AstroDAbis: Annotations and Cross-Matches for Remote Catalogues

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Abstract. Astronomers are good at sharing data, but poorer at sharing knowledge. Almost all astronomical data ends up in open archives, and access to these is being simplified by the development of the global Virtual Observatory (VO). This is a great advance, but the fundamental problem remains that these archives contain only basic observational data, whereas all the astrophysical interpretation of that data – which source is a quasar, which a low-mass star, and which an image artefact – is contained in journal papers, with very little linkage back from the literature to the original data archives. It is therefore currently impossible for an astronomer to pose a query like “give me all sources in this data archive that have been identified as quasars” and this limits the effective exploitation of these archives, as the user of an archive has no direct means of taking advantage of the knowledge derived by its previous users.

The AstroDAbis service aims to address this, in a prototype service enabling astronomers to record annotations and cross-identifications in the AstroDAbis service, annotating objects in other catalogues. We have deployed two interfaces to the annotations, namely one astronomy-specific one using the TAP protocol (Dowler et al.\textsuperscript{2010}), and a second exploiting generic Linked Open Data (LOD) and RDF techniques.

1. Introduction

The AstroDAbis service provides a stand-off annotation service for astronomical catalogue entries. Catalogues appear in many forms, and at scales ranging from tables in journal articles (later made available electronically by the journals, in some cases) to large software-engineering efforts on the part of specialised archives. At all scales, however, there are three key problems when working with archives.

1. Catalogues contain information, but the knowledge derived from analysis of them resides elsewhere, typically only in journal articles. This separation is intentional and well-motivated – a catalogue contains only values for readily measurable quantities, and is, therefore, viewed as objective, while an astronomer’s judgement comes into play when those measurements are interpreted astrophysically – but the relationship between them is, typically, asymmetric: through hyperlinks provided by ADS (http://adsabs.harvard.edu/) a journal article can point to the online catalogue(s)
used in its analysis, but the data archives hosting the catalogue(s) do not implement analogous pointers to the additional information about catalogue entries that is present in the online literature.

2. **Objects in the sky do not come with unique labels.** Combining information from different catalogues requires *cross-matching*. This is expensive, and up to now the only way of speeding it up, by either preserving the results of cross-matches, or providing facilitating information on neighbour distances, has been to publish (effectively) a new catalogue which, because it must be in an archive-specific format and location, is hard to reuse widely.

3. **Catalogues are static objects.** Any such fresh catalogue, derived from one or more existing catalogues but with the addition of deduced or fresh information, is logically independent from its progenitors. Although there is a chain of provenance, of course, the relationship of the new information to the old is not available to the machine. AstroDAbis addresses these three problems.

1. It provides a **tagging** interface which allows users to associate annotations to catalogue objects. This ‘folksonomy’ tagging is inevitably imprecise, but (a) this imprecision may be acceptable in some circumstances, and (b) a very closely analogous mechanism will allow users to associate more semantically sophisticated annotations to objects, when consensus emerges on what such annotations should look like.

2. As a fundamental part of its design, the AstroDAbis service will implicitly create **URI names** for every object in every catalogue it knows about. This may seem profligate, or even impertinent, but (a) the service will be able to declare equivalences to any URI names that a catalogue already supports, and (b) as well as supporting cross-match tables, this creates the ‘raw materials’ for other experiments deploying the Semantic Web within astronomy. Although it is not part of TAP at present, one could imagine an extension to TAP which documented a service’s preferred pattern for URIs naming the objects it contains.

3. **Stand-off tagging** enables astronomer users to annotate catalogues, and objects in catalogues, to which they have no write access. This creates the possibility of Web 2.0 or Semantic Web infrastructures without requiring catalogues to make the potentially disruptive changes to their systems which built-in annotation would demand. One implication of the Linked Data interface to the service (see [http://linkeddata.org](http://linkeddata.org)) is that we provide RDF information about both the catalogue objects, and the celestial objects they refer to, in a flexible and open-ended way.

The use of annotations to enrich existing data resources is not new to science or to the Web world; indeed sites such as delicious.com or Flickr are primarily concerned with such annotation in the form of ‘tagging’, and the associated notion of ‘folksonomy’. Delicious-style tagging is one of the inspirations of the AstroDAbis project but the more immediate one is the Distributed Annotation System (DAS, [http://www.biolas.org](http://www.biolas.org)), which is a widely-used protocol for exchanging annotations on genomic and protein sequences. This system inspired previous work involving one of us (Mann), on the development of the AstroDAS system ([Bose et al. 2006](http://www.biolas.org)), which prototyped the recording and publication of annotations of astronomical catalogues. AstroDAS was a successful proof-of-concept, but the immaturity of the VO protocol suite
at that time meant that it could not be implemented using open standards developed by the IVOA, and this limited its utility. Since then, the IVOA has released TAP, which provides a standard means of accessing tabular astronomical datasets, and important catalogues are becoming published to the VO through TAP services.

