the open-source sky survey

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http://astrometry.net/
non-text searching

• need to search things that aren’t text, with queries that aren’t text
• even “image search” in Google requires accurate text meta-data
• multi-billion-dollar question: “Here’s a picture, what is it a picture of?”
• we have answered this in one tiny domain
people

- Jon Barron (NYU, Toronto)
- David W. Hogg (NYU) – astro PI
- Dustin Lang (Toronto)
- Keir Mierle (Toronto, Google)
- Sam Roweis (Toronto, Google) – comp sci PI
- (with help from Blanton, Finkbeiner, Stumm)
blind calibration

- easy parts:
  - the sky is just a set of points in 2-d
  - excellent catalogs exist (esp USNO-B)
blind calibration

• hard parts:
  • the sky is big; astronomical images are small
  • bandpasses and sensitivities of images do not match those of the astrometric catalogs
  • we don’t necessarily know *anything* about the images we see
demo

• [web demo]
how it works

• use quads of stars to identify hypotheses
• test explanatory power of each hypothesis to verify
• typically try thousands of hypotheses per image
  • that’s a lot, but a lot less than brute-force search
  • verify is fast
Re-project into the plane with tangent point at the midpoint of AB.

CODE: $(cx, cy, dx, dy)$

4D kdtree
project status

• we are currently alpha (invitation only)
• go beta this spring?
• all code is open source (vanilla c)
  • runs on Linux and Mac
  • (Windows if you have skills)
blind calibration works

• for astrometric WCS
  • limited by USNO-B at present

• for date
  • precision of years with pms; better with variables?

• for bandpass and photometric zeropoint
  • rough bandpass: UBVRIJK
  • tens of percent precision given current catalogs

• for point-spread function
web 2.0

- user-generated content
  - blogs, moblogs, flogs, vlogs, wikis, “friend” sites
- file sharing
  - Flickr, YouTube, bittorrent (all with APIs)
- communities
  - tags, groups, feeds, comments, reviews, favorites
- new technologies create new opportunities
astrophotographers

• typical data processing:
  • read many FITS files from CCD in several bands
  • hand-select good seeing (‘‘lucky imaging’’)
  • hand-align and stack
  • turn into jpegs and post to the web

• science-grade data but...
  • hard to use for science
  • how do we find them?
  • there are often no (or hard-to-use) meta-data
AAVSOers

- typical data processing:
  - take many images with a CCD
  - flatfield, calibrate, measure one point source carefully in every image
  - submit magnitudes, put data in basement

- clearly science-grade data, but
  - worth so much more than just individual magnitudes
  - needs to be archived and as an *imaging database*
science with hobbyists

• rapid and high time-resolution response
  • GRBs, planetary microlensing, variable stars
  • near-earth object orbit determination
• pre-event imaging for transient events
• \textit{ab initio} discovery
  • known classes, such as SNe, NEOs, transits
  • new classes, such as “gamma-free” GRBs
• deep, faint, and proper-motion science
going deep

- The combined aperture of all amateur telescopes exceeds the combined aperture of all professional
  - by far, but...
  - in the visible / optical
  - can we really get $\sqrt{N}$?
star model (favored)

galaxy model (disfavored, $\Delta \chi^2 = 169$)
historical data

• the best astrometric catalog is USNO-B
  • one billion stars with positions and proper motions
  • less than one percent of the available historical data

• archives
  • contain millions of science-grade plates
  • Harvard archive alone has the sky 500 times over
  • scanning is cheap but not done
  • meta-data are often more difficult than scanning
a new “observatory”

- automatically calibrate and archive all data
  - amateur, professional, historical; <1000 Tb
  - data vetting and interoperability
  - “opposite” of the Virtual Observatory

- create a global community of observers
  - information can flow both ways
  - think “astronomical” wikipedia or wikimapia
  - open-source sky survey
  - “if you like this part of the sky, you might also like...”
the end

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