Digraph3 Documentation

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CHAPTER

ONE

INTRODUCTION

This documentation describes the Python3 resources for implementing decision aid algorithms in the context of a bipolarly-valued outranking approach [1] . These computing resources are useful in the field of algorithmic decision theory and more specifically in outranking based multiple criteria decision aid.

Parts of the documentation:

1.1 Tutorial of the Digraph3 resources

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1.1.1 Content

1.1.2 Working with the `digraphs` module

Downloading of the Digraph3 resources

Using the Digraph3 modules is easy. You only need to have installed on your system the Python programming language of version 3+ (readily available under Linux and Mac OS). Notice that, from Version 3.3 on, Python implements very efficiently the decimal class in C. Now, Decimal objects are mainly used in the Digraph3 characteristic valuation functions, which makes the recent python version much faster (more than twice as fast) when extensive digraph operations are performed.

1

18. Bisdorff (2013) "On Polarizing Outranking Relations with Large Performance Differences" *Journal of Multi-Criteria Decision Analysis* (Wiley) **20**:3-12

Two download options are given:

1. Either (easiest under Linux or Mac OS-X), by using a subversion client:

   ```
   ..$ svn co http://leopold-loewenheim.uni.lu/svn/repos/Digraph3
   ```

2. Or, with a browser access, download and extract the latest distribution tar.gz archive from this page:

   `http://leopold-loewenheim.uni.lu/Digraph3/dist/`

Purpose

The basic idea of these Python3 modules is to make easy python interactive sessions or write short Python3 scripts for computing all kind of results from a bipolar valued digraph or graph. These include such features as maximal independent or irredundant choices, maximal dominant or absorbent choices, rankings, outrankins, linear ordering, etc. Most of the available computing resources are meant to illustrate the *Algorithmic Decision Theory* course given in the University of Luxembourg Master in Information and Computer Science (MICS).

The Python development of these computing resources offers the advantage of an easy to write and maintain OOP source code as expected from a performing scripting language without loosing on efficiency in execution times compared to compiled languages such as C++ or Java.

Starting an interactive python3 session

You may start an interactive Python3 session in the `Digraph3` directory for exploring the classes and methods provided by the `digraphs` module. To do so, enter the `python3` commands following the session prompts marked with >>>. The lines without the prompt are output from the Python interpreter:

```
[\$HOME/Digraph3]\$ python3
Python 3.4.0 (default, Apr 11 2014, 13:05:11)
[GCC 4.8.2] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> from digraphs import Digraph
>>> dg = Digraph('test/testdigraph')
>>> dg.save('tutorialdigraph')
>>> ...
```

Structure of a `Digraph` object

All `Digraph` object *dg* contains at least the following sub-objects:

1. the digraph nodes called **actions** (decision actions): a list, set or dictionary of nodes with 'name' and 'shortname' attributes,
2. the digraph **valuationdomain** , a dictionary with three decimal entries: the minimum (-1.0, means certainly false), the median (0.0, means missing information) and the maximum characteristic value (+1.0, means certainly true),
3. the graph **relation** : a double dictionary indexed by an oriented pair of actions (nodes) and carrying a characteristic value in the range of the previous valuation domain,
4. its associated **gamma function** : a dictionary containing the direct successors, respectively predecessors of each action, automatically added by the object constructor,
5. its associated **notGamma function** : a dictionary containing the actions that are not direct successors respectively predecessors of each action, automatically added by the object constructor. See the reference manual of the *digraphs module*.

Permanent storage of digraphs

The `dg.save('tutorialDigraph')` command stores the digraph *dg* in a file named `tutorialDigraph.py` with the following content:

```
# automatically generated random irreflexive digraph
actionset = ['1','2','3','4','5',]
valuationdomain = {'min': -1,
                   'med': 0,
                   'max': 1}
relation = {
'1': {'1':-1,'2':-1,'3':-1,'4':1,'5':-1},
'2': {'1':-1,'2':-1,'3':1,'4':-1,'5':-1},
'3': {'1':-1,'2':1,'3':-1,'4':-1,'5':1},
'4': {'1':1,'2':-1,'3':1,'4':-1,'5':1},
'5': {'1':1,'2':-1,'3':1,'4':-1,'5':-1}
}
```

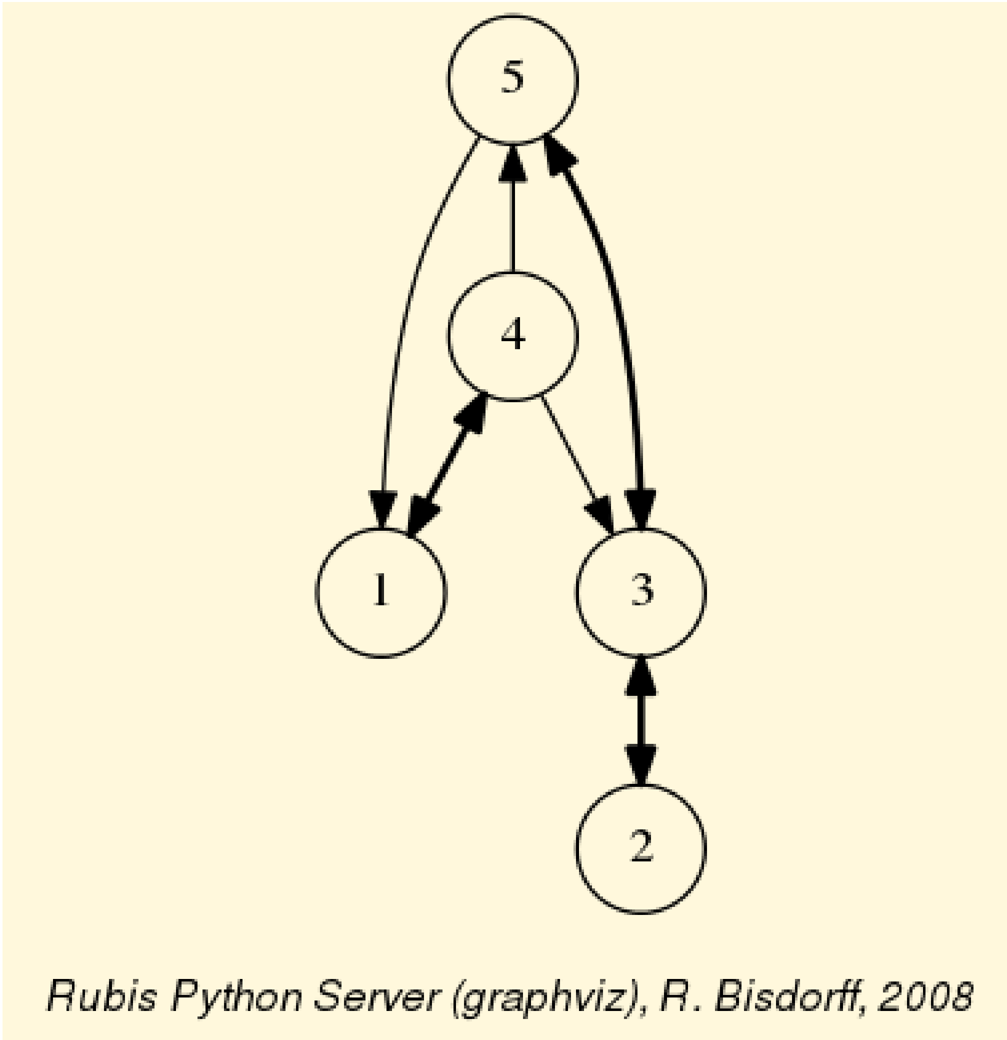
Inspecting a `Digraph` object

We may reload a previously saved `Digraph` instance from the file named `tutorialDigraph.py` with the `Digraph` class con

```
>>> dg = Digraph('tutorialDigraph')
>>> dg.showAll()
*----- show details --------------*
Digraph          : tutorialdigraph
Actions          : ['1', '2', '3', '4', '5']
Valuation domain : {'med': Decimal('0'),
                    'max': Decimal('1'),
                    'min': Decimal('-1')}
* ---- Relation Table -----
  S   |  '1'      '2'     '3'     '4'     '5'
 -----|-----------------------------------------------------------
  '1' |  -1.00   -1.00   -1.00   +1.00   -1.00
  '2' |  -1.00   -1.00   +1.00   -1.00   -1.00
  '3' |  -1.00   +1.00   -1.00   -1.00   +1.00
  '4' |  +1.00   -1.00   +1.00   -1.00   +1.00
  '5' |  +1.00   -1.00   +1.00   -1.00   -1.00
*--- Connected Components ---*
1: ['1', '2', '3', '4', '5']
```

The `Digraph.exportGraphViz()` method generates in the current working directory a `tutorial.dot` file and a `tutori`

```
>>> dg.exportGraphViz('tutorialDigraph')
*---- exporting a dot file do GraphViz tools ---------*
Exporting to tutorialDigraph.dot
dot -Grankdir=BT -Tpng tutorialDigraph.dot -o tutorialDigraph.png
```



Some simple methods are easily applicable to this instantiated Digraph object *dg* , like the following `Digraph.showStatisti`

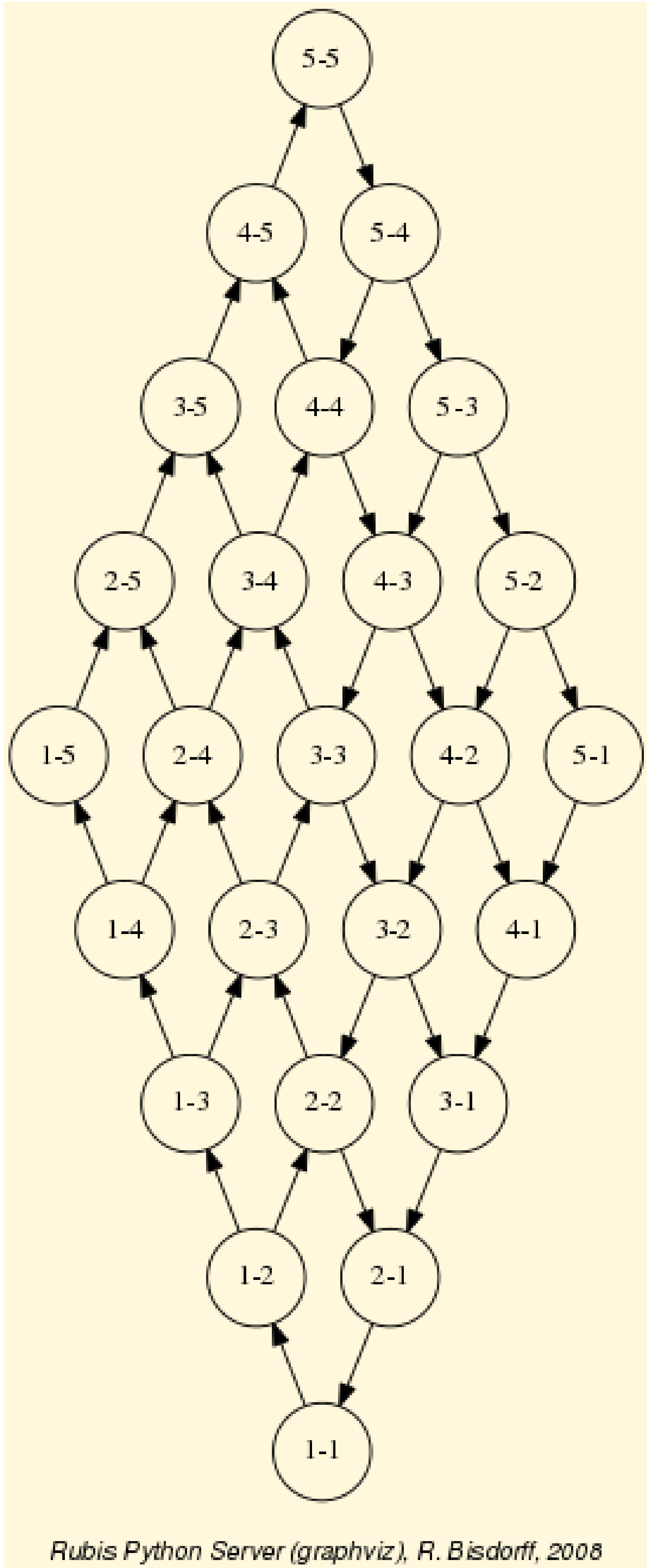
```
>>> dg.showStatistics()
*----- general statistics -------------*
for digraph              : <tutorialdigraph.py>
order                    :  5 nodes
size                     :  9 arcs
# undetermined           :  0 arcs
arc density              : 45.00
# components             :  1
                         :  [0, 1, 2, 3, 4]
outdegrees distribution  :  [0, 2, 2, 1, 0]
indegrees distribution   :  [0, 2, 2, 1, 0]
degrees distribution     :  [0, 4, 4, 2, 0]
mean degree : 1.80
                                    :  [0, 1, 2, 3, 4, 'inf']
neighbourhood-depths distribution :  [0, 0, 2, 2, 1, 0]
mean neighbourhood depth : 2.80
digraph diameter :  4
agglomeration distribution :
1 : 50.00
```

```
2 : 0.00
3 : 16.67
4 : 50.00
5 : 50.00
agglomeration coefficient : 33.33
>>> ...
```

Special classes of digraphs

Some special classes of digraphs, like the `CompleteDigraph`, the `EmptyDigraph` or the oriented `GridDigraph` class for ins

```
>>> from digraphs import GridDigraph
>>> grid = GridDigraph(n=5,m=5,hasMedianSplitOrientation=True)
>>> grid.exportGraphViz('tutorialGrid')
*---- exporting a dot file for GraphViz tools ---------*
Exporting to tutorialGrid.dot
dot -Grankdir=BT -Tpng TutorialGrid.dot -o tutorialGrid.png
```


5-5
4-5
5-4
3-5
4-4
5-3
2-5
3-4
4-3
5-2
1-5
2-4
3-3
4-2
5-1
1-4
2-3
3-2
4-1
1-3
2-2
3-1
1-2
2-1
1-1
Rubis Python Server (graphviz), R. Bisdorff, 2008

For more information about its resources, see the technical documentation of the *digraphs module* .

