THE QUASI-INTERACTIVE IMAGE PROCESING SYSTEM OF THE LA PLATA OBSERVATORY

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RESUMEN. Describimos los primeros pasos encaminados a la instalación de un sistema de procesamiento de imágenes empleando un "hardware" no especialmente diseñado para ello. Se dan breves descripciones de los módulos principales.

ABSTRACT. We describe the first steps towards the installation of an image processing system using non-specifically designed hardware. A brief description of the main modules is given.

The development of adequate software for digital image handling (direct or spectroscopic) has become an urgent necessity during the last years. Image processing, in a variety of forms, has proven to be the most efficient way to synthesize and improve large volumes of data. The interest in this field has been driven, mainly, by the development of fine grain plates which can provide almost nine bits of significance and also by the widespread use of solid state detectors of increasing quality. Satellite information, which presumably will grow explosively in the next years, and interferometric radio data are also a justification for the investment of a coordinate effort in order to settle a flexible system of data reduction.

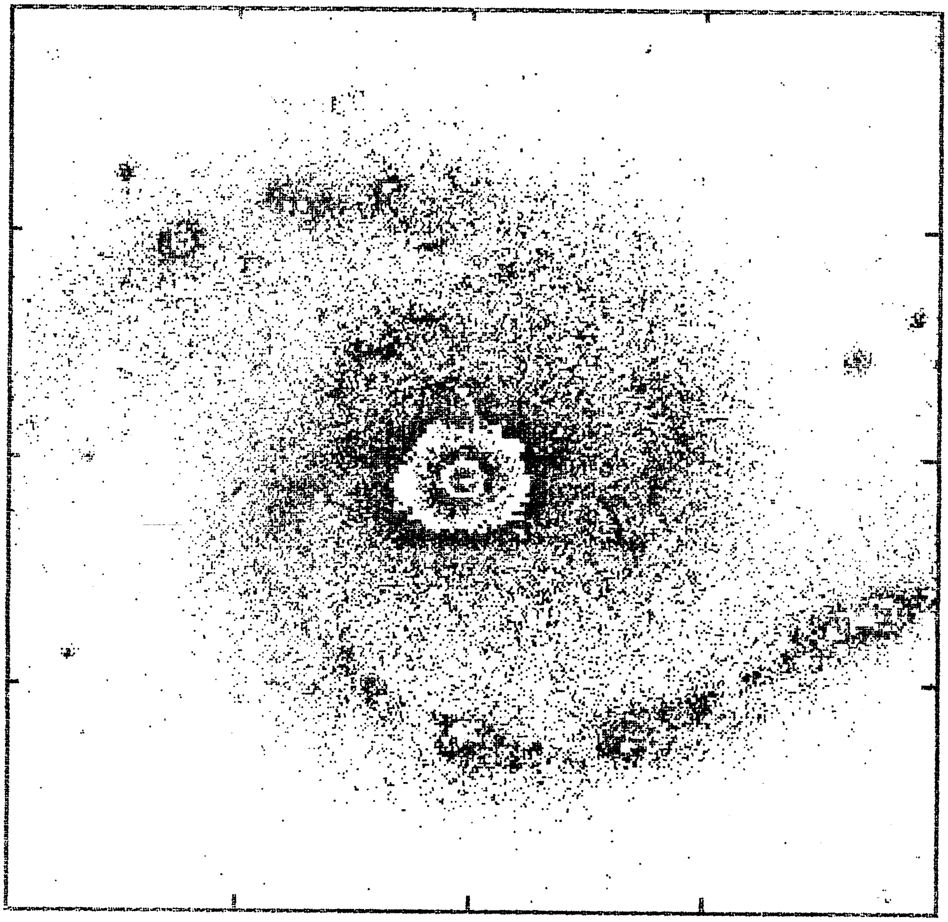
Unfortunately, the cost of specifically designed image processing systems is out of the economical capabilities of a single institution. This situation has led us to develop a number of programs, which, in the future may become the "seed" of a more complete system, using some hardware facilities available at La Plata Observatory. These facilities include an HP1000/F computer with 448 kilobytes of central memory and two 10 Megabytes disks. The graphical or image displaying necessities are covered with a dot graphic fast line printer and a multicolor flat bed plotter. These units are not designed for this kind of work but, at this moment, are the only alternative. For this reason our system lacks true interactive response.

In the following paragraphs we describe some of the characteristics of those basic programs (written in FORTRAN) whose capabilities have been tested by means of data obtained at Cerro Tololo (Vidicon direct and CCD spectroscopic frames), PDS records (from a tape kindly lent by Dr. J.L. Sersic) and a direct image on film (previously digitized with the Optronics system of the Comisión Nacional de Investigaciones Espaciales).

Currently the system consist of about two dozen modules. Each module, that may perform one or more functions, is implemented as a separate program. As the RTE program scheduler needs only to invoke the program name to start it running the differents modules can be used readily by simply invoking their names. No parameters are passed to the modules at that moment. The parameters are asked conversationally during the execution of each module. The prompts try to be self-explaining.

