Astronomical Data Analysis Software and Systems VI
ASP Conference Series, Vol. 125, 1997
Gareth Hunt and H. E. Payne, eds.

Refining the Guide Star Catalog: Plate Evaluations

Oleg M. Smirnov and Oleg Yu. Malkov

Institute of Astronomy, Russian Academy of Sciences, 48 Pyatnitskaya St., Moscow 109017, Russia

Abstract. This is a preliminary report on an investigation of the quality and properties of plates digitized during creation of the Guide Star Catalog (GSC). The results will be vital for reclassifying GSC objects.

1. Introduction

The GSC was created at STScI to support Hubble Space Telescope observations. It contains about 20 million objects, making it the largest all sky photometry source to date. The GSC was created by digitizing 1593 plates and by including bright stars from the HIPPARCOS INCA database. Many objects are measured on more than one plate, and thus have multiple catalog entries. We call such objects multiple-entry objects, or MEOs.

Among the shortcomings of the GSC are: biased magnitudes and incorrect classifications for certain objects, presence of artifact objects. These shortcomings hinder many interesting applications of the GSC, e.g., those involving stellar counts. The Refined GSC (RGSC) project currently in progress at the Center for Astronomical Data, Institute of Astronomy, Moscow,[1] is an attempt to rectify these shortcomings.

2. RGSC: a Refined GSC

The ongoing RGSC project is aimed at creating a new catalog, RGSC, based on the GSC. RGSC will contain all GSC data, plus, for many objects, corrected magnitudes and more detailed and (hopefully) correct classifiers, complete with confidence-of-classification ratings. The primary effort involves verification and reclassification of GSC objects. The following approaches are used:

1. Cross-identification with other catalogs and databases (Malkov & Smirnov 1997). These results are likely to be quite valuable on their own.

2. Multiple-plate analysis (MPA). A large number of objects (MEOs) are registered on more than one plate, and thus have several catalog entries. Each plate has, in effect, its own "opinion" on the nature of a MEO, expressed in that plate's entry for the object. Comparative analysis of multiple entries usually yields insight into the true nature of an object.

[1] http://www.inasan.rssi.ru/CAD

3. Probability maps showing the average density of objects of a particular class for given coordinates and magnitude will be built.

4. An expert system will be developed that evaluates results of approaches 1–3 and produces final classifications and confidence estimates.

For any MEO, properties of the individual plates on which the object is registered have at least as much of an effect on the resulting GSC entries as the nature of the object per se. Our initial studies show that these properties vary a great deal from plate to plate. Therefore, detailed analysis of individual plate characteristics is a prerequisite to carrying out accurate multiple-plate analysis of GSC objects.

3. Plate Analysis: Issues and Methods

To determine the likelihood of an object of magnitude M appearing on a given plate, we compute the luminosity function for the plate, calculating limiting magnitude, saturation magnitude, and maximal population magnitude.

To determine the likelihood of an object being misclassified on a given plate, and whether some plates are "special" in that they tend to bias classifications, we calculate $3 \rightarrow 0$ and $0 \rightarrow 3$ tendencies, or $P\{0|3\}$ and $P\{3|0\}$. The former reflects the tendency of a plate to misclassify extended (class 3) objects as stellar (classifier 0), and the latter the reverse. The $3 \leftrightarrow 0$ tendencies are computed using an iterative process. Initial studies demonstrate that $3 \leftrightarrow 0$ tendencies of the majority of plates are a very significant factor in GSC classifications. In particular, as seen in Figure 1, the $N_{non-stellar}$ to $N_{stellar}$ ratio depends on galactic latitude. The best fit to the average ratio as a function of galactic latitude is a sum of a Gaussian and a very small linear component:

$$N_{ns}/N_s = 0.372 \cdot e^{-0.5(|b|+1.44/15.7)^2} + 0.0187 + 2.98 \cdot 10^{-3} \cdot |b|$$

To determine whether the magnitude of objects is biased when measured near a plate edge, we calculate an average magnitude and flux as a function of distance from the plate center (separately for objects of both classes). To determine whether some plates bias magnitudes, for overlapping plates we compute the mean magnitude discrepancy among objects that appear on both plates. To determine whether an object's classification is biased if the object is near a plate edge, we calculate the average density of objects of both classes as a function of distance from the plate center. To determine whether GSC plate quality codes are meaningful, we look for a correlation between plate quality codes and the parameters mentioned above.

We examined whether an object at given coordinates should be expected to appear on a given plate (i.e., determining the area of the sky that the plate really covers). Plate centers are listed in the GSC, and plates are supposed to have a regular (square) shape of a known size. However, most of them have "dead zones"—irregular sections with no objects registered, e.g., clamp marks (evidently the result of scanning technique), broken-off corners, circular or rectangular areas near bright stars and globular clusters (manually removed during GSC production), etc. We produced a "plate atlas" (plots of all the objects registered on a plate), and developed algorithms to determine the "true" boundary of a plate using (a) the plate atlas, (b) actual GSC data, and (c) lists of bright stars, clusters, and other specific objects.

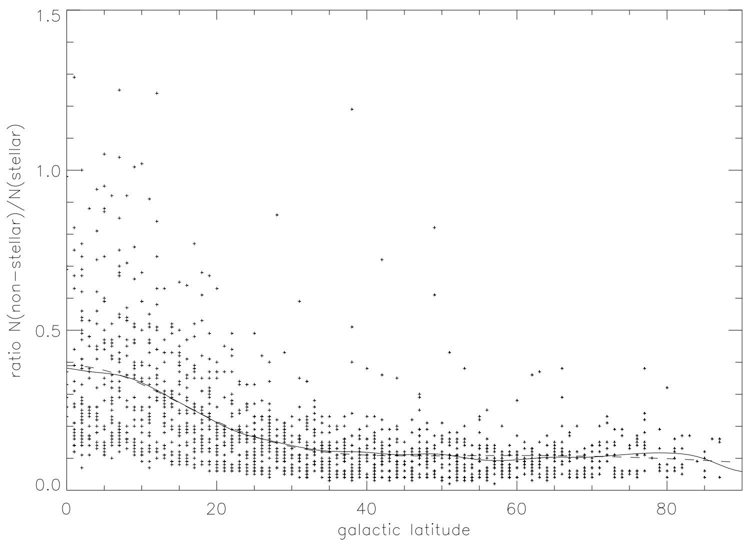

Figure 1. GSC plates: classifier ratios. Solid line is smoothed data, dashed line is the best fit.

4. Plate-related Effects

A number of problems can be traced to the plate-related effects discussed above. A stationary object overlapped by a given plate is not measured on the plate:

Possible causes:	Hit a "dead area."
	Brightness is below the limiting magnitude.
	Brightness is below the saturation magnitude.
Affects:	Multi-plate analysis.

The magnitude of an object (as measured on a given plate) is biased:

Possible causes:	The plate tends to bias magnitudes.
	The object is near the edge of the plate.
Affects:	Stellar counts.

An object is misclassified (and its magnitude is possibly biased):

Possible causes:	The plate biases classifications.
	The object is near the edge of the plate.
Affects:	Multi-plate analysis, stellar counts.

Acknowledgments. This presentation was made possible by financial support from the Logovaz Conference Travel Program. OM is grateful to the Russian Foundation for Fundamental Researches for grant No. 16304.

References

Malkov, O. Yu., & Smirnov, O. M. 1997, this volume, 298