The Digitising and Analysis of Astronomical Images

Abstract. Many astronomical research programs depend on the efficient use and analysis of photographic images. In order to fully exploit the ESO/SERC film surveys, to which we have access, we use fast real time video digitising and analysis systems. These systems also have applications in areas beyond pure astronomy.

1. Introduction

Photographic sky surveys, culminating in the ESO/SERC Sky Survey, the deepest photographic survey of the southern skies, have allowed astronomers to carry out a great variety of projects including:

- morphological studies and searches, e.g. supernova remnants;
- photometric studies, e.g. variable stars, nebulosities;
- astrometric measurements.

Quantitative measurement of photographic material has, until recently, required access to comparatively expensive equipment. The major plate digitising projects over the past decade have been carried out using the COSMOS or APM facilities in the UK or the Luytens machine and a variety of PDS machines in the USA and Europe. Access to these is sometimes difficult, and for many applications unnecessary.

The Astronomy research program in the Physics Department of the University of Wollongong has major elements which depend on image digitising and analysis. The Department holds the complete set of the Southern Sky Surveys (ESO R; SERC IIIa-J, I and R surveys). In order to use these in both teaching and research we have established a low cost image digitising and analysis facility based on IBM PC compatibles, commercial video frame grabbers and image analysis software. The real time image enhancement and background subtraction possible with this system allows the full exploitation of archival photographic images. These sophisticated but flexible systems, supported by a CD ROM based image and catalogue database:

- support established research projects, particularly those related to 'Galactic Star Formation';
- support Undergraduate, Honours and Postgraduate programs associated with astronomical image and data processing;
- allow the rapid development of new projects utilising UK Schmidt Telescope plate material.
- allow us to develop wide ranging courses in image analysis e.g. Medical Imaging.

2. Video Digitising Systems

The advent of powerful, low cost computers, frame grabbers and high quality CCD cameras has allowed the development of an image digitising facility which is both state of the art and low cost.

Conceived in its original form in 1988 the system provides for the real time, 8-bit (256 grey scale), video digitising and analysis of photographic plate material.

The image digitising systems are PC/AT based video frame grabbers. The digitising board used is the PCVisionplus board. Computer controlled Look Up Tables (LUTs) allow the stored 512 x 512 pixel image to be displayed in pseudo colour on a dedicated RGB image monitor. The video digitiser accepts video input from CCD video cameras (National and Phillips) mounted on a Polaroid

