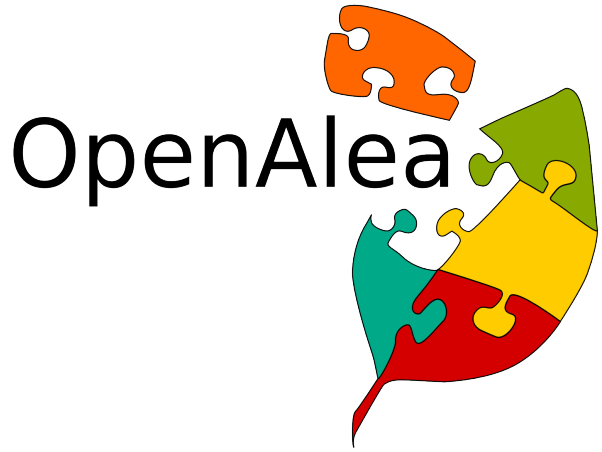
Openalea - visual programming and component based software for plant modeling

Christophe Pradal, Samuel Dufour-Kowalski



Visual Programming and Component based software for plant modeling

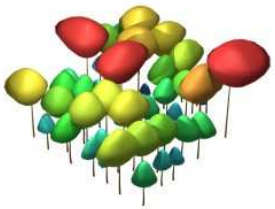
S. Dufour-Kowalski, C. Pradal

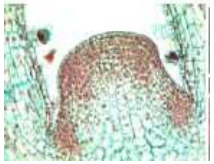
INRIA CIRAD INRA

Europython, 9 July 2007, Vilnius

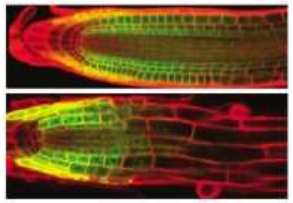
Plant Modeling

Forestery



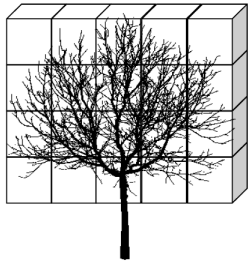


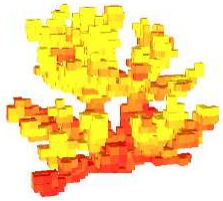
Biological objects at different scales



Measures

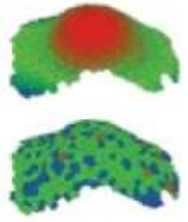
Mathematics



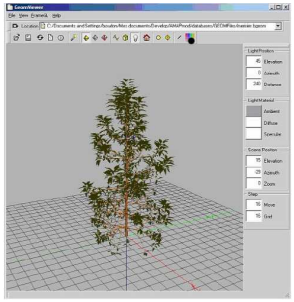


A pluri-disciplinary research

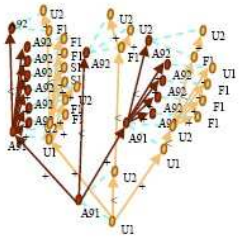
Simulation



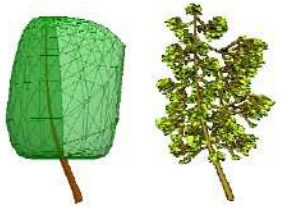
Visualization



Analysis

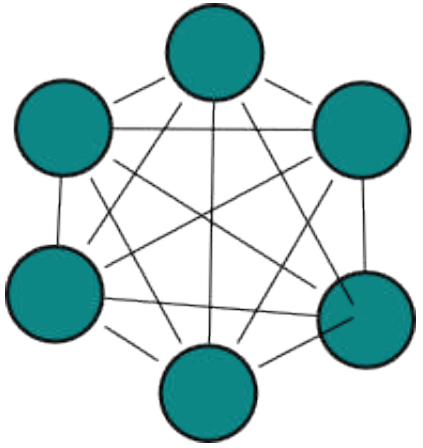


Biophysics



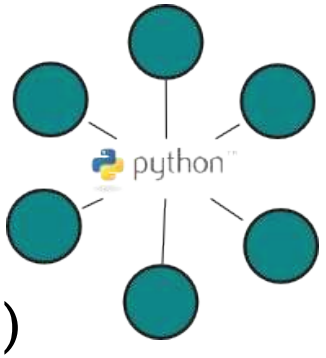
Problems

- Ad-hoc solutions for each problem
  - No reuse
- Models are difficult to interconnect
  - N^2 possibilities for N models
- Different types of actors in the community
  - Developers / Modelers / Users

