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Openalea - visual programming and component based software for plant modeling

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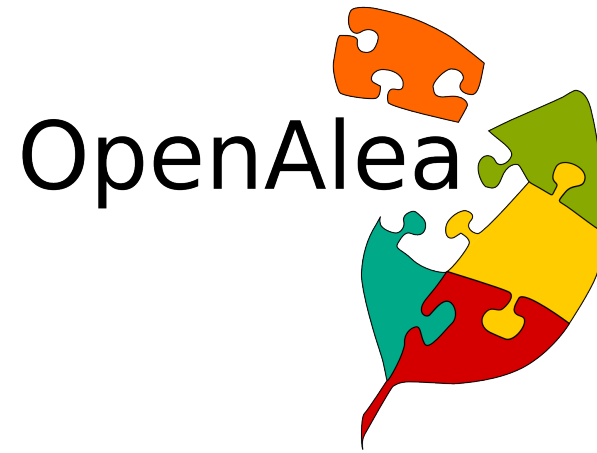
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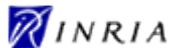
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Visual Programming and Component based software for plant modeling

S. Dufour-Kowalski, C. Pradal

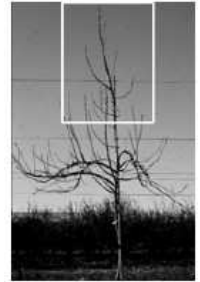
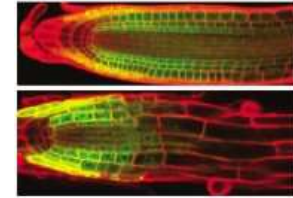
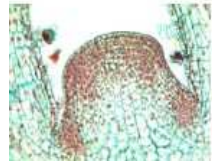
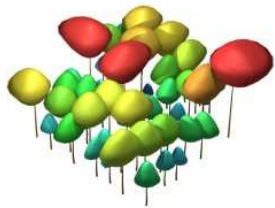


Europython, 9 July 2007, Vilnius

Plant Modeling



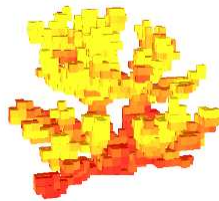
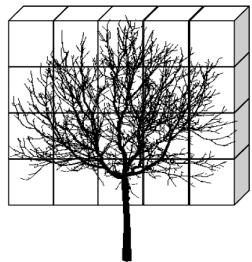
Forestry



Biological objects at different scales

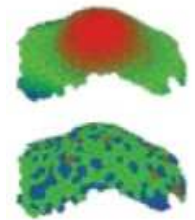
Measures

Mathematics



A pluri-disciplinary research

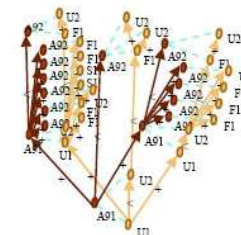
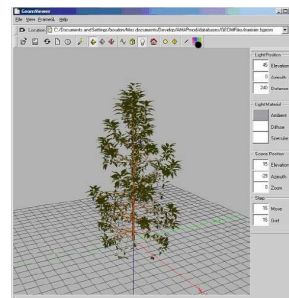
Simulation



