# A SYSTEM FOR OBJECT DETECTION AND IMAGE CLASSIFICATION ON PHOTOGRAPHIC PLATES

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## ABSTRACT

A system for detecting and classifying (faint) astronomical objects on photographic plates is presented. The system is planned to perform all the main operations, from the digitization of the plates with a PDS 1010A microdensitometer up to the final classification, under the control of the VAX-11/750 central processor. The aim of the project is to obtain an objective classification and reliable description of large amounts of objects, in a reasonable amount of time, for specific research projects. The detection and classification procedure is organized in modules, each of which is general enough to be applied to different kinds of analyses and to different classes of objects, according to astronomical requirements. An example of application to the problem of star/galaxy discrimination is given.

## 1. INTRODUCTION

The description of different interesting applications of systems for the automatic detection and classification of astronomical objects can be found in the literature (see, for instance, Jarvis and Tyson (1980), and references therein). Such systems are particularly important for the analysis of faint objects, whose dimensions are comparable with the seeing disk. Here we will describe the characteristics of the system under development at the Astronomical Observatory of Trieste, with reference to: (i) implementation of the hardware structure, (ii) development of suitable detection algorithms, for implementation both on-line with the acquisition process and off-line, and (iii) research on methodologies for image classification. The present configuration is planned for the classification of faint objects, with reference to the limit imposed by the S/N ratio of the images.



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## 2. THE SYSTEM

The actual configuration of the hardware structure comprises a standard PDS 1010A, controlled by a PDP 11/45 computer. The main computer, VAX-11/750, is connected to graphic and pictorial terminals, a hard-copy device, and standard printer -plotters. Future implementations are fully described by Pucillo and Sedmak (1983). With reference to the actual structure, the operational scheme is illustrated. Starting from the digital image, the object extraction module provides a general catalogue containing, for each object detected, a set of suitable parameters. A new algorithm, based on information measures and transforms, has been applied (Santin, 1983). The second module is used for the selection of representative objects of the categories under study. For the definition of the training objects we make use of objective criteria derived from previous studies and of subjective criteria as well. Third, some smoothing is performed to clean up the images from spurious pixels. Next, the analysis of the training images is performed. We use a set of textural features extracted from the modified co-occurrence matrix proposed by Malagnini and Sicuranza (1980). The results are evaluated for different choices of the textural features, by using random samples of training images. Once the results appear to be stable, a final choice is made and a standard procedure is applied to all the objects of the general catalogue.

## 3. EXAMPLE

We present some partial results, referring to the analysis of a limited region extracted from an on-film copy, kindly provided to us by R. West, of the ESO Red plate No. 3183 ( West and Kruszewski, 1981). Three regions of 4cmx4cm have been digitized with the PDS, using a 10 micron step and the slit of 20μ x20μ. The test refers to an image of 780x780 pixels, corresponding to 9x9 arcmin$^2$. Our purpose is to discriminate faint images into the two classes of stars and galaxies. The detection algorithm produced a catalogue of 245 objects, with a mean area of 27 pixels. For the analysis, a window of 20x20 pixels, centered on the centroid of each object, has been chosen; objects too close to the borders of the test region have been discarded. Figure 1 shows the classification plot for the remaining 230 objects, with reference to two of the most significant parameters. These parameters have been determined according to the methodology described by Malagnini et al. (1983). The straight line represents a linear classifier, computed from the covariance matrix of the training sets; ellipses represent the equiprobability contours at the 95% and 99% confidence levels, computed from the statistical distribution of the parameters of

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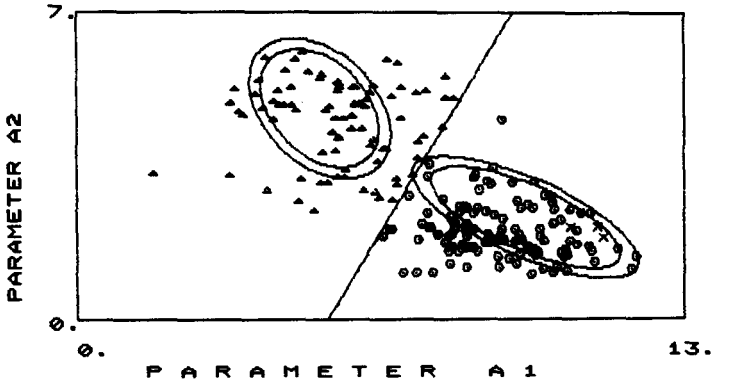


Figure 1. Classification plot for galaxies (open circles) and stars (triangles).

the training sets. The parameters $A_1$ and $A_2$ are measures of smoothness and contrast, respectively; therefore, galaxies have high $A_1$ values and low $A_2$ values, while stars have low $A_1$'s and high $A_2$'s. The plot appears rather scattered: only objects inside the ellipses can be reliably classified, while external ones cannot be classified as they are either multiple or very bright or extremely faint.
This kind of result gives an idea of the problems we intend to study further: (1) classification of individual objects of multiple images; (2) implementation of the procedure for taking saturation into account, and (3) a more precise quantitative definition of the limit of the classification.

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