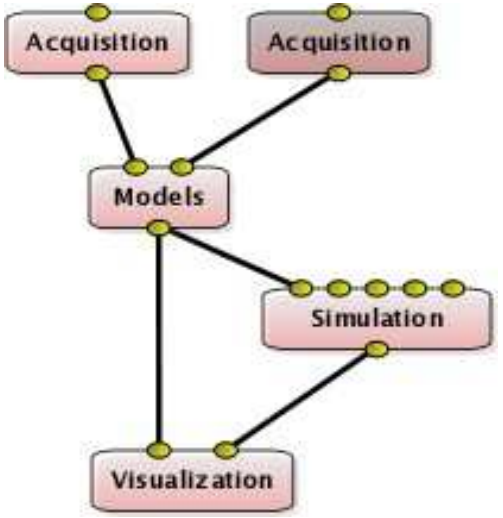


Design principles

- Python as a glue
  - Common modeling language
  - Python simplicity + scientific libraries
  - Integrate existing softwares (C/C++, Fortran)



- Connectable components
  - Autonomous / Reusable
  - High level **data flow** approach

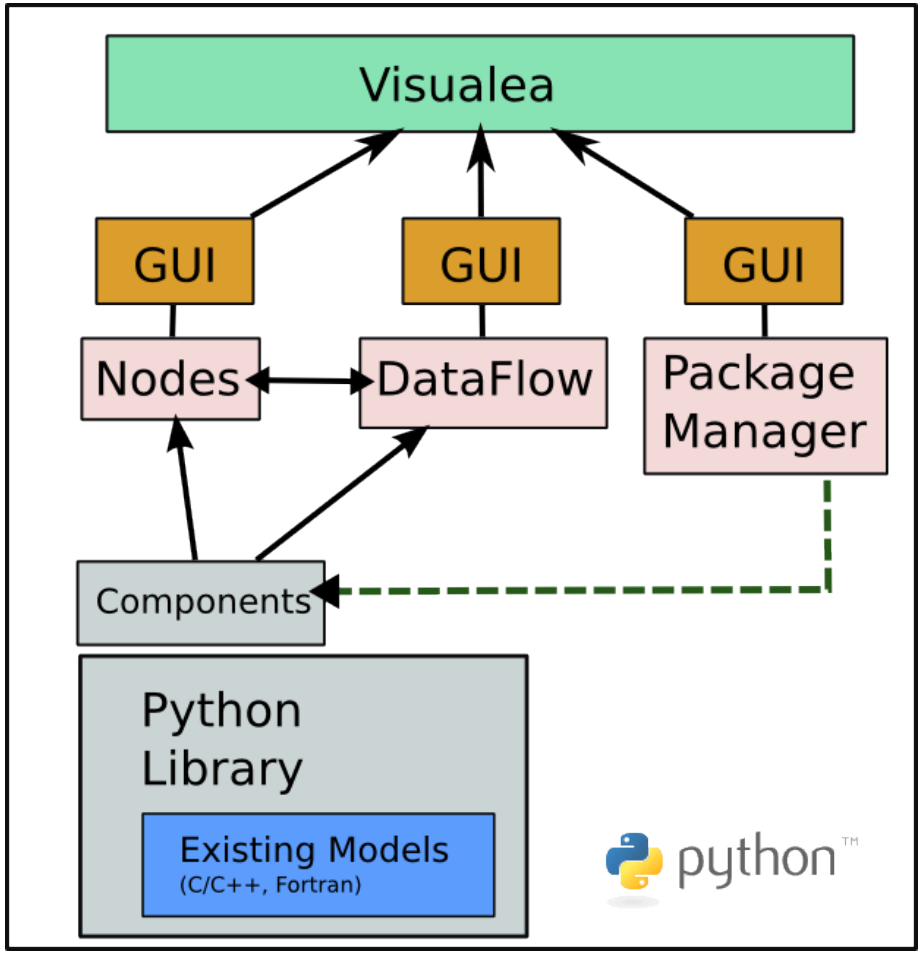


- Visual programming
  - Visual representation of a model
  - Less expressive, more intuitive