Visualization

Analysis

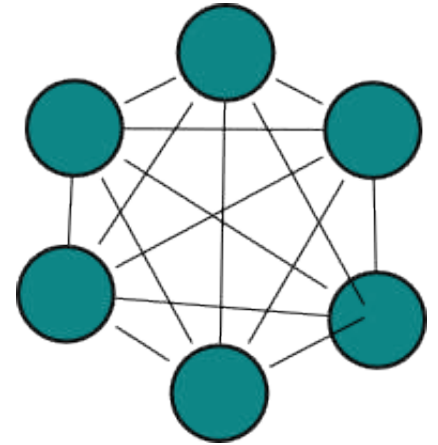
Biophysics



Problems



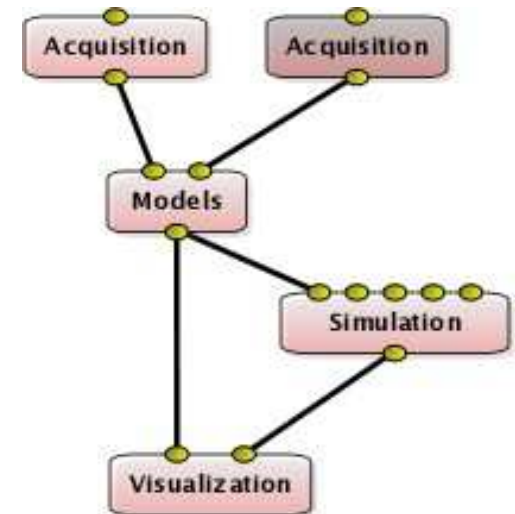
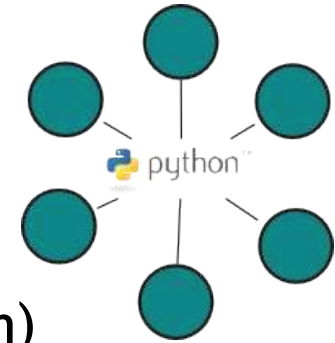
- Ad-hoc solutions for each problem
 - No reuse
- Models are difficult to interconnect
 - N^2 possibilities for N models
- Different types of actors in the community
 - Developers / Modelers / Users



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

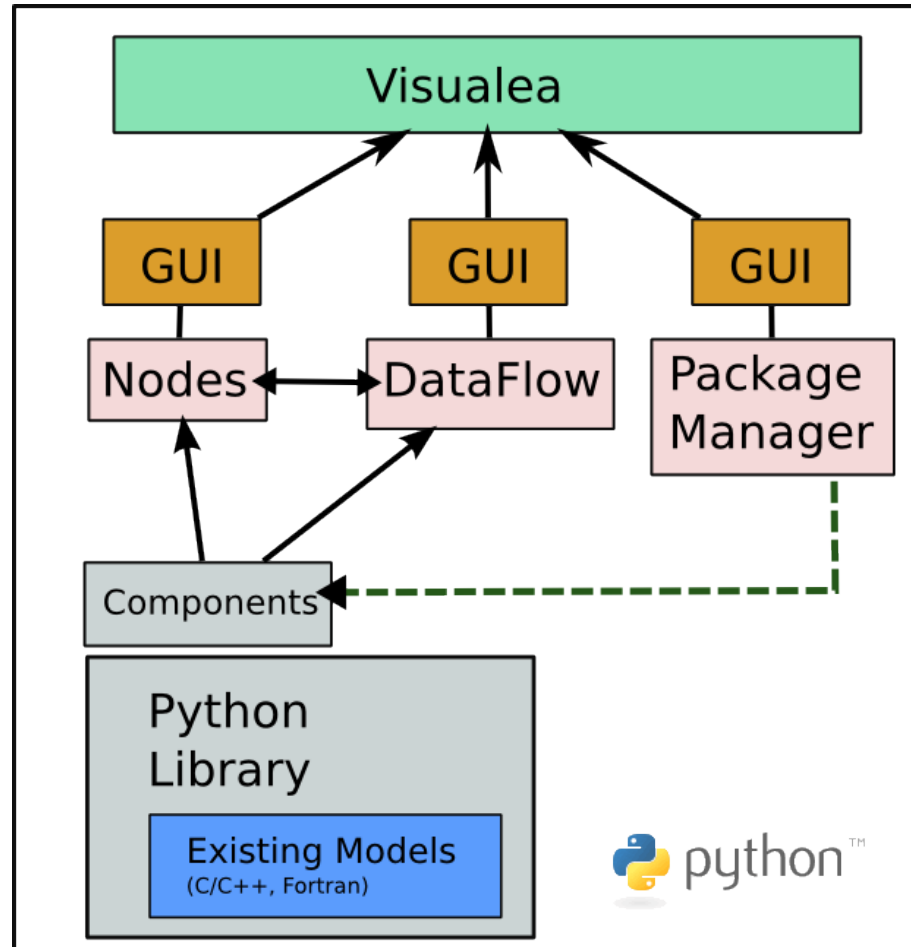


Related Work



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

Architecture



Visualea (PyQt4)



