Time-series data analysis in NIPY

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NIPY: Neuroimaging in Python

- NIPY (http://neuroimaging.scipy.org)
- A set of Python libraries for neuroimaging analysis and visualization
- Public source code development: open to any interested developer
fMRI

• functional Magnetic Resonance Imaging

• Measures blood flow to different locations in the brain, as a measure of local tissue metabolic demand

• Neural activity is coupled to metabolic demand
Typical sampling rate of a brain volume = 0.3 - 1 Hz
Time-series analysis

Hydrograph for the North Oconee River at Athens, GA

- Rainfall (mm)
- Flows (cfs)
- Minimum: 57°F
- Average: 65°F
- Maximum: 88°F
The TimeSeries Scikit

• Made for calendar-based time-series, not experimental time-series (absolute vs. relative time)

• Low frequencies
Hydrograph for the North Oconee River at Athens, GA

Rainfall (mm)

Flows (cfs)

2003 2004 2005 2006 2007

HydroClimpy
The TimeSeries Scikit

- Made for calendar-based time-series, not experimental time-series (absolute vs. relative time)
- Low frequencies
- Carries a lot of functionality we don’t need
- date/time dtype: R.Kern and T.Oliphant
Design: nipy.timeseries

Algorithms:
“The interesting part”
General-purpose
Inputs/outputs are numpy arrays
Testing

Time-series object
Analyzer Objects
Analyzer objects

- Each object implements a small set of related analysis routines
- Extraction of the relevant data
- Cacheing and book-keeping
- Consistent API
Design: nipy.timeseries

Algorithms:
- “The interesting part”
- General-purpose
- Inputs/outputs are numpy arrays

Testing

Time-series object

Analyzer Objects
In [101]: corrcoef = np.corrcoef(x,y)[0,1]

In [102]: corrcoef

Out[102]: 0.27115565081404325

In [103]: data = np.vstack([x,y])

In [104]: series =
   : ts.UniformTimeSeries(data,sampling_rate=Fs)

In [105]: series.
  : series.data               series.sampling_rate
  : series.metadata           series.time_unit
  : series.sampling_interval  series.t0
  : series.time

In [105]: series.data.shape

Out[105]: (2, 1024)
Coherency:

• Coherency (Sun et al. 2005) can be used as a measure of functional connectivity between two brain regions.

• In fMRI, different voxels have differences in the blood-signal impulse-response.

• Coherency looks at the correspondence in the frequency domain.
\[ Coherency_{xy}(\nu) = \frac{f_{xy}(\nu)}{\sqrt{f_x(\nu) \cdot f_y(\nu)}} \]
In [106]: Ch = ts.CoherenceAnalyzer(series)

In [107]: Ch.

<table>
<thead>
<tr>
<th>Ch.coherence</th>
<th>Ch.delay</th>
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<td>Ch.frequencies</td>
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\[ Coherence_{xy}(\nu) = \frac{|f_{xy}(\nu)|^2}{f_x(\nu) \cdot f_y(\nu)} \]
In [106]: tsa = ts.algorithms

In [107]: tsa.coherence(data)
\[ \text{Phase}_{xy} = \text{angle}[f_{xy}(\nu)] = \tan^{-1} \left( \frac{\Im[f_{xy}(\nu)]}{\Re[f_{xy}(\nu)]} \right) \]
Attentional control

Visual processing
brainx = Fernando Perez + MPL + networkx
Future developments:

- More algorithms:
  - Granger causality
  - Mutual information
- Visualization
- Non-uniform time-series
- Open source code development
- Generic design
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