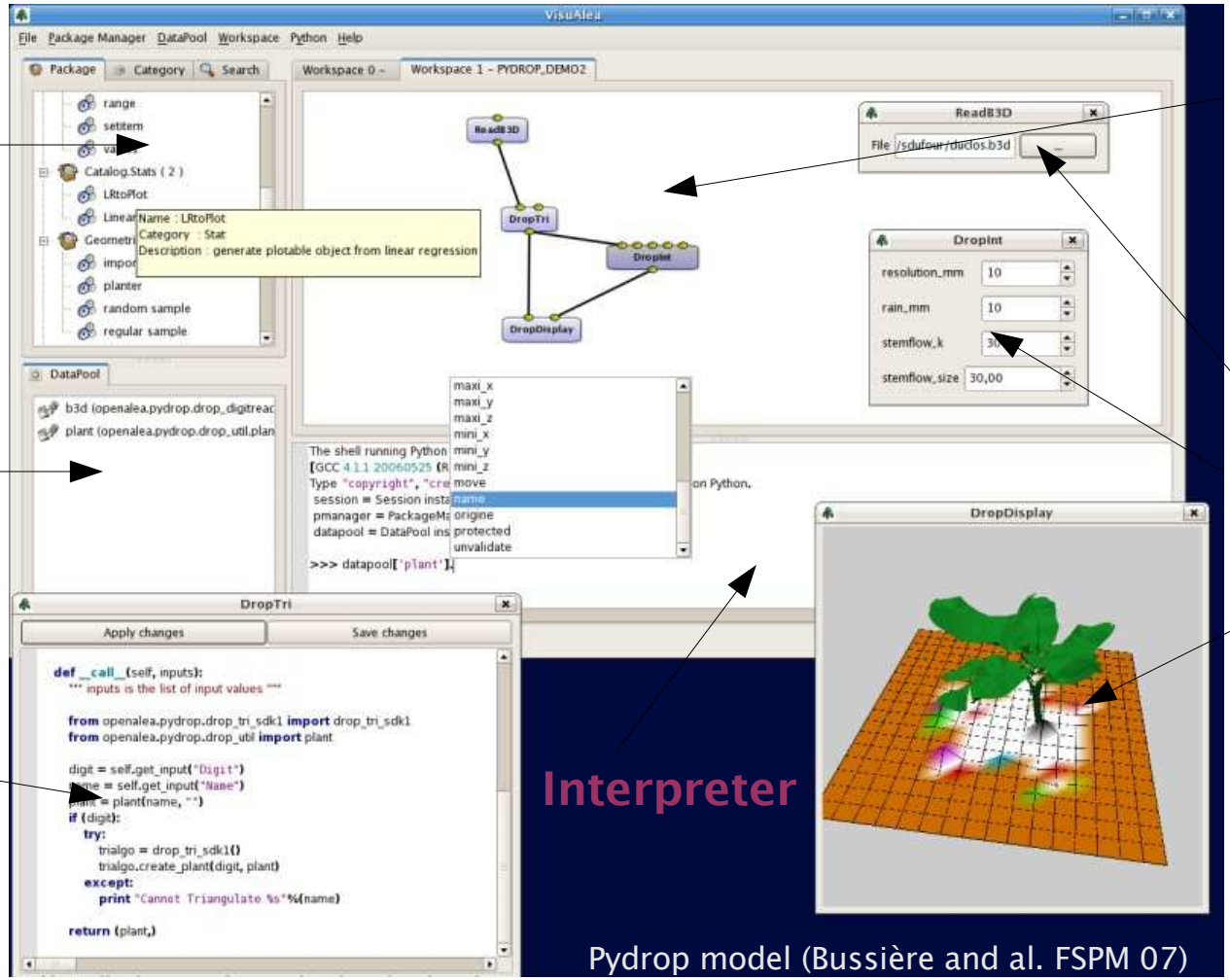
Related Work

- Vision/Viper (Sanner & al. 02)
  - Visual programming for bioinformatics
- Orange (Demsar & al., 04)
  - Visual programming for data mining
- Enthougth – TraitsUI
  - Automatic widget generation based on traits

Architecture



Visualea (PyQt4)



Concepts

- Node
- Component Widget
- Dataflow
- Composite Node
- Package Manager

Node / Component

Node

- A python callable
- Inputs/Outputs Ports (automatic or specified)

```
def linearmodel(x=0., a=0., b=0):
    ''' return a*x+b '''
    return a*x+b
```