The screenshot displays the Visualea interface with several key components:

- Package Manager:** Located on the left, it shows a list of packages such as 'range', 'setitem', 'va', 'Catalog.Stats (2)', 'LRtoPlot', 'Linear', 'Geometri', 'import', 'planter', 'random sample', and 'regular sample'. A tooltip for 'Linear' is visible, stating 'Name: LRtoPlot', 'Category: Stat', and 'Description: generate plotable object from linear regression'.
- Data Pool:** Below the package manager, it lists data objects like 'b3d (openalea.pydrop.drop_digitreac)' and 'plant (openalea.pydrop.drop_util.plan)'. A tooltip for 'plant' is also present.
- Dataflow Graph:** The central workspace shows a graph with nodes: 'ReadB3D', 'DropTri', 'DropTri', 'DropDisplay', and 'Dropint'. Arrows indicate the flow of data between these components.
- Code Editor:** At the bottom left, it shows Python code for the 'DropTri' widget. The code includes imports, a 'def __call__' function, and logic for creating a plant object based on input 'digit' and 'name'.

```
def __call__(self, inputs):  
    """ inputs is the list of input values """  
  
    from openalea.pydrop.drop_tri_sdk1 import drop_tri_sdk1  
    from openalea.pydrop.drop_util import plant  
  
    digit = self.get_input("Digit")  
    name = self.get_input("Name")  
    plant = plant(name, "")  
    if (digit):  
        try:  
            trialgo = drop_tri_sdk1()  
            trialgo.create_plant(digit, plant)  
        except:  
            print "Cannot Triangulate %s"%(name)  
  
    return (plant,)
```
- Interpreter:** At the bottom center, it shows the output of the Python shell, including the command 'datapool['plant']' and its execution.
- Widgets:** On the right, there are two widget windows: 'ReadB3D' with a file path '/sdlfour/dados.b3d' and 'Dropint' with parameters like 'resolution_mm: 10', 'rain_mm: 10', 'stemflow_k: 30', and 'stemflow_size: 30,00'. Below them is the 'DropDisplay' window showing a 3D visualization of a plant on a grid.

Package Manager

Dataflow

Data Pool

Widgets

Code Editor

Interpreter

Pydrop model (Bussière and al. FSPM 07)

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

The image displays a graphical user interface for a 'linearmodel' component. At the top, there is a node icon labeled 'linearmodel' with three yellow ports. A tooltip points to one of the ports, showing 'Class : FuncNode', 'Instance : 2', and 'Documentation : return a*x + b'. Below the node is a control panel with three input fields: 'x' (value 6,00), 'a' (value 1,00), and 'b' (value 2,00). At the bottom is a code editor window titled 'linearmodel' showing the Python function definition:

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

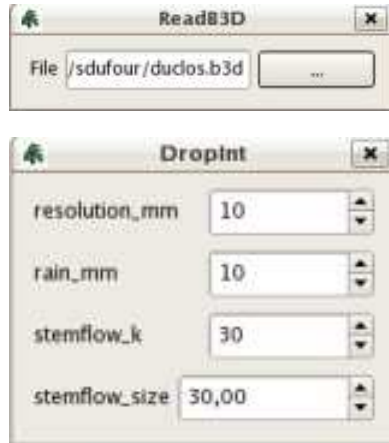
 The code editor has 'Apply changes' and 'Save changes' buttons at the top. The status bar at the bottom indicates the module path: '/home/sdufour/openalea/catalog/src/catalog/models.pyc'.

