# Automatic Star Image Identification on Astrographic Plates

## 1. Introduction

Our group at Valencia Observatory is working actively on the development of algorithms for the automatic measurement of astrographic plates. This project is carried out in close collaboration with Pulkovo Observatory, who help us in hardware and software improvement.

This work has a great interest for the preliminary analysis and the automatic measurement of crowded star fields, the search for asteroids, comets and supernovae, high proper motion determination and other similar topics.

## 2. Plate Measurement Process

Our instruments and working programs have been described elsewhere (Lopez 1991). The algorithms are applied in the central window of the CCD camera field of our measuring machine, whose images are digitized to 512 by 512 pixels and analyzed by a PC computer.

The plate holder of the measuring device is moved in X, Y directions by stepping motors under computer control and plate fields of several mm wide with a resolution of a few microns per pixel can be analyzed in real time (Lopez 1993).

The scale and tilt of the pixel array x, y versus stage coordinates can be determined using one selected image. A central square region (working window) is defined and the whole process is applied in it (Ortiz 1993).

Several parameters can be modified during the automatic measurement process, thus allowing the handling of different measuring conditions.

## 3. New Algorithm Steps

We present some new results on the process of automatic detection of objects on crowded field plates. Many automatic classification algorithms for cluster analysis can be found in bibliography (Murtagh 1987) and our method is an original and efficient one, based on hierarchical considerations.

Our stellar images have a circular pattern, corresponding to sidereal tracking. Other objects (asteroids, comets, galaxies) can present a peculiar aspect and will be analyzed by special routines.

Our algorithm, as described in Lopez (1994), has been partially modified. The actual version can be summarized in the following steps:

a) <u>The ACTIVE SQUARES definition</u>:

1) the signal to noise ratio is estimated in each window and the local ground signal and threshold are obtained;
2) a small squares mosaic is defined and those ones with signal above threshold (active squares) are selected.
   The size of the squares is smaller than star images and it can be modified if necessary. The intensity in each square is sampled in a few pixels in order to save computing time;
3) selected squares are ordered by total intensity and several auxiliary intensity and position vectors and a matrix are defined for quicker manipulation.

b) The ACTIVE ZONES definition:

Active zones are plate regions with isolated stellar images or star groups that cannot be solved automatically. Its analysis includes the steps:

4) the maximum active square in the window (active centre) is selected;
5) the image limits in sixteen symmetrical directions around the active centre are searched for. This defines a compact polygonal area filled with active squares (active zone);
6) the active squares inside the active zone are annulled one by one;
7) steps 4 to 6 are repeated until no more active squares remain in the window.

c) The IMAGE IDENTIFICATION and SEARCHING process is applied in each ACTIVE ZONE:

1) a centring process is applied to the maximum signal and the image is checked. The first image of each active zone is considered the main image. Marginal active zones are eliminated;
2) the maximum and mean image radius are determined;
3) the image profile in the mean radius direction is obtained. It is assumed that this image profile is free from the influence of other images. If the image is partially saturated, the central radius is obtained;
4) a gaussian model (Lindegren 1978) is fitted to this profile and the mean value of the sigma is obtained. If the profile is very noisy, an iterative smoothing process is applied first;
5) the image is eliminated up to its radius, subtracting to the pixels value the gaussian model. In case of saturation a central disk with ground signal is drawn.
If the image profile is not gaussian-like, a ground signal disk is applied over the whole image;
6) a new maximum intensity pixel is sought in the active area around the main image. It is done in the 16 radial directions inside the polygonal region of the active zone.
If a new maximum is obtained and accepted by intensity and distance to main image criteria, steps 1 to 6 are repeated. Otherwise, the process begins with a new active zone or continues to the next steps.

d) An IMAGE SELECTION process is done for each individual image:

1) the image contrast and shape are determined;
2) an image relative distances control is applied.
Images are finally selected by their radius, contrast, shape of distances.

e) The IMAGE POSITION is obtained from the centre of its marginal distribution in X and Y directions inside the image radius. A double process is applied in order to estimate the position error.

