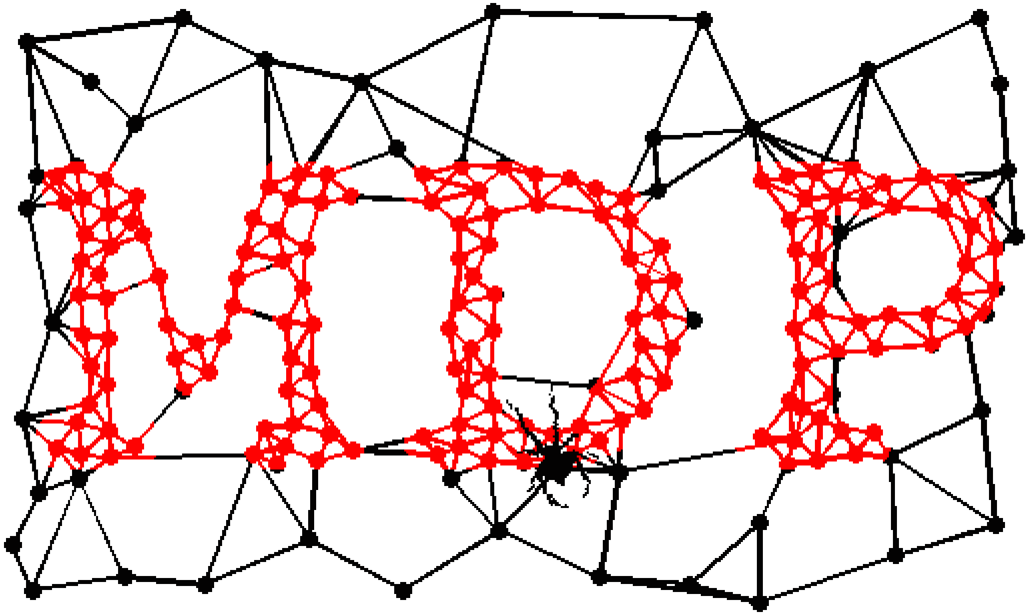
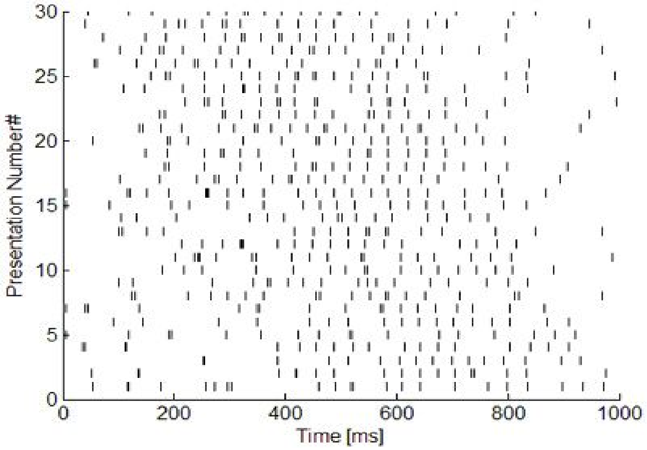
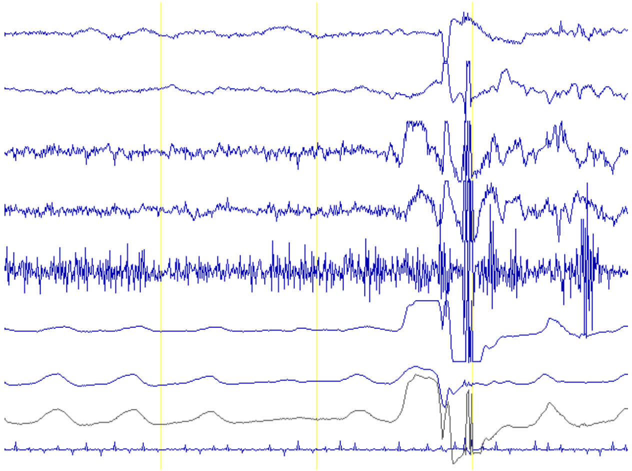
Modular Toolkit for Data Processing