Component Widgets

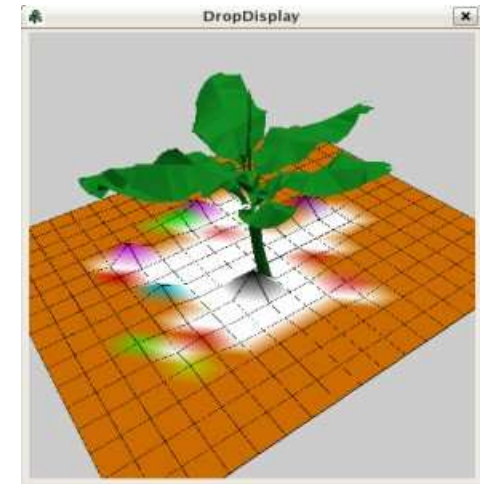
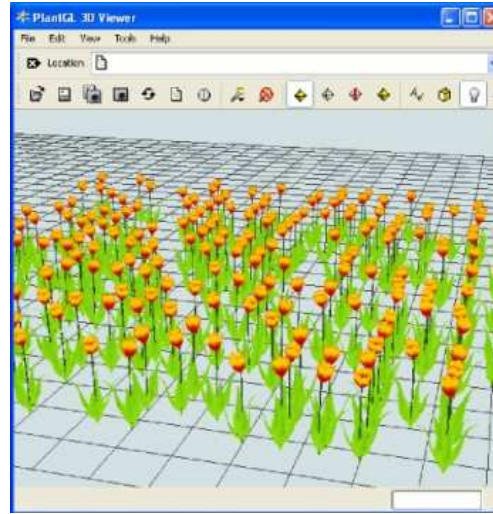


Automatically generated

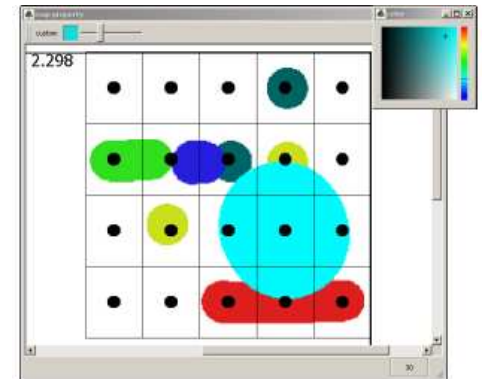
Use Input port Interfaces :
IInt, IFloat, IString, IFileName,
IColor, IList, IDict...



OR



Particular Widgets
(Viewer, Plots...)



Dataflow



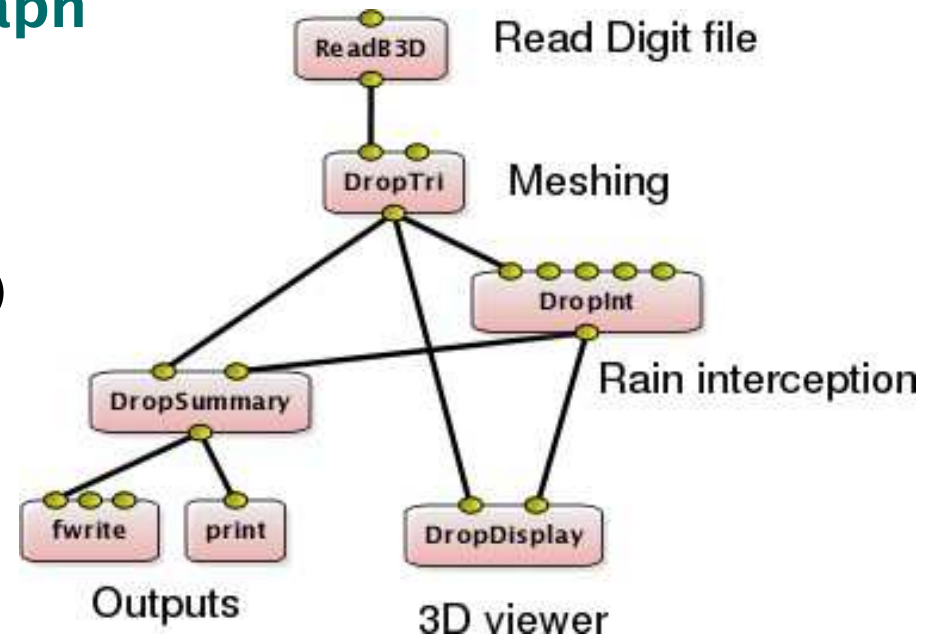
Connect Nodes in a directed graph

Evaluation algorithm is modular

- **Functional** (deterministic)
- **With tokens** (non deterministic)

