ICAT: a General Purpose Image Reduction and Analysis Tool for Robotic Observatories

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Summary. New technologies applied to astronomical facilities have allowed the development of fully automatically-controlled observatories. For an efficient operation, reliable and fast data calibration and analysis software is crucial to treat automatically the vast amount of images to be used in scientific studies. The IEEC Calibration and Analysis Tool (ICAT) software presented here has been developed as a tool for robotic observatories with the objective of managing astronomical images to extract relevant scientific information in real time. It has been implemented in a modular way to allow an easy use in combination with most CCD camera control software. ICAT is built on Perl and Unix shell scripts, for file managing, and it uses the NOAO PC-IRAF and Source Extractor (SExtractor) packages as image handling tools. Because of its modularity and design the software can be easily incorporated in the frame of a general observatory control system, under either batch or direct user control. All routines and products will conform to Virtual Observatory standards.

1 IEEC Calibration and Analysis Tool. General Description

ICAT's main objective is to provide a tool for fast and reliable calibration and analysis of astronomical images designed to be used in robotic observatories.

The software can be used in any robotic observatory just by modifying external aspects to adjust it to the general control system. Its general characteristics are: automatic management and treatment of FITS images, high accuracy photometric and astrometric data extraction and real time execution envisaged to be used in robotic observatories. The interface packages are changed when adjusting the external aspects of the software to the general control system or the detector control software for a specific observatory.

A description of the software's main design and implementation aspects is given in the following sections. A general use case diagram describing ICAT's functionalities can be seen in Fig. 1.

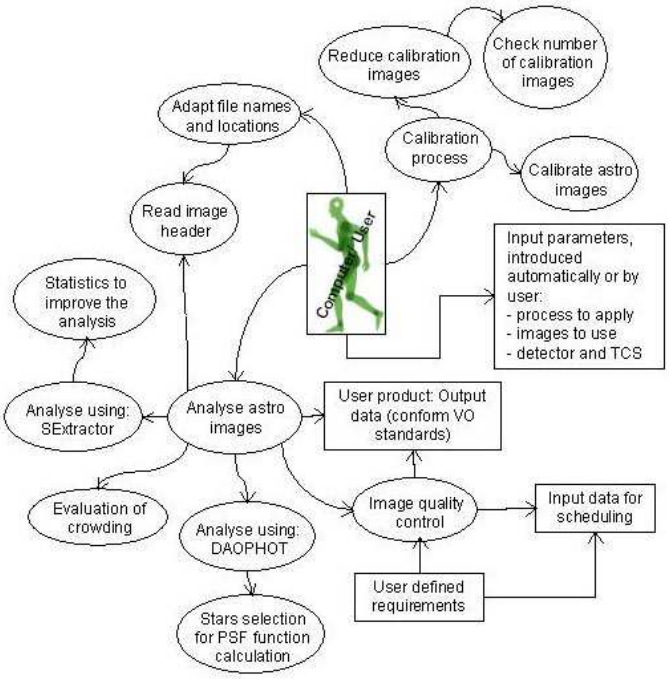

Fig. 1. Use case diagram describing ICAT's functionalities

1.1 Robotic observatories

The difficulty of extracting relevant information from the vast amount of images obtained in robotic observatories has motivated the creation of this tool. Although automatic execution is its main functionality, user-controlled execution is also available, enabling the controller to modify a few parameters to adjust the reduction process to different criteria. When doing the installation of this software, a few parameters must be set up according to the system: minimum number of calibration images to use, header keywords, analysis parameters (crowding boundary,...), etc. After that, the reduction is automatic. Two kinds of reductions are executed automatically:

On-the-fly reduction: done after each observation in order to identify if the image has the required quality; the obtained information is used by the scheduler programme to decide which object to observe next.

Final reduction: done during the day, includes obtaining a final calibration image before calibrating and analysing the astronomical images.

1.2 Managing astronomical images

ICAT is based on Perl scripting. Perl is a flexible and fast programming language that controls programme flux and manages image files. It is executed together with Unix shell and NOAO-IRAF scripts.

The initial process before treating the images is the modification of their locations and file names to give them a standard format with image date, filter (when required) and exposure time, type of image and type of file (raw image, calibrated image, data file,...).

Several checks, which are mainly based on the Perl scripting tool, are carried out during execution:

During calibration: number of calibration images (bias, dark and flats) to guarantee good photometry accuracy. When not enough calibration images are available, images from past nights are copied to the current night directory and used accordingly.

During analysis: It evaluates which areas have high crowding and changes between DAOPHOT PSF and SExtractor aperture photometry depending on the density of stars.

1.3 Reliable and fast data calibration and analysis software

Three packages are used for different purposes according to their capabilities: NOAO-IRAF, calibration and analysis software; DAOPHOT [1], reliable PSF photometry package; and SExtractor [2], fast and good precision analysis software, using flexible aperture photometry.

Calibration: NOAO-IRAF packages are used to combine raw astronomical images with processed bias, dark and flat images.

Analysis: Two different software packages are used depending on image crowding in order to obtain good photometric quality with a minimum time of execution. ICAT, after a fast analysis using SExtractor, defines a density function on each image and identifies the crowded areas. The DAOPHOT package is then applied to those areas to obtain PSF photometry using an improved selection of stars for the PSF matching function calculation. Non-crowded areas are analysed using SExtractor. Astrometric and photometric data for the totality of the objects in the entire image is then a combination of the data obtained with SExtractor and DAOPHOT.

1.4 Compatibility with most CCD camera control software

The initial procedure in image processing makes it possible to adapt images obtained with most CCD camera control software to ICAT. Small modifications need to be made to one of the scripts describing the header keywords that are relevant to compose the new file name. No further modifications are required because the FITS header parser will read all keywords necessary for the rest of the reduction.

2 Current status and future plans

Most ICAT's packages have already been completed. Several tests using astronomical images with different levels of crowding are currently underway in order to check the quality of the astrometric and photometrical data obtained with the analysis and to estimate the mean execution time per image. Once that process is finished, a final step on the development will be the creation of a user friendly web interface, before offering the software package to the scientific community.

References

1. P.B. Stetson: PASP 99, 191 (1987)
2. E. Bertin, S. Arnouts: A&AS 117, 393 (1996)