Statistical Challenges in 21st Century Cosmology
Proceedings IAU Symposium No. 306, 2014
A. F. Heavens, J.-L. Starck & A. Krone-Martins, eds.

doi:10.1017/S1743921314010874

Application of Statistical Methods on Automated Recognition of Solar Activity Phenomena and Analysis of Their Correlation

Ganghua Lin

Key Laboratory of Solar Activity, Chinese Academy of Sciences
National Astronomical Observatories, Chinese Academy of Sciences
Datun Rd.20A, Chaoyang District, Beijing, China
email: lgh@bao.ac.cn

Abstract. The recent immense volume of observation data has urged us to recognize solar features and to analyze their correlation with automation methods, and many of these automation methods are closely related to statistical methods. Author investigations the extensive literatures to sum up the function of statistical methods and their advantages in recognizing automatically solar features and analyzing their correlation. The review lists the results and summarizes conclusions of the investigations. The results and conclusions will be helpful to promote the further automation processing.

Keywords. solar feature, recognition, automation, methods: data analysis, statistics

1. Introduction

The solar features conclude flare, filament, coronal, and so on. On one hand, the further investigation of these solar features is of particular importance in studies pertaining to space weather. On the other hand, with the improvement of temporal and spatial solution, the volume of observation data has been increased greatly, and that the automation method raise the time efficiency of data process. So in recent years, The study of methods on the automation recognition of the solar features and the analysis of their correlation have been lasted.

2. Review

We do the investigation on the automation process method of solar features. The investigation results are put into table. The table mainly illustrates corresponding relationship between these recognized objects and adopted technology methods, recognition ratio or distinguishing features of these methods. The table also illustrates the application of statistical method in solar features recognition and their correlation. In the table or Figure 1 (Fig. 1), method means the method of recognition, object means recognized solar features. From the table, we learn that these solar features have been recognized automatically, for example, active area, active area properties, quiet area, magnetic field inversion-line, sunspot, sunspot group, facular, flare, flare properties, filament, filament properties, coronal faint variable microwave emission sources, coronal information on transverse and longitudinal wave, coronal Moreton (EIT) waves and propagating EUV dimming, signatures of wave and oscillatory processes in the solar corona, classification of coronal holes and filaments, solar coronal magnetic loops, CME classification, etc.

method	object	Recognition rate
SVM, MLP, RBF. Ming Qu, et al (2003)	flare	96.7%,94.2%,95%
an artificial neural network (ANN), V. V. ZHARKOVA, et al (2005)	Filament	82.5%
Image processing		
enhancement, segmentation, pattern recognition, and mathematical morphology.	Filament, Ming Qu et al, (2005)	Small filament:75%
An intensity filtering threshold value is used for detecting sunspots.	sunspot, faculae, and active-region detections, Colak and Qahwaji, 2008. Colak et al, (2011). Colak and Qahwaji, (2009).	The ASAP tends to detect small sunspots, which can be classified as pores. This is useful especially when grouping and classifying sunspots.
Using edge-detection methods, morphological operations.	Sunspot, Zharkov S. I.,et al, (2005)	95 to 98%
morphological analysis and intensity threshold	Active area, Jie Zhang et al.,(2010)	
A combination of image-processing techniques to determine the boundary of an AR. Using a gaussian kernel to identify potential features.	tracking active area, extracting characterise, Higgins et al.,(2011)	
enhancing their contrast	Classification of Coronal holes and filament, Isabelle F. Scholl, (2007)	
Bayesian spectral analysis of time series and image filtering.	solar atmosphere oscillation, J. Ireland et all,(2010)	
Wavelet Transform	Solar Coronal Magnetic Loops, S. Biskri, (2010). CME classification, D. I. González-Gómez et al, (2010).	it has successfully highlighted loop structures on the TRACE telescope images, without losing an appreciable amount of pixel based loop information.

Figure 1. The application of statistical method in solar feature recognition and their correlation.

In the table or Figure 1 (Fig. 1), the methods are mainly: supervised learning, image processing, Bayesian spectral analysisis, and Wavelet Transform. We learn that among the methods, the method of morphological analysis and intensity threshold is used for detecting small, large features and extracting properties, for example, active area, quiet area, sunspot, flare, filament, coronal dimming, etc. And the method of supervised classification is used for separating main identified object from background and misunderstood objects, for example,sunspot and filament. The wavelet transform is used for structure change, for example, solar coronal magnetic loops, CME. Bayesian spectral analysisis used for process of time series.

References

Biskri, S., Antoine, J.-P., Inhester, B., & Mekideche, F. 2010, *SoPh.*, 373, 385
Colak, T. & Qahwaji, R. 2008, *SoPh.*, 277, 296
Colak, T., Colak, Tufan, Qahwaji, Rami, Ipson, Stan, Ugail, & Hassan 2011, *Advances in Space Research*, 2092, 2104
Croat, T. K., Stadermann, F. J., & Bernatowicz, T. J. 2005, *ApJ.*, 631, 976
Gonzlez-Gmez, D. I., Blanco-Cano, X., & Raga, A. C. 2010, *SoPh.*, 337, 247
Higgins, P. A., Gallagher, P. T., McAteer, R. T. J., & Bloomfield, D. S. 2010, *Advances in Space Research*, 2105, 2117
Ireland, J., Marsh, M. S., Kucera, T. A., & Young, C. A. 2010, *SoPh.*, 403, 431
Isabelle, F. Scholl & Shadia Rifai Habbal 2007, *SoPh.*, 403, 431
Lodders, K. & Fegley, B. 1998, *Meteorit. Planet. Sci.*, 33, 871
Qu, Ming, Shih, Frank Y., Jing, Ju, & Wang, Haimin 2000, *SoPh.*, 157, 172
Qu, Ming, Shih, Frank Y., Jing, Ju, & Wang, Haimin 2005, *SoPh.*, 119, 135
Ott, U., Altmaier, M., Herpers, U., Kuhnhenn, J., Merchel, S., Michel, R., & Mohapatra, R. K. 2005, *Meteorit. Planet. Sci.*, 40, 1635
Zhang Jie, Wang, Yuming, Liu, & Yang 2010, *ApJ.*, 1006, 1018
Zharkova, V. V. & Schetinin, V. 2005, *SoPh.*, 137, 148
Zharkov, S. I., Zharkova, V. V., & Ipson, S. S. 2005, *SoPh.*, 377, 397