Optional features

- **multi-inputs** (list creation)
- **Priority management**
- **Lazy evaluation**
- **Object copy**
- ...



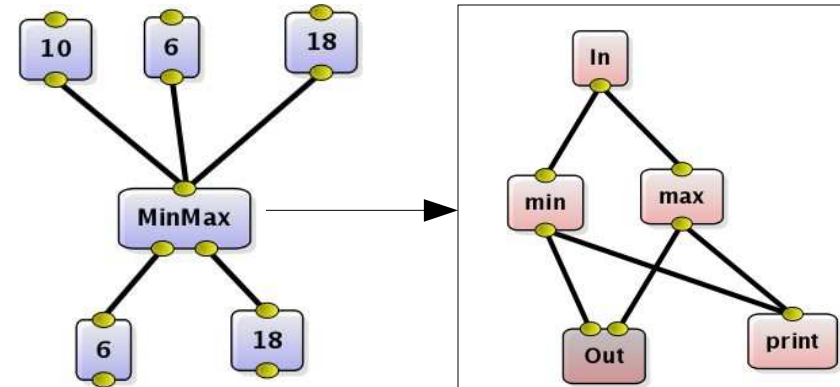
User documentation with graphical text annotations

Composite Nodes



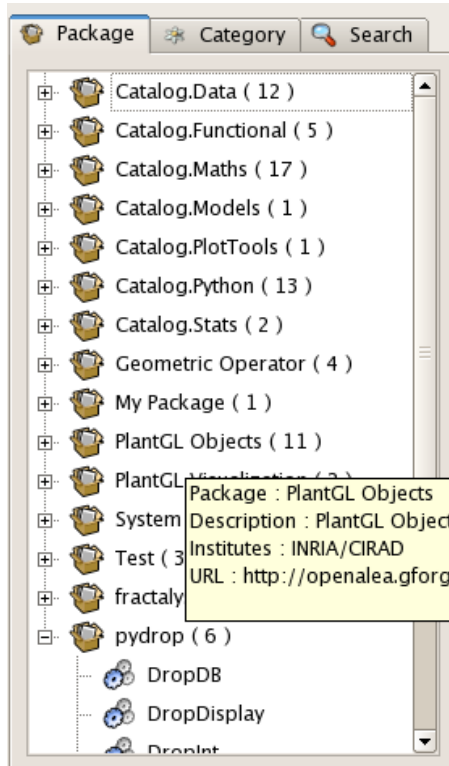
Composite/Macro Nodes encapsulate a dataflow.

- 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



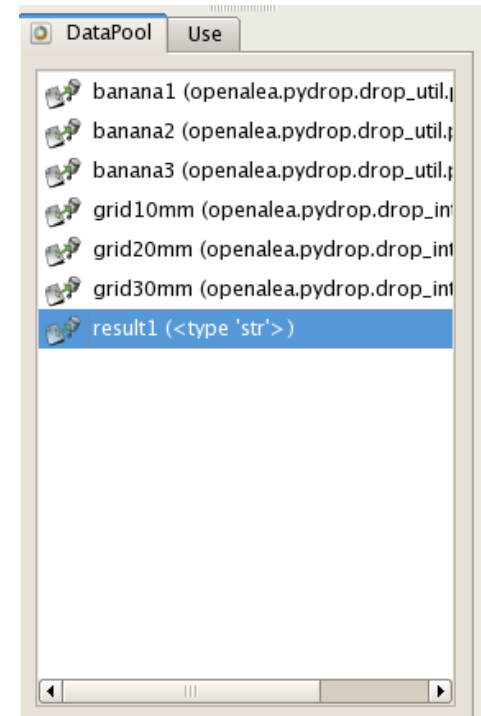
- Nodes are grouped by
 - **Package** (authors, license...),
 - **Category**
- Load packages on demand.
- Research and execute `*wralea.py` files found on the system. (*Future use of `setuptools` entry_points*).
- Search nodes by name, description, category, ...
- Instantiation with Drag-and-Drop.

