Astronomical Data Analysis Software and Systems IV
ASP Conference Series, Vol. 77, 1995
R. A. Shaw, H. E. Payne, and J. J. E. Hayes, eds.

Classification of Objects in the Guide Star Catalog

O. Yu. Malkov, O. M. Smirnov

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

Abstract. A status report of the The GSC Object Classifier (GOC) project is presented.

1. Introduction

As was reported at the ADASS III meeting (Malkov and Smirnov 1994a), software for retrieving data from the GSC (GUIDARES) and mapping of object regions has been developed. The GSC contains multiple entries for some objects due to plate overlap. It classifies objects as stars, non-stars, galaxies, blends and potential artifacts; the latter three classifications are rare, and only exist in GSC version 1.1, to which they were added manually. It should also be noted that many objects, especially near plate edges, are misclassified in the catalog.

The original GUIDARES had only two ways of dealing with multiple-entry objects (MEOs); compute a weighted average of the data, or report all entries for the object. We are working on a third way of looking at the GSC: analyzing the nature of the object, using data from the GSC, to come up with a "correct" classification. We do not have the intent nor the means to revise the GSC; rather, the object of the GOC project is to come up with extensions to the GUIDARES software that will be able to read the GSC and produce correct classifications within any region specified by the user. To implement GOC, we shall examine a set of object parameters, among which are; the brightness of an object, its coordinates (equatorial, galactic, and ecliptic), plate quality, distance from plate center, and others. Multiplate analysis will be done as well. We plan to establish probabilities for appearances of stars, galaxies, close binaries, "rapid" objects (like minor planets), as well as blends, defects and artifacts, as functions of these parameters. Artificial intelligence methods will be explored as well. The goal is to produce an automatic classifier that can overcome the original catalog's misclassifications by making use of all the other available information.

2. GSC classifications vs. GOC

GSC 1.1 contains the following classifications:

0 —star,

1 —galaxy,

2 —blend or incorrectly resolved blend,

3 —non-star,

5 —potential artifact.

We are designing GOC to recognize the following objects: stars, galaxies, close binaries, variable stars, objects in overcrowded stellar fields, Solar System objects, plate defects, and artifacts.

3. Implementation

The GOC will perform classification with the help of three separate modules. The first is a rule-based expert system that either produces definite classifications or fails. The second is a probability engine, which computes probabilities of the object belonging to one of the above classes, and the third is an artificial intelligence (AI) classifier that uses the test vote method to see if the object is similar to a class of predefined training objects. A fourth module will act as an arbitrator between the three classifiers to produce final results.

3.1. The basics: a Preliminary Analysis

To perform a preliminary analysis in the expert system, we will compare three values: (1) the number of GSC entries for the object (E), (2) the number of entries with the stellar (0) classification (S), and (3) the number of plates that overlap this point on the sky (P). Some obvious rules are, for example, $P = S = E \Rightarrow$ the object is a star; $E > 1 \Rightarrow$ the object exists on the sky (i.e., is not a plate defect) and has a "constant" position and brightness (i.e., is not a rapid object). We regard original GSC classifications of type 1, 2, and 5 as unconditionally correct (since they were added manually).

3.2. Carrying on: Multi-plate Analysis

For a multi-plate analysis, the entries originating from higher-quality plates, or those positioned closer to plate center (i.e., not distorted) are considered to be more "trustworthy" than those on low-quality plates and/or near plate edges. GOC will use this information when analyzing the different entries. Near plate edges, the original object images become distorted and often lead to incorrect classifications. The effective edge of plate is the threshold beyond which information from the plate should no longer be considered valid (Malkov & Smirnov 1994b).

3.3. Estimation of Probabilities

Can it be a galaxy? The probability of the object being a galaxy (independent of how the GSC classifies it) is a function of brightness and galactic latitude. GOC will combine this with the E-S-P analysis to produce final probability estimates.

Can it be a rapid (Solar System) object? The probability is a function of brightness, ecliptic latitude, date of plate exposure, and result of the E-S-P analysis (see above).

3.4. Internal Databases of Special Objects

The GOC will include a small database of special objects that can severely affect the original GSC classifications, for example, bright stars and clusters, or artifacts, which are usually expected in the vicinity of bright stars. The database can be used to quickly establish their locations (since searching the GSC itself can take much longer), and overcrowded regions in the vicinities of star clusters, which again can be established with the help of the database.

3.5. Artificial Intelligence Methods

A lot of artifacts are close to bright stars, and form line- and arc-like patterns. The distance from the nearest bright star, magnitude, and orientation relative to neighboring objects can indicate the nature of the object. AI methods will be used to analyze this information.

Close binaries are fully resolved on some plates, and have a single "non-star" or "stellar" classification on others. By using a catalogue of close binaries in multiparametric GSC-analysis, we hope to find an implicit dependence between separation, magnitude difference, plate quality, and some other parameters. The test vote method will be used to find this dependence and apply it to GSC objects.

4. Current Status and Future Plans

At the moment some principles of GOC are fully realized, others are taking shape, and others are still under discussion. When ready, GOC will be built into GUIDARES as an optional tool.

Acknowledgments. This presentation was made possible by financial support from ST ScI. Part of this work is funded by International Science Foundation Grant number R3Z000.

References

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