## 4. Observations and Results

For the completion of our algorithm we simulated several artificial star fields, with gaussian profiles. A maximum 255 intensity value is used and different ground level and random noise were added.

We present our results obtained with several stars of different central intensity (I) and size (sigma value, S). Rather high values of ground level (30) and random noise (25) are considered.

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|---|---|---|---|
| I1 = 250 | S1 = 10 | I4 = 225 | S4 = 6 |
| I2 = 210 | S2 = 6 | I5 = 195 | S5 = 4 |
| I3 = 135 | S3 = 4 | I6 = 230 | S6 = 8 |

The results of the algorithm steps are shown and explained in Figs. 1 to 9.

The algorithm has been tested also with real plate fields, stored in the same computer format, with similar results.

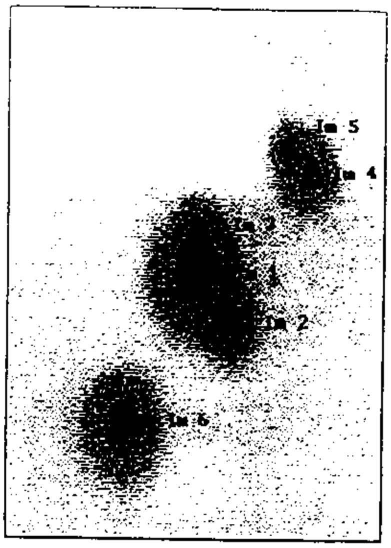


FIGURE 1. Gaussian like images used in this study.

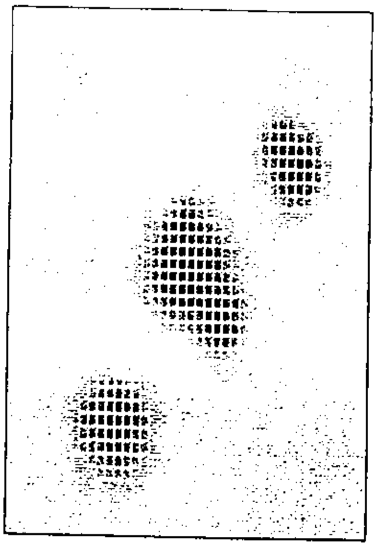

FIGURE 2. Active squares in image regions.

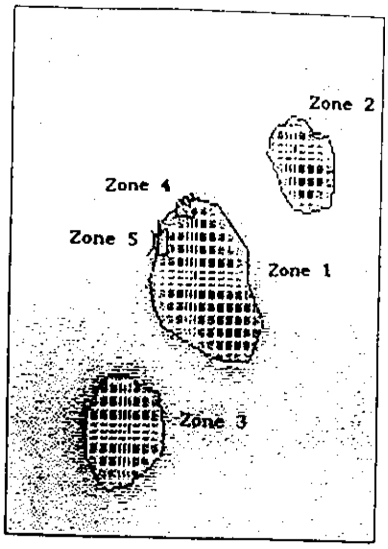


FIGURE 3. Active zones around local maxima.

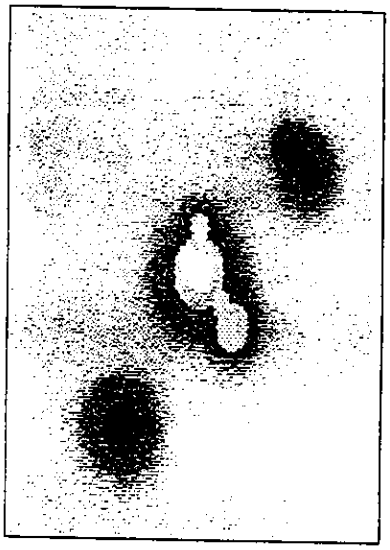

FIGURE 4. Image identification in zone 1.

