COSIS: Coimbra Observatory Solar Information System

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Abstract.
Since 1926 full-disk spectroheliograms have been routinely taken in Coimbra Observatory in the Ca II K-line (K1 and K3) and in 1990 regular observations in the H-alpha line have also started. These observations are preformed by a spectroheliograph, a twin of the spectroheliograph operated at the Observatoire de Meudon. Since 2002 we are digitalizing backwards our collection of more than 30000 solar images. In 2005 we started the project COSIS (Coimbra Observatory : Solar Information System). The purpose of the project (financed by FCT, MCTES, Lisbon, Portugal: POCTI-CTE-AST/58333/2004) is to develop a software tool for automatic image processing and feature recognition of sunspots (K1), chromospheric plages (K3), and filaments (H-alpha) for usage by astronomers and other interested parties. The project team is composed by astronomers and computer science researchers from two institutions: the Coimbra Observatory, Santa Clara, Portugal and UNINOVA-CA3, Campus FCT-UNL, Caparica, Portugal. At this stage of the project only automatic image processing of sunspot is being performed and the first results are presented in this contribution. However, we intend in the future to extend the automatic feature recognition process to chromospheric spectroheliograms (K3 and H-alpha) as well. More details can be found in http://www2.uninova.pt/ca3/en/project_COSIS.htm.

1. HISTORICAL BACKGROUND

Since 1926 full-disk spectroheliograms have been routinely taken in Coimbra Observatory in the Ca II K-line (K1 and K3); in 1990 started regular observations in the H-alpha line; in 2002 began digitalization (backwards) of our collection of more than 30000 solar images and also started colaboration of A. Garcia with M. Klvaňa (Astronomical Institute of CAS, Ondřejov, Czech Republic) to install a CCD camera as a recording equipment; in 2005 started the project COSIS (Coimbra Observatory: Solar Information System); in 2007 will start regular observations with videospectroheliograph of the OAUC in Coimbra.

2. OBJECTIVE OF THE PROJECT

The main objective of the project is:
1. to develop a software tool for automatic image processing and feature recognition of sunspots (Ca II K1), chromospheric plages (Ca II K3), and filaments (H-alpha) for usage by astronomers and other interested parties;
2. to process huge amount of images to enable to study temporal evolution of solar activity;
3. to compare criteria of feature recognition with other standards (eventual creation of a special standard).

The overall expected result for this project is to create a datacenter in the Coimbra Astronomical observatory, for storage and manipulation of solar data, extracted from the rich heritage of existing images.

The COSIS prototype to be developed integrates the following computing key technologies:
- *Decision support oriented database*
- *Image/feature recognition techniques*

3. AUTOMATIC DETECTION OF ACTIVE REGIONS AND INDIVIDUAL FEATURES IN SOLAR IMAGES

3.1 Sample spectroheliograms

At this stage of the project (till December 2006) only automatic image processing of sunspots is being performed (Fig. 1).

