MAXI Simulator

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Abstract

We are developing the MAXI simulator, a software that generates fully simulated data of the X-ray cameras of MAXI in space. The MAXI simulator is utilized for the development and tests of various software supporting the MAXI mission, including the "nova search" program (Negoro et al. 2008). To generate realistic data, the simulator is designed to take into account detailed conditions on the ISS, such as the occultation of the sky by the sun panel, background, and response functions of the instruments. We code the program in C++ by introducing "classes" that have hierarchical and expandable structure. With this design, it provides a framework for satellite simulators. In this paper, we present the design and current performance of the MAXI simulator, and discuss the possibility of its application to other space missions.

Key words: MAXI: software — sensitivity: simulations — simulator

1. Introduction

The MAXI simulator is a software that generates fully simulated data of the X-ray cameras of MAXI by Monte Carlo method (we have newly developed the code based on the original version written by Drs. B.C. Rubin and W. Yuan).

Figure 1 is a schematic view showing the data flow of MAXI. The data are downlinked via network of NASA and JAXA, pass through the operation control system (OCS), and finally enter the MAXI database (MAXI-DB; Ishikawa et al. 2008). The MAXI-DB compiles the telemetry data into scientific data. The quick look system, nova search program, and public release system are located in the downstream of the MAXI-DB.

The simulated data can be input to the MAXI-DB with a file-format converter by adding dummy housekeeping data. Once these data are registered in the MAXI-DB, all the downstream systems can operate to them in the same way as to the real data. Thus, the simulator is utilized for the development and tests of various software supporting the MAXI mission, including the MAXI-DB itself, nova search program (Negoro et al. 2008), and so on. In addition, we can study the realistic performance of MAXI, such as the sensitivity limit as a function of exposure (see Ueda et al. 2008 and Hiroi et al. 2008).

2. The structure of the MAXI simulator

The MAXI simulator is written in the C++ language, which introduces the concept of object oriented programming (OOP) into C. In OOP, software is composed of "classes." A class is a set of two or more variables and functions called "members." One can "derive" new classes from one by inheriting their original properties. Different from Java, another OOP language, C++ enables us to call libraries written not only in C but also in Fortran. With this feature, we can utilize various scientific libraries, such as spectral models in XSPEC[1] .

Figure 2 illustrates the structure of the MAXI simulator. It has a hierarchical structure. There is only one manager class on the top, below which sub-manager classes are placed. The role of the manager is to conduct the process of simulations; it takes "abstract" data from certain sub-manager, and passes the data to another sub-manager. Each sub-manager class owns abstract detector classes. "Concrete" detector classes, which have response functions and generate real data, are "derived" from these "abstract" detector classes.

The MAXI simulator can work as a framework for general satellite simulators. It is very important for the design of the MAXI simulator to separate the detector classes into abstract and concrete ones. The concrete detector classes are located in the lowest level in the simulator. We can thus easily develop simulators for other

*1 http://heasarc.nasa.gov/docs/xanadu/xspec/

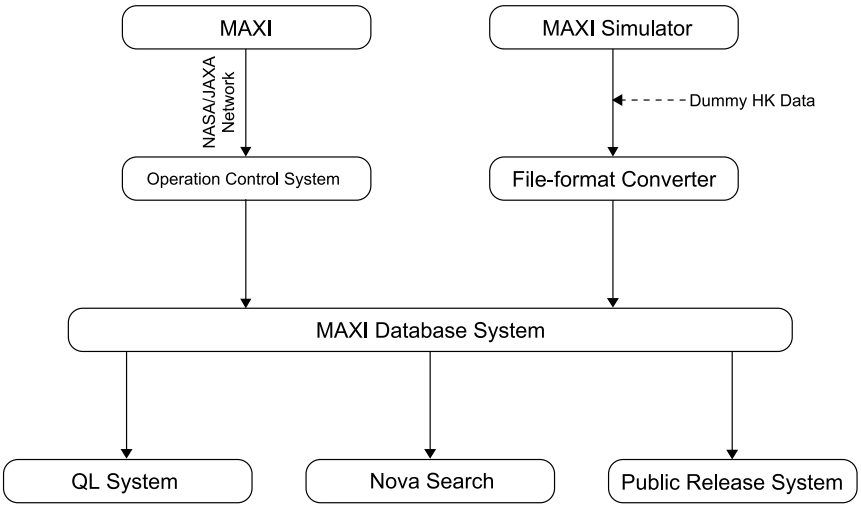

Fig. 1. The data flow of MAXI and the MAXI simulator.

