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THE GCS DATA PROCESSING KIT

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RESUMEN

Se describe a grandes rasgos el funcionamiento del paquete "Data Processing Kit (DPK)" que forma parte del subsistema de la "Data Factory" dentro del Sistema de Control de GTC. Mediante el uso de imágenes reales tomadas durante pruebas previas al commissioning del telescopio (correspondientes tanto a pruebas de la unidad de Adquisición y Guiado como a pruebas llevadas a cabo con el refractor que será empleado en los test de apuntado del GTC) se han comparado los resultados obtenidos con este paquete de procesado de datos con los obtenidos empleando rutinas más habituales basadas en IRAF, para verificar la fiabilidad y versatilidad de este subsistema.

ABSTRACT

As part of the GTC Control System (GCS) a data processing package is being developed. We will describe the perfomance of the Data Processing Kit (DPK), using real data obtained during the preliminary tests made prior to the commissioning of the GTC (both with a Refractor and the Acquisition and Guiding Camera). Some examples of the versatility of this pipeline will be shown. Comparisons with Data Reduction Packages that are more commonly used (e.g., those IRAF-based) have been made to show the DPK performance.

Key Words: **TELESCOPES**

1. DATA FACTORY AND DPK

The GTC Data Factory (DF), as the rest of the GTC software services are designed using an strict object-oriented approach and implemented in C++. This technique allows the existence of "layers" of software which represent different levels of complexity and abstraction, which eases and simplifies the implementation of data reduction pipelines (Reduction templates using the Data Factory Jargon).

The DF performs two sorts of data reduction, those which need to run in a real time (RT) enviroment, typically closing a control loop and the offline functionality ususally devoted to scientific data reduction.

From botton to top, the DF is organized in three software layers (see Figure 1).

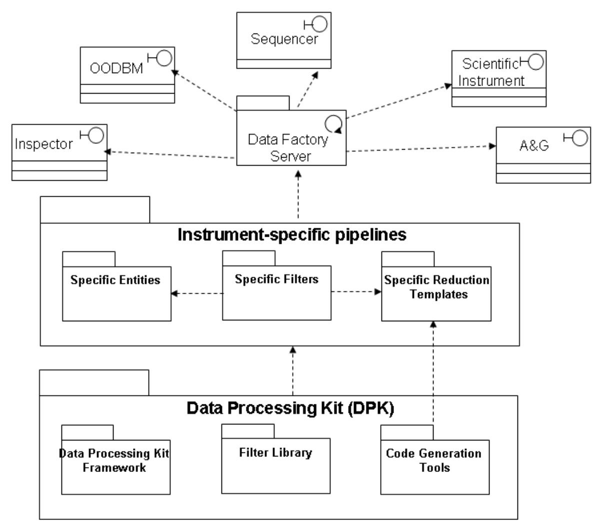

Fig. 1. Data Factory layered structure.

1.1. *The Data Processing Kit (DPK)*

The DPK is a software framework compose by those reusable elements used to implement the instrument-specific reduction templates. It also allows rapid building and prototyping of data reduction applications written in C++, encapsulating data reduction technicalities and thus allowing DPK users to concentrate on expressing data reduction procedures as directly as possible. Important effort has been invested in tracking errors along all the reduction steps. The DPK is composed by three modules:

- The DPK framework, that is composed by those entities which represent the fundamental concepts involved in any data reduction process, that is, the data and its associated errors.
- The filter library, that is composed by a series of multipurpose filters, which implement the

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most basic reduction proceedures as: cosmic ray cleaning, spectra extraction, flatfielding, error generation, basic arithmetical manipulations as well as data simulation capabilities.

- Code Generation tools, that contains utilities to quickly generate new types in the specific entities (see Figure 1) which are exclusive of the instuments and the generation of reduction template skeletons.