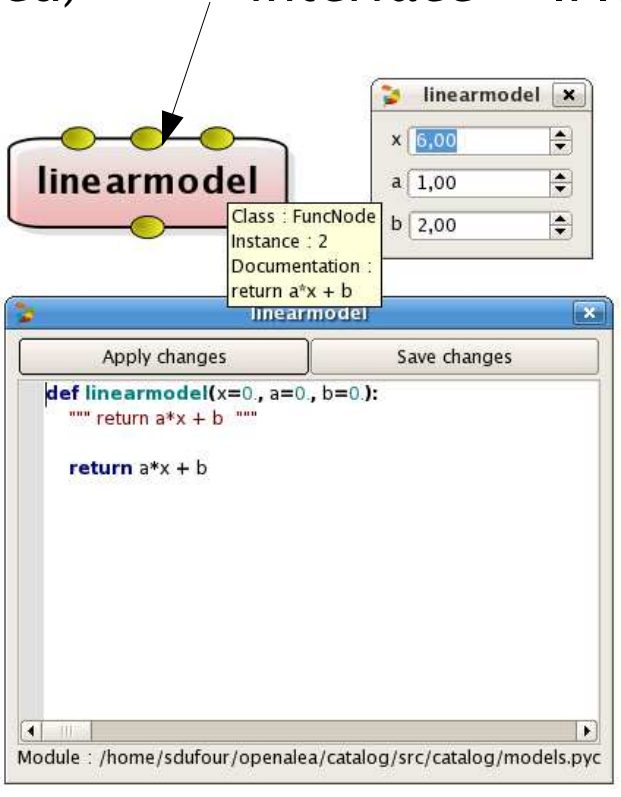
NodeFactory

- Component meta-information
- Lazy loading of modules
- Responsible to instantiate node

```
NodeFactory( name='linearmodel',
             description='ax+b',
             category='models',
             nodemodule='simplemodel',
             nodeclass='linearmodel',)
```

Port

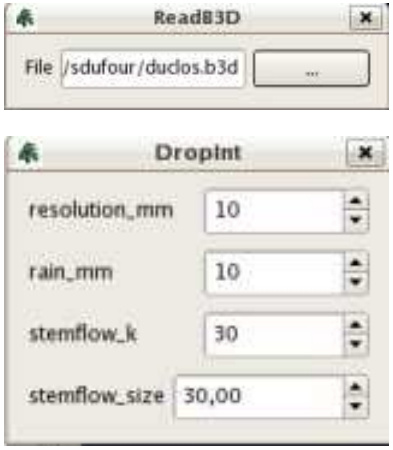
- name = 'a'
- interface = IFloat



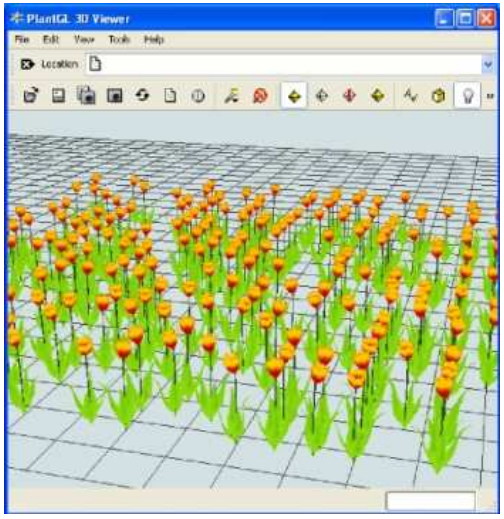
Component Widgets

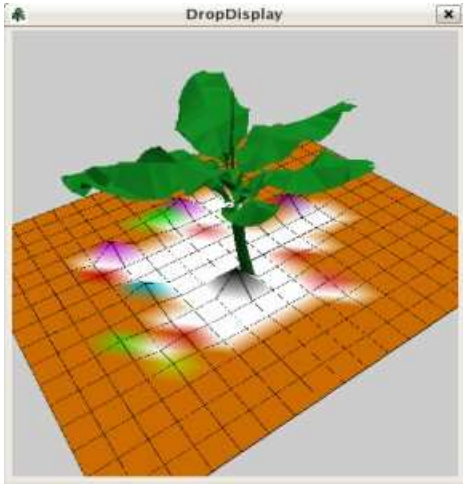
Automatically generated

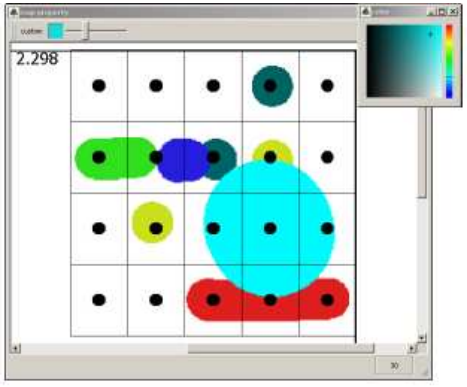
Use Input port Interfaces :
IInt, IFloat, IString, IFileName,
IColor, IList, IDict...