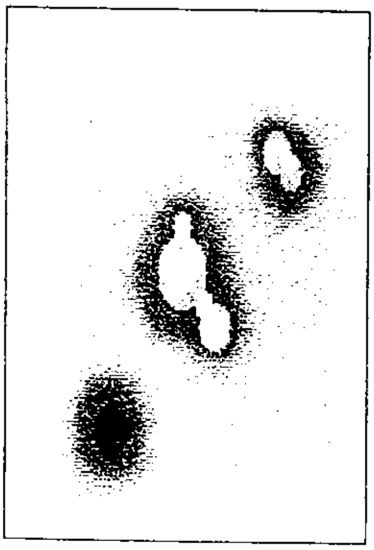

FIGURE 5. The same process for the second active zone.

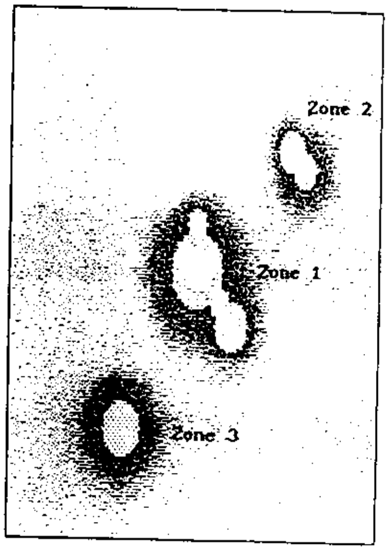


FIGURE 6. Final result of identification process.

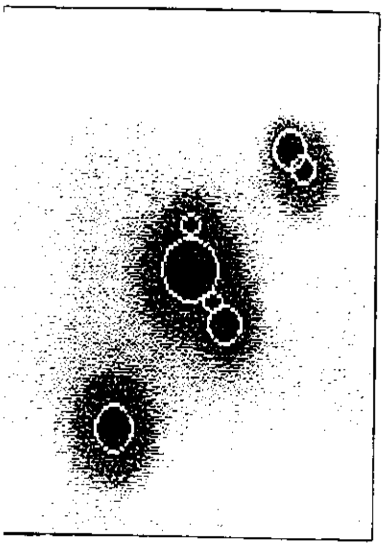

FIGURE 7. Images detected in the identification process.

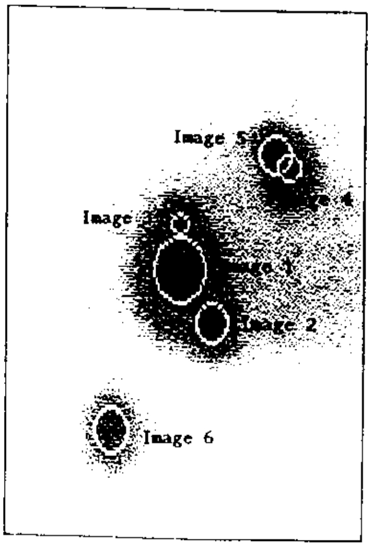


FIGURE 8. Final selected images.

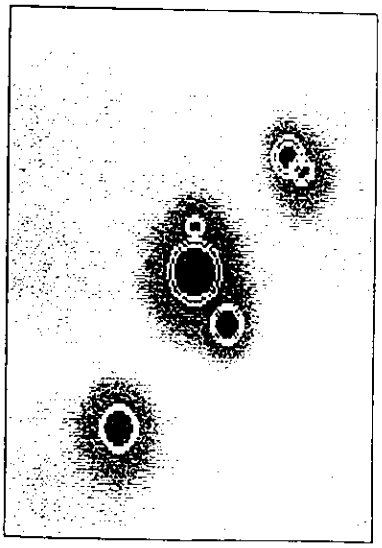

FIGURE 9. Stars positions got by marginal distributions.

## 5. Conclusions

We describe some improvements of our computer software for the automatic analysis and measurement of astrographic plates.

Our algorithm is implemented in the spatial domain. Other special routines (filters, masks and histogram modification in space domain, FT and filters in frequency domain) will be added if necessary.

This algorithm can be applied to many different situations with little change and will be implemented in the software of the measuring machines at Valencia and Pulkovo Observatories.

## References


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