

Practical Astroinformatics

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

Jaroslav Vážný / Masaryk University



evropský
sociální
fond v ČR



EVROPSKÁ UNIE



MINISTERSTVO ŠKOLSTVÍ,
MLÁDEŽE A TĚLOVÝCHOVY



OP Vzdělávání
pro konkurenceschopnost

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

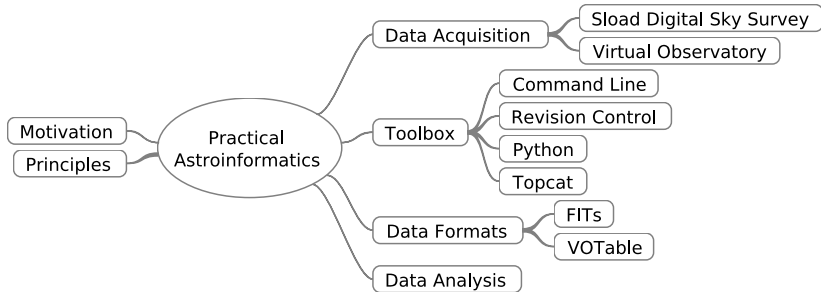
SoftComp reg. č. CZ.1.07/2.3.00/20.0072

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 \iff 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 argument
- 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

```

1 In [1]: import pyfits
2 In [2]: hdulist = pyfits.open('spSpec-53237-1886-248.fit')
3 In [3]: hdulist.info()
4 Filename: spSpec-53237-1886-248.fit
5 No.      Name          Type          Cards  Dimensions  Format
6 0        PRIMARY      PrimaryHDU    213    (3874, 5)   float32
7 1                  BinTableHDU   54     6R x 23C   [1E, 1E, ...
8 2                  BinTableHDU   54     44R x 23C  [1E, 1E, ...
9 3                  BinTableHDU   18     1R x 5C    [1E, 1E, ...
10 4                  BinTableHDU   32     53R x 12C  [1J, 1J, ...
11 5                  BinTableHDU   26     36R x 9C   [19A, 1E,
12 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

```
1 <?xml version="1.0" encoding="utf-8"?>
2   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
3   xsi:noNamespaceSchemaLocation="http://www.ivoa.net/xml/
4     VOTable/v1.0"
5   xmlns="http://www.ivoa.net/xml/VOTable/v1.0">
6   <RESOURCE type="results" >
7     <TABLE >
8       <FIELD ID="col0" name="wave" datatype="float" unit=""
9         precision="F9"/>
10      <DATA>
11        <TABLEDATA>
12          <TR>
13            <TD>4012.50757</TD>
14          </TR>
15        </TABLEDATA>
16      </DATA>
```

Example: Working with FITs in Python

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

Updating FITS file.

```
1 In [1]: prihdr = hdulist[0].header
2 In [2]: prihdr.update('observer', 'Astar')
3 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?
 - Stanford(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