Cross-Matching Surveys

Cross-matching surveys

- Aspects of mining data from large surveys are rapid
  - consider the *BETWEEN* queries for which we applied SQL in the previous lecture
  - or the *fGetNearbyObjEq*(α,δ,θ) query which returned objects in a "circle" (or radius θ around a specific coordinate)
- But, a particularly useful type of query on data is also one of the slowest to apply...cross-matching
- Cross-matching takes a (potentially long) list of (α,δ) positions in one sky survey and finds the closest set of objects at (α,δ) positions in a different survey
  - or, for that matter, in the same survey

Cross-matching surveys

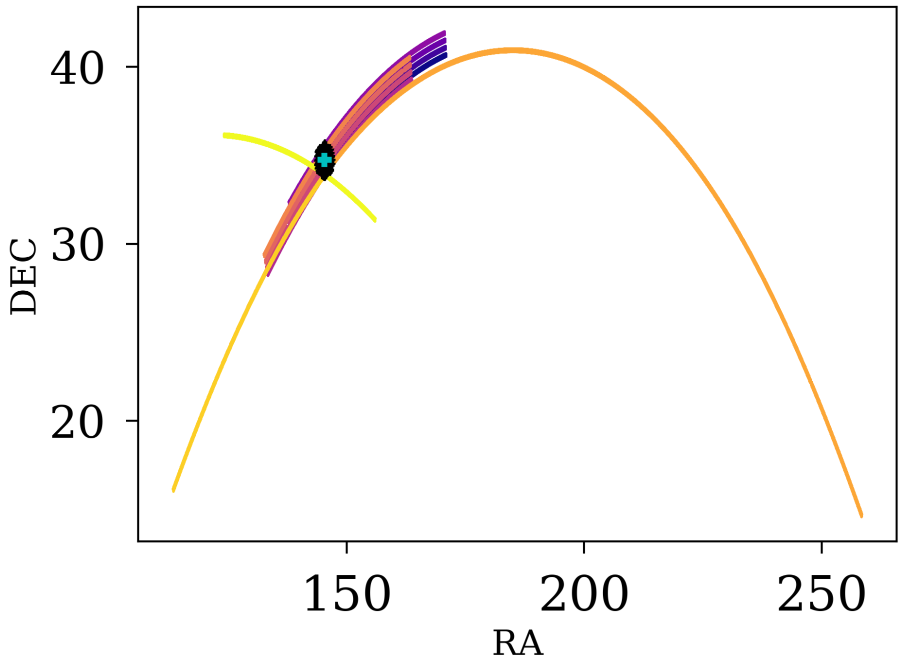
- One goal of data mining would be to obtain a flux measurement for a source (a star etc.) at any position in any sky survey (at any time and/or wavelength)
- In the era of cloud computing, the grand vision is a set of web services, where any user can send code or a query (e.g., SQL) to a massive central database
  - that database would then return requested data, or run code on that data for a science application
- But, in truth, computer processing remains expensive, while disk space is cheap. So, it still makes a lot of sense to store local copies of data and run code locally
  - In today's tasks, we'll consider both a web-services-type query, and a local-style query

