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ST–ECF Newsletter

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Software news

Standard Test Images

Test images are required frequently, both by the astronomer who requires a suitable test for envisaged software packages and by the algorithm developer as a benchmark for newly developed software. There appear, however, to be at present no easily available test images which can be readily dispatched to the general user. We are assembling a collection of test images

which can be used by both stellar and galaxy photometry packages. A number of major photometry software suites are of particular interest. These include those which are or will be supported in MIDAS, — INVENTORY and ROMAFOT; and others which have been widely used and/or extensively described in the literature, including DAOPHOT, COSMOS and FOCAS, cf., Murtagh & Warmels, "Photometric packages", (*Newsletter No. 7, May 1987, pp. 3–6*).

Over the next year, it is proposed to have analyses carried out by these packages on the same input images and the results made available. This should not only facilitate user choice of an appropriate tool but also lead towards standardised input/output and intermediate file formats, naming conventions and documentation among the various available systems. Many more personal packages have been described at one time or another: in the event of interest in comparing the output from these with others and having the results circulated and discussed, please make contact with the authors of this article.

The collection of test images, kept deliberately small, includes at present the following:

A uniform field in Fornax (two colours).

A very crowded field, 47 Tucanæ (NGC104), centre (two colours)

A not very crowded field of a non-central part of the foregoing.

A cluster of galaxies.

Another star/galaxy image with non-uniform background and defects.

Additionally, the inclusion of some simulated WF/PC images is planned. In accordance with requests and further discussion on this issue over the coming months, other images may be added or some of the above images may be superseded.

Fionn Murtagh and Rein Warmels (ESO)

Starfield simulation package

MIDAS contains many capabilities for the addition of noise and background features to existing image frames (*not during normal reduction we hope! — Ed.*). Lacking to date, however, has been the availability of a sophisticated stellar image simulation capability. This is necessary for testing photometric packages and for examining artificial images as a preliminary to the use of new instrumentation or software. In real observations, the precise properties of the "input" are necessarily unknown. Evaluation of the real performance of analysis software is therefore impossible if only real observations are available. The need to evaluate software using precisely specified input is of greatest interest when two or more similar packages produce different results.

A stellar image simulation package is currently under development, and is foreseen for release with the January 1988 version of MIDAS. Special attention has been given to allowing the user to define the characteristics of the image, including coordinate positions, the point spread function (PSF) to be used and intensities of the objects. In addition, efficiency is of prime importance since many thousands of stars may be required in one image.

Among options available are the generation of object coordinates according to various random distributions, including uniform and Gaussian functions and the King profile for globular clusters. A luminosity function is available which results from empirical work of Sandage on M3. The user may also define positions and intensities independently of these options. A table of radial intensity values is used to specify the PSF, thereby for example allowing expected HST possibilities. Since all user-specified options can be from MIDAS tables, it will also be possible to use the results obtained from photometric packages applied to real data. Hence images can be constructed which closely resemble the real ones. This allows the performance of the photometric package(s) to be assessed.

In the simulation package, a very small number of simulated stars are PSF–mapped individually with great precision and stored in a library; these, then, are mapped into the master image, which leads to considerable gains in computation time over alternative approaches.

At present, uniform and globular cluster fields are foreseen. Simulated images may be built up to produce much larger images, and sloping and noisy backgrounds added.

Fionn Murtagh and Dietrich Baade

Image sharpening update

In July 1987, A. Llebaria visited the ST–ECF to install the TRIM package, developed at the Observatoire de Marseille, (see *Newsletter No. 7, May 1987*). Although work to integrate fully the software into MIDAS is still in progress, (final testing, documentation, help facilities, etc.) it is already available for use.

TRIM stands for Time Resolved Imaging Mode, available on the ESA Photon Counting Detector (PCD; see *Newsletter No. 2, June 1985*). Using a *photon tagging* technique, many short exposure images are recorded instead of one long exposure image. The exposure time is shorter than the time scale on which one expects atmospheric effects and telescope pointing errors to play a rôle. The correction consists of a recentering of many short exposure images, and a final addition of the recentered images. Using standard MIDAS utilities one can use quality criteria to select which recentered images should go into the final sharpened image.

