Data acquisition
Processing
Plotting
GIS
GPR & SU
Conlusion

Geographical Information System (GIS) and opensource signal processing tools

J.-M Friedt

FEMTO-ST Time & Frequency, Besançon, France
Associations Projet Aurore & Sequanux, Besançon, France

Contact: jmfriedt@femto-st.fr

All references available at http://jmfriedt.free.fr

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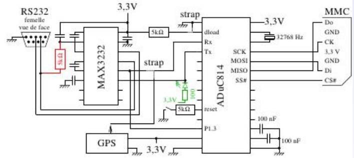
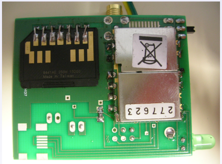
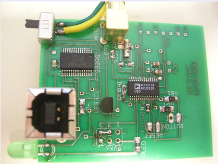
Management of geographical information

- How to acquire data ?
- Embedded GPS receiver logging once every second the position of the user.
- Very basic (sophomore level ?) digital circuit which takes best advantage of **mass storage** of SD card (SPI communication) [1]
- Very rich perspective: opensource mapping (OpenStreetMap), localization of pictures, measurement of glacier snout position !







[1] J.-M Friedt, É. Carry, *Acquisition et dissémination de trames GPS à des fins de cartographie libre*, GNU/Linux Magazine France, Hors Série 27 (Octobre 2006), `http://jmfriedt.free.fr/lm_hs27_gps.pdf`

Framework for processing scientific data

- Targetted towards plotting: `gnuplot`
- Targetted towards processing: `GNU/Octave` (mostly Matlab compatible), Scilab (INRIA, now GPL), SciPy/NumPy
- gcc (GNU Compiler Collection), a *homogeneous* set of tools (preprocessor, compiler, linker, libraries) for all general purpose processors (x86, ARM, SPARC, Freescale, Renesas ...) [2]
- GRASS dedicated to GIS + Google Maps (Google API) when web access is available
- Seismic Unix (SU) for processing Ground Penetrating (GPR) "synthetic aperture antenna" datasets.

Opensource processing software no longer means opensource operating system: most mainstream processing tools have been ported to MS-Windows (and MacOS is a unix derivative)

[2] `http://sequanux.org/jmfriedt/t/binary.iso` is a live-CD running Debian GNU/Linux providing all compilers and processing tools for a master2 teaching course on digital embedded electronics.

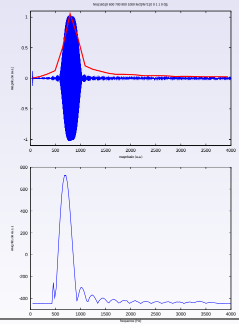
GNU/Octave

Design of a Finite Impulse Response (FIR) filter using GNU/Octave [3] (mostly Matlab compatible)

Find b_n so that the future (y) being a linear combination (convolution) of the past (x) matches some known transfer function:

$$y_n = \sum_{k=0..m} b_k x_{n-k}$$

The *sampling rate* f_e is normalized and knowing its value is fundamental in designing the filter




```
fe=16000;
ffin=4000;
fdeb=40;

b=firls(160,[0 600 700 900 1000 fe/2]/fe*2,[0 0 1 1 0 0]);
x=chirp([0:1/fe:5],fdeb,5,ffin);
f=linspace(fdeb,ffin,length(x));
plot(f,filter(b,1,x));

freq=[fdeb:150:ffin];
k=1;
for f=freq
  x=sin(2*pi*f*[0:1/fe:1]); y=filter(b,1,x); sortie(k)=max(y);
  k=k+1;
end
hold on;plot(freq,sortie,'r')
xlabel('frequence (Hz)') ylabel('magnitude (u.a.)')
```