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 Persistence
 - Pickling



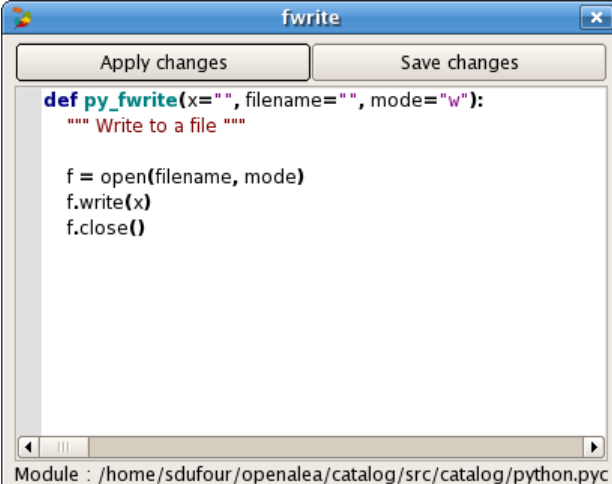
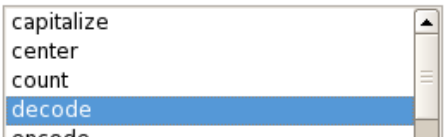
Python scripting



- 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)

```
The shell running Python 2.4.3 (#1, Oct 23 2006, 14:19:47)
[GCC 4.1.1 20060525 (Red Hat 4.1.1-1)] on linux2.
Type "copyright", "credits" or "license" for more information on Python.
session = Session instance.
pmanager = PackageManager instance.
datapool = DataPool instance.

>>> datapool["result1"].
```

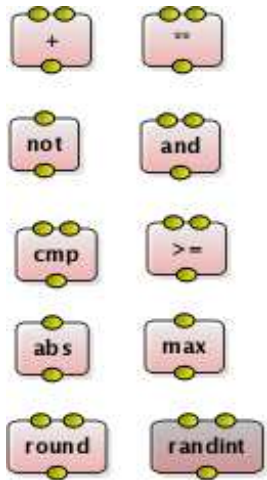


```
fwrite
Apply changes Save changes
def py_fwrite(x="", filename="", mode="w"):
    """ Write to a file """
    f = open(filename, mode)
    f.write(x)
    f.close()
Module : /home/sdufour/openalea/catalog/src/catalog/python.pyc
```