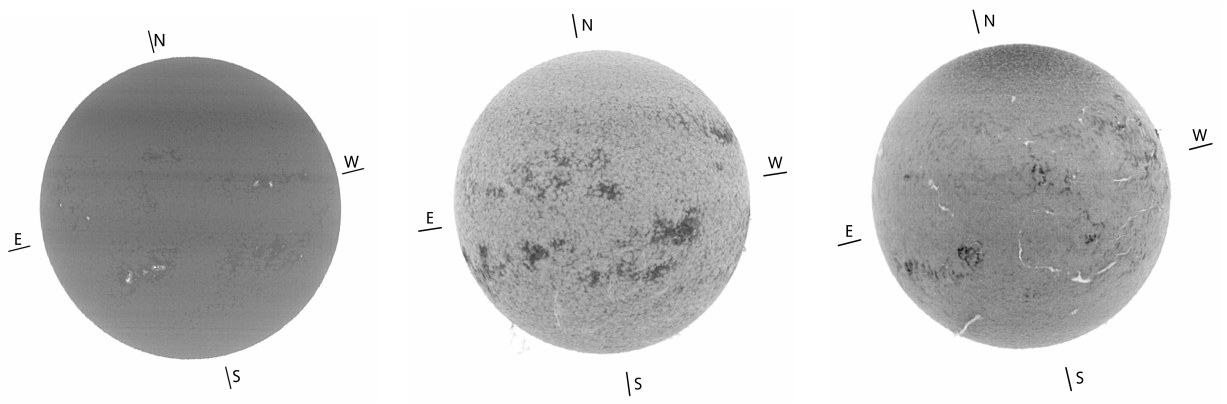

Figure 1. Sample spectroheliograms

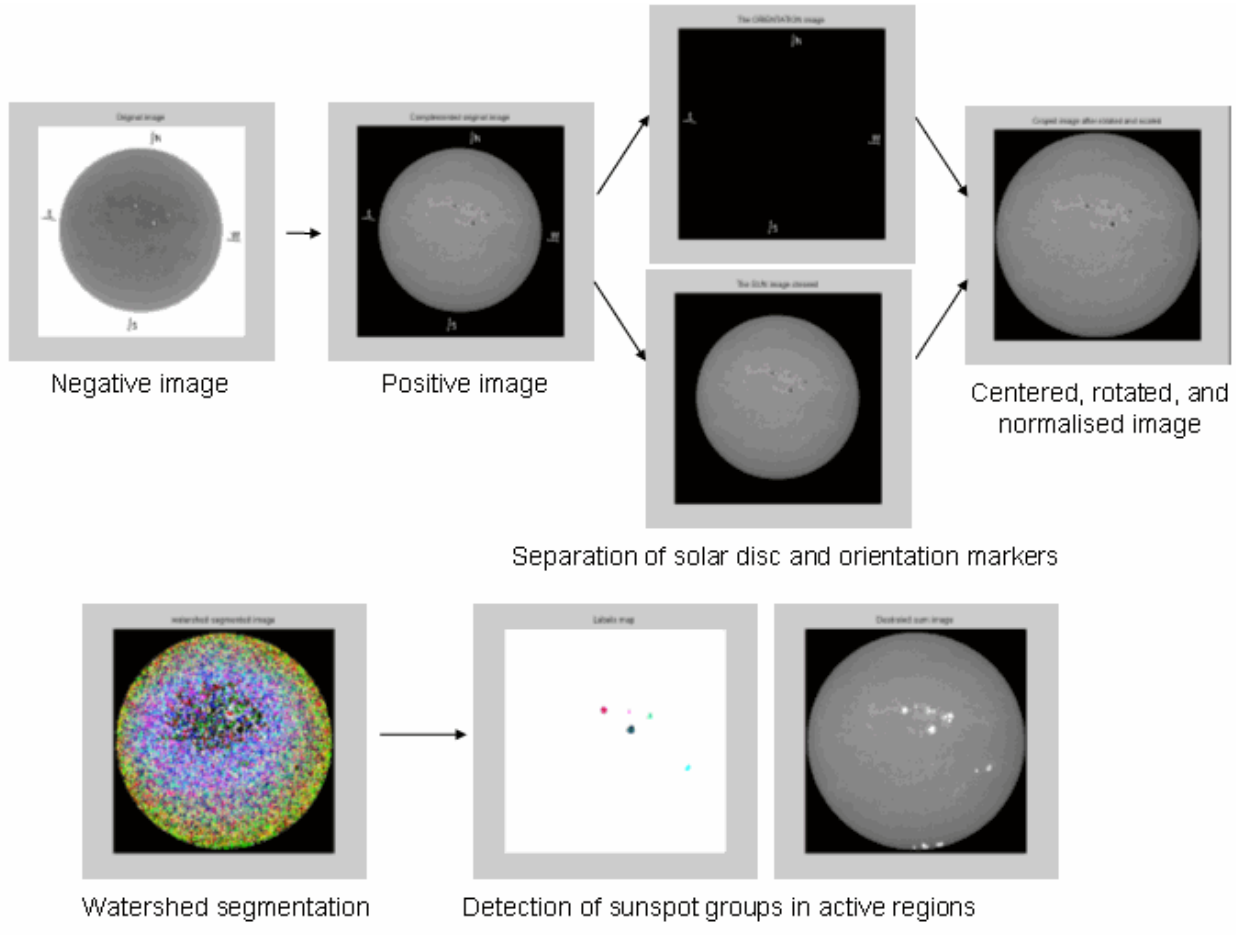

Figure 2. Detection and area estimation process.

3.2 Example of detection and area estimation

The software is divided in three steps. The first step consists of a pre-processing analysis of the images in order to create a standard orientation and dimension of the solar images, to achive a centered, rotated, and normalised image. The second step starts with a standard solar image and creates an image with the sunspots highlighted on it. The third step consists on counting and maping all the detected sunspots. After the solar image normalization the next step is the sunspots detection (Fig. 2).

