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Detecting coronal holes using a wavelet based noise reduction technique and image segmentation

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Coronal holes are regions of the solar corona magnetically open to interplanetary space that can be observed in several wavelengths such as X-ray, EUV or HeI 1083 nm line. The role of coronal holes and their variations in size and shape has recently been suggested to be important in the study of the solar- terrestrial relationship. The solar origins of geomagnetic storms seem to be associated to eruptive events observed in the solar corona adjacent to coronal holes. These transient changes in their geometry are suggested to be a cause of destabilization of the underlying coronal magnetic field. The accumulation of more than 10 years of solar full disk X-ray images with good spatial (<10") and temporal (<1 hr) resolution with the Soft X-ray Telescope on the Yohkoh spacecraft now gives us the opportunity to examine coronal hole boundaries in some detail and to address the recent ideas about coronal magnetic reconnection. Hence, precise determination of coronal hole boundaries as observed in X-ray solar images requires a high degree of accuracy in order to analyze their evolution in association with eruptive events. An object can be easily detected in an image if the it has sufficient contrast from the background. We use a wavelet based noise reduction, edge detection and basic morphology tools to detect coronal holes observed in X-ray solar images. The process includes the following steps: (1) The contrast of the objects is enhanced using a wavelet based noise reduction technique; (2) The image is rescaled so that it covers the entire dynamic range; (3) Since the objects to be segmented differ greatly in contrast from the background image, the changes in contrast are detected by the Sobel operator, which calculate the gradient of an image and creates a binary mask using a specified threshold value. (4) The gaps observed in the lines surrounding the object in the gradient mask are filled through a dilation of the image using a vertical structuring element followed by a horizontal structuring element. (6) The interior gaps observed in the dilated gradient mask are filled. (7) Any objects that are connected to the border of the image or that have a small area are removed; and, (8)finally, in order to make the segmented object look natural, we smooth the object by eroding the image twice with a diamond structuring element. Using this technique it is possible to detect successfully coronal holes observed in X-ray solar images and to determine accurately geometric parameters such as area and perimeter.

Keywords: **coronal holes**, **image processing**, **corona**

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