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1.1.3 Tools for manipulating `Digraph` objects

Inspecting a random digraph

We are starting this tutorial with generating a randomly [-1;1]-valued (*Normalized=True*) digraph of order 7, denoted *dg* and m

```
>>> from digraphs import RandomValuationDigraph
>>> dg = RandomValuationDigraph(order=7,Normalized=True)
>>> dg.save('tutRandValDigraph')
```

With the `save()` method we may keep a backup version for future use of *dg* which will be stored in a file called *tutRandValDig*

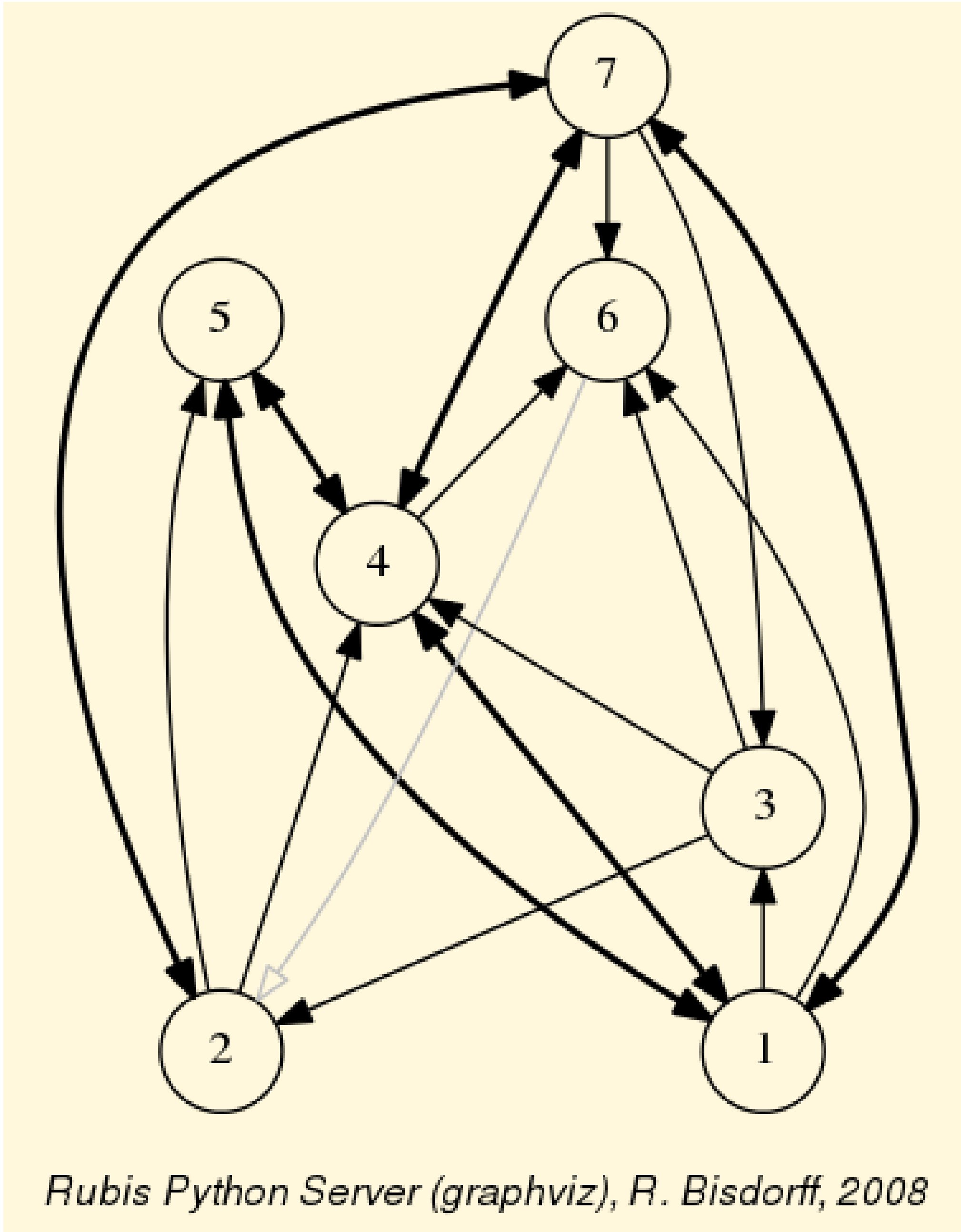
```
>>> dg.showShort()
*----- show summary -------------*
Digraph          : randomValuationDigraph
*---- Actions ----*
['1', '2', '3', '4', '5', '6', '7']
*---- Characteristic valuation domain ----*
{'med': Decimal('0.0'), 'hasIntegerValuation': False,
'min': Decimal('-1.0'), 'max': Decimal('1.0')}
*--- Connected Components ---*
1: ['1', '2', '3', '4', '5', '6', '7']
>>> dg.showRelationTable(ReflexiveTerms=False)
* ---- Relation Table -----
r(xSy) |  '1'    '2'    '3'   '4'    '5'    '6'   '7'
-------|-------------------------------------------------------------
'1'    |   -   -0.48  0.70  0.86  0.30  0.38  0.44
'2'    | -0.22   -   -0.38  0.50  0.80 -0.54  0.02
'3'    | -0.42  0.08   -    0.70 -0.56  0.84 -1.00
'4'    |  0.44 -0.40 -0.62   -    0.04  0.66  0.76
'5'    |  0.32 -0.48 -0.46  0.64   -   -0.22 -0.52
'6'    | -0.84  0.00 -0.40 -0.96 -0.18   -   -0.22
'7'    |  0.88  0.72  0.82  0.52 -0.84  0.04  -
>>> dg.showNeighborhoods()
Neighborhoods osberved in digraph 'randomdomValuation'
Gamma     :
'1': in => {'5', '7', '4'}, out => {'5', '7', '6', '3', '4'}
'2': in => {'7', '3'}, out => {'5', '7', '4'}
'3': in => {'7', '1'}, out => {'6', '2', '4'}
'4': in => {'5', '7', '1', '2', '3'}, out => {'5', '7', '1', '6'}
'5': in => {'1', '2', '4'}, out => {'1', '4'}
'6': in => {'7', '1', '3', '4'}, out => set()
'7': in => {'1', '2', '4'}, out => {'1', '2', '3', '4', '6'}
 Not Gamma :
'1': in => {'6', '2', '3'}, out => {'2'}
'2': in => {'5', '1', '4'}, out => {'1', '6', '3'}
'3': in => {'5', '6', '2', '4'}, out => {'5', '7', '1'}
'4': in => {'6'}, out => {'2', '3'}
'5': in => {'7', '6', '3'}, out => {'7', '6', '2', '3'}
'6': in => {'5', '2'}, out => {'5', '7', '1', '3', '4'}
'7': in => {'5', '6', '3'}, out => {'5'}
```

Warning: Notice that most Digraph class methods will ignore the reflexive couples by considering that the relation is indeterminate (the characteristic value *r(x S x)* for all action *x* is put to the median, i.e. indeterminate, value) in this case.

Graphviz drawings

We may have an even better insight into the `Digraph` object *dg* by looking at a graphviz [2] drawing:

```
>>> dg.exportGraphViz('tutRandValDigraph')
*---- exporting a dot file for GraphViz tools ---------*
Exporting to tutRandValDigraph.dot
dot -Grankdir=BT -Tpng tutRandValDigraph.dot -o tutRandValDigraph.png
```



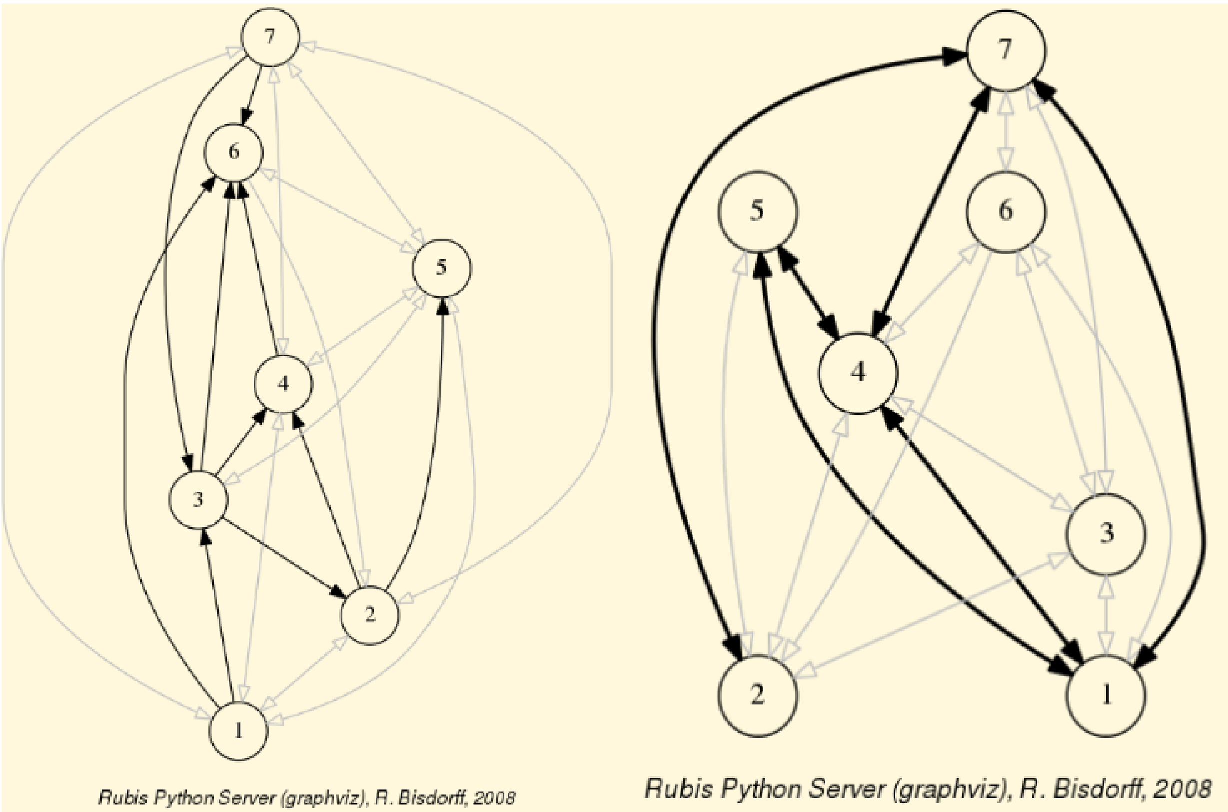
Double links are drawn in bold black with an arrowhead at each end, whereas single asymmetric links are drawn in black with an arrowhead showing the direction of the link. Notice the undetermined relational situation (*r(6 S 2) = 0.00*) observed between nodes '6' and '2'. The corresponding link is marked in gray with an open arrowhead in the drawing.

Asymmetric and symmetric parts

We may now extract both this symmetric as well as this asymmetric part of digraph *dg* with the help of two corresponding const

```
>>> from digraphs import AsymmetricPartialDigraph, SymmetricPartialDigraph
>>> asymDg = AsymmetricPartialDigraph(dg)
```

```
>>> asymDg.exportGraphViz()
>>> symDG = SymmetricPartialDigraph(dg)
>>> symDg.exportGraphViz()
```



Note: Notice that the partial objects *asymDg* and *symDg* put to the indeterminate characteristic value all not-asymmetric, respectively not-symmetric links between nodes.

Here below, for illustration the source code of *relation* constructor of the `AsymmetricPartialDigraph` class:

```
def _constructRelation(self):
    actions = self.actions
    Min = self.valuationdomain['min']
    Max = self.valuationdomain['max']
    Med = self.valuationdomain['med']
    relationIn = self.relation
    relationOut = {}
    for a in actions:
        relationOut[a] = {}
        for b in actions:
            if a != b:
                if relationIn[a][b] >= Med and relationIn[b][a] <= Med:
                    relationOut[a][b] = relationIn[a][b]
                elif relationIn[a][b] <= Med and relationIn[b][a] >= Med:
                    relationOut[a][b] = relationIn[a][b]
                else:
                    relationOut[a][b] = Med
            else:
                relationOut[a][b] = Med
    return relationOut
```

Digraph fusion by epistemic disjunction

We may recover object *dg* from both partial objects *asymDg* and *symDg* with a bipolar fusion constructor, also called epistemic

```
>>> from digraphs import FusionDigraph
>>> fusDg = FusionDigraph(asymDg,symDg)
>>> fusDg.showRelationTable()
* ---- Relation Table -----
r(xSy)  |  '1'    '2'    '3'   '4'    '5'    '6'   '7'
-------|------------------------------------------------------------
'1'     |  0.00 -0.48  0.70  0.86  0.30  0.38  0.44
'2'     | -0.22  0.00 -0.38  0.50  0.80 -0.54  0.02
'3'     | -0.42  0.08  0.00  0.70 -0.56  0.84 -1.00
'4'     |  0.44 -0.40 -0.62  0.00  0.04  0.66  0.76
'5'     |  0.32 -0.48 -0.46  0.64  0.00 -0.22 -0.52
'6'     | -0.84  0.00 -0.40 -0.96 -0.18  0.00 -0.22
'7'     |  0.88  0.72  0.82  0.52 -0.84  0.04  0.00
```

Dual, converse and codual digraphs

We may as readily compute the dual, the converse and the codual (dual and converse) of *dg*:

```
>>> from digraphs import DualDigraph, ConverseDigraph, CoDualDigraph
>>> ddg = DualDigraph(dg)
>>> ddg.showRelationTable()
-r(xSy) |  '1'    '2'    '3'   '4'    '5'    '6'   '7'
--------|------------------------------------------
'1 '     |  0.00  0.48 -0.70 -0.86 -0.30 -0.38 -0.44
'2'      |  0.22  0.00  0.38 -0.50  0.80  0.54 -0.02
'3'      |  0.42  0.08  0.00 -0.70  0.56 -0.84  1.00
'4'      | -0.44  0.40  0.62  0.00 -0.04 -0.66 -0.76
'5'      | -0.32  0.48  0.46 -0.64  0.00  0.22  0.52
'6'      |  0.84  0.00  0.40  0.96  0.18  0.00  0.22
'7'      |  0.88 -0.72 -0.82 -0.52  0.84 -0.04  0.00
>>> cdg = ConverseDigraph(dg)
>>> cdg.showRelationTable()
* ---- Relation Table -----
 r(ySx) |  '1'    '2'    '3'    '4'    '5'    '6'    '7'
--------|------------------------------------------
'1'      |  0.00 -0.22 -0.42  0.44  0.32 -0.84  0.88
'2'      | -0.48  0.00  0.08 -0.40 -0.48  0.00  0.72
'3'      |  0.70 -0.38  0.00 -0.62 -0.46 -0.40  0.82
'4'      |  0.86  0.50  0.70  0.00  0.64 -0.96  0.52
'5'      |  0.30  0.80 -0.56  0.04  0.00 -0.18 -0.84
'6'      |  0.38 -0.54  0.84  0.66 -0.22  0.00  0.04
'7'      |  0.44  0.02 -1.00  0.76 -0.52 -0.22  0.00
>>> cddg = CoDualDigraph(dg)
>>> cddg.showRelationTable()
* ---- Relation Table -----
-r(ySx) |  '1'    '2'    '3'    '4'    '5'    '6'    '7'
--------|------------------------------------------------------------
'1'      |  0.00  0.22  0.42 -0.44 -0.32  0.84 -0.88
'2'      |  0.48  0.00 -0.08  0.40  0.48  0.00 -0.72
'3'      | -0.70  0.38  0.00  0.62  0.46  0.40 -0.82
'4'      | -0.86 -0.50 -0.70  0.00 -0.64  0.96 -0.52
'5'      | -0.30 -0.80  0.56 -0.04  0.00  0.18  0.84
```

```
'6'      | -0.38  0.54 -0.84 -0.66  0.22  0.00 -0.04
'7'      | -0.44 -0.02  1.00 -0.76  0.52  0.22  0.00
```