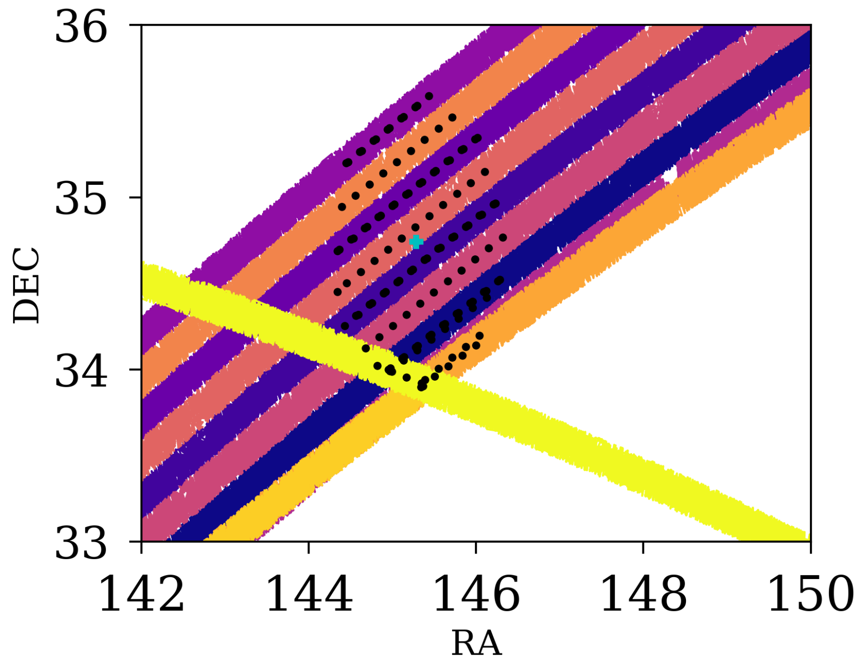
SDSS Sweeps

- In SDSS, the data sweeps are locally stored trimmed versions of photoObj containing the most commonly used parameters.
  - e.g., RA, dec, *ugriz* magnitudes, and more
- Each SDSS field can be uniquely specified by three numbers: *run, camcol, field*. See the SDSS Imaging link.
- You can follow the SDSS DRD15 data link to see the sweeps. These are stored locally on tomservo, so we will use them to work with SDSS photometry.
- To find photometry for one source, you could (slowly) read in all the sweeps or…

SDSS Sweep Index

- There are index files that contain arrays of RA and dec to mark the center of each sweep across the sky. The margin on the index width is 0.36 deg.
- To get photometry near the position in cyan, nearby index values (black) suggest searching 11 different sweeps (color).





Some logistical notes

1. We'll be working with SDSS DR15, which is too much data to store locally.
   - Our data directory is */astro/astr8020/* on tomservo
   - *du -h ./dr15/* will print the data directory size.
2. You will need to clone a version of the git repo to your vpac account (ask about this if you're not sure):
   - *ssh -XYl username tomservo.phy.vanderbilt.edu* (gives vpac home with access to /astro/astr8020/).
   - create a location, e.g., *~/repos/ASTR8020/; cd repos/ASTR8020*
   - *git clone username@vpac01.phy.vanderbilt.edu:/home/runnojc1/repos/bare/F20/ASTR8020/ ./*

Some logistical notes

1. If you want to use Anaconda on vpac, you'll need to install it.
   - In your .cshrc file put (ask if you use bash):
     alias sconda "/home/runnojc1/anaconda3/etc/profile.d/conda.csh"
     alias gopy3 "conda activate python37"
2. You can alternatively install Anaconda yourself. Run:
   - *bash /astro/astr8020/Anaconda3-2019.07-Linux-x86_64.sh*
   - Use all the defaults. You'll need to conda install some things.

Some new rules

1. No more Jupyter notebooks. You can't run them from the command line on a remote machine.
2. Don't save big files to the *Git* repo.
3. Don't write to /astro/astr8020/ or /home/runnojc1/repos/bare/F20/ASTR8020/.
4. You may work in your *ASTR8020/username/week** directories on your vpac account or on your local machine. Treat each machine as a separate user with *git add, git commit, git fetch, git status, git pull, git push*.
5. I recommend writing code locally, running code that uses big data on tomservo, and then doing analysis on the results locally.