OR







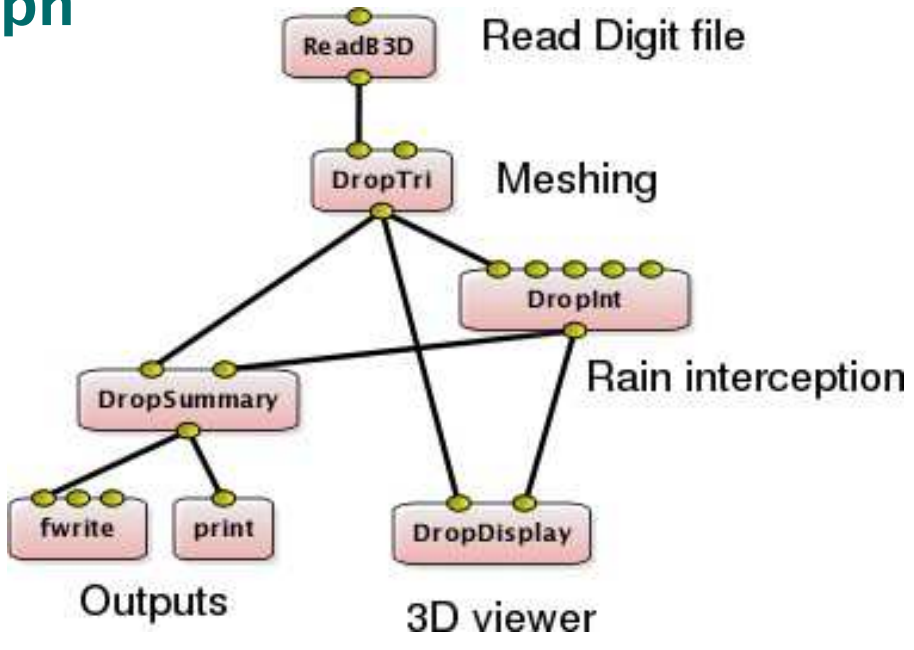
Particular Widgets
(Viewer, Plots...)

Dataflow

Connect Nodes in a directed graph

Evaluation algorithm is modular
- **Functional** (deterministic)
- **With tokens** (non deterministic)

Optional features
- **multi-inputs** (list creation)
- **Priority management**
- **Lazy evaluation**
- **Object copy**
- **…**

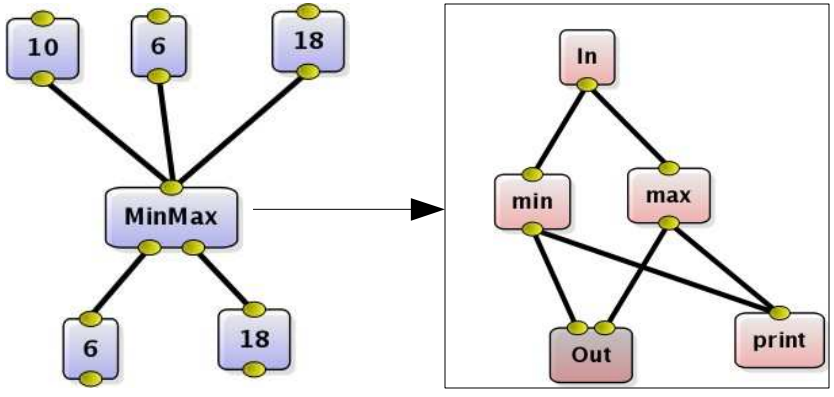


User documentation with graphical text annotations

Composite Nodes

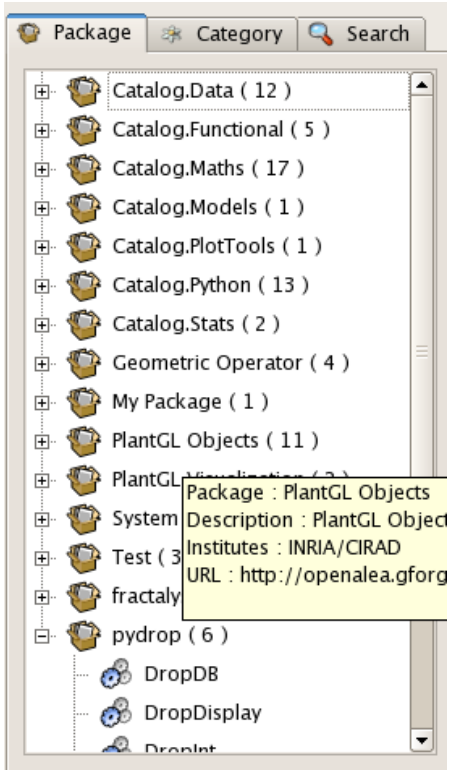
Composite/Macro Nodes encapsulate a dataflow.