1.2. *The instrument-specific software*

The instrument specific software is developed by the instruments groups and include the classes and specific filters which are particular of the instrument data reduction. The reduction templates are implemented by means of a concatenated set of filters (both specific and generic), in such a way that each observing mode of the instrument is reduced in a predefined way by using those specific reduction templates.

Currently three groups are developing specific pipelines following the provided GTC framework:

- IAC group for the OSIRIS data pipeline.
- UCM group for the EMIR data pipeline (Gallego et al. 2003).
- LAOMP group for the EMIR simulator.

1.3. *The data factory server*

The Data Factory Server is responsible of integrating the DF in the GTC control system. It implements a CORBA interface (Penataro et al. 2000) allowing the access to the DF functionality by the other subsystemas. It main responsabilities comprises:

- Exporting an interface visible from the GTC graphical user interface (Inspector).
- Indentifying the incoming raw Frames to be reduced and retrieve all the necessary data of an observing mode.
- Retrieving from the Object-Oriented data base (OODB) the most recent calibration data.
- Instantiating and executing the appropiate Reduction Template.
- Storing raw and processed data in the OODB.

The final archive of GTC will contain a browsable list of observation products with utilities to export and send data to authors in common used formats (FITS, Virtual Observatory, etc.).

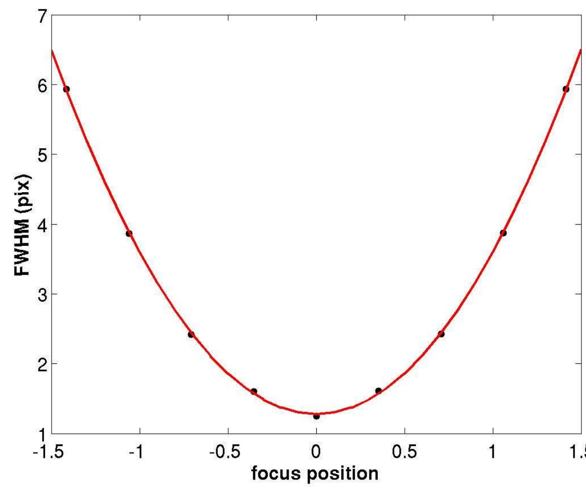

Fig. 2. Focus sequence obtained along the test with the refractor that will be used in obtaining the full pointing model of the GTC.

2. REDUCTION TEMPLATES DEVELOPED IN-HOUSE

The Reduction templates developed at the GTC Project Office are those pertaining to the ELMER instrument, the Acquisition and Guiding Camera and the Commissioning Instrument. In each case, the first part of any reduction is the so-called *basic reduction*, which is composed by: trimming, bias/dark subtraction, flatfielding, cosmic rays and cosmetic defects cleaning.

2.1. *Tests with real data*

2.1.1. *Refractor*

A small refractor will be mounted on the GTC for the calibration of the pointing and tracking of the telescope. It is expected this will be done at the end of October 2006, thus prepearing the GTC for the first light by the end of the year. DF pipeline for the refractor includes a basic reduction to determine focus, plate scale, limiting magnitude, orientation on the sky, find source positions in the image, etc., issues that must be quickly derived during the full commissioning of the telescope, at least at the very beginning, where several poiting models have to be calculated along the tests.

Comparisons with some pipelines based on standard IRAF packages show how the GTC DPK is reliable in deriving those quantities mentioned above but it is also much faster and precise than the traditional ones. As an example, in Figure 2 a focus sequence with nine images taken with the refractor at the Project Office is shown, with the best sec-

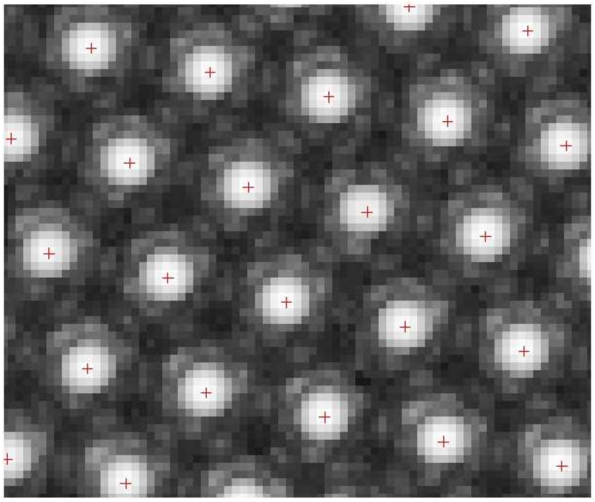

Fig. 3. Star detection as part of the Process Commissioning Frame reduction template.

