Practical Astroinformatics

... or what I wish to knew when I was younger

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INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

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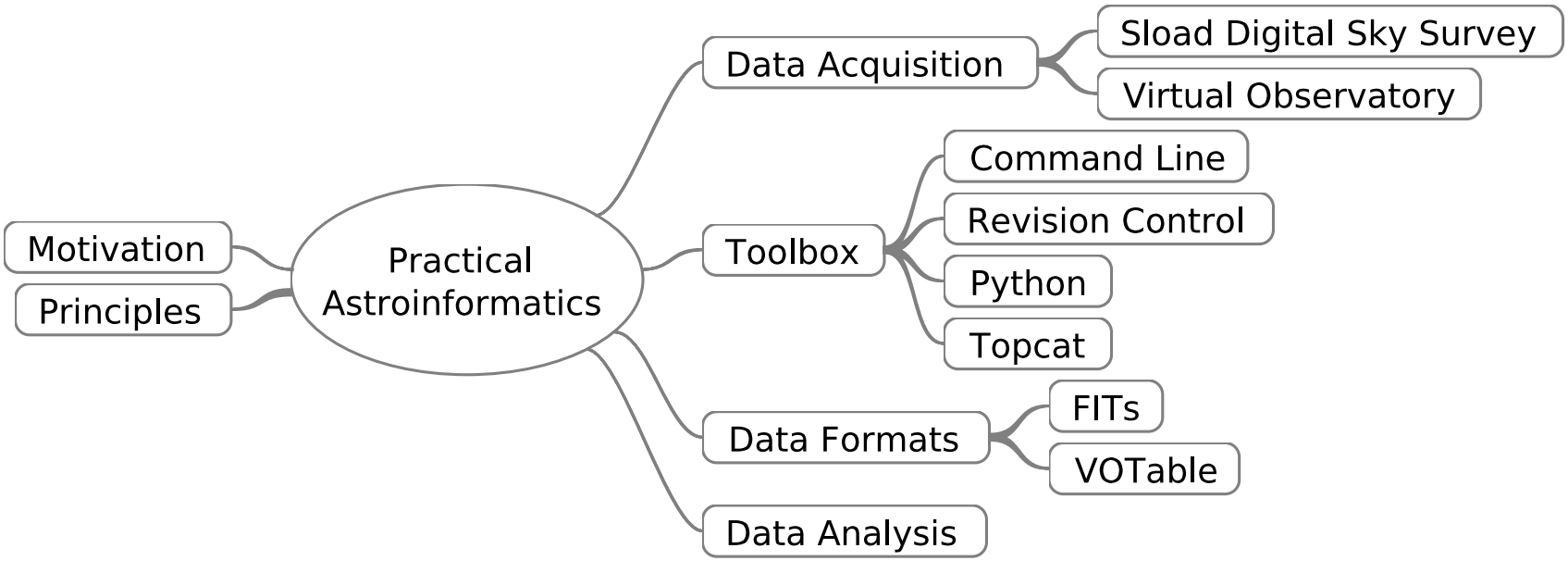
Prelude

motto: The only way to keep away from computers in science is to understand them ...

`https://www.coursera.org/`

Concepts introduced in this talk



Data Avalanche?

- Large Synoptic Survey Telescope
  - 20 TB per night
  - 60 PB for the raw data (after 10 years)
  - 15 PB for the catalog database

  The total data volume after processing will be several hundred PB

- Where I can learn more?
  - `http://www.lsst.org/`

Sloan Digital Sky Survey

- Why is it important?
  - Lots of data ($>10^6$ objects)
  - Perfect documentation
  - Tools to access the data
- Where I can learn it?
  - `http://www.sdss3.org/`

Virtual Observatory

- Why is it important?
  - Uniform access to astronomy data
  - Based on Web standards
  - Many tools with vo support (Topcat, Aladin, Tapsh)
- Where I can learn it?
  - `http://physics.muni.cz/~vazny/wiki/index.php/Diploma_work`

Example: Virtual Observatory Protocols

Cone Search Protocol

```
1 http://simbad.u-strasbg.fr/simbad-conesearch.pl?RA=24.5&
      DEC=-57.2&SR=0.1
```

Simple Image Access Protocol

```
1   http://hubblesite.org/cgi-bin/sia/hst_pr_sia.pl?POS
        =83.6,22.0&SIZE=1.0
```

Simple Spectra Access Protocol

```
1   http://archive.eso.org/apps/ssaserver/EsoProxySsap?
        REQUEST=queryData&POS=83.63,22&SIZE=1
```