The standard procedure consists of a number of steps:

Convert the raw data into the required format. This is a MIDAS table containing one row per photon event. Software to create such a table is available for both the PCD and the Image Photon Counting System (IPCS) on La Palma.

Integrate the table containing the raw data to one *fuzzy* image. This way one can select a bright object to use in the recentering analysis.

Determine the optimum grouping of frames. Often the exposure per frame is too short to determine the centre with sufficient accuracy; then groups of frames must be added together at the cost of a poorer time resolution.

Find the barycentre of each grouping of frames, and determine an *rms* which is a measure of the quality of this determination. Perform the actual recentering using only those (groups of) frames which obey certain quality criteria.

These steps are chosen in such a way that an optimum use of existing MIDAS capabilities (plotting, table handling) is possible. There is also a capability to correct for effects due to the remanence of the image-tube phosphor but these have not been fully tested. We welcome contacts from people interested in the technique.

Gustaaf van Moorsel

New CCD software

A new set of MIDAS commands has been contributed to the *context* 'CCD' by Steven Jörsäter (Stockholm Observatory). The package is designed primarily for the reduction of CCD images but some tools can also be used in the prereduction of CCD spectra. It includes provisions for bias and dark subtraction, "hybrid" flat-fielding, i.e., using a set of flat-fields with different exposure levels, to take into account non linearities in the response, sky subtraction and combination of multiple images of the same field or of adjacent fields. It is possible to process efficiently a large amount of data, since the commands can work on a catalogue of frames. On-line MIDAS help is available.

Sperello di Serego Alighieri

The Artificial Intelligence Pilot Project at the ST–ECF

Hans-Martin Adorf and Mark Johnston (on leave from STScI)

The rapid development of the software techniques which originated within the area of "artificial intelligence" (AI) has raised the question of possible applications to astronomical problems (Albrecht *et al.* 1986, 1987; Albrecht & Johnston 1987). AI, as a branch of computer science, investigates topics such as *search methods*, *symbolic computation*, *image understanding*, *knowledge representation* and, in particular, *expert systems*. Other topics — somewhat more exotic from an astronomer's perspective — are *natural language processing* and *speech recognition*, *inferencing*, *learning*, *planning* and *problem solving*. In the last few years AI "toolkits" have become commercially available which make it relatively easy to apply such powerful new techniques as *object-oriented programming* and *rule systems* (see Bobrow & Stefik 1986), integrated on workstations with multi-window high-resolution bitmapped screens.

To investigate how these tools might be used in astronomy we started, in the autumn of 1986, an "AI Pilot Project" in collaboration with the STScI (for an overview of AI-related work done at STScI see the proceedings of the *Conference on Space Applications of Artificial Intelligence and Robotics*, NASA Goddard Space Flight Center, March 1987). We concentrated on the development of prototype expert systems to serve as "astronomer's assistants", in particular for data analysis and HST proposal preparation. We have also investigated the use of these tools for classification and to facilitate access to heterogeneous distributed astronomical databases.

Expert Assistant prototypes

We found that the AI techniques can be used to produce meaningful results in a short time. One prototype, the *Data Analysis Assistant* (Johnston 1987) will accept input, specific to the relevant subject area (domain), through a graphical interface and generate, for instance, a CCD calibration procedure in IRAF script or MIDAS procedure language. This approach shows potential for allowing an astronomer to develop analysis procedures that are largely independent of a particular command language and could be especially useful for novice users. It could also provide a way to capture expert knowledge about, for example, HST calibration which could then be made widely available.

As part of the development of a prototype *Proposal Preparation Assistant* we are assembling an HST 'knowledge base', which splits into a 'fact base' and a 'method base'. Stored facts represent general assertions about HST, its instruments, configurations, modes, filters etc. and can be used to answer questions, e.g., about instrumental configurations which suit a particular observation and target type. The dynamic part of the knowledge base is encoded in methods which access the (static) facts if needed. The *Proposal Preparation Assistant*, in its current state, can be used to estimate exposure times and signal-to-noise ratios for imaging observations with the Faint Object Camera. The structure of the HST knowledge base is quite general and could easily be extended to include ground-based telescopes as well.