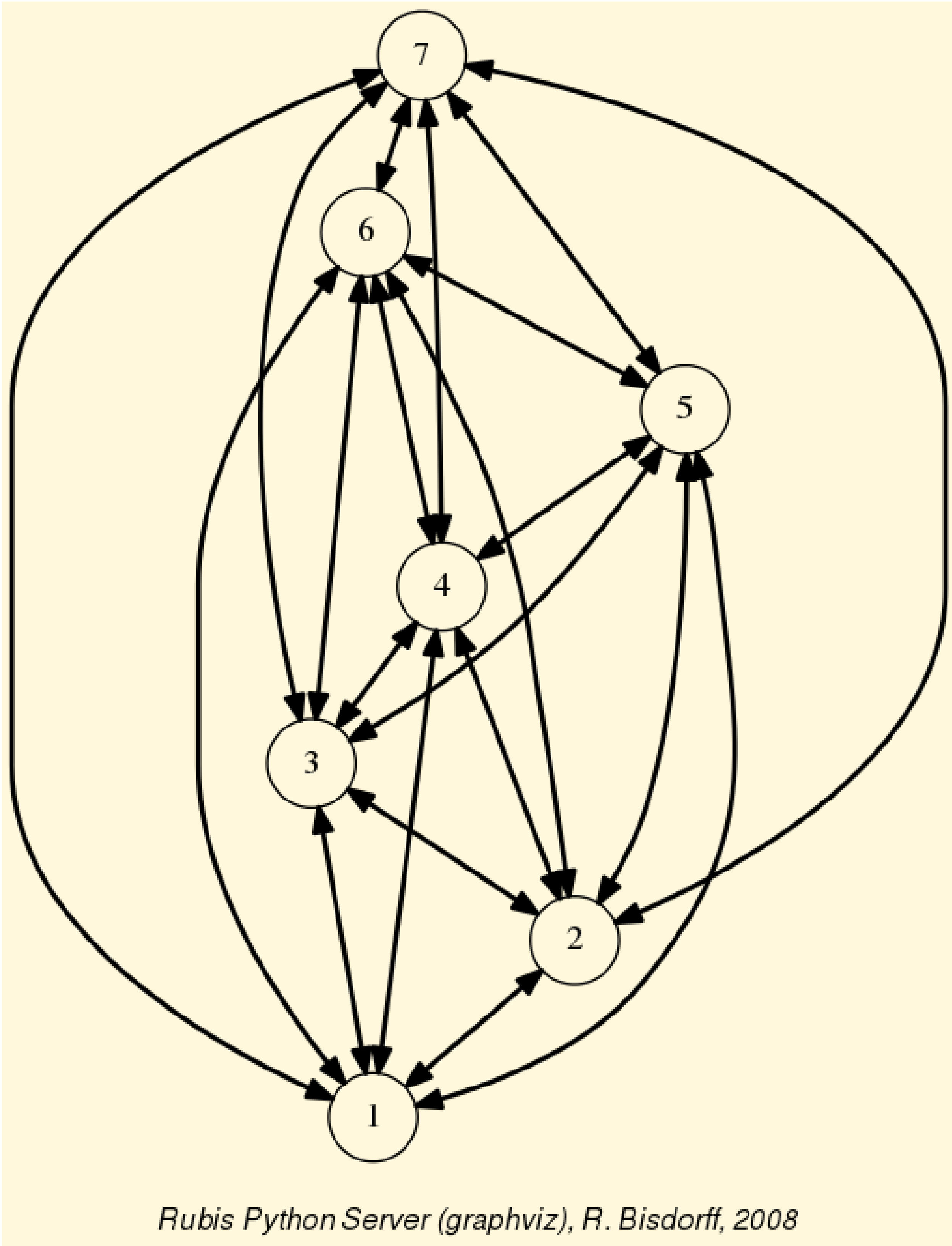
Computing the dual, respectively the converse, may also be done with prefixing the `__neg__` `(-)` or the `__invert__` (~) ope

```
>>> ddg = -dg   # dual of dg
>>> cdg = ~dg   # converse of dg
>>> cddg = -(~dg) = ~(-dg)  # codual of dg
>>> cddg.showRelationTable()
* ---- Relation Table -----
-r(ySx) |  '1'    '2'   '3'   '4'   '5'   '6'   '7'
--------|------------------------------------------------------------
'1'     |  0.00  0.22  0.42 -0.44 -0.32  0.84 -0.88
'2'     |  0.48  0.00 -0.08  0.40  0.48  0.00 -0.72
'3'     | -0.70  0.38  0.00  0.62  0.46  0.40 -0.82
'4'     | -0.86 -0.50 -0.70  0.00 -0.64  0.96 -0.52
'5'     | -0.30 -0.80  0.56 -0.04  0.00  0.18  0.84
'6'     | -0.38  0.54 -0.84 -0.66  0.22  0.00 -0.04
'7'     | -0.44 -0.02  1.00 -0.76  0.52  0.22  0.00
```

Symmetric and transitive closures

Symmetric and transtive closure in site constructors are also available, Note that it is a good idea,before going ahead with these

```
>>> dg.save('tutRandValDigraph')
>>> dg.closeSymmetric()
>>> dg.closeTransitive()
>>> dg.exportGraphViz('strongComponents')
```


7
6
5
4
3
2
1
Rubis Python Server (graphviz), R. Bisdorff, 2008

Strong components

As the original digraph *dg* was connected (see above the result of the `dg.showShort()` command), both the symmetric and tr

```
>>> from digraphs import StrongComponentsCollapsedDigraph
>>> sc = StrongComponentsCollapsedDigraph(dg)
>>> sc.showAll()
*----- show detail -----*
Digraph          : tutRandValDigraph_Scc
*---- Actions ----*
['_7_1_2_6_5_3_4_']
* ---- Relation Table -----
  S      |  'Scc_1'
 -------|---------
'Scc_1'  |  0.00
short         content
Scc_1         _7_1_2_6_5_3_4_
Neighborhoods:
  Gamma     :
'frozenset({'7', '1', '2', '6', '5', '3', '4'})': in => set(), out => set()
  Not Gamma :
'frozenset({'7', '1', '2', '6', '5', '3', '4'})': in => set(), out => set()
>>> ...
```

Saving and reloading in CSV format

Sometimes it is required to exchange the graph valuation data in CSV format with a statistical package like R. For this purpose

```
>>> dg = Digraph('tutRandValDigraph')
>>> dg.saveCSV('tutRandValDigraph')
# content of file tutRandValDigraph.csv
"d","1","2","3","4","5","6","7"
"1",-1.0,0.48,-0.7,-0.86,-0.3,-0.38,-0.44
"2",0.22,-1.0,0.38,-0.5,-0.8,0.54,-0.02
"3",0.42,-0.08,-1.0,-0.7,0.56,-0.84,1.0
"4",-0.44,0.4,0.62,-1.0,-0.04,-0.66,-0.76
"5",-0.32,0.48,0.46,-0.64,-1.0,0.22,0.52
"6",0.84,0.0,0.4,0.96,0.18,-1.0,0.22
"7",-0.88,-0.72,-0.82,-0.52,0.84,-0.04,-1.0
```

It is possible to reload a Digraph instance from its previously saved CSV file content:

```
>>> dgcsv = CSVDigraph('tutRandValDigraph')
>>> dgcsv.showRelationTable(ReflexiveTerms=False)
* ---- Relation Table -----
r(xSy) |   '1'    '2'    '3'    '4'    '5'    '6'    '7'
-------|------------------------------------------------------------
'1'    |    -    -0.48   0.70   0.86   0.30   0.38   0.44
'2'    |  -0.22    -    -0.38   0.50   0.80  -0.54   0.02
'3'    |  -0.42   0.08    -     0.70  -0.56   0.84  -1.00
'4'    |   0.44  -0.40  -0.62    -     0.04   0.66   0.76
'5'    |   0.32  -0.48  -0.46   0.64    -    -0.22  -0.52
'6'    |  -0.84   0.00  -0.40  -0.96  -0.18    -    -0.22
'7'    |   0.88   0.72   0.82   0.52  -0.84   0.04    -
```

Complete, empty and indeterminate digraphs

Let us finally mention some special universal classes of digraphs that are readily available in the `digraphs` module, like the Co

```
>>> from diggraphs import CompleteDigraph, EmptyDigraph, IndeterminateDigraph
>>> help(CompleteDigraph)
Help on class CompleteDigraph in module digraphs:
class CompleteDigraph(Digraph)
 |  Parameters:
 |      order > 0; valuationdomain=(Min,Max).
 |  Specialization of the general Digraph class for generating
 |  temporary complete graphs of order 5 in {-1,0,1} by default.
 |  Method resolution order:
 |      CompleteDigraph
 |      Digraph
 |      builtins.object
...
>>> e = EmptyDigraph(order=5)
>>> e.showRelationTable()
* ---- Relation Table -----
  S   |  '1'     '2'     '3'     '4'     '5'
---- -|---------------------------------------
'1'   |  -1.00   -1.00   -1.00   -1.00   -1.00
'2'   |  -1.00   -1.00   -1.00   -1.00   -1.00
'3'   |  -1.00   -1.00   -1.00   -1.00   -1.00
'4'   |  -1.00   -1.00   -1.00   -1.00   -1.00
'5'   |  -1.00   -1.00   -1.00   -1.00   -1.00
>>> e.showNeighborhoods()
Neighborhoods:
  Gamma     :
'1': in => set(), out => set()
'2': in => set(), out => set()
'5': in => set(), out => set()
'3': in => set(), out => set()
'4': in => set(), out => set()
  Not Gamma :
'1': in => {'2', '4', '5', '3'}, out => {'2', '4', '5', '3'}
'2': in => {'1', '4', '5', '3'}, out => {'1', '4', '5', '3'}
'5': in => {'1', '2', '4', '3'}, out => {'1', '2', '4', '3'}
'3': in => {'1', '2', '4', '5'}, out => {'1', '2', '4', '5'}
'4': in => {'1', '2', '5', '3'}, out => {'1', '2', '5', '3'}
>>> i = IndeterminateDigraph()
* ---- Relation Table -----
  S   |  '1'     '2'     '3'     '4'     '5'
------|--------------------------------------
'1'   |  0.00    0.00    0.00    0.00    0.00
'2'   |  0.00    0.00    0.00    0.00    0.00
'3'   |  0.00    0.00    0.00    0.00    0.00
'4'   |  0.00    0.00    0.00    0.00    0.00
'5'   |  0.00    0.00    0.00    0.00    0.00
>>> i.showNeighborhoods()
Neighborhoods:
  Gamma     :
'1': in => set(), out => set()
'2': in => set(), out => set()
'5': in => set(), out => set()
'3': in => set(), out => set()
```

```
'4': in => set(), out => set()
  Not Gamma :
'1': in => set(), out => set()
'2': in => set(), out => set()
'5': in => set(), out => set()
'3': in => set(), out => set()
'4': in => set(), out => set()
```

Note: Notice the subtle difference between the neighborhoods of an *empty* and the neighborhoods of an *indeterminate* digraph instance. In the first kind, the neighborhoods are known to be completely *empty* whereas, in the latter, *nothing is known* about the actual neighborhoods of the nodes. These two cases illustrate why in the case of a bipolar valuation domain, we need both a *gamma* **and** a *notGamma* function.

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1.1.4 Working with the `graphs` module

Structure of a `Graph` object

In the `graphs` module, the root `Graph` class provides a generic **simple graph model**, without loops and multiple links. A given object of this class consists in:

1. the graph **vertices** : a dictionary of vertices with 'name' and 'shortname' attributes,
2. the graph **valuationDomain** , a dictionary with three entries: the minimum (-1, means certainly no link), the median (0, means missing information) and the maximum characteristic value (+1, means certainly a link),
3. the graph **edges** : a dictionary with frozensets of pairs of vertices as entries carrying a characteristic value in the range of the previous valuation domain,
4. and its associated **gamma function** : a dictionary containing the direct neighbors of each vertice, automatically added by the object constructor.

See the technical documentation of the *graphs module*.

Example Python3 session:

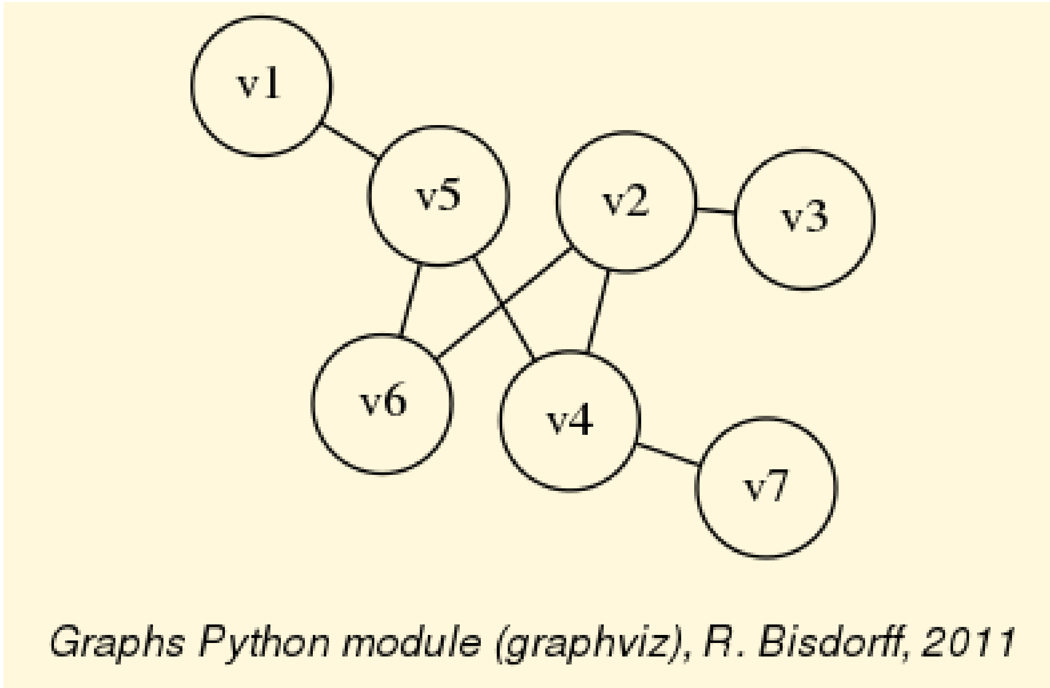
```
>>> from graphs import Graph
>>> g = Graph(numberOfVertices=7,edgeProbability=0.5)
>>> g.showShort()
*----- show short --------------*
Name             : 'randomGraph'
Vertices         :  ['v1', 'v2', 'v3', 'v4', 'v5', 'v6', 'v7']
Valuation domain :  {'med': 0, 'max': 1, 'min': -1}
Gamma function   :
v1 -> ['v5']
v2 -> ['v4', 'v6', 'v3']
v3 -> ['v2']
v4 -> ['v5', 'v2', 'v7']
v5 -> ['v4', 'v6', 'v1']
v6 -> ['v5', 'v2']
v7 -> ['v4']
>>> g.save(fileName='tutorialGraph')
```

The saved Graph instance named `tutorialGraph.py` is encoded in python3 as follows:

```
# Graph instance saved in Python format
vertices = {
'v1': {'shortName': 'v1', 'name': 'random vertex'},
'v2': {'shortName': 'v2', 'name': 'random vertex'},
'v3': {'shortName': 'v3', 'name': 'random vertex'},
'v4': {'shortName': 'v4', 'name': 'random vertex'},
'v5': {'shortName': 'v5', 'name': 'random vertex'},
'v6': {'shortName': 'v6', 'name': 'random vertex'},
'v7': {'shortName': 'v7', 'name': 'random vertex'},
}
valuationDomain = {'min':-1,'med':0,'max':1}
edges = {
frozenset(['v1','v2']) : -1,
frozenset(['v1','v3']) : -1,
frozenset(['v1','v4']) : -1,
frozenset(['v1','v5']) : 1,
frozenset(['v1','v6']) : -1,
frozenset(['v1','v7']) : -1,
frozenset(['v2','v3']) : 1,
frozenset(['v2','v4']) : 1,
frozenset(['v2','v5']) : -1,
frozenset(['v2','v6']) : 1,
frozenset(['v2','v7']) : -1,
frozenset(['v3','v4']) : -1,
frozenset(['v3','v5']) : -1,
frozenset(['v3','v6']) : -1,
frozenset(['v3','v7']) : -1,
frozenset(['v4','v5']) : 1,
frozenset(['v4','v6']) : -1,
frozenset(['v4','v7']) : 1,
frozenset(['v5','v6']) : 1,
frozenset(['v5','v7']) : -1,
frozenset(['v6','v7']) : -1,
}
```

