Improvements of the auto-detection algorithm in the MAXI Nova-Alert system and on-line stored data processing

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Abstract

We have developed the MAXI Nova-Alert system in order to detect transient objects. The system has successfully detected a number of transient objects/phenomena since MAXI began observation. The system is composed of the Nova-Search system and the Alert system. In this study, we improve the detection algorithm of the Nova-Search system. We have introduced a slide-bin window to reduce the effect of binning time series data, and to decrease the detection limit of intensity variability. Another improvement is data processing of stored data in addition to real-time data. This increases the amount of the processed data, i.e., the number of burst/flare detection, by 20 - 30 %. The improved system has worked since December 16, 2010. We are reanalyzing archival data using the improved and optimized system, because we did not search transient objects systematically for the first four months.

Key words: system: detectors - X-rays

1. Introduction

MAXI (Monitor of All-sky X-ray Image) was installed on the ISS (International Space Station) on July 25, 2009. The main subject of MAXI is to discover transient objects. We have developed the MAXI Nova-Alert system in order to detect transient objects (Negoro et al. 2010). The system is composed of the Nova-Search system and the Alert system.

Fig. 1 shows data-flow from MAXI to the system. MAXI observes all-sky and sends observed data to the ground software system at TKSC. There are three data paths from MAXI to the ground software system. Data sent in real time are called real-time data. When the network between MAXI and the ground is disconnected, data are once stored in the buffer called HCOR (High Rate Communication Outage Recorder) on the ISS, and sent to the ground when the network is available. The stored data are called COR data. Data sent to the ground are stored into database called DARS (Data Archives and Retrieval Sub-system) and MAXI-DB (MAXI database). If data loss occurs in the MAXI-DB, the data are resent from the DARS. The data is called playback data.

The Nova-Search system analyzes and draws receiving data in real time. If the system detects intensity variability over a threshold, it sends data of the event to the Alert system (Suwa et al. 2011). The Alert system checks whether the event is significant. The system uploads information of the event to a web page called Flash Report. If the MAXI team confirms that the event is a real transient event, alert e-mails are sent to the world.

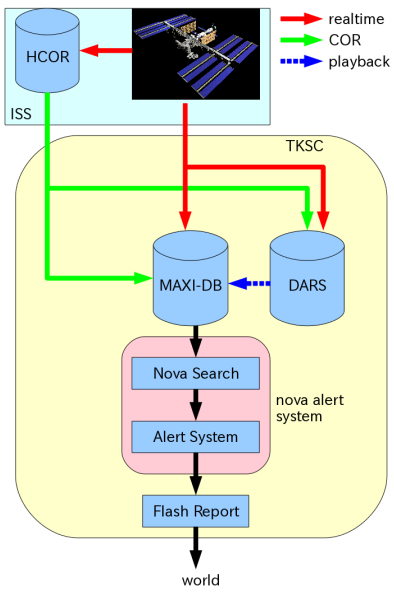

Fig. 1. Data-flow from MAXI to the Nova-Alert system.

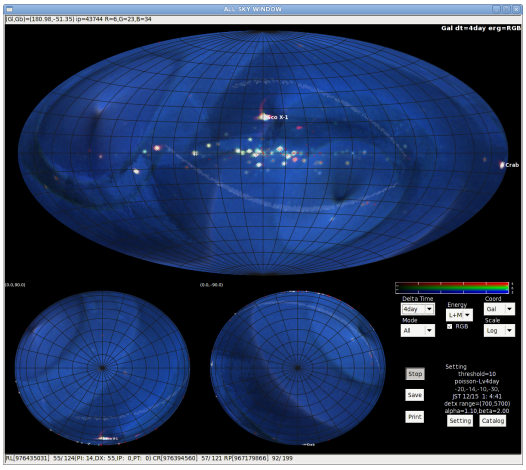

Fig. 2. All sky image window of the Nova-Search system

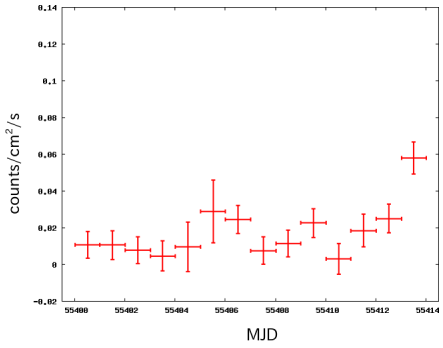

Fig. 3. An example of a light curve produced by the Nova Search system in each spherical bin.

