

## Automated Identification of Spectra in Schmidt Plates

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**Abstract.** We present the first results of a system for automatic analysis of astronomical images from digitized plates. This system will automatically identify spectral lines in low resolution spectra employing image processing and analysis. We propose to carrying out an identification of spectral lines with minimum human intervention, considering factors such as type of emulsion, objective prism, telescope characteristics, etc. Our pursuing goal is to obtain totally automatic software for the identification of the spectra and its lines (emission /absorption). In this work we present the first results of the automatic segmentation and the calculated spectra in 1-D.

### 1. Introduction

INAOE has a great collection of astronomical plates taken with the Tonantzintla Schmidt Camera between 1941 to 1995, there are altogether 15686 photographic plates of three different types, 4484 are spectral type, 8432 are direct type and 2540 are direct of three images type (Tepanecatl, et. al. 2002). There are also different types of emulsions (mainly the Series 103a of Kodak Spectroscopy Plates). This work is focused in the spectral plates only. The Tonantzintla Schmidt Camera has the following features: Focal length 231.4 cm, Focal relation 3.2, Plate scale 95 arcsec/mm, Correcting plate 66.4 cm. Mirror 76.20 cm. The objective prism 3.96 degrees with dispersion of 1533 Å/mm between  $H_\beta$  and  $H_\gamma$ ; 954 Å/mm between  $H_\gamma$  and  $H_\delta$ ; and 626 Å/mm between  $H_\delta$  and  $H_e$  (Haro, 1956). The plates have a size of 8x8 inches and they cover a 5x5 degree square.

Our objective is to develop an algorithm of optimal and robust segmentation of stellar spectra on spectral plate images with the purpose of identifying its spectral lines in an automatic form. People inside and outside of INAOE are interested in analyzing this information in an automatic form. For such a task we have the works by Borra et. al. 1998, and Zamorano et. al. 1990 as a basis. In figure 1 we show a flow chart with the processes necessary to obtain our goal.

### 2. Algorithm and Plate Digitization

For plate digitization an EPSON Expression 1680 Professional Firewire scanner is used which is able to scan a full photographic plate in a few minutes, it has a resolution of 1600 dpi which correspond to a pixel size of 20 microns using the transparency (positive) mode. The dynamic range is 8 bit (gray scale of 256

values, spanning the range 0 (dark) to 256 (white)). We get images of 12600 x 12600 pixels with a size of about 150 MB. Each spectrum has approximate dimensions of 350 pixels in length and 8 pixels in width.

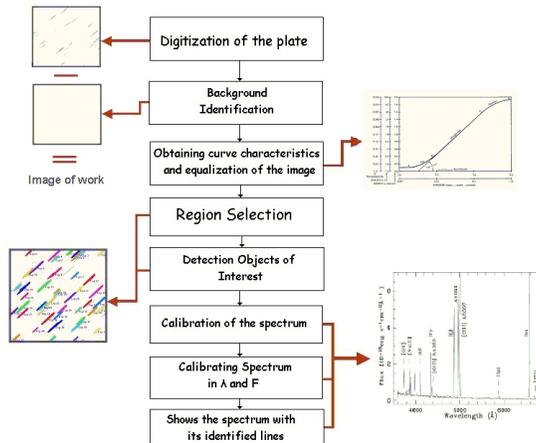


Figure 1. Processes for the automatic identification of spectral lines.

## 2.1. Background Identification and Characteristic Curve

After the digitization we have images containing both sky, spectra and spurious objects. The aim of this step is to rawly identify the spectra and sky regions. We use a segmentation process for this goal and later extract the properties of the resulting regions (Awcock, 1996; Lira, 2002).

The next step is to obtain the mean sky level or background identification from the image. This value is calculated by summing all the pixels forming the region considered as sky and divided by the total number. Taking the sky level as a constant gray value, the program creates a new image with this value, subtracting it from the original and creating an image without the sky contributions but with all the spectral objects, including the spurious ones.