The stored graph can be recalled and plotted with the generic `exportGraphViz` [1] method as follows:

```
>>> g = Graph('tutorialGraph')
>>> g.exportGraphViz()
*---- exporting a dot file for GraphViz tools ---------*
Exporting to tutorialGraph.dot
fdp -Tpng tutorialGraph.dot -o tutorialGraph.png
```



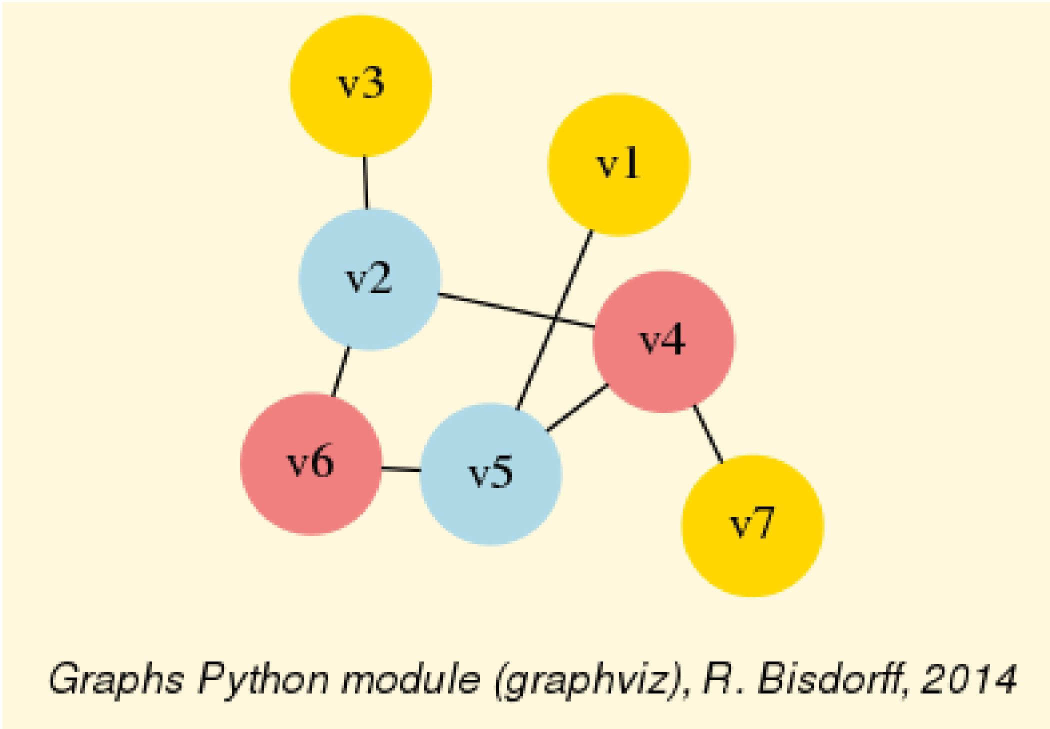
Chordless cycles may be enumerated in the given graph like follows:

```
>>> g = Graph('tutorialGraph')
>>> g.computeChordlessCycles()
Chordless cycle certificate -->>>  ['v5', 'v4', 'v2', 'v6', 'v5']
[(['v5', 'v4', 'v2', 'v6', 'v5'], frozenset({'v5', 'v4', 'v2', 'v6'}))]
```

q-coloring of a graph

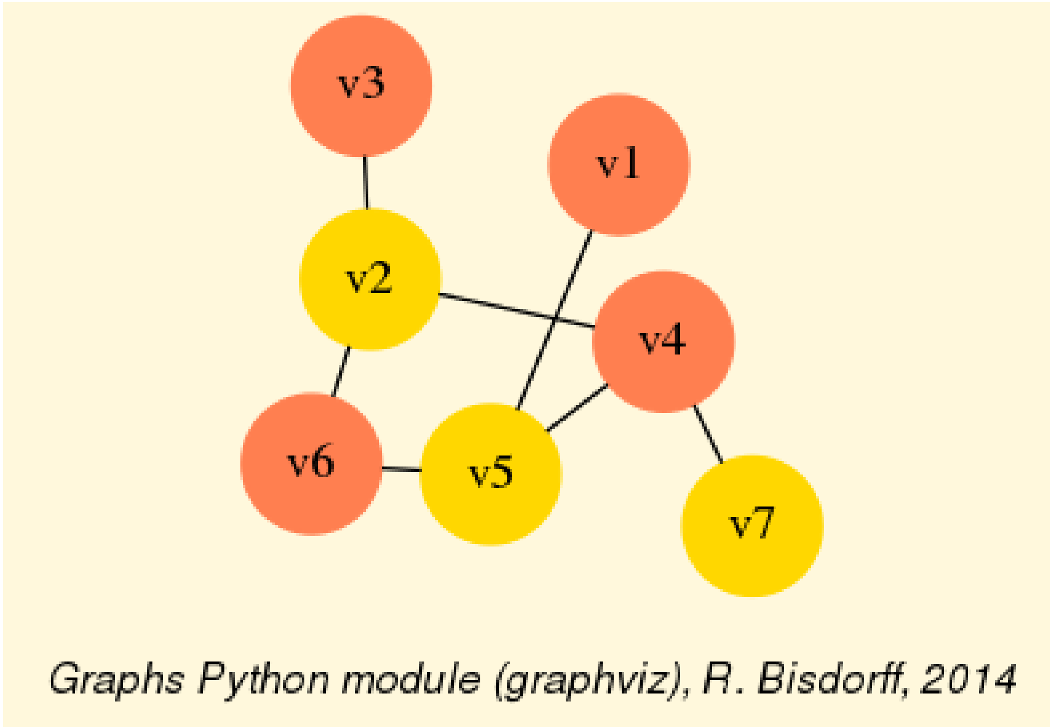
And, a 3-coloring of the tutorial graph may be computed and plotted as follows:

```
>>> g = Graph('tutorialGrah')
>>> qc = Q_Coloring(g)
Running a Gibbs Sampler for 42 step !
The q-coloring with 3 colors is feasible !!
>>> qc.showConfiguration()
v5 lightblue
v3 gold
v7 gold
v2 lightblue
v4 lightcoral
v1 gold
v6 lightcoral
>>> qc.exportGraphViz('tutorial-3-coloring')
*---- exporting a dot file for GraphViz tools ---------*
Exporting to tutorial-3-coloring.dot
fdp -Tpng tutorial-3-coloring.dot -o tutorial-3-coloring.png
```



Actually, with the given tutorial graph instance, a 2-coloring is already feasible:

```
>>> qc = Q_Coloring(g,colors=['gold','coral'])
Running a Gibbs Sampler for 42 step !
The q-coloring with 2 colors is feasible !!
>>> qc.showConfiguration()
v5 gold
v3 coral
v7 gold
v2 gold
v4 coral
v1 coral
v6 coral
>>> qc.exportGraphViz('tutorial-2-coloring')
*---- exporting a dot file for GraphViz tools ---------*
Exporting to tutorial-2-coloring.dot
fdp -Tpng tutorial-2-coloring.dot -o tutorial-2-coloring.png
```



MIS enumeration

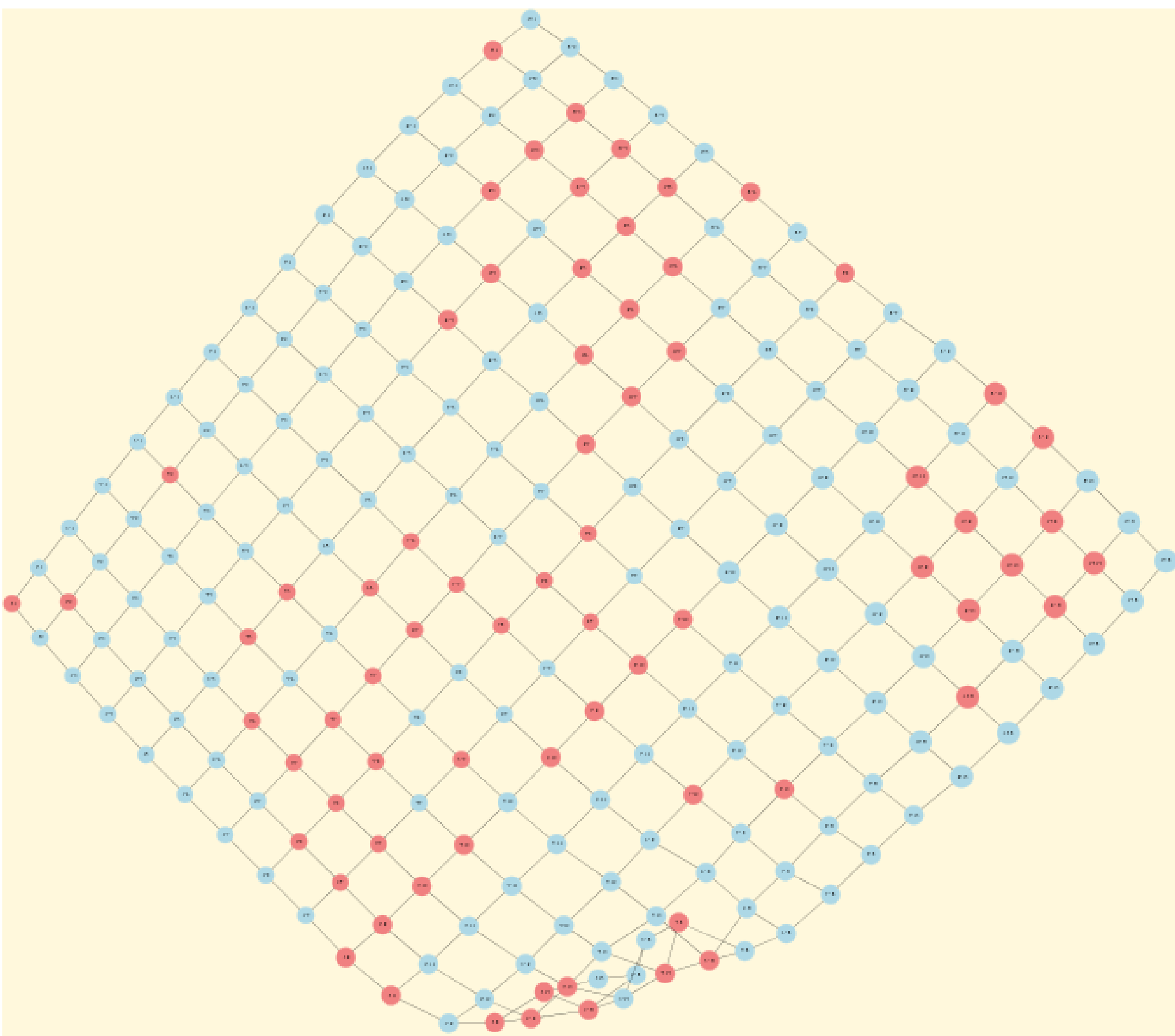
2-colorings define independent sets of vertices that are maximal in cardinality; for short called a MIS. Computing such MISs in

```
>>> g = Graph('tutorialGrah')
>>> dg = g.graph2Digraph()
>>> dg.showMIS()
*---  Maximal independent choices ---*
['v5', 'v3', 'v7']
['v5', 'v7', 'v2']
['v6', 'v3', 'v4', 'v1']
['v6', 'v3', 'v7', 'v1']
['v7', 'v2', 'v1']
number of solutions:  5
cardinality distribution
card.:  [0, 1, 2, 3, 4, 5, 6, 7]
freq.:  [0, 0, 0, 3, 2, 0, 0, 0]
execution time: 0.00050 sec.
Results in self.misset
>>> dg.misset
{frozenset({'v6', 'v3', 'v7', 'v1'}),
 frozenset({'v5', 'v7', 'v2'}),
 frozenset({'v6', 'v3', 'v4', 'v1'}),
 frozenset({'v7', 'v2', 'v1'}),
 frozenset({'v5', 'v3', 'v7'})}
```

Grids and the Ising model

Special classes of graphs, like *n* x *m* rectangular or triangular grids are available in the `graphs` module. For instance, we may u

```
>>> from graphs import GridGraph. IsingModel
>>> g = GridGraph(n=15,m=15)
>>> g.showShort()
*----- show short --------------*
Grid graph    :  grid-6-6
n             :  6
m             :  6
order         :  36
>>> im = IsingModel(g,beta=0.3,nSim=100000,Debug=False)
Running a Gibbs Sampler for 100000 step !
>>> im.exportGraphViz(colors=['lightblue','lightcoral'])
*---- exporting a dot file for GraphViz tools ---------*
Exporting to grid-15-15-ising.dot
fdp -Tpng grid-15-15-ising.dot -o grid-15-15-ising.png
```



Simulating Metropolis random walks

Finally, we provide a specialisation of the `Graph` class for implementing a generic Metropolis MCMC (Monte Carlo Markov Ch

```
>>> from graphs import MetropolisChain
>>> g = Graph(numberOfVertices=5,edgeProbability=0.5)
>>> g.showShort()
*---- short description of the graph ----*
Name              : 'randomGraph'
Vertices          :  ['v1', 'v2', 'v3', 'v4', 'v5']
Valuation domain :  {'max': 1, 'med': 0, 'min': -1}
Gamma function    :
v1 -> ['v2', 'v3', 'v4']
v2 -> ['v1', 'v4']
v3 -> ['v5', 'v1']
v4 -> ['v2', 'v5', 'v1']
v5 -> ['v3', 'v4']
>>> probs = {}  # initialise a potential stationary probability vector
>>> n = g.order # for instance: probs[v_i] = n-i/Sum(1:n) for i in 1:n
>>> i = 0
>>> verticesList = [x for x in g.vertices]
>>> verticesList.sort()
>>> for v in verticesList:
...     probs[v] = (n - i)/(n*(n+1)/2)
...     i += 1
>>> met = MetropolisChain(g,probs)
>>> frequency = met.checkSampling(verticesList[0],nSim=30000)
>>> for v in verticesList:
...     print(v,probs[v],frequency[v])
v1 0.3333 0.3343
v2 0.2666 0.2680
v3 0.2    0.2030
v4 0.1333 0.1311
v5 0.0666 0.0635
>>> met.showTransitionMatrix()
* ---- Transition Matrix -----
  Pij  | 'v1'    'v2'    'v3'    'v4'    'v5'
  -----|-------------------------------------
  'v1' |  0.23   0.33    0.30    0.13    0.00
  'v2' |  0.42   0.42    0.00    0.17    0.00
  'v3' |  0.50   0.00    0.33    0.00    0.17
  'v4' |  0.33   0.33    0.00    0.08    0.25
  'v5' |  0.00   0.00    0.50    0.50    0.00
```

The `checkSampling()` method generates a randomwalk of *nSim=30000* steps on the given graph and records by the way the observed relative frequency with which each vertice is passed by. In this exmaple, the stationary transition probability distribution, shown by the `showTransitionMatrix()` method above, is quite adequately simulated.

For more technical information and more code examples, look into the technical documentation of the *graphs module*. For the readers interested in algorithmic applications of Markov Chains we may may recommend consulting O. Häggström's 2002 book: [FMCAA].