- Manage complexity
- Exported as Python code.
- Composite Node
  -> Composite Widget




```
CompositeNodeFactory(
            name='MinMax',
            description='Return min and max of a list',
            category='Maths', doc='...',
            inputs=[{'interface': ISeq, 'name': 'IN1'}],
            outputs=[{'interface': None, 'name': 'OUT1'},
                     {'interface': None, 'name': 'OUT2'}],
            elt_factory={ 2: ('catalog.math', 'max'),
                          3: ('catalog.math', 'min'),
                          4: ('catalog.python', 'print') },
             elt_connections={0: (3, 0, 4, 0), 1: ('__in__', 0, 2, 0),
                              2: (2, 0, '__out__', 1), 3: ('__in__', 0, 3, 0),
                              4: (2, 0, 4, 0), 5: (3, 0, '__out__', 0)}, )
```

Package Manager

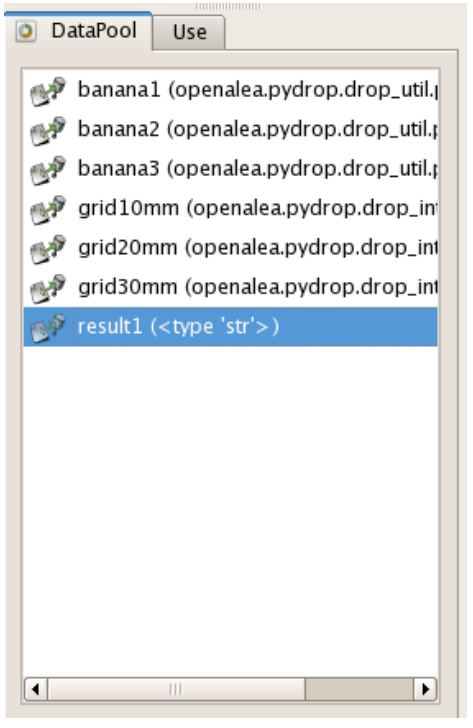


- Nodes are grouped by
  - Package (authors, license...),
  - Category
- Load packages on demand.
- Research and execute *wralea.py files found on the system. (*Future use of setuptools entry_points).*
- Search nodes by name, description, category, ...
- Instantiation with Drag-and-Drop.

All python packages can declare OpenAlea components.