Python tasks

1. At */astro/astr8020/FIRST/first_08jul16.fits* there is a file containing sources from the VLA FIRST (20cm radio) Survey that lie near the SDSS area (as of July 2008). Read it using *fits* and plot (α,δ) to *png*.
2. In our *git* repository in my *week8* directory there is a file called *sdssDR15query.py* that can be used to query the SDSS database with SQL remotely over the web
   - try the example query provided in the code header
   - try a few random RA and dec (α,δ) positions
   - using the *SDSS Navigator Tool* linked from the syllabus, find the RA and dec of an object that exists in the SDSS and pass *sdssDR15query.py* that position

Python tasks

3. Write Python code that reads in the FIRST radio data, takes the coordinates of the first 100 objects and uses *sdssDR15query.py* to obtain the SDSS optical data
   - Code that runs at the terminal can be run from Python using *os.system,* so you could call the example in my code as follows (after *import os*):
     - *os.system("python sdssDR15query.py 145.285854 34.741254 >> file.txt")*
     - the query results would then be written to *file.txt*
   - note how slow it is to match 100 objects in this manner (web services are limited to 1 query per second so as to not overburden the server)
   - note that objects that are bright in the radio do not necessarily have matches in the SDSS optical data

Python tasks

4. Let's perform the query "locally". */astro/astr8020/dr15/* contains popular measurements from the entire SDSS
    - download one from SDSS DR15 Data to examine
    - you can use *fits.open()* to read a FITS file, even if that file is gzipped
5. These local SDSS files are called *sweep* files (read about the sweep files in the syllabus links). One (slow) method to cross match FIRST and SDSS would be to read in *all* of the sweep files
    - note the two main sweep files: "*gal*" files which are objects that are extended in imaging and "*star*" files, which are objects that are point sources in imaging

Python tasks

6. An index file prevents us needing to read all the sweeps
   - Read the index data model linked in the syllabus, read in datasweep-index-star.fits, plot RA and dec. Compare this to the figures earlier in the notes.
   - In my week8/ find *sdss_sweep_data_index.py* which calculates the subset of sweeps files that intersect regions of the sky.
   - Import this and use it to calculate which sweep files would be read to find objects within 0.5° of $(\alpha,\delta) =(180^{\circ},45^{\circ})$. Make sure you understand what this code is doing.
   - Note that you can pass *sdss_sweep_data_index* an array of RAs and decs, instead of just one position

Python tasks

7. Use *sdss_sweep_data_index* to determine which files are needed to cross-match the first 100 objects in the FIRST radio data and match to those objects
   - note that *sdss_sweep_data_index* defaults to listing the "star" files (which is what we want, here)
   - use *astropy's search_around_sky* to return SDSS matches to the FIRST objects (you'll find many objects, as the sweeps contain *every* SDSS object, not just "primary" objects...more on that in the next HW)
   - for 100 objects, this method likely isn't quicker than using the web services approach, but, relatively, it will be *much* quicker for larger numbers of objects

Some useful commands:

- ssh -XYl username tomservo.phy.vanderbilt.edu
  - X enables X11 forwarding
  - Y enables trusted X11 forwarding
  - l uses specific username syntax
  - Can also ssh into e.g., vpac01.phy.vandebilt.edu.
- du -h filename to print size of a file
  - -h prints in human readable format
  - You can also use this on a directory.

Some useful commands:

- rsync -auvzn --progress ./download_dr15.csh runnojc1@vpac01.phy.vanderbilt.edu:/home/runnojc1/
  - -a archive, makes it recursive
  - -u update, don't overwrite the target file if it is newer
  - - v verbose, -z zip
  - --progress, show progress
  - -n dry run (remove to actually move files)
- screen
  - ctl-a ctl-d to detach. In ssh on Mac, detach to leave process running. screen -r to return.

Some useful commands:

- wget -r -N -np -e robots=off exclude_directories =‘skip_this/‘ -nH --cut-dirs=2 --spider https://dr15.sdss.org/sas/dr15/eboss/sweeps/dr13_final/
  - --spider, dry run remove to download
  - -e robots=off, ignore the robots.txt file that tells search engines to ignore these files
  - -np, never descend above the parent directory
  - -r, recursive
  - -N turns on time stamps