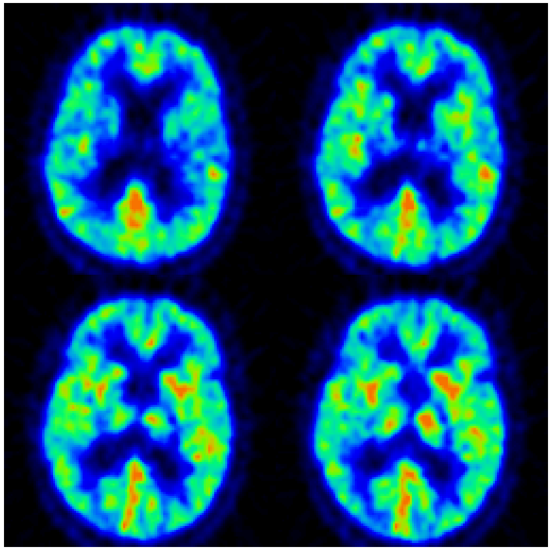


28.06.2005
Pietro Berkes & Tiziano Zito
Institute for Theoretical Biology
Berlin, Germany

Data Processing in Neuroscience







Wish List

- Collection of standard algorithms
- Efficient in RAM and CPU usage
- No limits for data set size
- No limits for data set dimensionality
- Combine many data processing units
- Easily extensible framework

Python versus Matlab®

- Python is good
- OO, reference calls
- OS: community assistance
- OS: reproducible results
- No numerical extension in stdlib

Python Numerical Extensions

- Numeric, Numarray, SciPy
- F2PY (used in symeig)
- Scientific visualization software?
- Small community, *lazy* developers

Modular toolkit for Data Processing

Python library to perform data processing:

- **Data processing units (nodes)**
- **Data processing flows**
- **Static typing design**
- **Many standard algorithms**
- **Easy to use and to extend**
- **Documentation and demos**

MDP Building Blocks: Node

Data processing unit:

- Typecode
- Input and output dimensions
- Training (batch, online, block-mode)

```
>>> pca = mdp.PCANode(output_dim=10, typecode='f')
>>> for x in train_stream:
...       pca.train(x)
...
>>> pca.stop_training()
>>> out = pca.execute(data)
>>> # helper function for one-shot train and exec
>>> out = pca(data)
```

MDP Building Blocks: Node

Already implemented nodes:

- Principal Component Analysis
- Independent Component Analysis
- Slow Feature Analysis
- Growing Neural Gas Network
- Polynomial Expansion
- Time Frames
- Hit Parades
- Noise

To be added soon:

- Fisher Discriminant Analysis
- Gaussian Classifiers

MDP Building Blocks: Flow

Data processing sequence:

- Automatic training and execution
- Automatic sanity checks
- Use of generators to receive input data

```
>>> flow = SimpleFlow([EtaComputerNode(),
...                    PCANode(output_dim=10),
...                    PolynomialExpansionNode(5),
...                    SFANode(),
...                    EtaComputerNode(),
...                    VisualizationNode()])
...
>>> def generator(seed, cycles):
...     set_random_seed(seed)
...     for i in range(cycles):
...           x = produce_stuff()
...           yield x
...
>>> flow.train([None, generator(seed, cycles), ...])
>>> out = flow.execute(data)
```

MDP: framework for developers

Write your own nodes:

- Implement `train` and `execute`
- Integrated with existing library

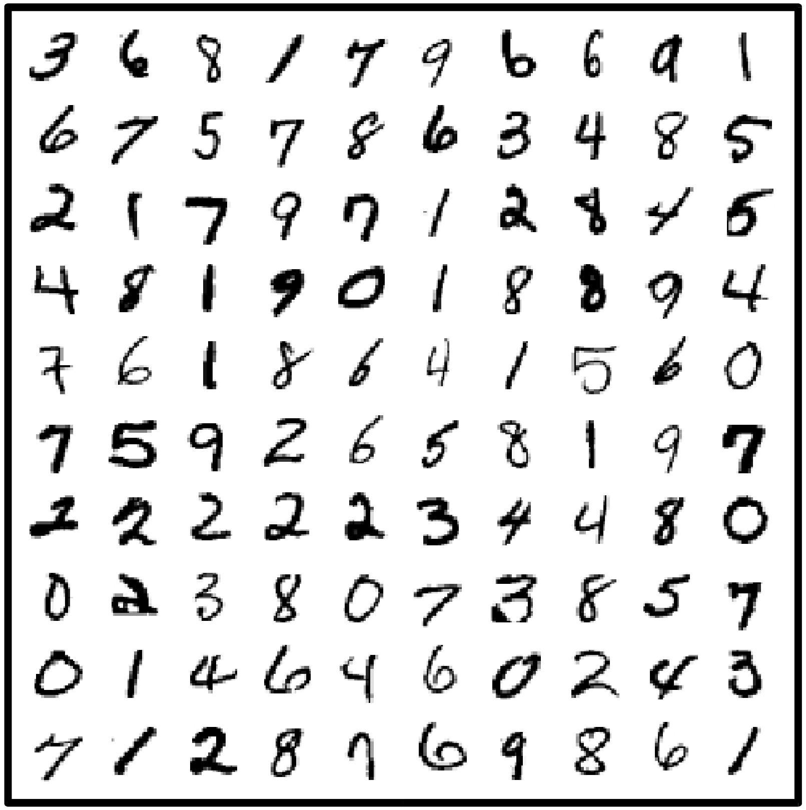
```
>>> class MyNode(SignalNode):
...       def train(self, x):
...           train_code()
...       def execute(self, x):
...           execute_code()
...       def get_supported_typecodes(self):
...           return ['f', 'd', 'i']
...
>>> flow = SimpleFlow([PCANode(), MyNode()])
>>> flow.train([generatorPCA(), generatorMyNode()])
>>> out = flow.execute(data)
```