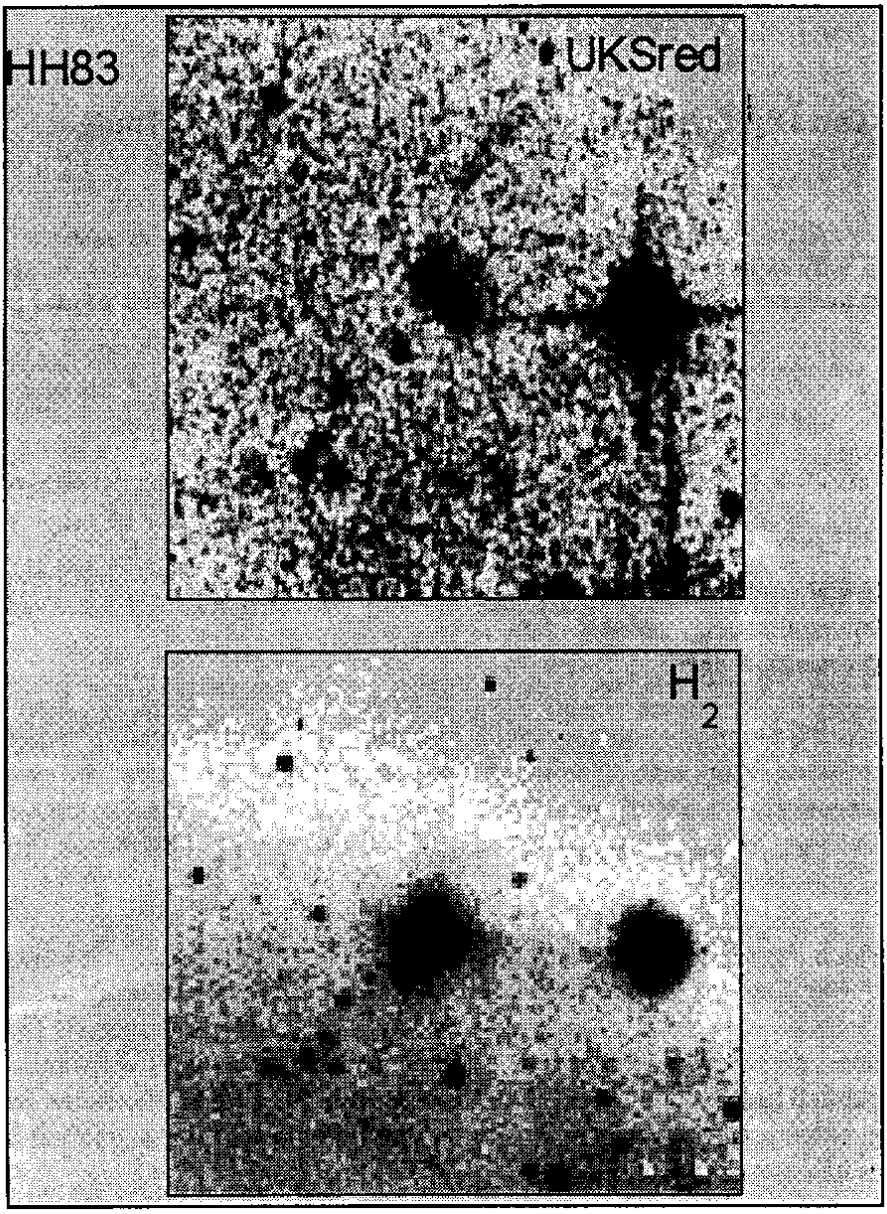

Figure 1. A video image of HH83 from an ESO R plate (top) and an infrared image taken using IRIS (bottom).

Laboratory Camera. A combination of lenses allows both wide-field (300mm square; 6mm pixels) and microscopic (5mm square; 10μm pixels) imaging of sky survey plates. Plate illumination is provided either by a Chromega colour enlarger head for regions up to 5mm square or a light box for larger areas.

Jandell's JAVA software allows real time enhancement and measurement of the digitised images which are displayed on an RGB monitor. This low cost but sophisticated software package supports spatial filtering, contrast enhancement, thresholding, simple backgrounding and source counting as well as photometric analysis. Images are stored as 8 bit TIFF files and as such are compatible with a wide range of software.

The two PC ATs equipped as video digitisers can be networked to the Department's PC, Sun and Macintosh network via Ethernet. Normally however we transfer small numbers of images on floppy disks. Larger amounts of imaging data may be stored on a 6259BPI, 9 track tape unit, a 20 Mbyte tape streamer or a 600 Mb Ricoh Magneto Optical Drive.

We normally carry out off-line analysis and printing using JPL's IMDISP and Alchemy

Mindworks GWS packages. GWS is particularly useful for a first look at images, cropping and scaling and conversion to GIF or other image formats. GWS provides low quality b/w or colour hardcopy using bubblejet printers. High quality output is obtained by using Pizzaz Plus, a screen capture program, to save print files which can then be imported to CORELDRAW for enhancement, addition of text, and printing.

The JAVA software is also flexible enough to allow the import and analysis images from a variety of sources including archival CD ROM images from IRAS, Einstein, and the NASA Voyager and Magellan missions after cropping and reformatting as TIFF files.

3. Astronomical Applications

3.1 MORPHOLOGY

The video systems have provided a platform for the rapid development of expertise in CCD digitising and of software for image processing. One of their main uses has been in scanning plates for selected low brightness sources.

Searches for interesting, but faint, sources often require the rapid measurement and real-time analysis of small areas on a large number of plates. In the past, work of this kind has relied on the use of polaroid cameras or 'wet' photography for plate scanning or large and expensive measuring machines like COSMOS and the APM for photometric measurements. Real time video digitising allows one to display contrast enhanced images while plate scanning.