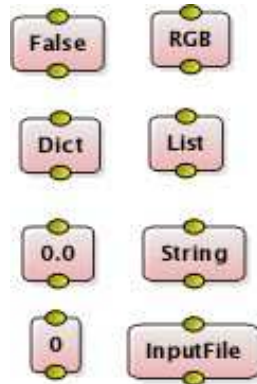

OpenAlea.Catalog



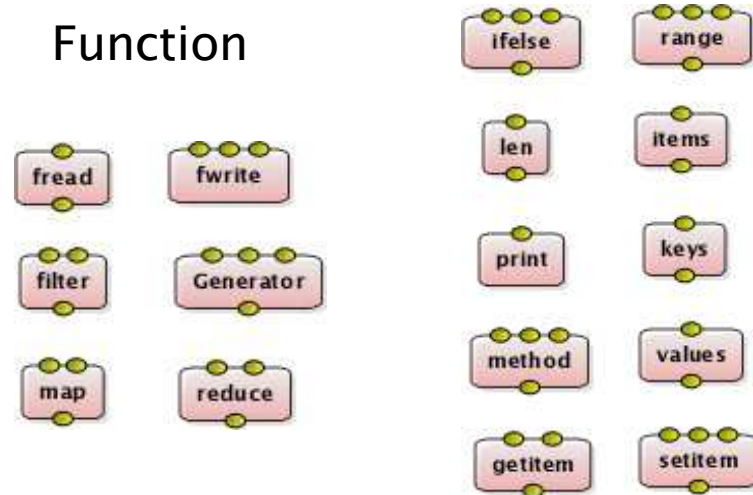
Math



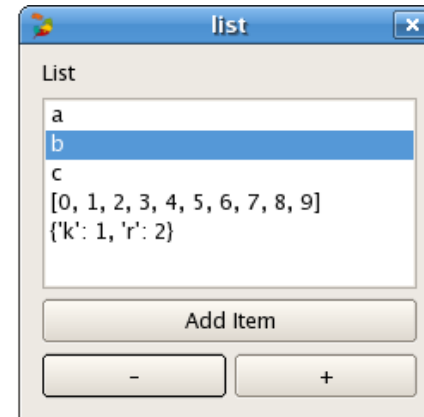
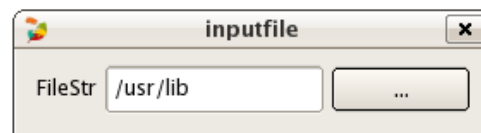
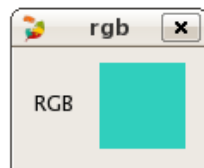
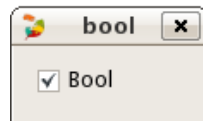
Type



Function



Widget



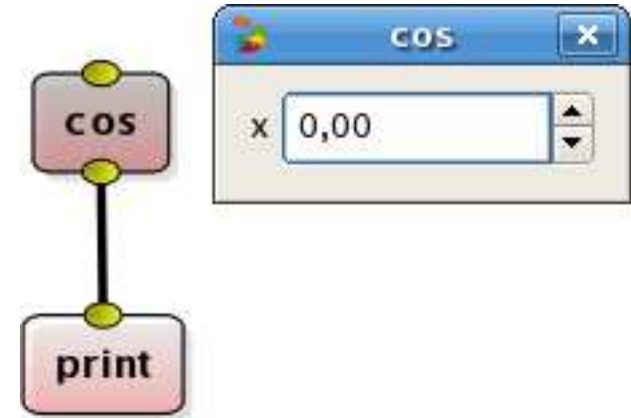
How to wrap a module



```
math.py :  
    def cos(x:float): return float
```

```
wrlea.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

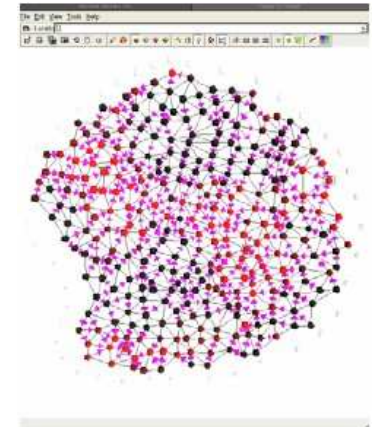
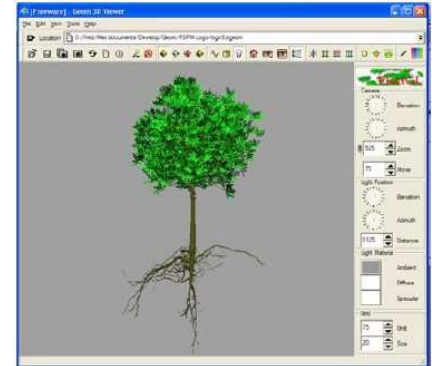
- Install shared dynamic libraries, data and application (shortcuts, environment variables)
- Use SConsX as a build system
- Extend Distutils (Setuptools migration ?)

```
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 (Bussièrre, 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>