3.3 Watershed based colour image segmentation technique

Image segmentation is an essential process for most subsequent image analysis tasks.

- Watershed transform is built by implementing a flooding process on the solar gray-tone image that identifies the most active areas on the solar image and delimits the area that is related with each sunspot.
- Because this segmentation process often produces significant over segmentation we developed a merging algorithm that combines compatible areas in the watershed segmented image reducing the number of false splitting borders.
- The selection of the areas found on the segmented image is done based on a set of rules that weight different factors such as area, gray level and form factor in order to find only the relevant spots and discard all the non-significant areas found by the watershed process.

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After the solar image normalization the next step is the sunspots detection. The software detects individual sunspots (not sunspot groups) and total area of umbra and penumbra (U+P) is estimated. The watershed transform divides the solar image into small areas. These areas receive a label depending on its grey level, meaning that the darkest areas are possible sunspots. The areas are labelled from 1 to a maximum of areas defined (the area with the darkest grey level is labelled with 1). For each identified sunspot its position, area in pixels and in MSH (millionths of the solar hemisphere) is determined and available at the webpage. The area (in pixels) is multiplied by mean greyscale intensity of corresponding watershed label. This resulting value is used in further tresholding process. The darkest and considerable big areas are set to 1 (black), identifying a possible sunspot. The area in MSH is corrected for foreshortening (sphere-to-plane projection)We decided to omit the spots of corrected sunspot area being smaller than 6 MSH to avoid eventual consideration of large pores as tiny spots.

3.4 COSIS Dialog Page

The COSIS interface (Figure 3) is available at http://cosis.uninova.pt . In this page one can choose particular observation for certain limits of date and hour (initial/end date or hour), sunspots number, position, area of sunspots. The second level page (resulting page) shows then available observational material for the selected criteria such as number of results (how many images fulfill the criteria), date of the photo, time of the photo, number of sunspots in photo. Clicking on "Click here for image details" it will open the 3rd level page with processed images including also information on group number, X/Y position, area (MSH), area (pixels). The resulting images for the specific date of 2 June, 1981 are shown in Figure 4.

Besides the sunspots features the file containing information of solar image (name, format, date and hour of the image) is generated as well.

Project Team

The project team is composed by astronomer/solar physicist and computer science researchers from two institutions: the Coimbra Observatory, Santa Clara, Portugal and UNINOVA-CA3, Campus FCT-UNL, Caparica, Portugal.

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Recently also started cooperation with Virtual Observatory Alliance - http://www.ivoa.net and the Sunspot Index Data Center (SIDC) - Solar Weather Browser project, Royal Observatory of Brussels, Belgium - http://sidc.oma.be/, and the Belgium site already includes some images from Coimbra arquive.

Acknowledgements

The project is financed by FCT, MCTES, Lisbon, Portugal: POCTI-CTE-AST/58333/2004.

