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# DENIS: Source Extractions

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**Abstract.** A description of the source extraction method as employed in the Deep Near Infrared Survey of the Southern Sky is given. Some first insights, obtain by analyzing artificial images, of the performance and quality of the extraction technique are presented.

## 1. Introduction

The DEep Near Infrared Survey of the Southern Sky (DENIS) (Epchtein et.al. 1992) has the objective to provide full sky coverage in 2 near infrared bands (J at 1.25$mu$m and K at 2.1$\mu$m) and one optical band (I at 0.8$\mu$m), using a ground-based telescope and digital array detectors. DENIS is a joint project of 18 European and South American Institutes, aiming to provide digitized maps of and source lists for objects in the southern sky. The products of this survey will be databases of calibrated images, extended sources, and small objects. In addition catalogs of small and extended sources will be produced. With the anticipated $3\sigma$ limiting magnitudes of 18, 16 and 14 at I,J, and K$\prime$, respectively we expect to detect several $10^7$ sources. With a datarate of $\sim$ 5Gb per observing night an efficient and reliable source extraction algorithm is required. Two datacenters at Institut d'Astrophysique de Paris and at Leiden Observatory provide a full off-line data reduction pipeline. Paris is responsible for the standard detector array reduction steps such as flat-fielding, bias corrections, etc., while Leiden Observatory is responsible for the actual source extraction. The observations will be performed in step-and-stare mode, using "strips" as basic units. Each strip is $12'$(one frame) wide in RA, and $30°$ long in declination, consisting of 180 overlapping frames. For each IR channel the sky is micro-scanned at 9 different matrix positions to mimic a 768$\times$768 detector with a 256$\times$256 array.

The extracted objects, being either survey object, photometric calibration sources, or position calibration sources are all stored in a tailor made database management system. This database management system allows for storing all the information in raw parameter format. Upon extraction or the creation of a final Small Sources Catalog the conversion to astronomically relevant units

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will take place. This allows for the use of the most up to date version of the conversion algorithms and their associated parameters.

## 2. Source Detection

Before we describe the results on quality assessment of the source extraction method, we will first describe the actual algorithm in some detail. For a more thorough description see Epchtein et.al. (1992).

### 2.1. Background Determination

To allow extraction of objects from the basic images, we need to subtract any "large" scale structure, which may be due to detector imperfections, remaining sky emission or true diffuse emission. The background determination algorithm divides a basic image (768x768 pixels) into equal squared sub-matrixes, producing a detection cutoff at a given spatial resolution twice that of the sub-matrix size ($1'$). For each submatrix a single background level and an rms estimate are computed by fitting a gaussian curve to the low intensity end of the matrix histogram. The background pixels have a mean position usually not coincident with the center of the sub-matrix. Background maps are interpolated using one of the well established procedures for unequal spaced grids.

### 2.2. Object Detection

Using the background determination algorithm's rms estimate for each submatrix the background subtracted input images will be thresholded at a positive fraction of this rms noise level. Pixels with values above the threshold are denoted object pixels. A software pattern analyser using an 8-fold neighbour connectivity algorithm determines the pixels belonging to a coherent structure (object). The shape of the object is irrelevant in this scheme. Rejection of objects can be done on the basis of the number of pixels per threshold level, effectively removing "noise" objects and/or using interband correlations.

### 2.3. Interband Connectivity

All three wavelength bands will be processed simultaneously. Objects are searched for in each band separately, meaning that there will be no bias to any of the three passbands. Having found an object in one band, this bands object geometry parameters are used to derive photometric properties of the same area in the other passbands, provided no objects were detected there, effectively producing lower limits for this object in the other passbands. During the extraction when objects are positively detected at the other passbands, this information is used to combine the multi-color information of the single object.

The result will be a catalog that is not biased to any of the three passbands and contains, for passbands at which the object has not been positively detected, a lower limit photometric value.

## 3. Deblending

Once an object has been detected above the lowest threshold level it may consist of a number of blended point sources (or extended sources). The purpose of the deblending algorithm is to separate the individual components both in position and intensity.

### 3.1. Blending Detection

Using the above mentioned thresholding/pattern-analyser technique, objects are detected at a number of equidistant intensity levels. The effect of this thresholding is to generate contour information in log(intensity) space. At higher levels the object may split into separate components. A tree structure is produced representing the splitting up of the blended object. If an object does not split up this technique does not differ from the above single threshold object detection.

### 3.2. Deblending of the Object

The deblending starts at the leafs of this tree structure, where the object peak information is stored, and uses a fitted Gaussian profile to determine the intensity contribution of each source peak to the low level pixels. The faint pixel intensities are apportioned between competing object components using a distance estimator in the Gaussian fit and then comparing their relative contributions. In cases where no object contributes significant intensity to a given pixel, the pixel is allocated completely to the object contributing most to it. Although a Gaussian profile is used to determine the faint pixel contribution, this profile is not forced upon an object because a source will gather up the faint pixels around it.

As the pattern analyser recognizes the objects cumulative sums of pixel intensity (at all three passbands), and intensity weighted and unweighted pixel positions are saved.

## 4. Quality Assessment

Tests on the source extraction algorithm were performed using synthetic data of the form as will be produced by the actual data acquisition equipment, and preprocessed at the PDAC. For the description of the density and brightness distribution of stars we used models of Robin (1993) Images with different amounts of stars (200 – 5000) were made with microscanning mimiced by interlacing 9 0.33-pixel-offset subimages.

### 4.1. Crowding

To assess the crowding loss we applied Monte Carlo methods to create artificial images and tried to retrieve the objects put in. Many different images, with a large range of object densities, were fed into the DENIS source extraction pipeline. The extracted source list was compared, after some massaging, to the input list (Holl and Deul 1993).

### 4.2. Positional Accuracy

The relative rms errors (within a DENIS frame) will be in the order of 0$''$.1 well below the image pixel dimensions (1'×1'). The positional accuracy of the survey will thus mainly be influenced by the systematic errors of the reference catalog (Guide Star Catalog) (Taff et al. 1990) which on average are about 1".

### 4.3. Photometric Accuracy

The regime of noise dominated extractions (M > 16.5m) and that of the overexposure effects (M < 9.5m). Generally photometric accuracy of well below 0.1m can be achieved.

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