2. Nova-Search system

The Nova-Search system analyzes time series data and draws an X-ray map image on a monitor in real time. Fig. 2 shows an all-sky X-ray image window of the Nova-Search system. The system analyzes time series data in each pixel for each energy band and each integral time (Negoro et al. 2010). The pixel has equally divided spherical surface partitioned by the HEALPix library (Gorski et al. 2005).

Fig. 3 shows an example of a light curve of the system. The system calculates an expected value for the latest time-bin from past data. The system compares the expected value with the latest time-bin value. If the later value is higher than a threshold calculated from the expected value, the system sends data to the Alert system.

3. Stored data processing

As mentioned in §1, there are three data paths from MAXI to the Nova-Search system. Real-time data account for about 70 - 80 % of the total data. COR data account for about 20 - 30 % of the total data. There are few playback data because playback data are not sent unless data loss occurs in the MAXI-DB.

Data through these paths are not sent in time order. The detection algorithm of the system to process all the data becomes complex because the system should sort data by observation time. The system had processed only real-time data till December 16, 2010 to avoid such complexity in data processing.

Here, we have vastly improved the system to process all the data. Fig. 4 and 5 show all-sky images before and after the improvement, respectively. It is recognized that the sky coverage in Fig. 5 is larger than that in Fig. 4. The difference between Fig. 4 and 5 is whether or not the system processed COR data. This increases the amount of the processed data, i.e., the number of burst/flare detection, by 20 - 30 %.

4. Slide Bin

The Nova-Search system analyzes time series data in various (1 s - 4 day) time-bins. There was a problem resulting from binning time series data.

Fig. 6 shows a schematic light curve of time variability. If the peak intensity is in the middle of the bin (Fig. 7), the system easier detects a transient object. The columns indicate X-ray intensity in time-bins. Intensity variability is clearly seen. In case, however, the peak intensity splits into two bins (Fig. 8), it becomes difficult to detect it.

Here, we have newly introduced a slide bin window which is free from binning the data (Fig. 9). The slide-bin is shown by the hatching area. The slide-bin is created using the latest bin and a part of the previous bin. An expected value of the slide-bin is calculated from data except the two bins used to create the slide-bin. Intensity variability becomes clearer than that in Fig. 8, and the system easier detects a transient event in any case by the slide-bin. It enables us to get rid of low statistical fake events, and to decrease the detection limit of intensity variability.

5. Future Work

We are reanalyzing archival data using the improved system. Especially, we focus on data for the first four months because we did not search transient objects systematically. Background counts had largely fluctuated during the observations, and the system often detects the background variability by mistake. We have to improve the system algorithm to consider the background variability to reanalyze archival data.

References

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Gorski K. M. et al., 2005, Ap.J., 622, p.759

Suwa, F. et al. 2011, (In this volume)