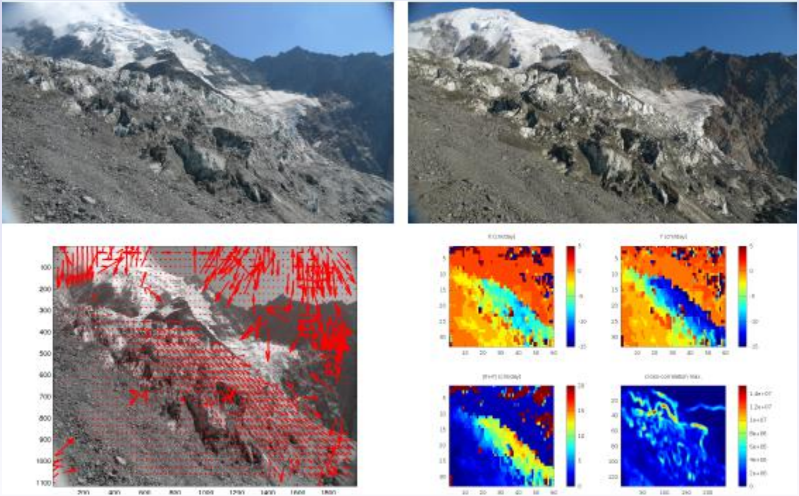
Top: modelling, blue by filtering a chirp, red by sampling discrete frequencies.

Bottom: experimental measurement of a FIR bandpass filter tuned for [700:900] Hz.

[3] J.-M Friedt, *Affichage et traitement de données au moyen de logiciels libres*, GNU/Linux Magazine France, 111 (Dec. 2008), `jmfriedt.free.fr/lm_octave.pdf`

GNU/Octave

Image processing: motion detection through cross-correlation [4]



[4] J.-M Friedt, *Auto et intercorrélation, recherche de ressemblance dans les signaux : application l'identification d'images floutées*, GNU/Linux Magazine France 139 (2011)

GNU/Octave

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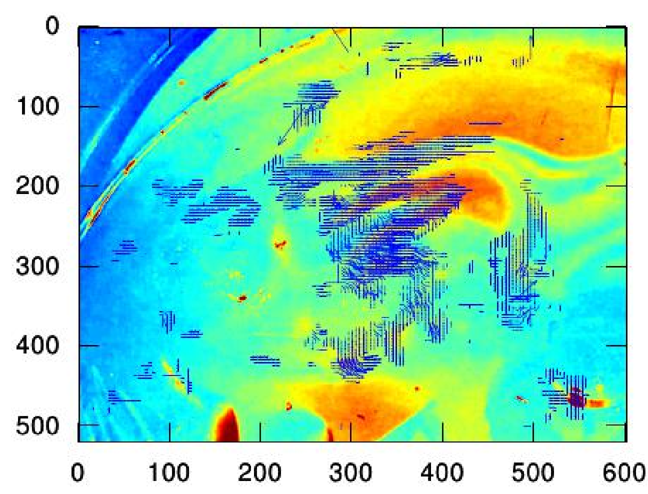
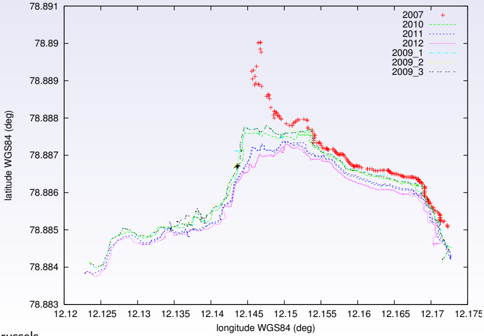


