Data Challenges for the Gaia Science Alerts System

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Gaia – brief overview
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Astrometry (V < 20) - MAIN TARGET:
- completeness to 20 mag: $10^9$ stars
- parallax accuracy: 7 μas at <10 mag; 12–25 μas at 15 mag 100–300 μas at 20 mag

Photometry (V < 20):
- low-dispersion spectro-photometry
- 8–20 mmag at 15 mag: Teff ~ 200 K, log g, [Fe/H] to 0.2 dex, extinction

Radial velocity (V < 16.5–17):
- Third component of space motion, perspective acceleration
- <1 km/s at 13-13.5 mag and <15 km/s at 16.5-17 mag
Gaia – focal plane

**Total field:**
- active area: 0.75 deg$^2$
- CCDs: 14 + 62 + 14 + 12
- 4500 x 1966 pixels (TDI)
- pixel size = 10 µm x 30 µm
  = 59 mas x 177 mas

**Sky mapper:**
- detects all objects to 20 mag
- rejects cosmic-ray events
- FoV discrimination

**Astrometry:**
- total detection noise: ~6 e$^-$

**Photometry:**
- spectro-photometer
- blue and red CCDs

**Spectroscopy:**
- high-resolution spectra
- red CCDs

Star motion in 10 s
4.4 s per CCD

Figure courtesy Alex Short

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Gaia – Data Processing and Analysis Consortium (DPAC)
Science Alerts

Aims:

– detect unexpected and rapid changes in the flux, spectrum or position or appearance of new objects
– trigger ground-based follow-up
– provide targets to the community to be studied at peculiar states

Methods:

– run in near-real-time: between couple of hours and 24h after observation
– use photometric, spectroscopic and astrometric Gaia data
– cross-match against existing information
Science Alert Triggers

- GRBs optical counterparts
- M-dwarf flares
- Be stars
- Asteroids
- Dwarf novae
- Supernovae
- NEW THINGS??
- Classical novae
- Lensed supernovae
- R Coronae Borealis
- FU Orionis and similar
- Microlensing events
Gaia – Scanning law

- Two telescopes - time between subsequent FOVs: 106.5m
- Time between successive scans: 6 h
- Field revisited every ~70 days
- Each object measured ~80 times (200 at the nodes)
Science Alerts - Timeline

- **d-1**: 16h backlog
- **d**: 8h visibility real time
- **d+1**: Acquisition Gaia, transmission MOC, transmission SOC

**Timeline**
- 0: one operational day
- 24: Initial Data Treatment
- 48: First Look

**Instruments**
- Astrometry (Cambridge): (50 mas) or (100 μas)

**Locations**
- Madrid, Spain

**Figures**
- Figure courtesy Francois Mignard, updated by LW
Science Alerts - AlertPipe

Operation scheme

- New Transits
- Candidate Alerts
- Gaia DB
- Anomaly Detector
- Gaia Classifier
- Cross-match

Available catalogues:
- SDSS
- 2MASS
- NED
- ASAS
- OGLE

World-wide follow-up network of telescopes
Science Alerts – Anomaly Detection

Anomaly Detection
- known sources
- new sources
Science Alerts – Data Storage Challenge

Simulated ingestion
• ~30 mins per day

Simulated ingestion + source history retrieval
• ~3-4 hrs per day

Challenge:
How to speed up ingestion + source history ingestion?

~13.5 million per day (down to 19 mag)

![Diagram of data flow involving Gaia DB, Multiple PSQL, New Transits, and Anomaly Detector]
Science Alerts - Classification

Available Data:
- G-band photometry (light curve)
- BP/RP colour
- raw BP and RP spectra
- morphology of the source (galaxy/star)
- source motion flags (fast asteroid?)
- Gaia catalogues (later in the mission)

Current Investigations:
- Lightcurve classification using Gaussian Mixtures
- Spectral classification using Self-Organising Maps
Science Alerts – Cross-matching

Catalogue Access (current):
• Astrogrid cone search http:// query
• But:
  • Variable query return time
  • Limited search parameters

Catalogue Access (future):
• Identity most useful catalogues
• Store local copies
Science Alerts – Cross-matching

Cross-matching:
• Identification of robust and efficient techniques - e.g.
  • decision trees

• Complementary to or based upon classification results?
Science Alerts – Dissemination

Format:
- VOEvent

Dissemination
1. E-mail via subscription
2. Website hosting all alerts and auxiliary data (basic)
3. VOEvent repository: to be accessible SkyAlert.org, eStar etc... (advanced)
Further Gaia and Science Alerts Info

Thank you

• http://www.ast.cam.ac.uk/research/gsawg/

• P025 O'Mullane, William. Gaia: Processing to Archive