At the time of writing the service is available as a prototype, but as it matures (during 2012) we plan to bring it up to a supported service, hosted by the Wide Field Astronomy Unit at Edinburgh.

2. Using the service

2.1. TAP Factory and OGSA-DAI

Although it is not a dependency, the AstroDAbis system was designed to be naturally usable with a TAP Factory (Hume et al. 2011) based on OGSA-DAI (a framework for distributed data and query management; see http://www.ogsadai.org.uk/). Using the TAP factory a service provider can create a service, with a TAP interface, which allows a user to make a TAP query which refers to multiple other TAP services. The OGSA-DAI service then decomposes the query into a group of single-service queries, and re-combines the result streams into a single result set which it passes back to the end-user. By this means, and as illustrated in Table 1, an astronomer user can easily create a query which uses observational information from one catalogue along with annotation, identification or neighbour information from the AstroDAbis service.

By providing a simple annotation service, the AstroDAbis mechanism has the potential to support annotation of a very broad range of astronomical objects, in a very broad range of repositories.

2.2. Adding and retrieving annotations

The service supports a web-based interface, which allows a user to enter templated queries (which expand to ADQL queries (Ortiz et al. 2008)), tagging the objects which result. Alternatively (and more suitably for batch-mode or bulk annotation), users can upload annotations contained in a VOTable, as illustrated in Table 1.

Since the AstroDAbis service exposes a TAP interface to the world, its annotation information is available through ADQL interfaces similar to the one illustrated.

The TAP interface makes the AstroDAbis a first-class citizen in the VO, so that its users’ annotations can be combined with information from other VO services to support
SELECT TOP 100 masterObjID as pts_key,
slaveObjID as objID, distanceMins as tagvalue
FROM twomass_pscXBestDR7PhotoObjAll

<FIELD name='pts_key' ID='masterObjID'
ucd='meta.id;meta.main' datatype='long'>
<DESCRIPTION>The unique ID in twomass_psc</DESCRIPTION>
</FIELD>

<FIELD name='objID' ID='slaveObjId'
ucd='meta.id;meta.dataset' datatype='long'>
<DESCRIPTION>The unique ID of the neighbour
in BestDR7..PhotoObjAll (=objID)</DESCRIPTION>
</FIELD>

<FIELD name='tagvalue' ID='distanceMins'
ucd='pos.angDistance' datatype='float' unit='arcminutes'>
<DESCRIPTION>Angular sep. between neighbours</DESCRIPTION>
</FIELD>

Table 1. An ADQL query which creates a VOTable, which can subsequently be
uploaded to the AstroDAbis service to create a two-object annotation.

high-level queries such as, for example, “find me the redshifts of all the objects which
Fred Bloggs identifies as quasars”.

As well as the TAP-based interface, AstroDAbis has a ‘Linked Data’ interface. Although
this provides utility by itself, it additionally provides a mechanism for creating
URI-based names for the objects in the catalogues it annotates. These can act as a
springboard for future experiments with the Semantic Web in astronomy.

2.3. Further information

See http://code.google.com/p/astrodabis/ for project source code and documen-
tation.

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whatwedo/programmes/digitisation.aspx).

References

Bose, R., Mann, R. G., & Prina-Ricotti, D. 2006, in International Provenance and An-
notation Workshop (I-PAW), edited by L. Moreau, & I. Foster (Springer Verlag),
vol. 4145 of LNCS, 154. URL http://www.ipaw.info/ipaw06/proceedings/
CameraReady_s7_4.pdf

Dowler, P., Rixon, G., & Tody, D. 2010, Table access protocol (TAP, v1.0), IVOA Recommen-
dation. arXiv:1110.0497. URL http://www.ivoa.net/Documents/TAP/

Hume, A. C., Krause, A., Holliman, M., Mann, R. G., Noddle, K., & Voutsinas, S. 2011, in
these proceedings

Ortiz, I., Lusted, J., Dowler, P., Szalay, A., Shirasaki, Y., Nieto-Santisteban, M. A., Ohishi,
M., O’Mullane, W., & Osuna, P. 2008, IVOA astronomical data query language, ver-
sion 2.0, IVOA Recommendation. arXiv:1110.0503, URL http://www.ivoa.net/
Documents/latest/ADQL.html