Another area which has been studied within the Pilot Project is "classification", both supervised and unsupervised. A *rule-based classifier* has been constructed and used for IUE low-resolution spectra (Rampazzo *et al.* 1987, see also the next article). A *trainable statistical classifier* has been implemented and applied to a

relevant subset of the IRAS Point Source Catalog (Meurs *et al.* 1987). We are also conducting experiments in untutored classification using the AUTOCLASS classifier, originally developed at NASA/Ames (Cheesman *et al.* 1987).

Development environment

AI-based developments greatly profit from special hardware which, in our case, was procured for the *AI Pilot Project* after an evaluation period of several months. Most of our prototypes have started as an application within the *Knowledge Engineering Environment* (KEE) expert system shell running on a dedicated LISP workstation, a *Symbolics 3620*. One of the expert assistants has been successfully ported into another shell, the *Automated Reasoning Tool* (ART), and also to a general purpose workstation, a *SUN 3/160*. Current development proceeds within KEE on a *Texas Instruments Explorer* LISP machine. We are surveying the market for possibilities to deliver our AI-based tools on local, low cost, general purpose workstations and/or on wide area networks.

Summary

We have been very encouraged by the results obtained to date and with the relative ease with which they have been achieved. We are planning to continue development of both the Proposal Preparation and Data Analysis Assistants and also to investigate other areas where these techniques might be used to advantage. At present, a very interesting and demanding application appears to be in the area of access to remote databases, where an expert system could effectively mediate a user's browse and query requests (see Adorf *et al.* 1987; Rosenthal 1987).

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Rule Based Classification of IUE Spectra

Roberto Rampazzo, Fionn Murtagh and André Heck (CDS)

Introduction

Classification of celestial objects is one of the central themes in astronomy and artificial intelligence techniques have already demonstrated their suitability for this purpose (Bernat & McGraw 1986; Thonnat, Granger & Berthod 1985). The increasing availability of stellar spectra in wavelength ranges other than the visual creates new problems for classifiers. The MK classification scheme that is defined on the visual range cannot, for example, be immediately extended to wavelength regions for which it is not calibrated, although a classical approach, similar to the MK one, may be used (Jaschek & Jaschek 1984, 1987).

The low resolution ultraviolet stellar spectra obtained with IUE are fairly homogeneous. Although they do not have the characteristics of a survey, it has nonetheless been possible to characterise standard stars independently of their visual classification (see, *inter alia*, Heck 1987). The ultraviolet classification of "normal" stars has already been defined (Heck *et al.*, 1984) and that of "peculiar" stars has been started (Heck *et al.* 1986).

We present here the backbone of a *rule based classifier*, the aim of which is to reproduce automatically the IUE classification, starting from a wavelength calibrated spectrum. The grid of the classification rules is deduced directly from a well classified set of stars on the basis of 29 parameters. Among these, 28 are a measure of line intensities and one, the asymmetry coefficient, a parameter that describes the continuum on which a reddening correction has already (empirically) been performed. The definition of these parameters is similar to the definitions adopted in Heck *et al.* (1986).

Structure of the prototype

The development of the system is being performed using the KEE 3.0 (*Knowledge Engineering Environment*) system from IntelliCorp on a *Texas Instruments Explorer* LISP Machine. A *Knowledge Base*, an *Explanation Subsystem* and a *User Interface* are, logically, the main blocks of the system.

The Knowledge Base contains (*a*) classification rules, (*b*) rules for the comparison with standards and (*c*) a static part mainly concerning the spectra of standard stars and related parameters and data.

The Explanation Subsystem is a link between the Knowledge Base and the User Interface. It contains explanation rules on the lines actually found in the spectrum and those that should be found, given a spectral type. It also contains an explanation of the criteria and of the processing path followed by the system in the classification process. The on-line help facilities are also part of the Explanation Subsystem.

The User Interface is responsible for overall control of the system and of the Explanation Subsystem queries. It is controlled by active panels (windows) on which the user may click with the mouse. The activities of the system controlled by the panel are (*a*) initialization, (*b*) help, (*c*) start system, (*d*) the selection procedure, which enables the user to select his/her own series of spectra to classify and (*e*) the I/O link with the VAX-8600.