[4] J.-M Friedt, *Auto et intercorrélation, recherche de ressemblance dans les signaux : application l'identification d'images floutées*, GNU/Linux Magazine France 139 (2011)

gnuplot

gnuplot does *not* lock the file it reads ⇒ simultaneous record and plot

```
pl 'front_glacier_2007/2007_tmp.txt' u 1:2 w p t '2007',
  './front_glacier_2010/front2010.txt' u 1:2 w l t '2010',
  './front_glacier_2011/front2011.txt' u 1:2 w l t '2011',
  './front_glacier_2012/front2012.txt' u 1:2 w l t '2012',
  'front_glacier_2009/090921_jaune_front.txt' u 1:2 w l t '2009_1',
  'front_glacier_2009/090921_rouge_front.txt' u 1:2 w l t '2009_2',
  'front_glacier_2009/090921_rs232_front.txt' u 1:2 w l t '2009_3'
set xlabel 'longitude WGS84 (deg)'
set ylabel 'latitude WGS84 (deg)'
```



- usual functions (point, line, ...)
- 3D and surface
- fit
- time series with date

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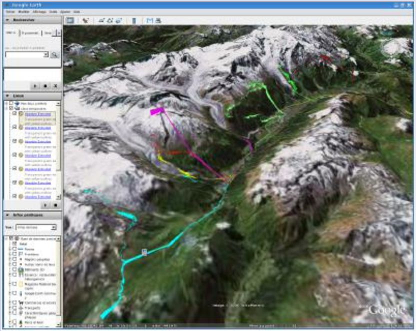
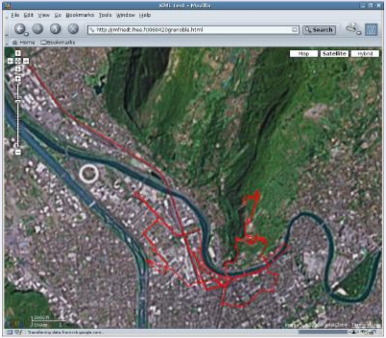
GIS through the web

- Google Maps/Earth tiles are not free ... but available.
- KML language/Google API
- OpenStreetMap: combining datasets and interpreting for vectorization





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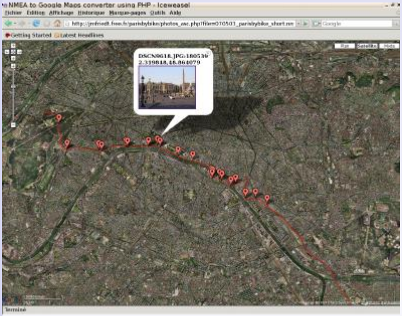

J.-M. Friedt, *Géolocalistion de photographies numériques*, GNU/Linux Magazine France 96, July/August 2007, `http://jmfriedt.free.fr/lm_photos.pdf`

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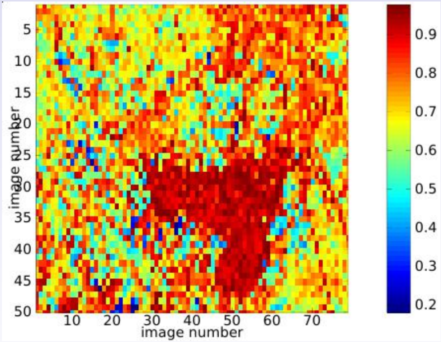

J.-M Friedt, *Auto et intercorrélation, recherche de ressemblance dans les signaux : application l'identification d'images floutées*, GNU/Linux Magazine France 139 (2011), `http://jmfriedt.free.fr/xcorr.pdf`

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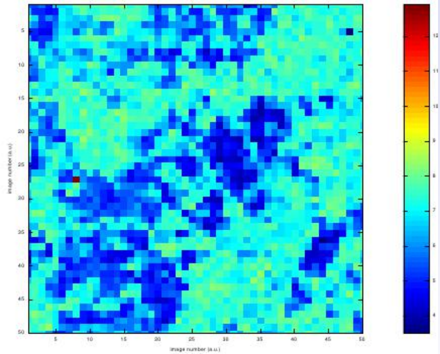