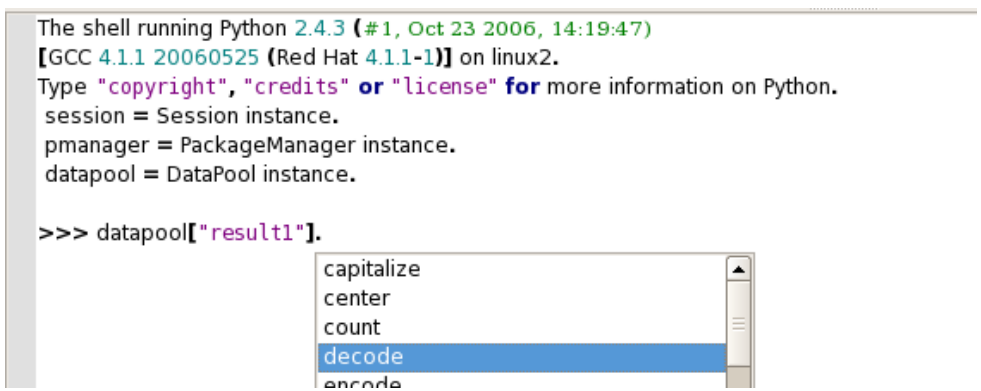
Data Management

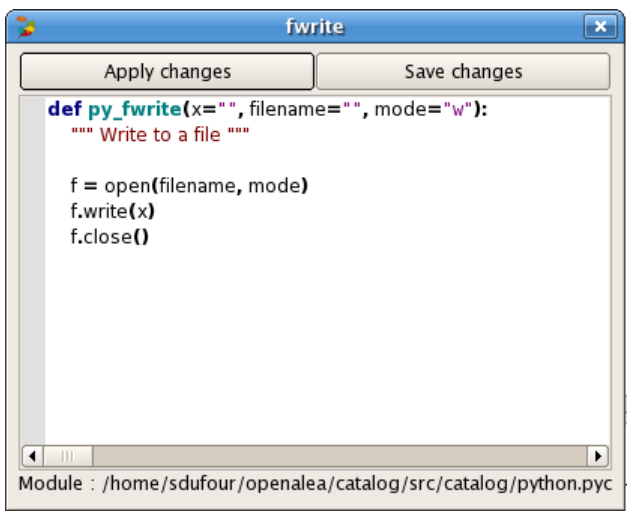
- Data Pool
  - Container of global instances
  - Drag and Drop operations
- Data conversion between nodes
  - Based on interfaces/adapters
- Data Persistance
  - Pickling



Python scripting

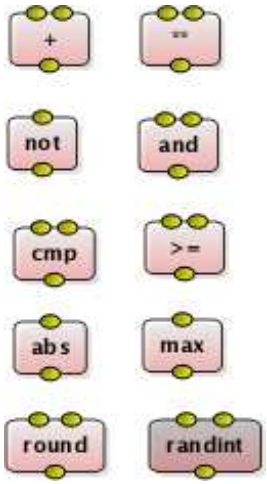
- Visual programming for high level modeling
  - Do not replace python scripting
- Low-Level interaction
  - Interpreter : Access directly to python object
  - On the fly *code edition* and *node creation*
  - Completion & introspection (QScintilla)





OpenAlea.Catalog

Math



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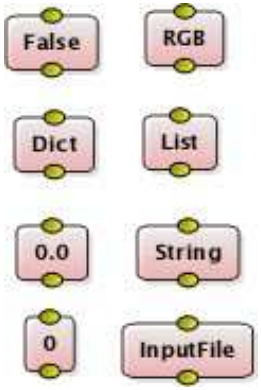
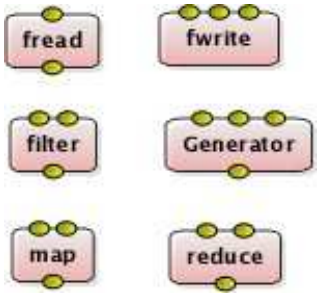
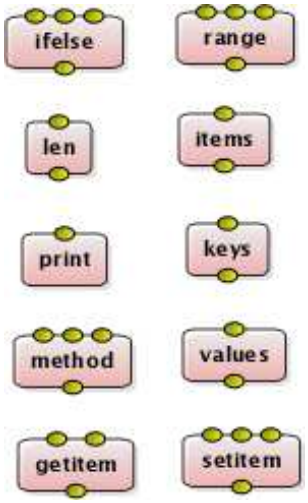
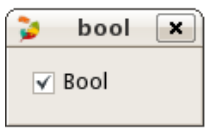


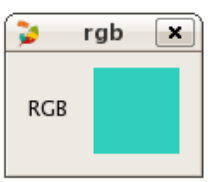
Function

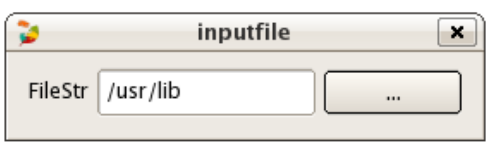


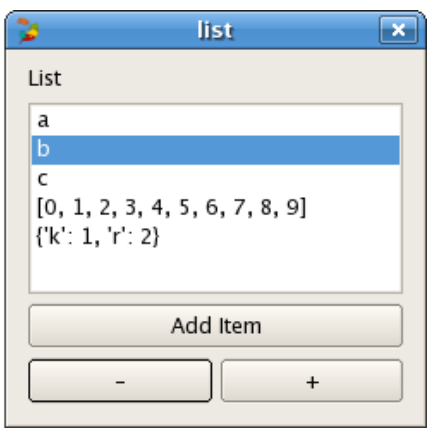


Widget





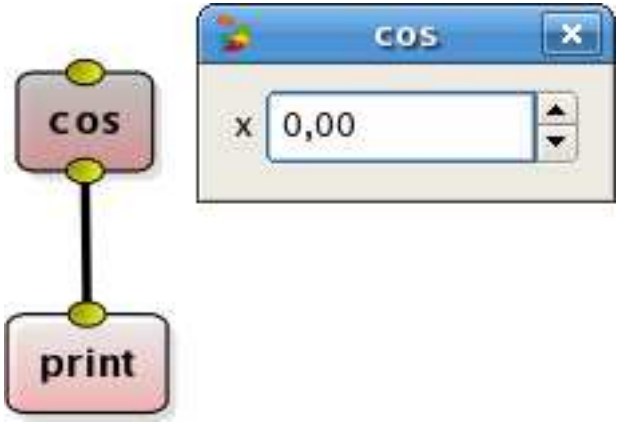




How to wrap a module

math.py :