MDP: additional features

- Flows are container types
- Checkpoint functions
- Optional crash recovery
- Invert nodes and flows

MDP: a real life example

Handwritten digit recognition



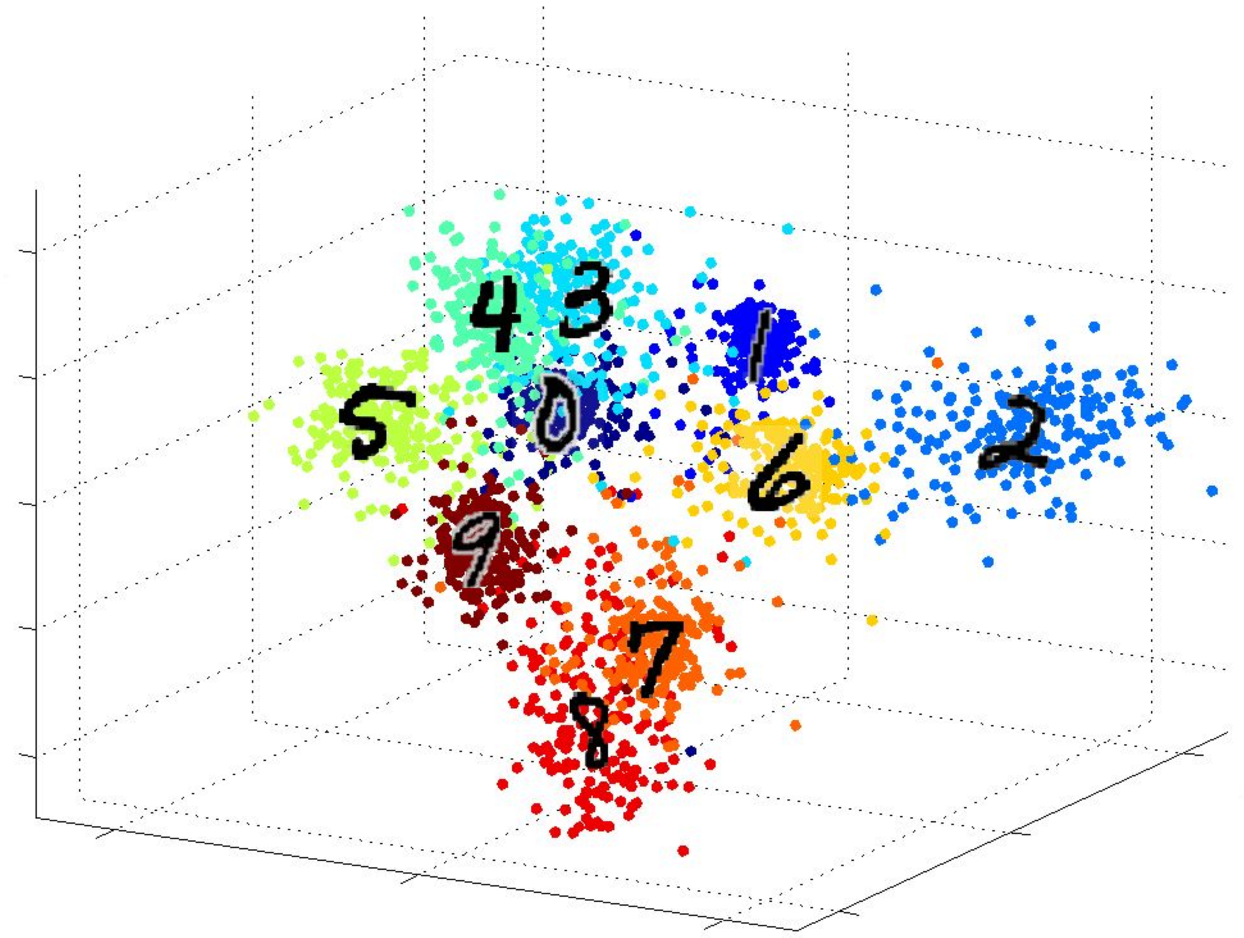
Pietro Berkes
Handwritten digit recognition with Nonlinear Fisher Discriminant Analysis
ICANN 2005