ond order polynomial fit to the data. As a major achievement, the DPK implements a lot of interaction with several stellar catalogues (USNOB1, 2MASS, Tycho...) which adds a lot of versatility through the process. Also, all the packages are implemented within the GTC Control System, so an off-line reduction of the images is completely unnecessary.

2.1.2. *Acquisition and Guiding Camera*

The Acquisition, Guiding and wavefront sensing (AGWFS) pipeline has been developed with the same tools and software infrastructure that the scientific pipelines, a nove approach that has been possible thanks to the DPK and GTC control system felxibility and portability. While for acquisition and slow/fast guiding a basic reduction is needed, for the wavefront sensing data the reduction steps include basic reduction and the precise determination of the spot positions and errors, as the the images obtained are formed by a Shack-Hartmann wavefront sensor. Using a 2-D fitting procedure we have been able to compute very precise positions with typical errors of 0.03 pixesls, as tested by means of simulations. The resulting data is then passed to the Observing Engine which reconstruct the imcoming light phase and operates aver the available degrees of freedom of the optics to compensate the observed errors, thus closing the loop for active optics.

2.1.3. *Commissioning Instrument*

The commissioning instrument (CI) provides imaging and high resolution wavefront sensing capabilities. Thus, the reduction templates used to reduce this data are similar to those used by the AGWFS pipeline. Figure 3 shows the centroid determination for a frame taken with the CI detector and lenslet under laboratory conditions (Figure 4).

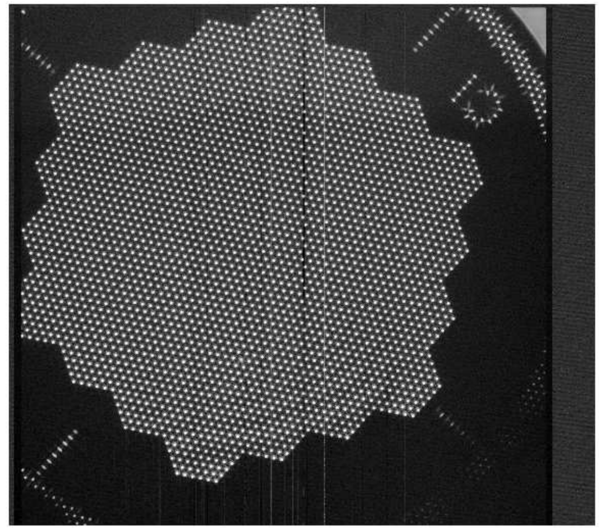

Fig. 4. Wavefront Sensing image taken with the Commissioning Instrument after the basic reduction of data.

The preliminary results with refractor and AG pipelines show that the DF is ready to handle the data gathered by the first test that will lead to first light of GTC.

3. CONCLUSIONS

The GTC telescope will have a complete and reliable set of scientific pipelines from first light. In order to support data reduction pipelines developed outside the GTC PO, a developing framework is provided and upgraded every 6 months to the instrument groups. The data reduction pipeline of the ELMER instrument is being developed within the GTC project office allowing not only a working scientific instrument at GTC first light but also reliable reduced data from the very beginning. The engineering data reduction requirements for acquisition, guiding and wavefront sensing will be satisfied using the same framework used for scientific data reduction.

We expect that the GTC DF will be a key tool which catalyze the GTC commissioning, allowing a quick scientific return and producing and mantaining an homogeneus data archive.

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