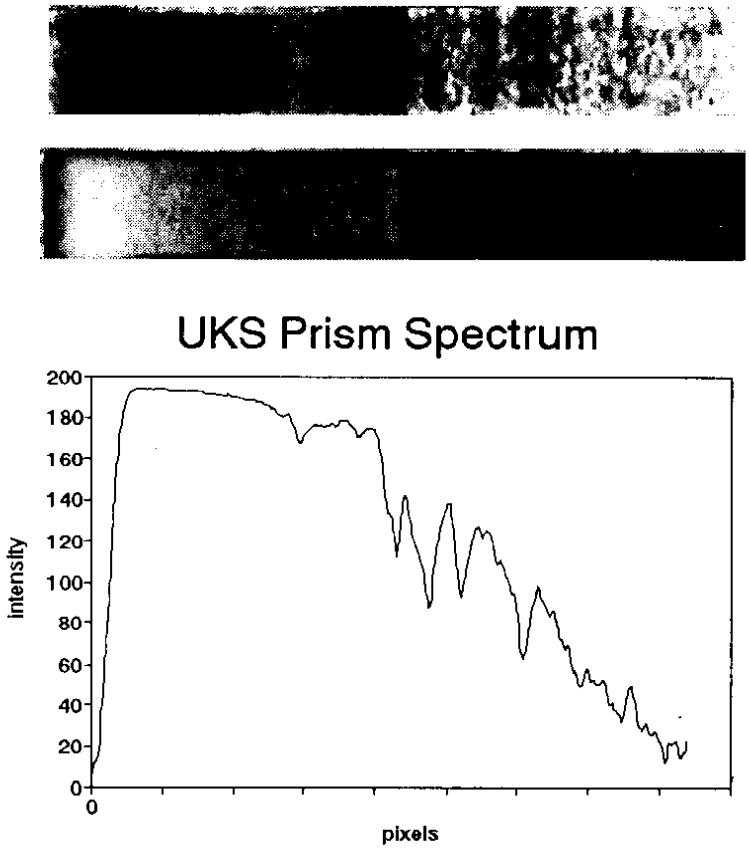

Figure 2. A video image of a stellar objective prism spectrum (top).
The enhanced and reversed image (middle).
A vertically averaged trace through the raw spectrum (bottom).

An example of this kind of search is provided by our programs on Herbig-Haro objects (Fig. 2). In this program we are imaging ESO/SERC J, R and I survey material and infrared K band images obtained with IRIS (the AAO's infrared camera) to identify the driving sources of the outflows. In parallel with this we are searching dark clouds for new Herbig-Haro objects.

3.2 OBJECTIVE PRISM SPECTROSCOPY

Other applications include the digitising UKS objective prism spectra. The ability to enhance spectra, allowing identification of faint features and to output digital spectra in a form suitable for use in spread sheets makes these systems powerful tools both in teaching and research.

3.3 ASTROMETRY AND PHOTOMETRY

The astrometric use of the system is limited by the 512 × 512 pixel field. While positions accurate to better than an arc second can be derived usefully for small 4 arc minute regions, the accuracy degrades as the field size increases.

JAVA supports the measurement of the area, the peak intensity and summed intensity above a designated threshold. The software also allows the user to calibrate the plate using the superimposed spot or wedge calibrations. Subsequent measurements are then directly in intensity units simplifying photometric measurements. This allows users to carry out both surface and integrated photometry of extended sources e.g. galaxies. The added ability to perform automated object counting, can allow low accuracy photometry to be carried out in small, < 4 arcminute, uncrowded fields. This kind of data is most suitable for the analysis of absorption in dark clouds using star counting techniques. Work undertaken by Honours students indicates that, while video digitisers are highly suitable for morphological studies, it is difficult to obtain photometric accuracies of better than 0.2^{m} using ESO/SERC plates.

4. Other Applications

As part of deliberate policy we have linked the digitising systems closely with our teaching. We have been able to introduce image processing topics into our Honours and Postgraduate programs. The video digitiser has supported hands-on image analysis assignments which form a major part of the Masters subject, 'The Physics of Imaging', introduced in 1991. This has now been included as a core subject in our Bachelor of Medical Physics.

In the push to make at least some of our research more closely related to industry we have evaluated applications in several areas outside astronomy. Such work has included trials of the systems for:

- automatic leaf area analysis;
- analysis of Forest Canopy Dieback (as part of a trial for ALCOA);
- analysis of Gas Explosions using video tape;
- analysis of CAT scans and other medical images.

It has become clear that while video digitising may be used from time to time in such work, expansion of the commercial aspects of this kind of program are not financially viable (though they are instructive).

Useful Addresses

Jandell Scientific:	2591 Kerner Blvd, San Rafael, CA 94901
Alchemy Mindworks:	PO Box 500, Beeton, Ontario, LOG1A0, Canada
PCVision Plus:	Imaging Technology Inc., 600 West Cummings Park, Woburn, Mass 01801.

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