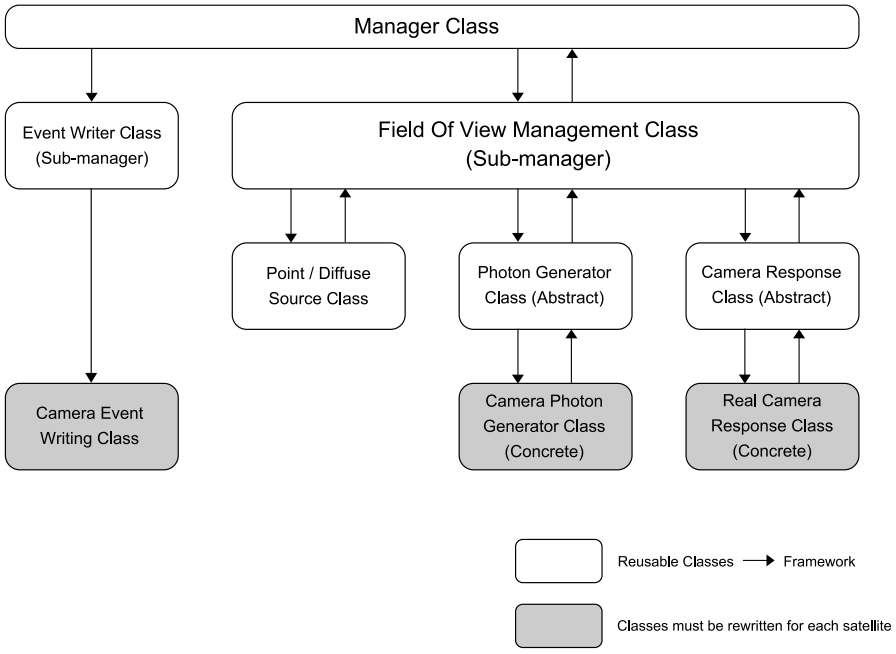

Fig. 2. The schematic structure of the MAXI simulator.

satellites just by replacing the concrete detector classes, keeping most classes of the MAXI simulator with the same structure.

3. The development status of the simulator and qualitative sensitivities of MAXI

The latest version of the MAXI simulator (Ver.6.3.103) can simulate both the Gas Slit Camera (GSC) and the Solid-state Slit Camera (SSC) events from not only point sources but also diffuse sources, although the detailed response function of the SSC is not fully taken into account. In the simulator, the image of diffuse sources (such as the cosmic X-ray background) are divided into meshes of equi solid-angle, with the HEALPix library[2] , and are treated in the same manner as for point sources. Although it is a general-purpose algorithm, this method requires much CPU time. To solve this problem, we introduce a multi-thread method based on OpenMP into the simulator. By using multi-core PCs, one can obtain the results 1.5–3 times faster than the case of a single-thread method.

Figure 3 is the result of all-sky simulations with GSCs, plotted in the Galactic coordinates. Here we input about 1700 point sources from the INTEGRAL General Reference Catalog (Ver.27)[3] . The non X-ray background are included. We excluded data when MAXI cannot perform observations due to the sun-angle constraint or in the South Atlantic Anomaly. Figure 3 shows the results with different exposures, 1-orbit (90 minutes), 1-day, 1-week, and 1-month, from the left top to the right bottom. It is clearly seen that the longer MAXI is exposed, the fainter sources MAXI can detect. A quantitative analysis of the sensitivity limits is reported by Hiroi et al. (2008).