MDP: a real life example

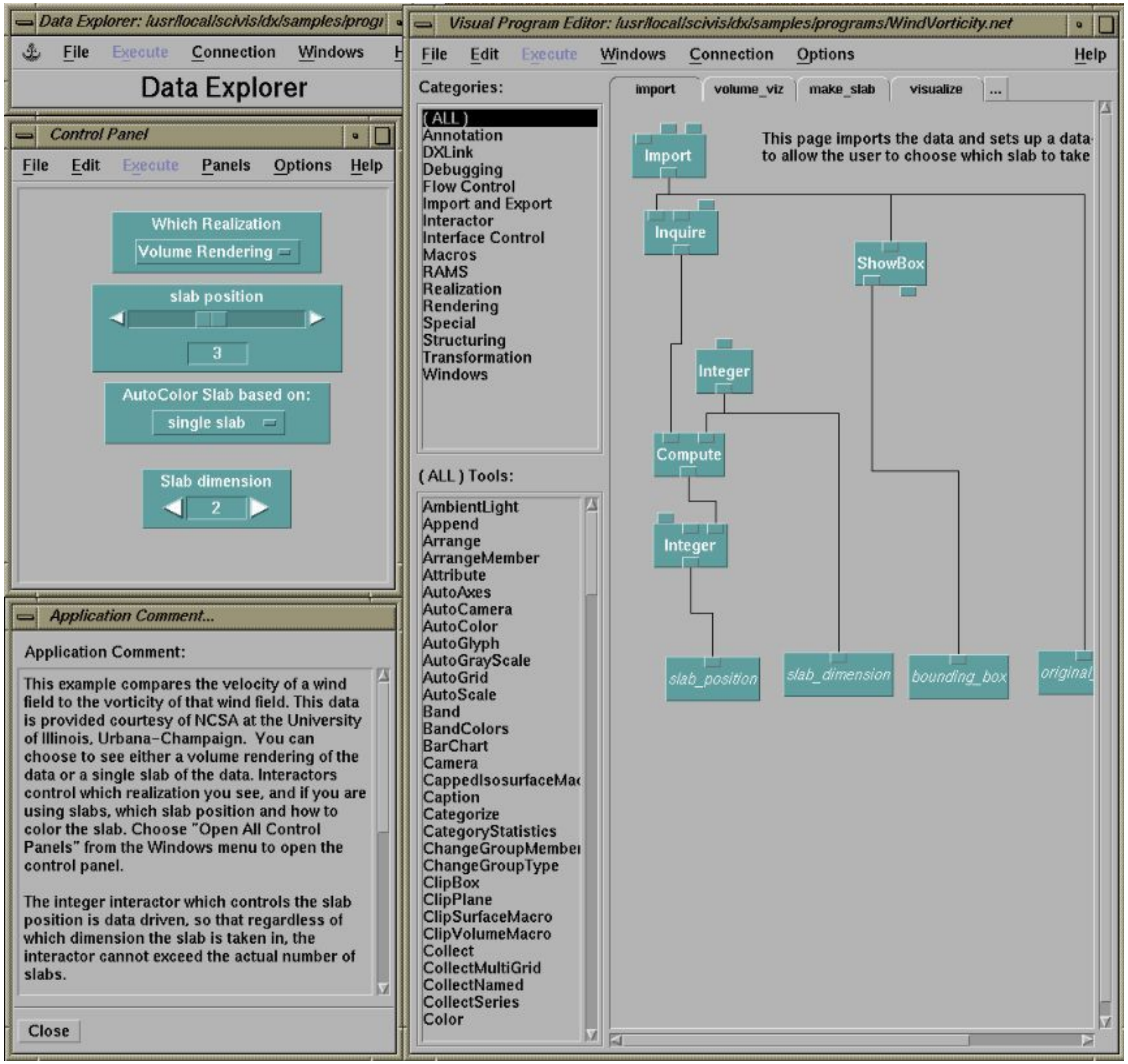
```
>>> flow = SimpleFlow([PCANode(output_dim=35),
...                    PolynomialExpansionNode(3),
...                    FDANode(output_dim=9),
...                    GaussClassifierNode()])
...
>>> def generator(database):
...     for label, digits in database.items():
...         yield digits
...
>>> flow.train([generator(train_digits), ...])
>>> guess_labels = flow.execute(generator(test_digits))
>>> error_rate = check_error(guess_labels, known_labels)
>>> visualize_feature_space(generator(test_digits))
```