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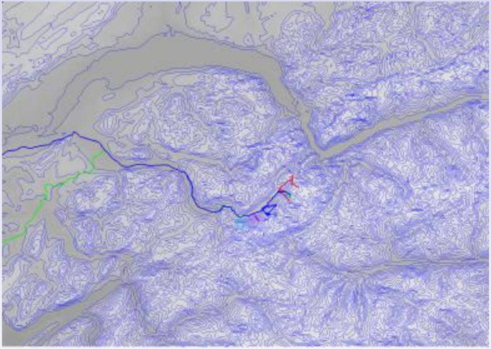
GRASS

GIS = fusion of geographically tagged information on a common substrate (map)



Using the free Digital Elevation Model acquired by the Space Shuttle Mission (SRTM [5]) – 90×90 m resolution – or GDEM (Japan METI/ US NASA [6]) – 30×30 m.

[5] http://www2.jpl.nasa.gov/srtm/

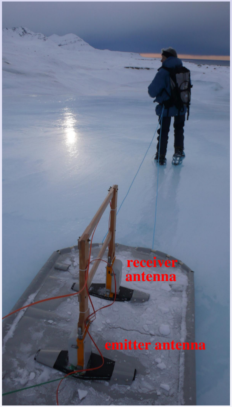
[6] http://asterweb.jpl.nasa.gov/gdem.asp

Ground Penetrating RADAR

- bistatic configuration (physically separated emitter and receiver)
- electromagnetic pulse propagates in soil ($\varepsilon_{soil} \gg \varepsilon_{air}$)
- echos due to electromagnetic impedance variations (permittivity ε_r and conductivity σ)

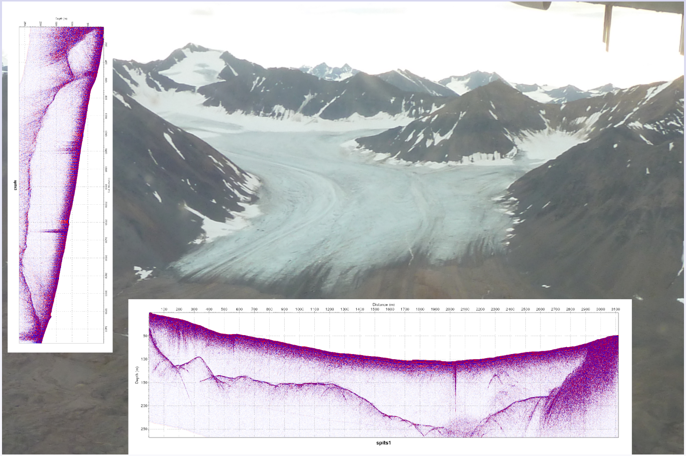
$$v = \frac{c}{\sqrt{\frac{\varepsilon_r}{2}\left(\sqrt{1+\frac{\sigma^2}{\varepsilon^2\omega^2}}+1\right)}}$$

- typical frequency range: 50-1600 MHz, depending on antenna dimensions
- lighweight, cost-effective geophysical characterization instrument



Seismic Unix

Even (especially ?) highly specialized topics such a RADAR data processing is accessible through opensource [7].



[7] A. Saintenoy, J.-M. Friedt & *al.*, *Deriving ice thickness, glacier volume and bedrock morphology of the Austre Lovnbreen (Svalbard) using Ground-penetrating Radar*, accepted Near Surface Geophysics, `jmfriedt.free.fr/gpr-lovenbren-nsg12.pdf`

Conclusion

As an active scientist both in industry and academia, I use exclusively opensource tools for all research and development activities, and have never found myself limited in my processing capabilities by this choice [8].

The only two exceptions are FPGA (closed source) synthesis tools (Altera, Xilinx) and very dedicated electronics simulation tools (Cadence with proprietary foundry libraries).

Opensource will not make data processing easier, but it moves the issue from tool availability to **hard work**.

Opensource is not a choice, it is a way of life

Caveat: requires an internet connexion

[8] J.-M Friedt, *Controle d'instruments scientifiques : les protocoles GPIB, VXI11 et USBTMC*, GNU/Linux Magazine France 124, 26-39 (2010), pp.60-66