Example: Virtual Observatory Protocols

Table Access Protocol

```
1  -- Display all identifiers of a given object.
2  SELECT id2.id
3  FROM ident AS id1 JOIN ident AS id2 USING(oidref)
4  WHERE id1.id = 'M1';
```

http://simbad.u-strasbg.fr/simbad/sim-tap

Command Line

- Why is it important?
  - Efficient dialog computer $\Longleftrightarrow$ human
  - In all advanced tools (Programming, mathematica, CAD, ...)
  - Cooperation, re-usability, automatize
- Where I can learn it?
  - PEEPCODE: Meet the Command Line, Advanced Command Line

Examples

- TAB, CTRL-A, CTRL-E (=Emacs)
- !! Repeat last command
- !$ Repeat last agrument
- history command history
- CTRL+R search in history

Text tools

- Why is it important?
  - "Everything"is a text
  - head, tail, sed, awk, join, paste, vim, emacs ...
- Where I can learn it?
  - PEEPCODE: Meet Emacs, Smash Into Vim, Vim Emacs tutorials

Revision Control Systems

- Why is it important?
  - Distributed systems (Git, Mercurial)
  - Almost everything is local
  - Branching
  - Natural (subjective?)
- Where I can learn it?
  - PEEPCODE: Git, Mercurial
  - `https://github.com`
  - `http://gitref.org/`
  - `http://www.youtube.com/watch?v=ZDR433b0HJY`

Python

- Why is it important?
  - Language of science ?
  - Cooperation between scientist (Scipy conference)
  - Perfect for experiments (iPython)
  - Real free language (!= MATBLAB)
- Where I can learn it?
  - `http://pyvideo.org/`
  - `http://www.youtube.com/watch?v=B9MvjMFokLc`
  - `http://ipython.org/`

Topcat

- Why is it important?
  - Perfect for big data (not only astro)
  - Example of cooperation between GUI applications
  - Learning Astrophysics
- Where I can learn it?
  - `http://www.star.bris.ac.uk/~mbt/topcat/`
  - `http://www.eurovo-ice.eu/twiki/bin/view/EuroVOICE/ICESchool`

FITs

- Why is it important?
  - De-Facto standard in Astronomy
  - Flexible, Efficient, ASCII Meta-Data
- Where I can learn it?
  - `http://fits.gsfc.nasa.gov`

Example: Reading FITS file

```
In [1]: import pyfits
In [2]: hdulist = pyfits.open('spSpec-53237-1886-248.fit')
In [3]: hdulist.info()
Filename: spSpec-53237-1886-248.fit
No.    Name         Type      Cards   Dimensions   Format
0    PRIMARY    PrimaryHDU     213  (3874, 5)    float32
1               BinTableHDU     54  6R x 23C     [1E, 1E, ...
2               BinTableHDU     54  44R x 23C    [1E, 1E, ...
3               BinTableHDU     18  1R x 5C      [1E, 1E, ...
4               BinTableHDU     32  53R x 12C    [1J, 1J, ...
5               BinTableHDU     26  36R x 9C     [19A, 1E,
    ...
6               BinTableHDU     14  3874R x 3C   [1J, 1J, 1E]
```

VOTable

- Why is it important?
  - Standard in Virtual Observatory
  - Flexible, Efficient, XML
- Where I can learn it?
  - `http://www.ivoa.org`

Example: VOTable

```
<?xml version="1.0" encoding="utf-8"?>
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:noNamespaceSchemaLocation="http://www.ivoa.net/xml/
     VOTable/v1.0"
 xmlns="http://www.ivoa.net/xml/VOTable/v1.0">
 <RESOURCE type="results" >
  <TABLE >
   <FIELD ID="col0" name="wave" datatype="float" unit=""
   precision="F9"/>
  <DATA>
    <TABLEDATA>
     <TR>
      <TD>4012.50757</TD>
     </TR>
 </TABLEDATA>
  </DATA>
```

Example: Working with FITs in Python

```
In [1]: import atpy
In [2]: tbl = atpy.Table('spSpec-53401-2052-458.fit')
Auto-detected input type: fits
In [3]: tbl.write('votableExample.xml')
Auto-detected input type: vo
```

Updating FITS file.

```
In [1]: prihdr = hdulist[0].header
In [2]: prihdr.update('observer', 'Astar')
In [3]: prihdr.add_history('Updated 3/27/11')
```

Data Mining

- Why is it important?
  - Astrology of data
  - Data preprocessing
- Where I can learn it?
  - Standford(Andrew Ng)
  - `www.avc.cvut.cz`

Example: Decison Tree

```
1  ug <= 0.663668
2  |   gr <= -0.191208: 1 (7.0)
3  |   gr > -0.191208: 3 (104.0/5.0)
4  ug > 0.663668
5  |   ri <= 0.285854: 1 (88.0/5.0)
6  |   ri > 0.285854
7  |   |   ri <= 0.314657
8  |   |   |   gr <= 0.692108: 2 (6.0)
9  |   |   |   gr > 0.692108: 1 (3.0)
10 |   |   ri > 0.314657: 2 (90.0/2.0)
```

Discussion