Present status and direction

The static knowledge base has been built and the classification rules grid has been completed for "normal" O, B, A, F and some G stars. The

correct classification of spectra used for test purposes has been demonstrated. A simple I/O structure that allows communication with the VAX-8600, in order to build a batch procedure running in MIDAS, is under test. The objective is to build a procedure which, starting from the extraction of general spectral parameters (asymmetry coefficient and more evident line intensities), builds the classification. The grid of rules is passed through in such a way that, after giving a rough classification (e.g., "early", "intermediate", "type earlier than B2", etc.), various expected lines are suggested and control is passed to the MIDAS image processing system to look for these features. This step is iterated until a stable classification (determined by comparison with standard stars) is reached. All of these operations are written in a sort of *blackboard* (a unit for the system) and if the iterations do not converge, the various operations may be stored and the spectrum checked to see if it really represents a new spectral class.

The objective in the short term is to provide a general structure for spectral classification which is reusable in different spectral ranges. We expect many general insights to be gained during the building of this system, including experience in the automatic preparation and control of reduction procedures (Johnston, 1987). The longer term aim is to build a "learning" structure that recognizes and remembers classes of astronomical objects in large data sets.

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STARCAT and Proteus developments

Guido Russo and Alan Richmond

A new version (1.9) of STARCAT has been released. The major enhancements include: more uniformity between catalogues, e.g., in coordinates; improved MIDAS `.fmt` files — e.g., field units; new and more complete documentation for the catalogues; some minor faults have been corrected.

STARCAT is layered on the *Proteus* software construction system, which in turn uses the *TermWindows* library (F. Ochsenbein, ESO). All three systems have been further rationalised to facilitate maintenance by third parties.

STARCAT is now available at the CSADC (Canadian Space Archive Data Center) which is located at the Dominion Astrophysical Observatory, Victoria, Canada. The next step in this collaboration will include the homogenisation of the database and the adoption of the FITS table extension for catalogue interchange. The STScI in Baltimore has also adopted STARCAT as the user interface to the HST Archive.

Future enhancement will include a user interface (application decoupling) to allow access to the database via a Local Area Network and a redesign of the query software, currently overly dependent on commercial products.

The captive account CAT on ESOMC1 will serve remote users; however, the `SIMBAD` command is not enabled for such users, because ESO computers may not be used as gateway between networks.

In the area of the user interface, the major development in both Proteus and TermWindows is the provision of simple interfaces to the forms handling software; these interfaces are now being tested in the *EasyMail* e–mail prototype, by B. Loodts (ESO), Ph. Defert (ST–ECF) and ourselves.

A prototype form design parser (interpreter) is available in *ProGen* (a Proteus utility) in the `Macro` command. Fields may be specified in a file with name, type, default and description. This is used to create a very simple columnar form on screen. The supporting software actually allows *ad–hoc* form designs; the restriction to columnar layout was purely to keep the file scanning simple. Version 1.3 uses a built-in public domain version of *Yacc** to allow easy specification and extension of the screen description. This specification is created by an ordinary text editor, laying out the fixed text as it will appear on screen, using special characters to identify the location of variable fields. Field attributes are defined separately from the fixed text, e.g., name, type, maximum length, etc. Further details are given in the Proteus Software Handbook, available on request.

* Yacc: a parser generator which allows syntax analysis — recognising the structure of the input — to be specified very concisely in a form which can automatically be converted into a programming language such as 'C'.

Conference report: "Astronomy from Large Databases"

Fionn Murtagh

The conference "Astronomy from Large Databases: scientific objectives and methodological approaches" took place in Garching on 12–14 October 1987. Approximately 150 people attended, including many from North America. The projects and missions represented at the conference included, amongst others, HST, IUE, IRAS, ROSAT, EXOSAT, EUVE, and Hipparcos. In the three days of the conference, 74 presentations were discussed. These were organized in sessions on: Astrophysics from Large Databases, Object Classification Problems, Statistics, Pattern Recognition and Expert Systems, and Databases — Current Trends.

Half of the presentations were in the latter category and hence a comprehensive view of work in progress in this area of astronomy can be gleaned from the papers. The diversity of approaches in this area (for example, the range of database systems in use — generally "home-grown") points to the need for coordination. The conference provided a good start in this direction.

In other sessions, discussion took place on the applications of new technologies to stored astronomical data. Some of the papers on expert systems and statistics will provide useful reference material — not easily available elsewhere — when considering the application of methods in these fields.