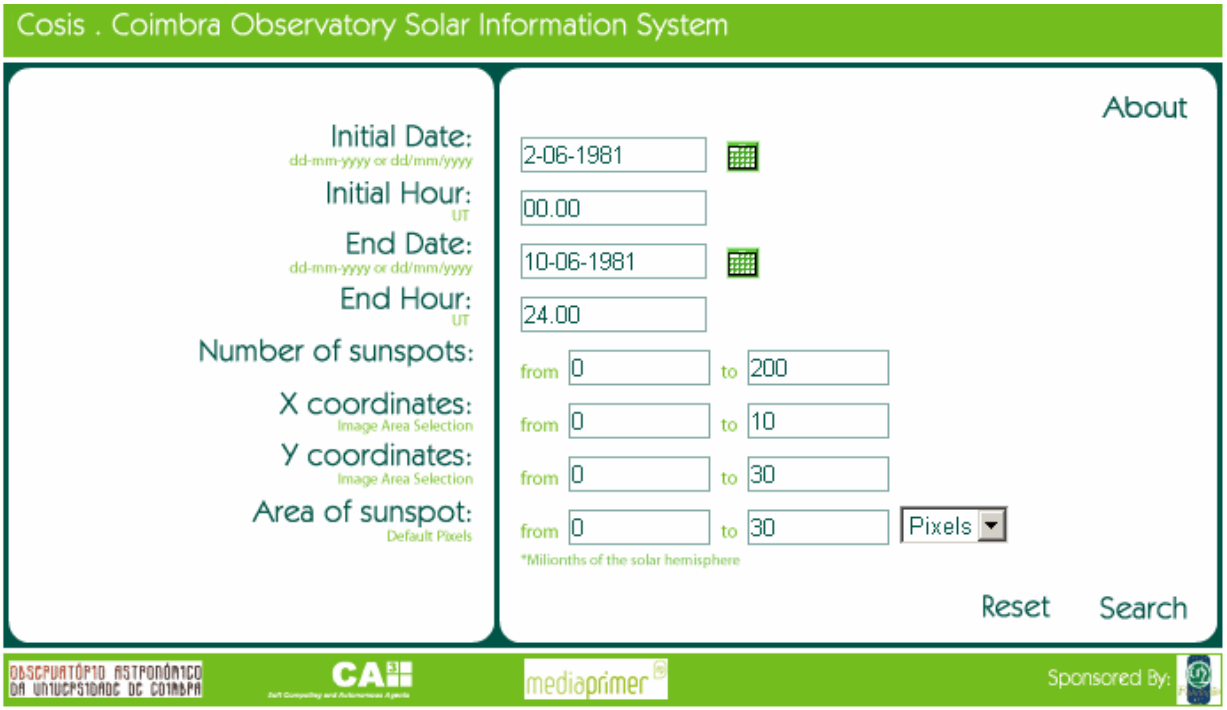

Figure 3. Interface of the COSIS webpage.

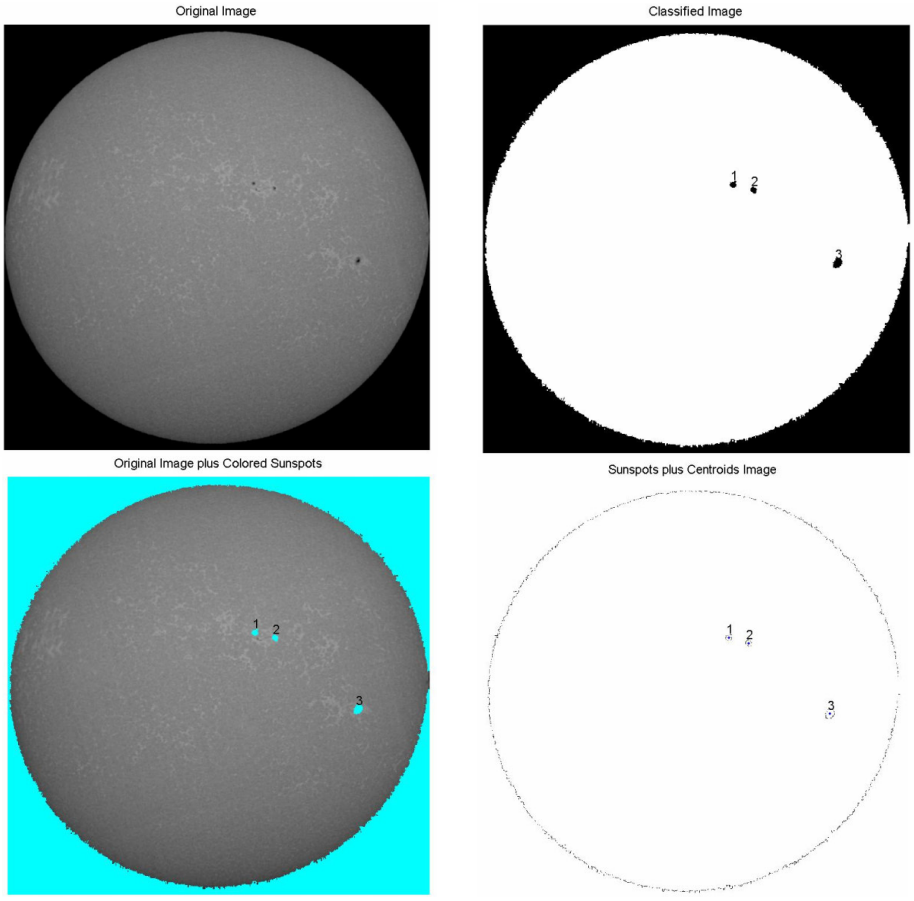

Figure 4. Four types of images are presented for each selected observational day in the image details: 1. original spectro-heliogram (upper left panel), 2. recognized sunspots - original image plus colored sunspots (lower left panel), 3. classified image – sunspots (upper right panel), 4. sunspots and centroids image (lower right panel): 2. júna 1981.