.

When all points are marked, by clicking the End button (upper left corner) the process of entering points for the particular object will be finished. The procedure can be repeated as many times as necessary. For comparison of measurements from the different sources the option Tools – Compare has to be chosen. Marks related to measurements on the comparison image will appear over the current image. In the upper part of the window the time of the comparative measurement and difference in time between that measurement and the current image will be shown (Figure 4). A different comparative measurement can be shown by pressing the keys $p$ and $o$ respectively. The measurements are stored in the file Dpd.txt. If there is a need for a different set of measurements, the data in the file Dpd.txt can be changed easily.

3. Accuracy

There is the important question about the accuracy. The main problem is the quality of the solar drawings. It is practically impossible to determine the errors originated in performing the drawings. There are a lot of influences on...
Table I: Differences between the coordinates obtained by Sungraber and the ones measured by Debrecen Observatory. Standard errors (M) as the maximum differences in heliographic longitude (ΔL) and heliographic latitude (ΔB) are expressed in degrees.

<table>
<thead>
<tr>
<th>Date</th>
<th>ΔL</th>
<th>MΔL</th>
<th>ΔB</th>
<th>MΔB</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/4/1993</td>
<td>0.36</td>
<td>0.10</td>
<td>-0.12</td>
<td>0.06</td>
</tr>
<tr>
<td>2/5/1993</td>
<td>-0.14</td>
<td>0.08</td>
<td>0.21</td>
<td>0.03</td>
</tr>
<tr>
<td>2/6/1993</td>
<td>0.08</td>
<td>0.09</td>
<td>0.17</td>
<td>0.04</td>
</tr>
</tbody>
</table>

the quality of the drawings, especially conditions in the atmosphere, stability of the telescope mount, accuracy of the tracking, accuracy of positioning the projected solar image and the time needed to perform the drawing. Maybe the most important factor is observer’s experience. A small influence arises from the lens aberrations of the projected image, but it can be easily measured and eliminated. If the drawings are scanned on a low quality scanner the problem of the effect of non-linearity of the scanning process due to non-constant movement of the scanner lamp/photodiodes can also occur. All the influences mentioned above can sometimes contribute more than 1 degree of inaccuracy in heliographic coordinates at the centre of the image (where the highest resolution and accuracy is achieved). The accuracy is decreasing towards the solar limb. There are some remarks which could help to make better measurements using the Sungraber. First of all, scans of the Sun’s drawings must be of high quality, with high resolution. For example, on a scan of the Sun’s drawing where the solar diameter is about 1500 pixels, the resolution in the centre of the image is about 0.08 degree per pixel. The resolution at about 70 degrees from the centre of the Sun drops down to the value of more than 0.2 degree per pixel. So, a high resolution scan will give higher resolution for the measurements. The built-in algorithm for calculating the ephemeris for physical observations of the Sun is sufficiently accurate for processing the scans. The absolute errors in the elements for physical observations of the Sun are less than ±0.01° for the period from 1980 - 2000. If better values are required they can be changed (and also checked) simply "by hand" in the text file associated with the image. When the same image is reloaded, Sungraber will use these updated values. We have checked differences between the coordinates obtained by Sungraber and the ones measured by Debrecen Observatory.
(Győri et al., 2004). The differences are shown in Table I and as one can see, they are very small.

4. Conclusions

The main motivation for developing the Sungrabber software is to make measurements on the Sun’s drawings as easy as possible. The Sungrabber can be very useful for the measurements of the tracer’s positions on synoptic solar images. The results can be used for many purposes: determination of the solar rotation rate, movement of the tracers, morphological changes of solar features etc. The Sungrabber can be used for scientific purposes free of charge. The software is being further developed and improved. The Sungrabber can be downloaded from: www.zvjezdarnica.hr/sungrabber.

Acknowledgements

The authors would like to thank Dr. B. Vršnak for helpful comments and suggestions.

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