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1.1.5 Computing the winner of an election

Linear voting profiles

The *votingDigraphs module* provides resources for handling election results [ADT-L2], like the LinearVotingProfile class. We consider an election involving a finite set of candidates and finite set of weighted voters, who express their voting preferences in a complete linear ranking (without ties) of the candidates. The data is internally stored in two Python dictionaries, one for the candidates and another one for the linear ballots:

```
candidates = {'a': ,'b':  ,'c', ..., ...}
voters = {'1':{'weight':1.0},'2':{'weight':1.0}, ...}
## each voter specifies a linearly ranked list of candidates
## from the best to the worst (without ties
linearBallot = {
'1' : ['b','c','a', ...],
'2' : ['a','b','c', ...],
...
}
```

The module provides a class for generating random instances of the `LinearVotingProfile` class. In an interactive Python s

```
>>> from votingDigraphs import *
>>> v = RandomLinearVotingProfile(numberOfVoters=5,numberOfCandidates=3)
>>> v.candidates
{'a2': {'name': 'a2'}, 'a3': {'name': 'a3'}, 'a1': {'name': 'a1'}}
>>> v.voters
{'v4': {'weight': 1.0}, 'v3': {'weight': 1.0},
 'v1': {'weight': 1.0}, 'v5': {'weight': 1.0},
 'v2': {'weight': 1.0}}
>>> v.linearBallot
{'v4': ['a1', 'a3', 'a2'], 'v3': ['a1', 'a3', 'a2'], 'v1': ['a1', 'a2', 'a3'],
 'v5': ['a2', 'a3', 'a1'], 'v2': ['a3', 'a2', 'a1']}
 >>> ...
```

Notice that in this example, all voters are considered to be equi-significant. Their linear ballots can be viewd with the `showLin`

```
>>> v.showLinearBallots()
voters(weight)       candidates rankings
v4(1.0):     ['a1', 'a2', 'a3']
v3(1.0):     ['a1', 'a3', 'a2']
v1(1.0):     ['a2', 'a1', 'a3']
v5(1.0):     ['a3', 'a1', 'a2']
v2(1.0):     ['a3', 'a1', 'a2']
>>> ...
```

Editing of the linear voting profile may be acheived by storing the data in a file, edit it, and reload it again:

```
>>> v.save('tutorialLinearVotingProfile')
*--- Saving linear profile in file: <tutorialLinearVotingProfile.py> ---*
>>> v = LinearVotingProfile('tutorialLinearVotingProfile')
```

Computing the winner

We may easily compute uninominal votes, i.e. how many times a candidate was ranked first, and see who is consequently the sin

```
>>> v.computeUninominalVotes()
{'a2': 1.0, 'a1': 2.0, 'a3': 2.0}
>>> v.computeSimpleMajorityWinner()
['a1','a3']
>>> ...
```

As we observe no absolute majority (3/5) of votes for any of the three candidate, we may look for the instant runoff winner inste

```
>>> v.computeInstantRunoffWinner()
['a1']
>>> ...
```

We may also follow the Chevalier de Borda's advice and, after a rank analysis of the linear ballots, compute the Borda score of

```
>>> v.computeRankAnalysis()
{'a2': [1.0, 1.0, 3.0], 'a1': [2.0, 3.0, 0], 'a3': [2.0, 1.0, 2.0]}
>>> v.computeBordaScores()
{'a2': 12.0, 'a1': 8.0, 'a3': 10.0}
>>> v.computeBordaWinners()
['a1']
>>> ...
```

The Condorcet winner

In our randomly generated election results, we are lucky: The instant runoff winner and the Borda winner both are candidate *a*

```
>>> cdg = CondorcetDigraph(v,hasIntegerValuation=True)
>>> cdg.showAll()
*----- show detail -------------*
Digraph          : rel_randLinearProfile
*---- Actions ----*
['a1', 'a2', 'a3']
*---- Characteristic valuation domain ----*
{'hasIntegerValuation': True,
'max': Decimal('5.0'),
'min': Decimal('-5.0'),
'med': Decimal('0')}
* ---- Relation Table ----
 M(x,y) |  'a1' 'a2' 'a3'
 -------|-----------------
   'a1' |   -    3    1
   'a2' |  -3    -   -1
   'a3' |  -1    1    -
```

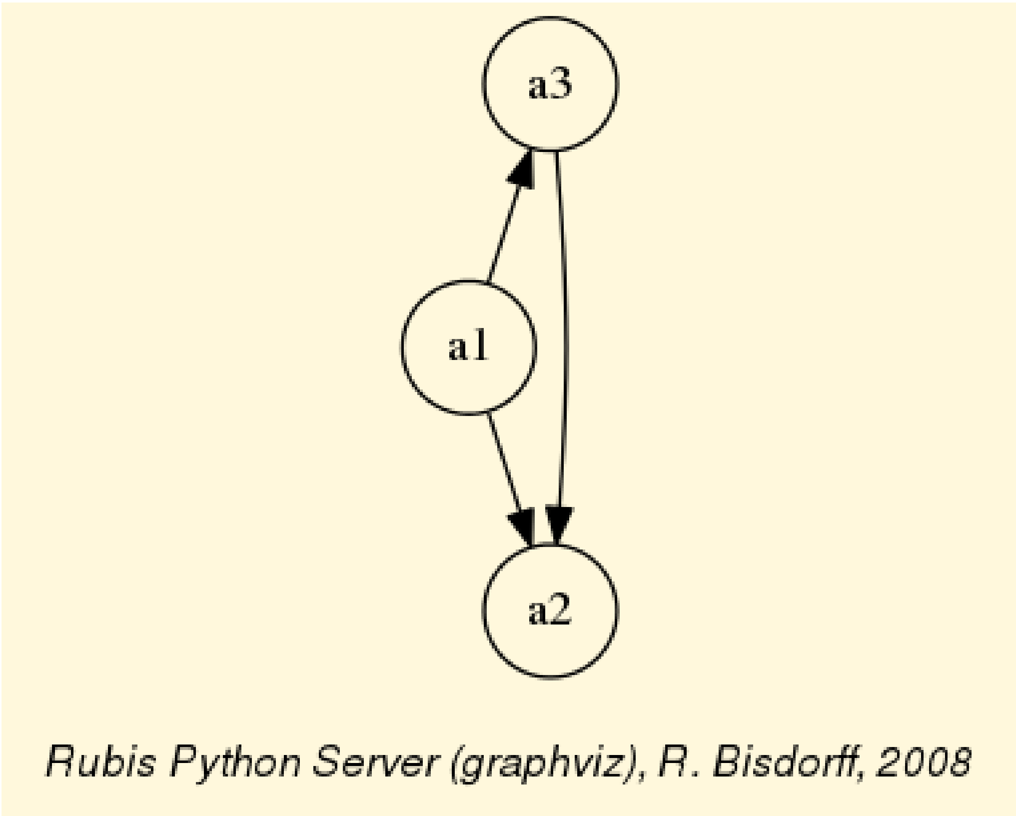
A candidate *x*, showing a positive majority margin *M(x,y)*, is beating candidate *y* with an absolute majority in a pairwise voting.

```
>>> cdg.computeCondorcetWinner()
['a1']
```

By seeing the majority margins like a bipolarly-valued characteristic function for a global preference relation defined on the set

```
>>> cdg.exportGraphViz('tutorialLinearBallots')
*---- exporting a dot file for GraphViz tools ---------*
```

```
Exporting to tutorialLinearBallots.dot
dot -Grankdir=BT -Tpng tutorialLinearBallots.dot -o tutorialLinearBallots.png
```



Cyclic social preferences

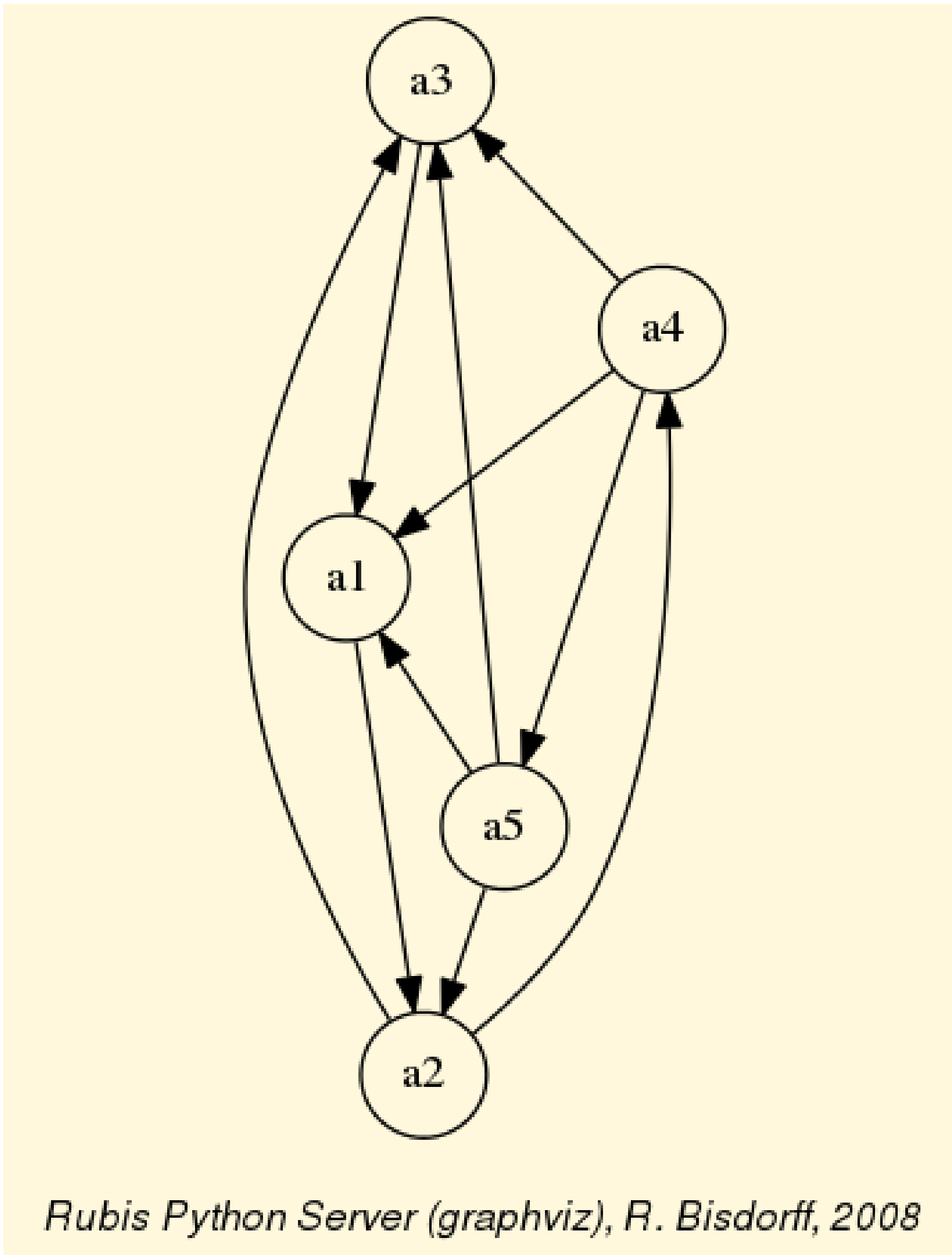
Usually, when aggregating linear ballots, there appear cyclic social preferences. Let us consider for instance the following linear

```
>>> v.showLinearBallots()
voters(weight)       candidates rankings
v1(1.0):     ['a1', 'a3', 'a5', 'a2', 'a4']
v2(1.0):     ['a1', 'a2', 'a4', 'a3', 'a5']
v3(1.0):     ['a5', 'a2', 'a4', 'a3', 'a1']
v4(1.0):     ['a3', 'a4', 'a1', 'a5', 'a2']
v5(1.0):     ['a4', 'a2', 'a3', 'a5', 'a1']
v6(1.0):     ['a2', 'a4', 'a5', 'a1', 'a3']
v7(1.0):     ['a5', 'a4', 'a3', 'a1', 'a2']
v8(1.0):     ['a2', 'a4', 'a5', 'a1', 'a3']
v9(1.0):     ['a5', 'a3', 'a4', 'a1', 'a2']
>>> cdg = CondorcetDigraph(v)
>>> cdg.showRelationTable()
* ---- Relation Table -----
  S    |  'a1'   'a2'   'a3'   'a4'    'a5'
------|---------------------------------------
'a1'   |   -     0.11  -0.11  -0.56   -0.33
'a2'   | -0.11    -     0.11   0.11   -0.11
'a3'   |  0.11  -0.11    -    -0.33   -0.11
'a4'   |  0.56  -0.11   0.33    -      0.11
```

```
'a5'  |  0.33   0.11   0.11  -0.11     -
```

Now, we cannot find any completely positive row in the relation table. No one of the five candidates is beating all the others with

```
>>> cdg.exportGraphViz('cycles')
*---- exporting a dot file dor GraphViz tools ---------*
Exporting to cycles.dot
dot -Grankdir=BT -Tpng cycles.dot -o cycles.png
```



But, there may be many cycles appearing in a digraph, and, we may detect and enumerate all minimal chordless circuits in a Di

```
>>> cdg.computeChordlessCircuits()
[(['a2', 'a3', 'a1'], frozenset({'a2', 'a3', 'a1'})),
 (['a2', 'a4', 'a5'], frozenset({'a2', 'a5', 'a4'})),
 (['a2', 'a4', 'a1'], frozenset({'a2', 'a1', 'a4'}))]
```

Condorcet's approach for determining the winner of an election is hence not decisive in all circumstances and we need to exploit more sophisticated approaches for finding the winner of the election on the basis of the majority margins of the given linear ballots (see [BIS-2008]).

Many more tools for exploiting voting results are available, see the thechnical documentation of the *votingDigraphs module*.

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1.1.6 Working with the `outrankingDigraphs` module

See also the technical documentation of the *outrankingDigraphs module*.

Structure of an outranking digraph

In this *Digraph3* module, the root `OutrankingDiraph` class provides a generic **outranking digraph model**. A given object of this class consists in:

1. a potential set of decision **actions** : a dictionary describing the potential decision actions or alternatives with 'name' and 'comment' attributes,
2. a coherent family of **criteria**: a dictionary of criteria functions used for measuring the performance of each potential decision action with respect to the preference dimension captured by each criterion,
3. the **evaluations**: a dictionary of performance evaluations for each decision action or alternative on each criterion function.
4. the digraph **valuationdomain**, a dictionary with three entries: the *minimum* (-100, means certainly no link), the *median* (0, means missing information) and the *maximum* characteristic value (+100, means certainly a link),
5. the **outranking relation** : a double dictionary defined on the Cartesian product of the set of decision alternatives capturing the credibility of the pairwise *outranking situation* computed on the basis of the performance differences observed between couples of decision alternatives on the given family if criteria functions.

