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XCAT-DB a Public Interface for the SSC XMM-Newton Catalogue

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Abstract.
The first XMM-Newton serendipitous source catalogue has been released on 2003 April 7. The XCAT-DB (http://xcatdb.u-strasbg.fr) is one of the sites from which it is available. The database offers powerful tools to perform various kinds of scientific analysis, particularly designed to deal with links between catalogue sources and correlated entries extracted from many archival catalogues available at CDS and NED. The XCAT-DB is able to inter-operate with CDS databases providing multi-wavelength views on regions of interest. Online views and downloads of pipeline products related to selected X-ray sources are also available.

1. The 1XMM Catalogue

1XMM is the first comprehensive catalogue of serendipitous X-ray sources from the European Space Agency's (ESA) XMM-Newton observatory. The catalogue has been constructed by the XMM-Newton Survey Science Centre (SSC) on behalf of ESA. Most of the entries have not been previously reported as X-ray sources. The catalogue contains 33026 X-ray source detections with high likelihood values, together with a further 23685 detections with lower likelihood values. These latter sources have lower reliability. The 33026 X-ray source detections relate to 28279 unique X-ray sources (SSC 2003).

2. Database Access

A public access to the XCAT-DB is provided at:

```
http://xcatdb.u-strasbg.fr
```

The detail of any 1XMM source can also be retreived with a simple URL:

```
http://xcatdb.u-strasbg.fr/\
cgi-bin/xcat_asu.pl?OBS_ID=iiiiiii&XMMSRCNAME="xxxxxxxx"
```


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3. Database Content

The XCAT-DB contains all 1XMM catalogue entries associated with products from related XMM-Newton observations and correlated archival sources as extracted from Vizier, NED and Simbad. The XCAT-DB data model is derived from that of the SSC-DB (Michel et al. 2003). The Pipeline Processing System (PPS) used for 1XMM provides for all observations EPIC images and source lists (Fyfe et al. 2001). In addition, the PPS computes cross correlations with a group of $\sim$ 200 archive astronomical catalogues. Correlated archival source information is delivered as FITS tables, HTML pages and other graphical products (SSC 2000). All correlation links are implemented in the XCAT-DB by using qualified association vectors (the correlation vectors). The built-in cross-matches allows to restore the unicity of archival sources at loading time. An archival source correlated with 2 X-ray sources for instance will appear twice in the pipeline products whereas it will appear only once in the XCAT-DB but with 2 links toward the X-ray sources. These N-M relationships between X-ray entries and archival sources are well suited to handle cross-identifications.

4. XCAT-DB features

4.1. Two entry points

XCAT-DB data can be accessed by making selections either on 1XMM sources or on archival sources. Archival sources can be selected in one specified catalogue or in all catalogues. Once data are selected, the database can be browsed by following instrumental links (source-observation-camera-energy bands) or scientific links (correlations). Pages describing individual sources or source lists are generated on the fly but all registered pipeline products can be viewed online or can be downloaded through an automatic redirection toward the AIO (Arviset 2004).

4.2. Building Complex Queries

The graphical user interface has been designed to edit very complex queries. Query constraints are setup one by one and appended to the current query. The current query can be executed at any time and then refined. A simpler (one-click) interface is also provided. The current query is summarized on the screen by a human readable (but not editable yet) text. Queries can include constraints on search cones, on any source attributes and on some related observation parameters. The XCAT-DB is furthermore able to handle constraints on the content of the correlation vectors modeled by correlation patterns.

4.3. Searching by Correlations Patterns

A correlation pattern is a sub-query applied on the vectors of correlations. Sources having a correlation vector matching the pattern are selected. Correlation patterns are built in 2 steps. The pattern itself is first built including e.g. constraints on catalogue name and on distance.

```
NED or Simbad entries at less than 3 arcsec.
```

In the second step, the number of correlated sources expected to match the pattern is set:

```
at least one NED or Simbad entries at less than 3 arcsec.
```

Finally, the new constraint can be included into the current query. It will be processed as any other constraints.

```
select X-ray sources
    having a hardness ratio 2 in the range of 0.5 to 1.0
    and detected in observations having a duration > 10000 sec
        done by "I. Newton" or by "G. Galileo"
    and correlated with
        at least NED or Simbad entries at less than 3 arcsec.
```

This feature offers the possibility to build very focused queries but requires users to know very well all of the 200 archival catalogues. A simpler interface similar to that of Vizier (Ochsenbein 1998) provides patterns based catalogue categories instead of specific catalogues. X-ray sources can be then selected by constraining the existence of counterparts in a given category:

```
select X-ray sources
    having a hardness ratio 2 in the range of 0.5 to 1.0
    and detected in observations having a duration > 10000 sec
        done by "I. Newton" or by "G. Galileo"
    and having Hipparcos counterparts
    and having counterparts with spectroscopic data
    and having no Radio counterpart.
```

4.4. A Real Example

The XCAT-DB has been extensively used by the SSC to prepare optical identification campaigns of serendipitous field and X-ray selected EPIC sources. Searching the XCAT-DB already led to several remarkable scientific results. A bright 'historical' source 4U1344-60 was identified with a low galactic latitude low redshift AGN. A number of very young active stars and new massive X-ray binaries were found in a group of hard X-ray emitters located in the galactic plane and correlated with optically bright object. The nature of ultra-hard X-ray emitting AGN with optical counterparts brighter than R $\sim$ 19 has also been studied in details. On the other side of the X-ray band, the density of very soft X-ray sources without any known optical counterparts was used to constrain possible LogN-LogS curves of isolated neutron stars while optical follow-up has revealed a couple of new good candidates. Preliminary results have been published in Motch et al. (2003).

4.5. Interoperability

The system allows EPIC fields of view and source positions to be overlayed on any external image using the Aladin applet (Bonnarel et al. 2001). Vizier catalogues may also be queried around any X-ray or archival source. Finally, users can download their selections in FITS tables allowing further local processing.

4.6. User Databases

An expected consequence of constraining correlation vectors is that query execution times are even less deterministic than usual. Query execution duration are usually below 3 seconds but they can exceed 2 minutes in some extreme cases. In order to make such answer delays acceptable, user query results are stored in the XCAT-DB. User selections are thus persistent over different sessions. Queries are actually executed only after a user's request (e.g. due to a query modification). These user databases are totally private and they can be erased at any time. Queries are stacked over a batch queue processing only 3 jobs at the time in order to keep the largest bandwidth for browsing accesses.

5. Prospects

The XCAT-DB is totally based on the OODBMS O2. All the code is written in O2C, a 4LG a bit similar to Java but managing the persistence transparently. No major evolutions of the XCAT-DB are scheduled out of the normal upgrade operations (e.g. correlation with new catalogues, new layout). The main issue concerns O2 which is reaching its very end of life and must be replaced. A Solution based on SQL/Java is under development. It will use the SAADA technology (Nguyen 2004).

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