There are presently two kind of "images": pictures and spectra. Both are kept in direct access unformatted disk files. Pictures are always integer values and the spectra consist of two vectors in floating point values. The files contain no other complementary information but, in the case of the spectra, the total number of pixels. The pictures are stored as one line equal one record. Then the record-size plus the total file size allow one special module to present a directory of the pictures present in the system indicating their size in lines and columns.

The first modules developed dealed with the input of images from the tape to the disk. A new input routine must be written each time someone brings a tape from a different installation: CTIO Vidicon system, CNIE Optronics Specscan film digitizer, MPIA PDS plate digitizer and CTIO CCD system. Some of these data are encoded in FITS format (Wells & Greisen 1981) a practice that must be encouraged.



The southern galaxy NGC 1566 reproduced with the "dithering" technique. Here each pixel is represented by 2x2 dots.

Inmediately after the input modules the display modules were needed. A routine was designed to take advantage of the dot graphic capability of our line printer. Each pixel is represented as square of nxn dots. Usual values of n are 1,2 and 3. Within each pixel the gray scale is simulated with a process known as "dithering" that works in a way much similar to the half-tone pictures of the newspapers. Each dot has a probability of being printed proportional to the darkness of the gray of the pixel to which it belongs. In this way the fraction of dots that are actually printed in each area is proportional to its shade. The gray-scale itself can be manipulated prior to the output process in a way quite similar to the "lookup tables" or "function memories" of the sophisticated visual display buffers. This manipulation can be as simple as changing the contrast and removing the background in a linear way or, after computing the histogram of the pixel values of the whole picture, make a contrast enhancement by histogram flattening.

The problem of generating a display containing level contours of the pictures was solved in three ways. The easier one was done by manipulating the "lookup table" in the module described above. Instead of using a linear transfer function between internal gray and displayed gray, the transfer function was set alternately to give black, then white, then black ... as many times as needed along a predetermined range of internal gray values. The result is alternative areas of black and white in the displayed image, the levels contours are the edges between the areas. This method does not discriminate between high and low areas. In the remaining two methods the four colors of the plotter were used to solve this problem.

Using the pen plotter to "paint" areas of the paper with different colors is easy. Using one color at once to avoid changing oftenly pens and avoiding to send move instructions to the plotter while the pen is up and the software is scaning the picture to find the next pixel that must be painted in the current color are essential speed considerations. The results are visually impacting but the process is slow and can take between 10 minutes and one hour.

To draw real contour lines with the plotter an algorithm that allows to follow the contour while riding on it was designed. The process is then highly interactive and the operator must indicate the line along which the level will be searched for, if it must be searched from high to low or from low to high and if the contour will be followed clockwise or anticlockwise. Once that the pixel closer to the specified level is located in the original line, three lines are brought to memory: the already present and the preceeding and following. The eight pixels that surround the current location are used to decide which will be the next location of the pen that is slaved to the algorithm. The vertical and horizontal gradients are computed and compared in their absolute values. The movement will be done in a direction perpendicular to the higher gradient and with a sense given by the gradient sign. Once that the decision is taken concerning direction and sense (let us say upwards) then the three appropriate border (upper in our example) pixels of the 3x3 box are scanned and that one with a value closer to the level value is selected as the center of the new box. The pen is moved accordingly and, if neccessary, the lines currently in memory updated.

This method is fast and elegant but care must be exercised with the kind of data to which is applied. This data must be highly smoothed, otherwise a multitude of small saddlepoints will bother the algorithm.

There is one further way of displaying pictures: the hidden line profile. The approach that was used was simple. Each representation was started with the foreground lines. The lines after the first were plotted somewhat shifted along a 45 degree line. At any time during the plotting a horizont profile containing the highest points reached at each abcissa was kept updated. Each point was checked against this horizont and only plotted when it emerged.

There are two kinds of filtering: mean filtering in a 3x3 box and median filtering in boxes up to 27x27. For the later Huang's algorithm (Tyan 1981) is used.

Operations between images are possible in the pictures as well as in the spectra. In the first case the pictures must be already congruent.

There is one highly interactive module that can show, in the HP 2621 terminals, bilevel representations of 46 lines each of 80 columns. The cursor can be then positioned and its coordinates plus the pixel value can be displayed. Another interactions include 80 columns profiles and 10x10 numerical showups.

One module deals with the extraction of spectra from CCD frames. The terminal is used as described above to determine in which columns the spectrum resides. The module uses the adjacent sky columns to substract pixel by pixel its contribution to the object's spectrum.

Finally there are some modules that deal specifically with spectra. Plotting them with the HP 9872 plotter allows later to interact digitizing on the same plot points selected by the operator. One module determines the centroid of emission as well as absorption lines once that they have been bracketted. Moving filters of various sizes can be applied to the spectra, the kind of filtering can be mean, median or mode.

We emphasize that the current stage of this image processing system is still open to the contribution of our colleages in the form of suggested modifications, improvements and/or addenda.

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