With the help of the `RandomBipolarOutrankingDigraph` class (of type `BipolarOutrankingDigraph`) , let us generate

```
>>> from outrankingDigraphs import *
>>> odg = RandomBipolarOutrankingDigraph()
>>> odg.showActions()
*----- show digraphs actions --------------*
key:  a01
name:       random decision action
comment:    RandomPerformanceTableau() generated.
key:  a02
name:       random decision action
comment:    RandomPerformanceTableau() generated.
...
...
key:  a07
name:       random decision action
comment:    RandomPerformanceTableau() generated.
>>> ...
```

In this example we consider furthermore a family of seven equisignificant cardinal criteria functions *g01*, *g02*, ..., *g07*, measurin

```
>>> odg.showCriteria()
*----  criteria -----*
g01 'digraphs.RandomPerformanceTableau() instance'
  Scale = [0.0, 100.0]
  Weight = 3.0
  Threshold pref : 20.00 + 0.00x ; percentile:  0.28
  Threshold ind : 10.00 + 0.00x ; percentile:  0.095
  Threshold veto : 80.00 + 0.00x ; percentile:  1.0
g02 'digraphs.RandomPerformanceTableau() instance'
  Scale = [0.0, 100.0]
  Weight = 3.0
  Threshold pref : 20.00 + 0.00x ; percentile:  0.33
  Threshold ind : 10.00 + 0.00x ; percentile:  0.19
  Threshold veto : 80.00 + 0.00x ; percentile:  0.95
...
...
g07 'digraphs.RandomPerformanceTableau() instance'
  Scale = [0.0, 100.0]
  Weight = 10.0
  Threshold pref : 20.00 + 0.00x ; percentile:  0.476
  Threshold ind : 10.00 + 0.00x ; percentile:  0.238
  Threshold veto : 80.00 + 0.00x ; percentile:  1.0
```

The performance evaluations of each decision alternative on each criterion are gathered in a *performance tableau*:

```
>>> odg.showPerformanceTableau()
*----  performance tableau -----*
criteria |  'a01'   'a02'   'a03'   'a04'   'a05'   'a06'   'a07'
---------|---------------------------------------------------
  'g01'  |   9.6    48.8    21.7    37.3    81.9    48.7    87.7
  'g02'  |  90.9    11.8    96.6    41.0    34.0    53.9    46.3
  'g03'  |  97.8    46.4    83.3    30.9    61.5    85.4    82.5
  'g04'  |  40.5    43.6    53.2    17.5    38.6    21.5    67.6
  'g05'  |  33.0    40.7    96.4    55.1    46.2    58.1    52.6
  'g06'  |  47.6    19.0    92.7    55.3    51.7    26.6    40.4
  'g07'  |  41.2    64.0    87.7    71.6    57.8    59.3    34.7
>>> ...
```

We may visualize the same performance tableau in a more colorful setting in the default system browser with the command:

```
>>> dog.showHTMLPerformanceTableau()
>>> ...
```

Performance table

criterion	a01	a02	a03	a04	a05	a06	a07
g01	9.56	48.84	21.73	37.26	81.93	48.68	87.73
g02	90.94	11.79	96.56	41.03	33.96	53.90	46.27
g03	97.79	46.36	83.35	30.89	61.55	85.36	82.53
g04	40.53	43.61	53.22	17.50	38.65	21.51	67.62
g05	33.04	40.67	96.42	55.13	46.21	58.10	52.65
g06	47.57	19.00	92.65	55.32	51.70	26.64	40.39
g07	41.21	63.95	87.70	71.61	57.79	59.29	34.69

It is worthwhile noticing that *green* and *red* marked evaluations indicate *best*, respectively *worst*, performances of an alternative on a criterion. In this example, we may hence notice that alternative *a03* is in fact best performing on *four* out of *seven* criteria.

Semantics of the bipolar valuation

Considering the given performance tableau, the `BipolarOutrankingDigraph` class constructor computes the characteristic

1. If r(x S y) > 0.0 it is more *True* than *False* that *x outranks y*, i.e. alternative x is at least as well performing than alternative y **and** there is no considerable negative performance difference observed in disfavour of x,
2. If r(x S y) < 0.0 it is more *False* than *True* that *x outranks y*, i.e. alternative x is **not** at least as well performing than alternative y **and** there is no considerable positive performance difference observed in favour of x,
3. If r(x S y) = 0.0 it is *indeterminate* whether *x outranks y or not*.

The resulting bipolarly valued outranking relation may be inspected with the following command:

```
>>> odg.showRelationTable()
* ---- Relation Table -----
r(x S y)|  'a01'   'a02'   'a03'   'a04'   'a05'   'a06'   'a07'
--------|------------------------------------------------------------
 'a01'  |   +0.00  +29.73  -29.73  +13.51  +48.65  +40.54  +48.65
 'a02'  |  +13.51   +0.00 -100.00  +37.84  +13.51  +43.24  -37.84
 'a03'  |  +83.78 +100.00   +0.00  +91.89  +83.78  +83.78  +70.27
 'a04'  |  +24.32  +48.65  -56.76   +0.00  +24.32  +51.35  +24.32
 'a05'  |  +51.35 +100.00  -70.27  +72.97   +0.00  +51.35  +32.43
 'a06'  |  +16.22  +72.97  -51.35  +35.14  +32.43   +0.00  +37.84
 'a07'  |  +67.57  +45.95  -24.32  +27.03  +27.03  +45.95   +0.00
```

```
>>> odg.valuationdomain
{'min': Decimal('-100.0'), 'max': Decimal('100.0'), 'med': Decimal('0.0')}
```

Pairwise multiple criteria comparisons

From above given semantics, we may consider that *a01* outranks *a02* (r(a01 S a02) > 0.0), but not *a03* (r(a01 S a03) < 0.0). In ord

```
>>> odg.showPairwiseComparison('a01','a02')
*------------  pairwise comparison ----*
Comparing actions : (a01, a02)
crit. wght.   g(x)  g(y)    diff         | ind     p    concord  |
------------------------------- ---------------------------------
g01    3.00   9.56  48.84  -39.28        | 10.00  20.00   -3.00  |
g02    3.00  90.94  11.79  +79.15        | 10.00  20.00   +3.00  |
g03    6.00  97.79  46.36  +51.43        | 10.00  20.00   +6.00  |
g04    5.00  40.53  43.61   -3.08        | 10.00  20.00   +5.00  |
g05    3.00  33.04  40.67   -7.63        | 10.00  20.00   +3.00  |
g06    7.00  47.57  19.00  +28.57        | 10.00  20.00   +7.00  |
g07   10.00  41.21  63.95  -22.74        | 10.00  20.00  -10.00  |
-----------------------------------------------------------------
Valuation in range: -37.00 to +37.00; global concordance: +11.00
```

The outranking valuation characteristic appears as majority margin resulting from the difference of the weights of the criteria i

```
>>> odg.showPairwiseComparison('a03','a02')
*------------  pairwise comparison ----*
Comparing actions : (a03, a02)
crit.  wght.  g(x)  g(y)    diff         | ind     p    concord  |  v  veto/counter-
---------------------------------------------------------------------------------
g01    3.00  21.73  48.84  -27.11        | 10.00  20.00   -3.00  |
g02    3.00  96.56  11.79  +84.77        | 10.00  20.00   +3.00  |  80.00  +1.00
g03    6.00  83.35  46.36  +36.99        | 10.00  20.00   +6.00  |
g04    5.00  53.22  43.61   +9.61        | 10.00  20.00   +5.00  |
g05    3.00  96.42  40.67  +55.75        | 10.00  20.00   +3.00  |
g06    7.00  92.65  19.00  +73.65        | 10.00  20.00   +7.00  |
g07   10.00  87.70  63.95  +23.75        | 10.00  20.00  +10.00  |
---------------------------------------------------------------------------------
 Valuation in range: -37.00 to +37.00; global concordance: +31.00
>>> ...
```

This time, we observe a considerable out-performance of *a03* against *a02* on criterion g02 (see second row in the relation table above). We therefore notice a positively polarised *certainly confirmed* outranking situation in this case [BIS-2013].

Recoding the valuation

All outranking digraphs, being of root type `Digraph`, inherit the methods available under this class. The characteristic valuati

```
>>> odg.recodeValuation(-37,+37)
>>> odg.valuationdomain['hasIntegerValuation'] = True
>>> Digraph.showRelationTable(odg)
* ---- Relation Table -----
* ---- Relation Table -----
```

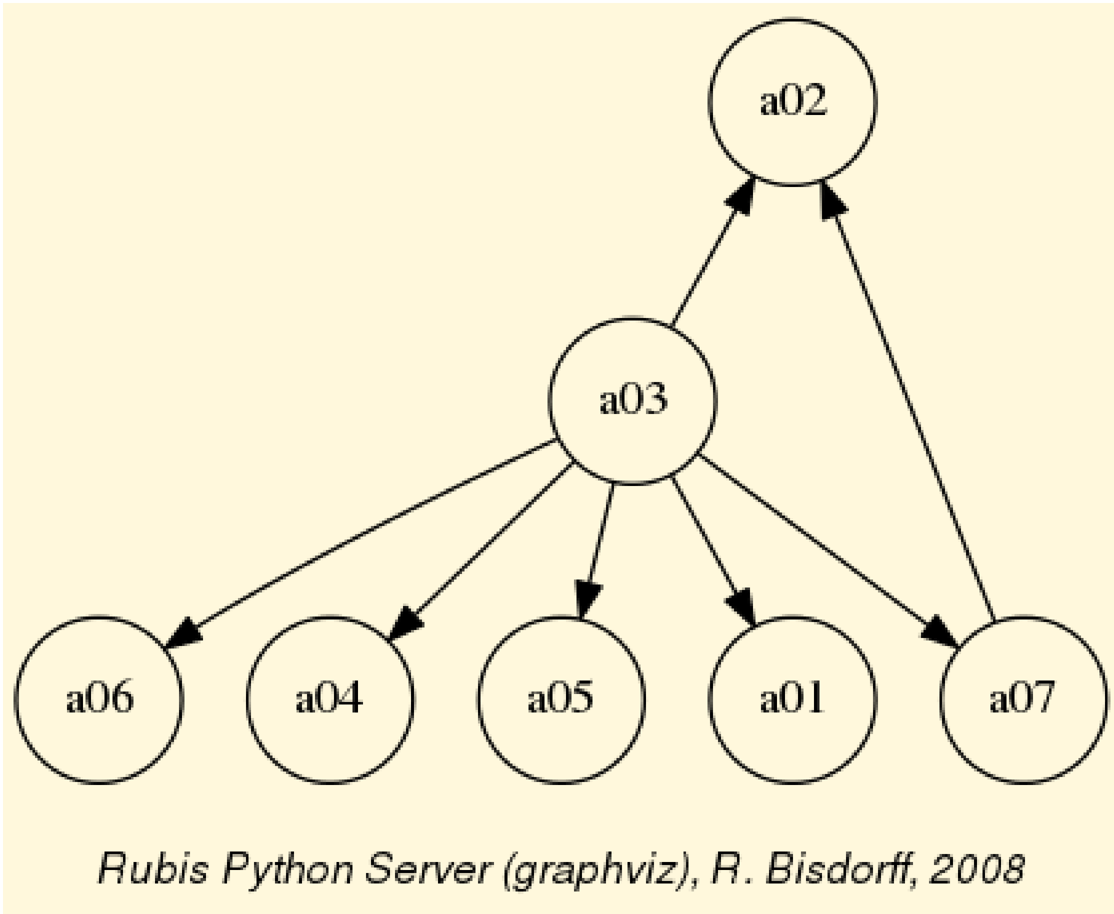
```
  S   | 'a01'   'a02'   'a03'  'a04'   'a05'   'a06'   'a07'
-----|------------------------------------------------------------
'a01' |    0     +11     -11     +5     +17     +14     +17
'a02' |   +5       0     -37    +13      +5     +15     -14
'a03' |  +31     +37       0    +34     +31     +31     +26
'a04' |   +9     +18     -21      0      +9     +19      +9
'a05' |  +19     +37     -26    +27       0     +19     +12
'a06' |   +6     +27     -19    +13     +12       0     +14
'a07' |  +25     +17      -9     +9      +9     +17       0
Valuation domain:  {'hasIntegerValuation': True, 'min': Decimal('-37'),
                    'max': Decimal('37'), 'med': Decimal('0.000')}
>>> ...
```

Note: Notice that the reflexive self comparison characteristic r(x S x) is set by default to the median indeterminate valuation value 0; the reflexive terms of binary relation being generally ignored in most of the `Digraph3` resources.

Strict outranking via the codual digraph

From the theory [BIS-2013] we know that the bipolarly outranking relation is weakly complete, i.e. if r(x S y) < 0.0 then r(y S x)

```
>>> cdodg = -(~odg)
>>> cdodg.exportGraphViz('codualOdg')
*---- exporting a dot file for GraphViz tools ---------*
Exporting to codualOdg.dot
dot -Grankdir=BT -Tpng codualOdg.dot -o codualOdg.png
>>> ...
```



It becomes readily clear now from the picture above that alternative *a03* strictly outranks in fact all the other alternatives. Hence, *a03* appears as **Condorcet winner** and may be recommended as *best decision action* in this illustrative preference modelling exercise.

XMCDA 2.0 storage

As with all Digraph instances, it is possible to store permanently a copy of the outranking digraph *odg*. As its outranking relatio

```
>>> PerformanceTableau.saveXMCDA2(odg,'tutorialPerfTab')
*----- saving performance tableau in XMCDA 2.0 format  -------------*
File: tutorialPerfTab.xml saved !
>>> ...
```

The resulting XML file my be visualized in a browser window (other than Chrome or Chromium) with a corresponding XMCD

```
>>> pt = XMCDA2PerformanceTableau('tutorialPerfTab')
>>> odg = BipolarOutrankingDigraph(pt)
>>> odg.showRelationTable()
* ---- Relation Table -----
  S   |  'a01'     'a02'   'a03'   'a04'   'a05'   'a06'   'a07'
------|------------------------------------------------------------
'a01' |   +0.00   +29.73  -29.73  +13.51  +48.65  +40.54  +48.65
'a02' |   +13.51  +0.00  -100.00  +37.84  +13.51  +43.24  -37.84
'a03' |   +83.78  +100.00  +0.00  +91.89  +83.78  +83.78  +70.27
```

```
'a04' |   +24.32  +48.65  -56.76   +0.00  +24.32  +51.35  +24.32
'a05' |   +51.35  +100.00  -70.27  +72.97  +0.00  +51.35  +32.43
'a06' |   +16.22  +72.97  -51.35  +35.14  +32.43   +0.00  +37.84
'a07' |   +67.57  +45.95  -24.32  +27.03  +27.03  +45.95   +0.00
>>> ...
```

We recover the original bipolarly valued outranking characteristics, and we may restart again the preference modelling process.

Many more tools for exploiting bipolarly valued outranking digraphs are available in the Digraph3 resources (see the thechnical documentation of the *outrankingDigraphs module* and the *perfTabs module*).

Back to *Content*

1.1.7 Links and appendices

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- Introduction
- Reference manual
- Tutorial

Indices and tables

- *genindex*
- *modindex*
- *search*

References

Footnotes

1.2 Technical Reference of the Digraph3 modules

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Version Revision: Python 3.4

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1.2.1 Introduction

Dowloading the Digraph3 ressources

Two downlaod options are given:

1. Either (easiest under Linux or Mac OS-X), by using a subversion client:: ..$svn co http://leopold-loewenheim.uni.lu/svn/repos/Digraph3

2. Or, download and extract the latest distribution tar.gz archive:: http://leopold-loewenheim.uni.lu/svn/repos/Digraph3/dist/digraphs-Python3-xxx.tar.gz

Developping the Rubis decision support methodology is an ongoing research project of Raymond Bisdorff <http://charles-sanders-peirce.uni.lu/bisdorff/>, University of Luxembourg.

To be fully functional, the Digraph3 resources mainly need the graphviz tools and the R statistics resources to be installed. When exploring digraph isomorphisms, the nauty isomorphism testing program is required. two specific criteria and actions clustering methods of the Digraph class furthermore require the calmat matrix computing resource to be installed.

Organisation of the Digraph3 python3 source code

The Digraph3 source code is split into several interdependent modules, where the `digraphs` module is the master source.

- ***digraphs module*** main part of the Digraph3 source code with the root Digraph class;
- ***graphs module*** specialization for undirected graphs with the root Graph class and a brigde to the `digraphs` module resources;
- ***outrankingDigraphs module*** new Python3 versioned root OutrankingDigraph class and specializations;
- ***perfTabs module*** everything needed for handling Multiple Criteria Decision Aid performance tableaux with root PerformaceTableau class;
- ***votingDigraphs module*** additional classes and methods for computing election results with main LinearVotingProfile class;
- ***sortingDigraphs module*** additional tools for solving sorting problems with the root SortingDigraph class;
- ***linearOrders module*** additional tools for solving linearly ranking problems with the root LinearOrder class;
- ***weakOrders module*** additional tools for solving ranking by choosing problems with root WeakOrder class.