To obtain the characteristic curve is a complicated task because we do not have sensitometric spots in our photographic plates. This implies that we cannot construct a characteristic curve taking as a base the densities and the noise associated with them as is normally done. We considered an alternative way of obtaining this curve directly from the same plate using all its properties, because the characteristic emulsions such as class, exposition time and development conditions can be different among plates. In consequence, we obtained as a result of this process a look-up-table (lut) for each image and modified the image using this table. We are also analyzing the idea of using stellar spectra to construct a characteristic curve for each image (Stienon, 1972). This technique basically involves the use of spectra of several stars whose monochromatic magnitude differences are known.

## 2.2. Selection and Shape Analysis of the Spectra

At this point we have a linearized image without sky contributions, then we applied filters for contrast improvement and image smoothing with the purpose of emphasizing the spectra on the plate and eliminating the noise. After this a thresholding segmentation is made, obtaining regions corresponding to each spectrum. Characteristics such as position (X,Y), area, diameter, length of the contour, direction, ellipticity and anisometry are extracted. A second process of selection must be made using the calculated characteristics to eliminate spurious objects (arrows and/or annotations on the plate) that were not eliminated with the previous criteria. The objects truncated by the edges of the plate are eliminated too (Borra 1987 and 1988). Hartmanns formula was used in order to know the spectra length for each type of emulsion (Sawyer 1948).

Once the spectra that we are interest in are identified, the first step for their extraction in 1-D is to find their exact area and center, with the purpose of considering only lines near to the spectral center and avoiding lines very near the edges. We repeat the process for the columns too. This analysis is made in the same way that IRAF does in the routine of APALL. The average intensities are stored in a text file which is drawn later to show the spectra in 1-D. The graphics at this point show only values of intensity for each point without wavelength calibration.

## 3. Results

We presented the first results of the automatic segmentation and the calculated spectra in 1-D. The results obtained are comparable with those in the 1-D spectra using IRAF. The selection of objects is made with greater precision and in a shorter time than by visual inspection. The processing time for a whole plate is about 10 min. The results are show in figures 2 and 3. The first tests were done with plates that have a 103a-O emulsion, it has a rank of effective sensitivity from 250 to 550 nm, and it allows us to make an identification of lines with greater clarity in the blue region of the electromagnetic spectrum. More information about this is available in <http://www.inaoep.mx/~raqueld/>

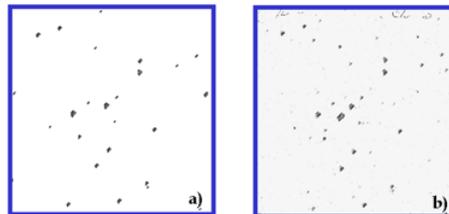


Figure 2. Segmentation of an image by different methods. a) Objects selected with our method. b) Objects selected with SExtractor. Note the automatic elimination of unwanted regions (small spectra and observation notes).

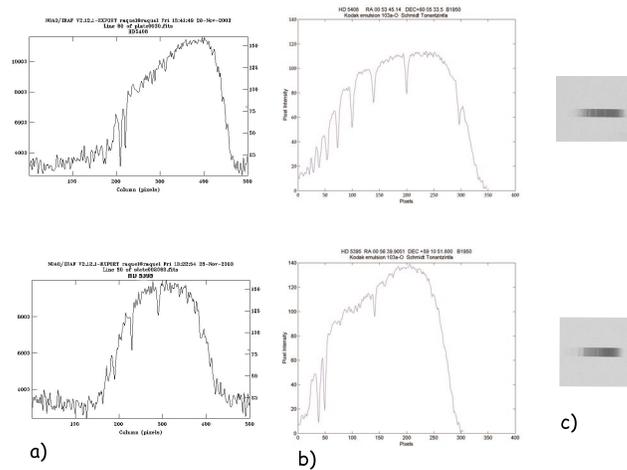


Figure 3. First results 1-D spectrums. a) Objects analyzed without any process. b) Objects analyzed with our method. c) Section of the digitized plate.

#### 4. Future Work

Currently it is possible to identify the spectral lines by visual inspection in 1-D spectra; we are working in the process of automatic identification. We plan to produce a process that automatically identifies lines in spectra (emission /absorption). The algorithm should be applied to plates with a different exposition time and different class emulsion in order to work with all the spectral plates of INAOE's collection.

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