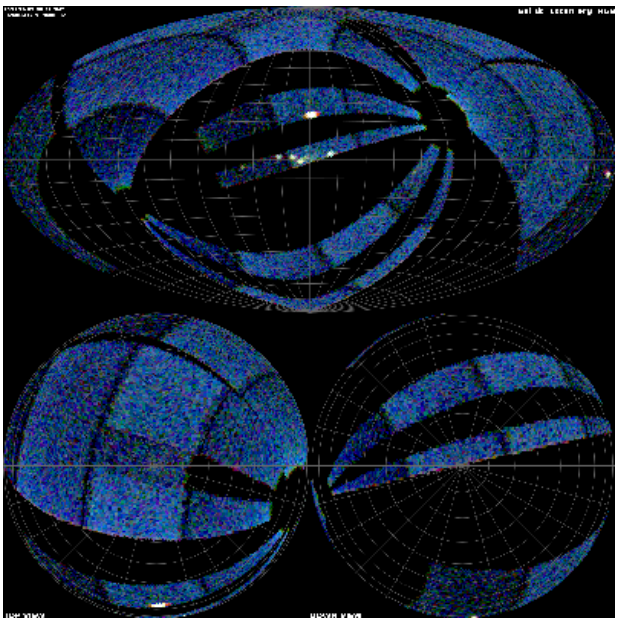

Fig. 4. (Before the improvement) All sky image using only real-time data.

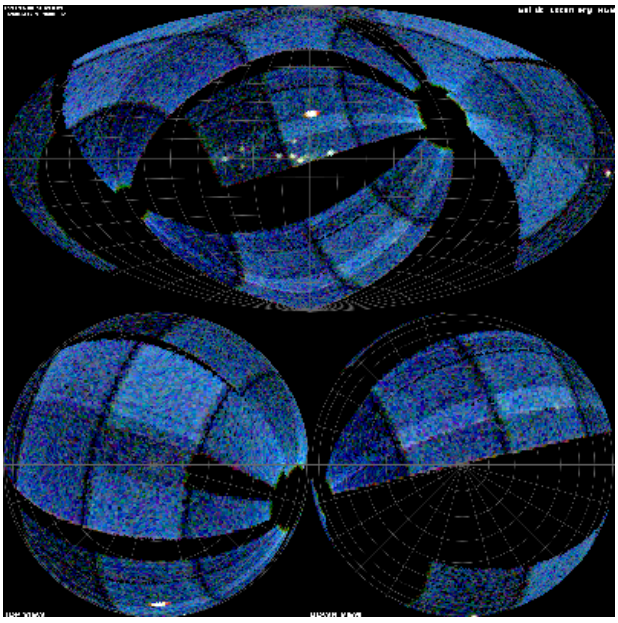

Fig. 5. (After the Improvement) All sky image using not only real-time data but stored data. The sky coverage in this image is lager than that in Fig. 4.

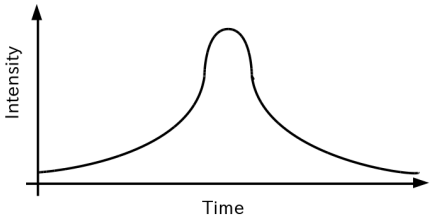

Fig. 6. A schematic light curve of time variability

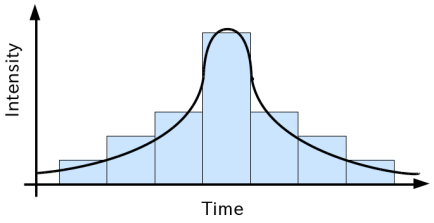

Fig. 7. If the peak intensity is in the middle of the bin, the system easier detects a transient object.

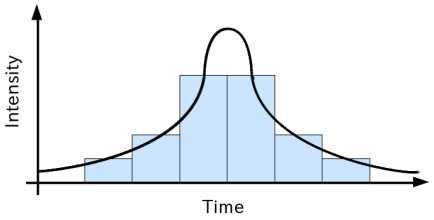

Fig. 8. If the peak intensity splits into two bins, the system becomes difficult to detect a transient object.

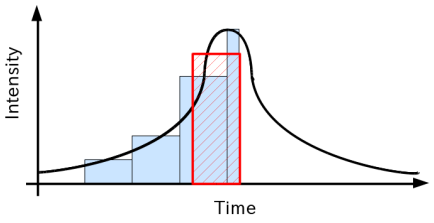

Fig. 9. Slide-bin. The slide-bin is shown by the hatching area. Intensity variability becomes clearer than Fig. 8, and the system easier detects a transient event in any case.