1.2.2 digraphs module

A tutorial with coding examples is available here: *Working with the digraphs module*

class `digraphs.`**`AsymmetricPartialDigraph`**(*digraph*)

Bases: `digraphs.Digraph`

Renders the asymmetric part of a Digraph instance

> **Warning:** Note that the non asymmetric pairs are all put to the median indeterminate characteristic value!

class `digraphs.`**`CSVDigraph`**(*fileName='temp'*, *valuationMin=-1*, *valuationMax=1*)

Bases: `digraphs.Digraph`

Specialization of the general Digraph class for reading stored csv formatted digraphs. Using the inbuilt module csv.

Param: fileName (without the extension .csv).

`showAll`()

class `digraphs.`**`CirculantDigraph`**(*order=7, valuationdomain={'max': Decimal('1.0'), 'min': Decimal('-1.0')}, circulants=[-1, 1]*)

Bases: `digraphs.Digraph`

Parameters:

order > 0;

valuationdomain ={'min':m, 'max':M};
circulant connections = list of positive and/or negative circular shifts of value 1 to n.

Specialization of the general Digraph class for generating temporary circulant digraphs

Default instantiation C_7:

order = 7,
valuationdomain = {'min':-1.0,'max':1.0},
circulants = [-1,1].

showShort()

class digraphs.**CoDualDigraph**(*other*, *Debug=False*)
Bases: digraphs.Digraph

Instantiates the associated codual digraph from a given Digraph called other.

Instantiates as other.__class__ !

Copies the case given the description, the criteria and the evaluation dictionary into self.

class digraphs.**CocaDigraph**(*digraph=None*, *Cpp=False*, *Piping=False*, *Comments=False*)
Bases: digraphs.Digraph

Parameters: Stored or memory resident digraph instance.

Specialization of general Digraph class for instantiation of chordless odd circuits augmented digraphs.

addCircuits(*Comments=False*)
Augmenting self with self.circuits.

closureChordlessOddCircuits(*Cpp=False*, *Piping=False*, *Comments=False*)
Closure of chordless odd circuits extraction.

showCircuits()
show methods for chordless odd circuits in CocaGraph

showComponents()

class digraphs.**CoceDigraph**(*digraph=None*, *Cpp=False*, *Piping=False*, *Comments=False*, *Debug=False*)
Bases: digraphs.Digraph

Parameters: Stored or memory resident digraph instance.

Specialization of general Digraph class for instantiation of chordless odd circuits eliminated digraphs.

iterateCocElimination(*Comments=True*, *Debug=False*)
Eliminates all chordless odd circuits with rising valuation cut levels. Renders a tuple (level,polarisedDigraph) where level is the necessary bipolar cut level for eliminating all chordless odd circuits, and polarisedDigraph is the resulting digraph instance. Renders (None,None) if no chordless odd circuit is detected.

class digraphs.**CompleteDigraph**(*order=5*, *valuationdomain=(-1.0, 1.0)*)
Bases: digraphs.Digraph

Parameters: order > 0; valuationdomain=(Min,Max).

Specialization of the general Digraph class for generating temporary complete graphs of order 5 in {-1,0,1} by default.

class digraphs.**ConverseDigraph**(*other*)
Bases: digraphs.Digraph

Instantiates the associated converse orreciprocal version from a given Digraph called other.

Instantiates as other.__class__ !

Copies the case given the description, the criteria and the evaluation dictionary into self.

class `digraphs.CoverDigraph` (*other*, *Debug=False*)

Bases: `digraphs.Digraph`

Instantiates the associated cover relation from a given Digraph called other.

Instantiates as other.__class__ !

Copies the case given the description, the criteria and the evaluation dictionary into self.

class `digraphs.Digraph` (*file=None*, *order=7*)

Bases: `builtins.object`

General class of digraphs, R.B. March 2006:

Python data file format:

- actionset = [‘1’,‘2’,‘3’,‘4’,‘5’]
- valuationdomain = { ‘min’:0, ‘med’:1, ‘max’: 2}
- relation = { ‘1’: { ‘1’:0, ‘2’: 2, ...}, ...}

Example python3 (3.3+ recommended) session::

```
>>> from digraphs import Digraph
>>> g = Digraph('tempdigraph')
>>> g.showShort()
*----- show short --------------*
Digraph          : tempdigraph
Actions          : ['1', '2', '3']
Valuation domain : {'med': Decimal("0.5"), 'max': Decimal("1.0"), 'min': Decimal("0")}
*--- Connected Components ---*
1: ['1', '2', '3']
```

`MISgen` (*S*, *I*)

generator of maximal independent choices (voir Byskov 2004):

- S ::= remaining nodes;
- I ::= current independent choice

Note: Inititalize: self.MISgen(self.actionscopy(),set())

`absirred` (*choice*)

Renders the crips -irredundance degree of a choice.

`absirredundant` (*U*)

Generates all -irredundant choices of a digraph.

`absirredval` (*choice*, *relation*)

Renders the valued -irredundance degree of a choice.

`absirredx` (*choice*, *x*)

Computes the crips -irredundance degree of node x in a choice.

`abskernelrestrict` (*choice*)

Parameter: prekernel Renders absorbent prekernel restricted relation.

`absorb` (*choice*)

Renders the absorbency degree of a choice.

absorbentChoices (*S*)
Generates all minimal absorbent choices of a bipolar valued digraph.

agglomerationDistribution ()
Output: aggloCoeffDistribution, meanCoeff Renders the distribution of agglomeration coefficients.

aneighbors (*node*)
Renders the set of absorbed in-neighbors of a node.

automorphismGenerators ()
Add automorphism group generators to digraph.

averageCoveringIndex (*choice*, *direction='out'*)
Renders the average covering index of a given choice in a set of objects, ie the average number of choice members that cover each non selected object.

bestRanks ()
renders best possible ranks from indegrees account

bipolarKCorrelation (*digraph*, *Debug=False*)
Renders the bipolar Kendall correlation between two bipolar valued digraphs computed from the average valuation of the XORDigraph(self,digraph) instance.

> **Warning:** Obsolete! Is replaced by the self.computeBipolarCorrelation(other) Digraph method

bipolarKDistance (*digraph*, *Debug=False*)
Renders the bipolar crisp Kendall distance between two bipolar valued digraphs.

> **Warning:** Obsolete! Is replaced by the self.computeBipolarCorrelation(other, MedianCut=True) Digraph method

chordlessPaths (*Pk*, *n2*, *Odd=False*, *Comments=False*, *Debug=False*)
New procedure from Agrum study April 2009 recursive chordless path extraction strating from path Pk = [n2, ..., n1] and ending in node n2. Optimized with marking of visited chordless P1s.

circuitAverageCredibility (*circuit*)
Renders the average linking credibility of a COC.

circuitMinCredibility (*circuit*)
Renders the minimal linking credibility of a COC.

closeSymmetric ()
Produces the symmetric closure of self.relation.

closeTransitive (*Irreflexive=True*, *Reverse=False*)
Produces the transitive closure of self.relation.

coSize ()
Renders the number of non validated non reflexive arcs

collectcomps (*x*, *A*, *ncomp*)
Recursive subroutine of the components method.

components ()
Renders the list of connected components.

computeAllDensities (*choice=None*)
parameter: choice in self renders six densitiy parameters: arc density, double arc density, single arc density, strict single arc density, absence arc density, strict absence arc densitiy.

computeArrowRaynaudRanking(*Debug=False*)
renders a ranking of the actions following Arrow&Raynaud's rule.

computeAverageValuation()
Computes the bipolar average correlation between self and the crisp complete digraph of same order of the irreflexive and determined arcs of the digraph

computeBadChoices(*Comments=False*)

Characteristic values for potentially bad choices.

[(0)-determ,(1)degirred,(2)degi,(3)degd,(4)dega,(5)str(choice),(6)absvec]

computeBadPirlotChoices(*Comments=False*)
Characteristic values for potentially bad choices using the Pirlot's fixpoint algorithm.

computeBipolarCorrelation(*other*, *MedianCut=False*, *filterRelation=None*, *Debug=False*)
Renders the bipolar correlation K of a self.relation when compared with a given compatible (same actions set)) digraph or a [-1,1] valued compatible relation (same actions set).

If MedianCut=True, the correlation is computed on the median polarized relations.

If filterRelation != None, the correlation is computed on the partial domain corresponding to the determined part of the filter relation.

> **Warning:** Notice that the 'other' relation and/or the 'filterRelation', the case given, must both be normalized, ie [-1,1]-valued !

K = sum_{x != y} [min(max(-self.relation[x][y]),other.relation[x][y]), max(self.relation[x][y],-other.relation[x][y])]

K /= sum_{x!=y} [min(abs(self.relation[x][y]),abs(other.relation[x][y]))]

Note: Renders a tuple with at position 0 the actual bipolar correlation index and in position 1 the minimal determination level D of self and the other relation.

D = sum_{x != y} min(abs(self.relation[x][y]),abs(other.relation[x][y])) / n(n-1)

where n is the number of actions considered.

The correlation index with a completely indeterminate relation is by convention 0.0 at determination level 0.0 .

computeChordlessCircuits(*Odd=False*, *Comments=False*, *Debug=False*)
Renders the set of all chordless odd circuits detected in a digraph. Result (possible empty list) stored in <self.circuitsList> holding a possibly empty list tuples with at position 0 the list of adjacent actions of the circuit and at position 1 the set of actions in the stored circuit.

computeConcentrationIndex(*X*, *N*)
Renders the Gini concentration index of the X serie. N contains the partial frequencies. Based on the triangle summation formula.

computeConcentrationIndexTrapez(*X*, *N*)
Renders the Gini concentration index of the X serie. N contains the partial frequencies. Based on the triangles summation formula.

computeCppChordlessCircuits(*Odd=False*, *Debug=False*)
python wrapper for the C++/Agrum based chordless circuits enumeration exchange arguments with external temporary files

computeCppInOutPipingChordlessCircuits(*Odd=False*, *Debug=False*)
python wrapper for the C++/Agrum based chordless circuits enumeration exchange arguments with external temporary files

computeCutLevelDensities(*choice*, *level*)
parameter: choice in self, robustness level renders three robust densitiy parameters: robust double arc density, robust single arc density, robust absence arc densitiy.

computeDensities(*choice*)
parameter: choice in self renders the four densitiy parameters: arc density, double arc density, single arc density, absence arc density.

computeDeterminateness()
Computes the Kendalll distance of self with the all median valued (indeterminate) digraph.

computeGoodChoices(*Comments=False*)

Characteristic values for potentially good choices.

[(0)-determ,(1)degirred,(2)degi,(3)degd,(4)dega,(5)str(choice),(6)domvec]

computeGoodPirlotChoices(*Comments=False*)
Characteristic values for potentially good choices using the Pirlot fixpoint algorithm.

computeKemenyIndex(*otherRelation*)
renders the Kemeny index of the self.relation compared with a given crisp valued relation of a compatible other digraph (same nodes or actions).

computeKemenyOrder(*isProbabilistic=False*, *orderLimit=7*, *seed=None*, *sampleSize=1000*, *Debug=False*)
renders a ranking of the actions with minimal Kemeny index. Return a tuple: kemenyOrder, kemenyIndex

computeKohlerRanking(*Debug=False*)
renders a ranking of the actions following Kohler's rule.

computeMeanInDegree()
Renders the mean indegree of self. !!! self.size must be set previously !!!

computeMeanOutDegree()
Renders the mean degree of self. !!! self.size must be set previously !!!

computeMeanSymDegree()
Renders the mean degree of self. !!! self.size must be set previously !!!

computeMedianOutDegree()
Renders the median outdegree of self. !!! self.size must be set previously !!!

computeMedianSymDegree()
Renders the median symmetric degree of self. !!! self.size must be set previously !!!

computeMoreOrLessUnrelatedPairs()
Renders a list of more or less unrelated pairs.

computeODistance(*op2*, *comments=False*)
renders the squared normalized distance of two digraph valuations. Parameters: op2 digraphs of same order as self. The digraphs must be of same order.

computeOrbit(*choice*, *withListing=False*)
renders the set of isomorph copies of a choice following the automorphism of the digraph self

computeOrdinalCorrelation(*other*, *MedianCut=False*, *filterRelation=None*, *Debug=False*)
obsolete: dummy replacement for Digraph.computeBipolarCorrelation method

computePairwiseClusterComparison(*K1*, *K2*, *Debug=False*)
compute the pairwise cluster comparison credibility vector from bipolar-valued digraph g. with K1 and K2 disjoint lists of action keys from g actions disctionary. Returns the dictionary {'I': Decimal(),'P+':Decimal(),'P-':Decimal(),'R' :Decimal()} where one and only one item is strictly positive.

computePreKernels()

computing dominant and absorbent preKernels: Result in self.dompreKernels and self.abspreKernels

computePreorderRelation(*preorder*, *Debug=False*)
Renders the bipolar-valued relation obtained from a given preordering (list of lists) result.

computePrincipalOrder(*plotFileName=None*, *Colwise=False*, *imageType=None*, *Comments=False*, *Debug=False*)
renders a ordered list of self.actions using the decreasing scores from the first rincipal eigenvector of the covariance of the valued outdegrees of self.

> **Warning:** The method, relying on writing and reading temporary files in the current working directory, is hence not threading and multiprocessing safe ! (see Digraph.exportPrincipalImage method)

computePrudentBestChoiceRecommendation(*CoDual=False*, *Comments=False*, *Debug=False*, *Limited=None*)
Renders the best choice recommendation after eliminating all odd chordless circuits with a minimal cut of the valuation.

computePrudentBetaLevel(*Debug=False*)
computes alpha, ie the lowest valuation level, for which the bipolarly polarised digraph doesn't contain a chordless circuit.

computeRankedPairsOrder(*Cpp=False*, *Debug=False*)
renders a ranking of the actions obtained from the ranked pairs rule.

computeRankingByBestChoosing(*CoDual=False*, *CppAgrum=False*, *Debug=False*)
Computes a weak preordering of the self.actions by recursive best choice elagations.

Stores in self.rankingByBestChoosing['result'] a list of (P+,bestChoice) tuples where P+ gives the best choice complement outranking average valuation via the computePairwiseClusterComparison method.

If self.rankingByBestChoosing['CoDual'] is True, the ranking-by-choosing was computed on the codual of self.

computeRankingByBestChoosingRelation(*rankingByBestChoosing=None*, *Debug=False*)
Renders the bipolar-valued relation obtained from the self.rankingByBestChoosing result.

computeRankingByChoosing(*actionsSubset=None*, *CppAgrum=False*, *Debug=False*, *CoDual=False*)
Computes a weak preordring of the self.actions by iterating jointly best and worst choice elagations.

Stores in self.rankingByChoosing['result'] a list of ((P+,bestChoice),(P-,worstChoice)) pairs where P+ (resp. P-) gives the best (resp. worst) choice complement outranking (resp. outranked) average valuation via the computePairwiseClusterComparison method.

If self.rankingByChoosing['CoDual'] is True, the ranking-by-choosing was computed on the codual of self.

computeRankingByChoosingRelation(*rankingByChoosing=None*, *actionsSubset=None*, *Debug=False*)
Renders the bipolar-valued relation obtained from the self.rankingByChoosing result.

computeRankingByLastChoosing(*CoDual=False*, *CppAgrum=False*, *Debug=False*)
Computes a weak preordring of the self.actions by iterating worst choice elagations.