def cos(x:float): return float



wralea.py

```
from openalea.core import *

def register_package(pkgmanager):

    pkg = Package('my_pkg', {'version':'0.0.1',
                             'license':'Python'}, )

    nf = Factory(
            name="cos",
            inputs=[{'name':'x', 'interface':IFloat},],
            outputs=[{'name':'y', 'interface':IFloat},],
            nodemodule="math",
            nodeclass="cos",)

    pkg.add_factory(nf)
```

Deployment : Building

- OpenAlea.SConsX
  - Simplify the build of complex multi-platform packages
  - Hide the complexity of the build system
  - Set options/flags for different tools and compilers
  - Add knowledge about existing tools (system dependent)

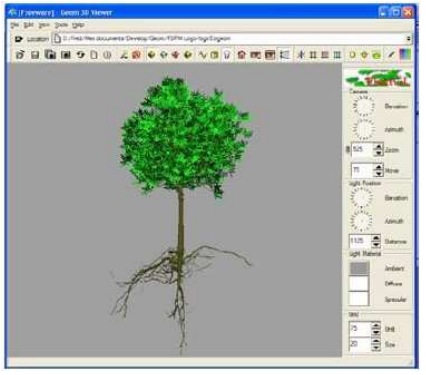
```
ALEAConfig(name, ['boost_python', 'alea', 'qt4', 'opengl'])
src = ALEAGlob('*.cpp')
inc = ALEAGlob('*.h')

ALEAInclude('mylib', inc)
ALEALibrary('mylib', src)
ALEAWrapper('mywrapper', src)
ALEAProgram('myprog', src)
```

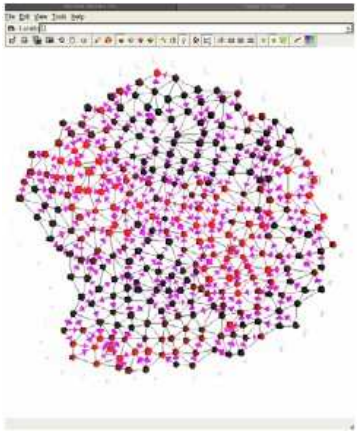
Deployment : Installing

- OpenAlea.DistX
  - Install shared dynamic libraries, data and application (shortcuts, environment variables)
  - Use SConsX as a build system
  - Extend Distutils (Setuptools migration ?)

```
setup(
    name=name,
    version=version,
    ...
    scons_scripts=['SConstruct'],
    scons_parameters=["build","build_prefix="+build_prefix],
    external_data={pj('test', name) : 'test',
                   pj('lib'):  pj(build_prefix,'lib'), ... },
    set_win_var=['PATH='+ ... ],
    set_lsb_var=['LD_LIBRARY_PATH='+ ...],
    win_shortcuts=[...], freedesk_shortcuts=[...]
    ... )
```

Components





- Analysis of plant architecture
  - VPlants (Godin, Guédon and al.)
- Geometric library and 3D viewer
  - PlantGL (Boudon, Pradal and al)
- Merristem simulation (Barbier de Reuille and al.)
- Radiation absorption
  - RATP (Sinoquet and al.)
  - Fractalysis (Da Silva and al.)
- Rain interception : PyDrop (Bussière, Dufour, and al.)
- ...

Perspectives

- Future work to address:
  - Parallelization of execution
  - Simulation issues (what is the best approach ?)
  - Installation & dependencies management with shared lib
  - Node creation wizard
  - New models and tools integration
- Application to other domains
  - Computer graphics
  - ... ?

Conclusions

- OpenAlea is an **open source** project.
- It aims to share softwares inside and outside the plant modeling community.
- Improve accessibility for biologists (python and visual programming).
- OpenAlea = set of libraries and components.
- OpenAlea modules are being integrated.

OpenAlea on the web

http://openalea.gforge.inria.fr