

# An intelligent method for solar flare observation

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**Abstract.** To capture the fine structure of the flare kernel during its explosive phase, we design a real time flare onset detecting algorithm named Near Saturation Area Threshold(NSAT), And an automatic CCD parameters control algorithm for the observing software. All the data from CCD, 48f/s, could be saved to the hard disk, and the GPS time of the flare onset also be saved in the log. These methods could avoid the data overflow and grab the fine structure data of the flare kernel. The simulation experiment works well and the software will be put into use in Huairou Solar Observatory soon.

**Keywords.** flare, intelligent, detection, automatic

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## 1. Introduction

Flare is a fascinating phenomenon on the solar surface, the typical feature of an H $\alpha$  solar flare is its fast increase of intensity, commonly it could increase from several to tens of times of the average value. There are lots of researches about solar flare, but we know little about its explosive phase, because its structure evolution and intensity increase are very fast. The routine H $\alpha$  observation has two obvious shortcomings: 1)Judgement far behind the flare onset, means key data lost; 2)Data overflow, means no structure could be identified in the flare kernel. Solar physicists believe the explosive phase of a flare holding the 'key' to understand it. So we developed this system to look for it.

Many efforts had been made to try to grab high temporal resolution H $\alpha$  flare data, for example, Big Bear Observatory had made a system could record data at 30f/s, with 15s interval for every group of data(Wang H.(2000)); Purple mountain Observatory had made a local H $\alpha$  data record system,which could grab data at 25 f/s(Ji H.S.(2004)); Huairou Solar Observatory had made a system could record full disk H $\alpha$  data at 48 f/s, with GPS stamp(Hu X.H.(2006)). All of these systems had got higher frame rate, but they paid little attention to the problem of data overflow.

At the same time, many intelligent methods for flare data recognition had been developed. A.Veronig *et al.* 2000) presented a recognition method based on area and edge analysis; M.Temmer *et al.* 2001) presented an analysis about the statistical features of the flare; Borda *et al.* 2002) present a recognition method based on NLP; Qu M. *et al.* (2003) presented a recognition method base on SVM. All of these work had got some successful results, but they are all post data process methods.

In our system, we designed a Near Saturation Area Threshold(NSAT) algorithm for real time flare onset detection and an automatic CCD parameters control algorithm, so as to get high temporal and spatial resolution data of the flare kernel.

## 2. Hardware

CCD: ImperX 1M48, 1004\*1004,7.4\*7.4(um); Grabber: Xcelera-CL PX4 Dual from Teledyne DALSA INC; Data disk: RAID0 4\*7200 r/m; Max data speed of the CCD = 48\*1K\*1K\*2 = 96MB/s; Host Computer: DELL T7500

## 3. Software

The observing software is programmed by VS.NET, including the SDK of the grabber and some algorithms designed by ourself.

Area size is one of the most important parameters of the radiation scale of a flare. According to the international optical flare classification standard, optical flare is classified into 5 classes, for the smallest one the area of its max size is less than ten thousandth of the half solar disk. In our system, the size of the CCD is 2048\*2048 and its a little larger than the solar disk, so in order to detect the smallest flare the threshold of the flare area should less than  $((2048*2048/2)/10000)$ , about 200.

Otherwise, from the statistical results of Huairou H $\alpha$  data, we found the saturation pixels number of B Class is about 100 pixels, C Class is about 200, M Class is more than 1500. As our principle of algorithm design is 'Misjudge better than Missed'. So, according to the statistical results and the optical flare classification standard, we chose the intensity threshold 4090, the area threshold 225. With these threshold and a matrix narrow algorithm we could detect C or S class and above flares in real time.

To capture the evolution detail of the flare kernel, detect the onset of the flare in real time is the first step. Then the observing software changes the CCD parameters(such as exposure time, gain) according to the flare detection automatically, so as to avoid data overflow.

## 4. Simulation Experiment and Results

Experiment: Under the same conditions, adjust the light of the electric lamp from dim to bright, grab the data from the CCD, directly saved and intelligent processed results are compared. Parameters: Simulation time: 16 s (simulate a flare); Frame rate: 48f/s; Data record: real time recording all data from the CCD.

Results: Data recorded directly, the kernel of the 'flare' is overflow; Data recorded with detection and automatic control algorithm, the structure of the 'flare' kernel is kept well.

What's next: 1)Try higher frame rate and lager CCD or bilinear CCD; 2)For higher speed, Cloud storage could provide more; 3)Joint observation with other telescopes.

## 5. Acknowledgements

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