MDP: a real life example

Feature Space



MDP: future perspectives



Which Realization: Volume Rendering

slab position: 3

AutoColor Slab based on: single slab

Slab dimension: 2

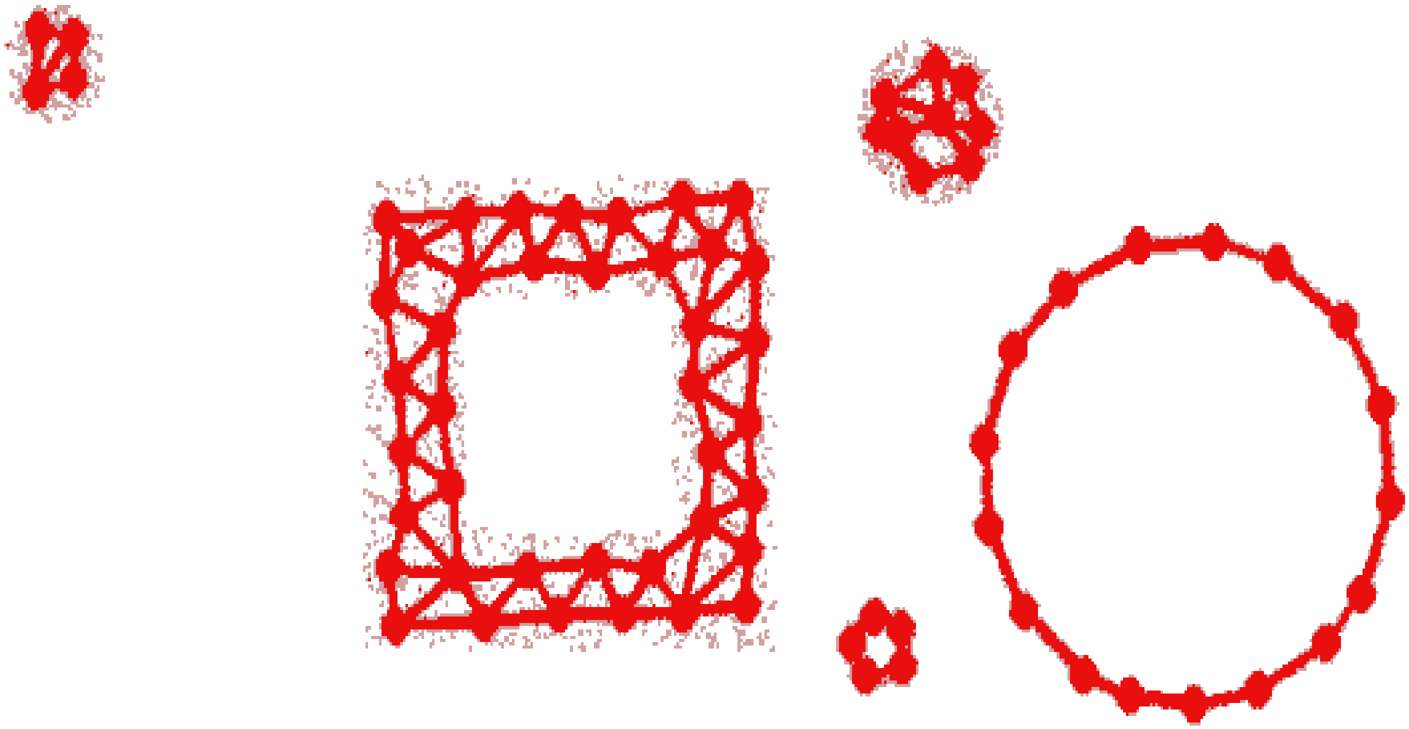
This page imports the data and sets up a data-
to allow the user to choose which slab to take

Application Comment:

This example compares the velocity of a wind field to the vorticity of that wind field. This data is provided courtesy of NCSA at the University of Illinois, Urbana–Champaign. You can choose to see either a volume rendering of the data or a single slab of the data. Interactors control which realization you see, and if you are using slabs, which slab position and how to color the slab. Choose "Open All Control Panels" from the Windows menu to open the control panel.

The integer interactor which controls the slab position is data driven, so that regardless of which dimension the slab is taken in, the interactor cannot exceed the actual number of slabs.

The End



http://mdp-toolkit.sourceforge.net