4. Future work

The current version of the MAXI simulator does not consider the screening of the sky by objects on the ISS, such as solar paddles. We plan to implement this function in the near future to perform even more realistic simulations.

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*2 http://healpix.jpl.nasa.gov/
*3 http://isdc.unige.ch/index.cgi?Data+catalogs

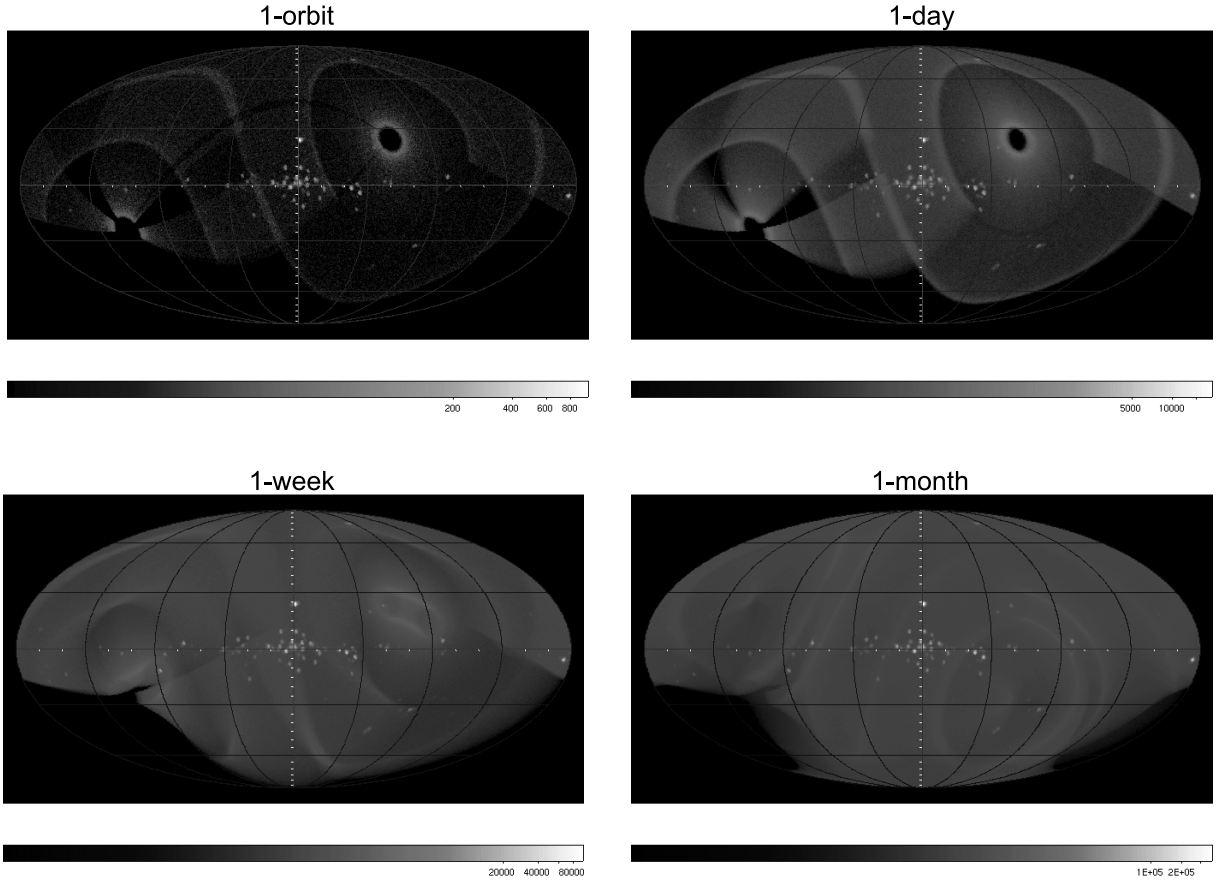

Fig. 3. The result of all-sky simulations with the MAXI simulator.