The proceedings will be published by the European Southern Observatory and are expected to be available around the end of December 1987.

News

HST proposal deadline

The deadline for the receipt at STScI of observing proposals for the first round of general observer (GO) observing time on the HST is now set at **June 1, 1988**. The current assumption is that the launch will take place approximately one year later, i.e., Summer 1989. For those users wishing to use the Remote Proposal Submission System (RPSS) available at STScI, we remind you that a copy of the checking and validation software is available for local or remote use on the ESO/ST–ECF computers in Garching (See *Newsletter No. 5, May 1986*).

Piero Benvenuti

Availability of the ST Model

We mentioned in our last Newsletter the full integration of the ST Model software package into the local MIDAS system at Garching. With the approach of what we all hope will be a real deadline for GO proposals, we take this opportunity to invite interested users to consider the value of the system for preparing their observations. Ask us for a User Guide if you don't have one already. We are particularly interested to hear from astronomers who would be willing to develop the model capabilities in an area where they have particular expertise. You should be reminded though that a visit of a couple of days is probably not enough unless you have very well prepared input data; two weeks is a better estimate of the time required to complete a project.

Ed.

Calibration of HST data

Scientific data from HST will receive their first calibration by means of the so-called Routine Science Data Processing (RSDP) pipeline at the STScI. More details can be found in the "Call for Proposals" document. This calibration will remove the most significant instrumental signatures to a stage where a scientific inspection of the data can be made. By necessity, this routine processing does not include different options for any of its component steps. It is therefore to be expected that the products of RSDP processing will not always satisfy the needs arising from a given scientific goal. Furthermore, since RSDP will process all observations soon after their acquisition, the calibration parameters used will be extrapolations from previous calibration observations. It is not presently foreseen to make a second pass of the science data through the pipeline in order to apply the calibration parameters appropriate for the epoch of the science observations. Apart from a lack of resources at the STScI or elsewhere to do this, there will probably not be such a thing as *the* set of calibration parameters, instead, their selection will arise from scientific criteria which depend on the intended use of the data.

We are currently studying in detail how European HST users can be enabled to recalibrate their data. Apart from access to the calibration parameters generated by the Calibration Data Base Software (CDBS) at the STScI, the most important requirement for this process is a data analysis system for performing the necessary image processing operations. The former is assured since the ST–ECF will maintain a copy of the HST archive which, in addition to the raw and RSDP processed observations, will contain also the CDBS parameters. For the latter, all calibration work at the STScI will eventually be integrated into STSDAS (the *new-look* SDAS) under IRAF. Again, a copy of that software will be installed at the ST–ECF. However, the ECF will not have the resources to support the reduction of all European HST data in Garching and

so a system distributable in Europe is required. We are therefore aiming to provide calibration tools in MIDAS, the system most widely available in Europe. Future issues of the *Newsletter* will keep you informed of our activities.

Dietrich Baade, Gustaaf van Moorsel and Michael Rosa

Network security

The event was covered in the international media: German hackers invaded the "super-secret" intercontinental NASA SPAN network, "gaining access to all the technological secrets of the Western World". The *International Herald Tribune* even insinuated that the damage was so large that the Secret Services of several countries were trying to hush things up. It adds a whole new dimension to our work, doesn't it?

Anyway, there was an invasion by hackers; no secret information was lost, because there was none. As far as we can tell, they did not cause any damage at all except for the computer cycles they used. However, just to be on the safe side, we are re-building the network software and putting in more security precautions. This is causing some connectivity disruption so if you have problems getting through to us on the computer please give us a quick call on the telephone to find out how to re-establish contact.

Rudolf Albrecht

Position vacant

Philippe Defert is leaving the Science Data and Software group of the ST–ECF to take up a post at CERN in Geneva. We should be interested to hear from potential applicants for the post which has, in consequence, become available. Further details will be supplied to enquirers; we expect that the successful candidate will have a degree in natural science, mathematics, computer science or a related field.

Piero Benvenuti

We should like this Newsletter to reach as wide an audience of European astronomers as possible. If you are not on the mailing list but would like to receive future issues, please write to the editor stating your affiliation (Ed).

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