Stores in self.rankingByLastChoosing['result'] a list of (P-,worstChoice) pairs where P- gives the worst choice complement outranked average valuation via the computePairwiseClusterComparison method.

If self.rankingByChoosing['CoDual'] is True, the ranking-by-last-chossing was computed on the codual of self.

computeRankingByLastChoosingRelation(*rankingByLastChoosing=None*, *Debug=False*)
Renders the bipolar-valued relation obtained from the self.rankingByLastChoosing result.

computeRelationalStructure(*Debug=False*)
Renders the counted decomposition of the valued relations into the following type of links: gt '>', eq '=', lt '<', incomp '<>', leq '<=', geq '>=', indeterm '?'

computeRubisChoice(*CppAgrum=False*, *Comments=False*)
Renders self.strictGoodChoices, self.nullChoices self.strictBadChoices, self.nonRobustChoices.

CppgArum = False (default | true : use C++/Agrum digraph library for computing chordless circuits in self.

computeRubyChoice(*CppAgrum=False*, *Comments=False*)
dummy for computeRubisChoice() old versions compatibility.

computeSingletonRanking(*Comments=False*, *Debug=False*)
Renders the sorted bipolar net determinatation of outrankingness minus outrankedness credibilities of all singleton choices. res = ((netdet,singleton,dom,absorb)+)

computeSizeTransitiveClosure()
Renders the size of the transitive closure of a digraph.

computeSlaterOrder(*isProbabilistic=False*, *seed=None*, *sampleSize=1000*, *Debug=False*)
renders a ranking of the actions with minimal Slater index. Return a tuple: slaterOrder, slaterIndex

computeTransitivityDegree()
Renders the transitivity degree of a digraph.

computeUnrelatedPairs()
Renders a list of more or less unrelated pairs.

computeValuationLevels(*choice=None*, *Debug=False*)
renders the symmetric closure of the apparent valuations levels of self in an increasingly ordered list. If parameter choice is given, the computation is limited to the actions of the choice.

computeValuationPercentages(*choice*, *percentiles*, *withValues=False*)
Parameters: choice and list of percentages. renders a series of quantiles of the characteristics valuation of the arcs in the digraph.

computeValuationPercentiles(*choice*, *percentages*, *withValues=False*)
Parameters: choice and list of percentages. renders a series of quantiles of the characteristics valuation of the arcs in the digraph.

computeValuationStatistics(*Sampling=False*, *Comments=False*)
Renders the mean and variance of the valuation of the non reflexive pairs.

computeupdown1(*s*, *S*)
Help method for show_MIS_HB2 method. fills self.newmisset, self.upmis, self.downmis.

computeupdown2(*s*, *S*)
Help method for show_MIS_HB1 method. fills self.newmisset, self.upmis, self.downmis.

computeupdown2irred(*s*, *S*)
Help method for show_MIS_HB1 method. fills self.newmisset, self.upmis, self.downmis.

condorcetWinners ()
Renders the set of decision actions x such that self.relation[x][y] > self.valuationdomain['med'] for all y != x.

contra (*v*)
Parameter: choice. Renders the negation of a choice v characteristic's vector.

convertRelationToDecimal ()
Converts the float valued self.relation in a decimal valued one.

convertValuationToDecimal ()
Convert the float valuation limits to Decimals.

coveringIndex (*choice*, *direction='out'*)
Renders the covering index of a given choice in a set of objects, ie the minimum number of choice members that cover each non selected object.

crispKDistance (*digraph*, *Debug=False*)
Renders the crisp Kendall distance between two bipolar valued digraphs.

> **Warning:** Obsolete! Is replaced by the self.computeBipolarCorrelation(other, MedianCut=True) Digraph method

detectChordlessCircuits (*Comments=False*, *Debug=False*)
Detects a chordless circuit in a digraph. Returns a Boolean

detectChordlessPath (*Pk*, *n2*, *Comments=False*, *Debug=False*)
New procedure from Agrum study April 2009 recursive chordless path extraction strating from path Pk = [n2, ..., n1] and ending in node n2. Optimized with marking of visited chordless P1s.

detectCppChordlessCircuits (*Debug=False*)
python wrapper for the C++/Agrum based chordless circuits detection exchange arguments with external temporary files. Returns a boolean value

determinateness (*vec*, *inPercent=True*)
Renders the determinateness of a bipolar characteristic vector

diameter (*Oriented=False*)
Renders the (by default non-oriented) diameter of the digraph instance

digraph2Graph (*valuationDomain={'max': 1, 'min': -1, 'med': 0}*, *Debug=False*, *conjunctiveConversion=True*)
Convert a Digraph instance to a Graph instance.

dneighbors (*node*)
Renders the set of dominated out-neighbors of a node.

domin (*choice*)
Renders the dominance degree of a choice.

dominantChoices (*S*)
Generates all minimal dominant choices of a bipolar valued digraph.

> **Note:** Initiate with S = self.actions,copy().

domirred (*choice*)
Renders the crips +irredundance degree of a choice.

domirredval (*choice*, *relation*)
Renders the valued +irredundance degree of a choice.

domirredx (*choice*, *x*)
Renders the crips +irredundance degree of node x in a choice.

domkernelrestrict (*choice*)
Parameter: prekernel Renders dominant prekernel restricted relation.

exportD3 (*fileName='index'*, *Comments=True*)
This function was designed and implemented by Gary Cornelius, 2014 for his bachelor thesis at the University of Luxembourg. The thesis document with more explanations can be found here .

***Parameters*:**

- fileName, name of the generated html file, default = None (graph name as defined in python);
- Comments, True = default;

The idea of the project was to find a way that allows you to easily get details about certain nodes or edges of a directed graph in a dynamic format. Therefore this function allows you to export a html file together with all the needed libraries, including the D3 Library which we use for graph generation and the physics between nodes, which attracts or pushes nodes away from each other.

Features of our graph include i.e. []

- A way to only inspect a node and it's neighbours
- Dynamic draging and freezing of the graph
- Export of a newly created general graph

You can find the list of fututres in the Section below which is arranged according to the graph type.

***If the graph is an outrankingdigraphs*:**

- Nodes can be dragged and only the name and comment can be edited.
- Edges can be inspected but not edited for this purpose a special json array containing all possible pairwiseComparisions is generated.

***If the graph is a general graph*:**

- Nodes can be dragged, added, removed and edited.
- Edges can be added, removed, inverted and edited. But edges cannot be inspected.
- The pairwiseComparisions key leads to an empty array {}.

In both cases, undefined edges can be hidden and reappear after a simple reload.(right click - reload)

***The generated files*:**

- d3.v3.js, contains the D3 Data-driven Documents source code, containing one small addition that we made in order to be able to easyly import links with a different formatself.
- digraph3lib.js, contains our library. This file contains everything that we need from import of an XMCDA2 file, visualization of the graph to export of the changed graph.
- d3export.json, usually named after the python graph name followed by a ticket number if the file is already present. It is the JSON file that is exported with the format "{"xmcda2": "some xml","pairwiseComparisions":"{"a01": "some html",...}"}.

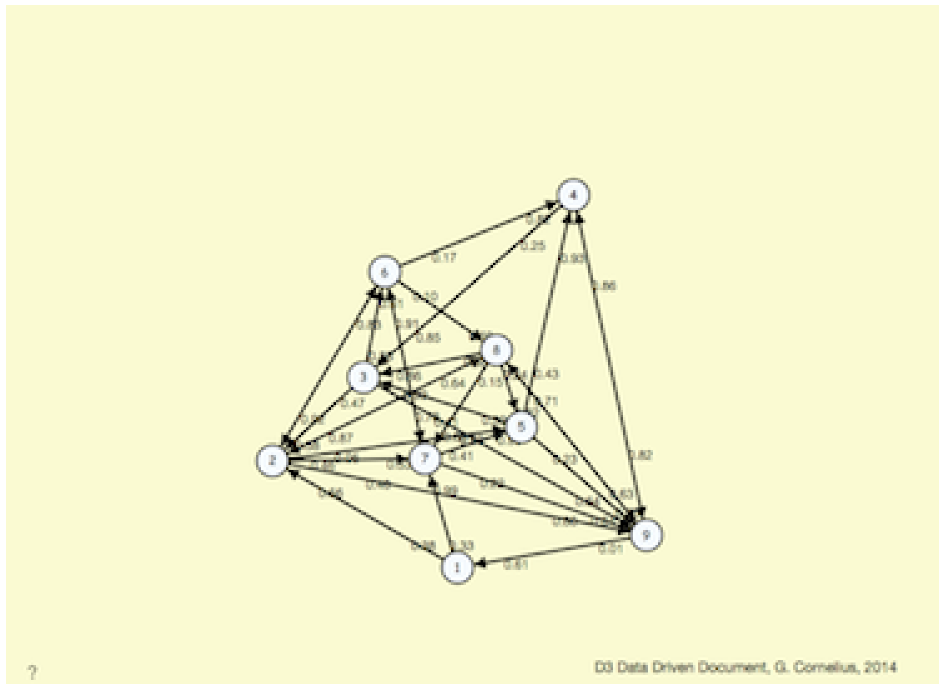
***Example 1*:**

1. **python3 session:**

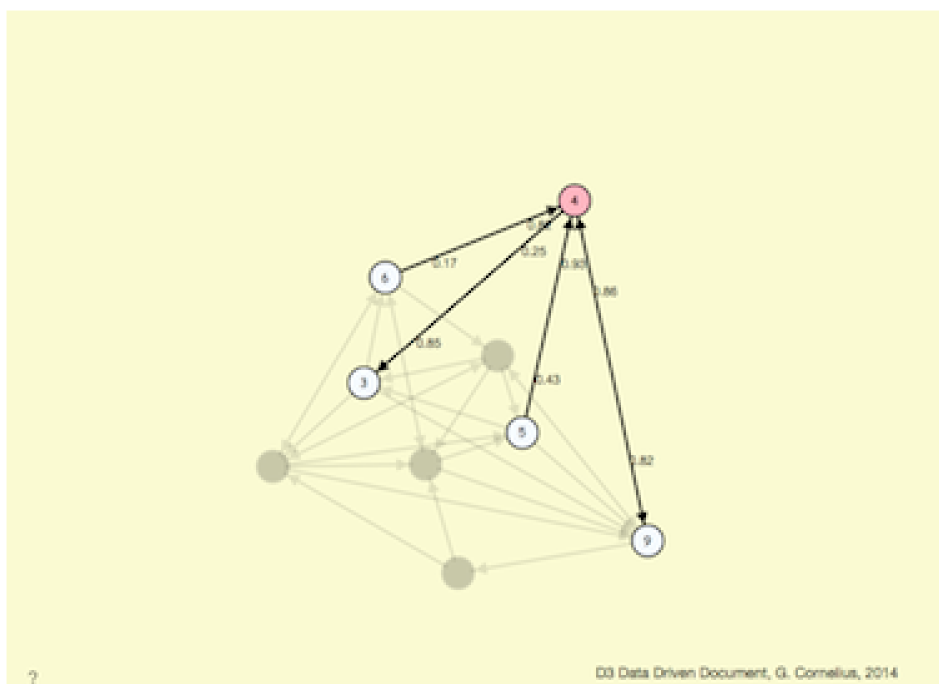
```
>>> from digraphs import RandomValuationDigraph
>>> dg = RandomValuationDigraph(order=5,Normalized=True)
>>> dg.exportD3()
or
>> dg.showInteractiveGraph()
```

2. **index.html:**

   - **Main Screen:**



   - **Inspect function:**



Note: If you want to use the automatic load in Chrome, try using the command: "python -m SimpleHTTPServer" and then access the index.html via "http://0.0.0.0:8000/index.html". In order to load the

CSS an active internet connection is needed!

---

exportGraphViz (*fileName=None*, *bestChoice=set()*, *worstChoice=set()*, *noSilent=True*, *graphType='png'*, *graphSize='7, 7'*)
export GraphViz dot file for graph drawing filtering.

exportPrincipalImage (*Reduced=False*, *Colwise=False*, *plotFileName=None*, *Type='png'*, *Comments=False*)
Export as PNG (default) or PDF the principal projection of the valued relation using the three principal eigen vectors.

> **Warning:** The method, writing and reading temporary files: tempCol.r and rotationCol.csv, resp. tempRow.r and rotationRow.csv, is hence not safe for multiprocessors' threading programs.

flatChoice (*ch*, *Debug=False*)
Converts set or list ch recursively to a flat list of items.

forcedBestSingleChoice ()
Renders the set of most determined outranking singletons in self.

gammaSets ()
Renders the dictionary of neighborhoods {node: (dx,ax)}

generateAbsPreKernels ()
Generate all absorbent prekernels from independent choices generator.

generateDomPreKernels ()
Generate all dominant prekernels from independent choices generator.

graphDetermination ()
Output: average arc determination

htmlRelationTable (*tableTitle='Relation Table'*, *relationName=' R '*, *hasIntegerValues=False*, *actionsSubset=None*, *isColored=False*)
renders the relation valuation in actions X actions html table format.

inDegrees ()
renders the median cut indegrees

inDegreesDistribution ()
Renders the distribution of indegrees.

independentChoices (*U*)
Generator for all independent choices with neighborhoods of a bipolar valued digraph:

Note:

- Initiate with U = self.singletons().
- Yields [(independent choice, domnb, absnb, indnb)].

---

inner_prod (*v1*, *v2*)
Parameters: two choice characteristic vectors Renders the inner product of two characteristic vetors.

intstab (*choice*)
Computes the independence degree of a choice.

irreflex (*mat*)
puts diagonal entries of mat to valuationdomain['min']

isComplete(*Debug=False*)
checks the completeness property of self.relation by checking for the absence of a link between two actions!!

> **Warning:** The reflexive links are ignored !!

isCyclic(*Debug=False*)
checks the cyclicity of self.relation by checking for a reflexive loop in its transitive closure !! self.relation is supposed to be irreflexive !!

isWeaklyComplete(*Debug=False*)
checks the weakly completeness property of self.relation by checking for the absence of a link between two actions!!

> **Warning:** The reflexive links are ignored !!

iterateRankingByChoosing(*Odd=False*, *CoDual=False*, *Comments=True*, *Debug=False*, *Limited=None*)
Renders a ranking by choosing result when progressively eliminating all chordless (odd only) circuits with rising valuation cut levels.

Parameters CoDual = False (default)/True Limited = proportion (in [0,1]) * (max - med) valuationdomain

kChoices(*A*, *k*)
Renders all choices of length k from set A

matmult2(*m*, *v*)
Parameters: digraph relation and choice characteristic vector matrix multiply vector by inner production

meanDegree()
Renders the mean degree of self. !!! self.size must be set previously !!!

meanLength(*Oriented=False*)
Renders the (by default non-oriented) mean neighbourhoor depth of self. !!! self.order must be set previously !!!

minimalChoices(*S*)
Generates all dominant or absorbent choices of a bipolar valued digraph.

minimalValuationLevelForCircuitsElimination(*Odd=True*, *Debug=False*, *Comments=False*)
renders the minimal valuation level <lambda> that eliminates all self.circuitsList stored odd chordless circuits from self.

> **Warning:** The <lambda> level polarised may still contain newly appearing chordless odd circuits !

neighbourhoodCollection(*Oriented=False*, *Potential=False*)
Renders the neighbourhood.

neighbourhoodDepthDistribution(*Oriented=False*)
Renders the distribtion of neighbourhood depths.

notGammaSets()
Renders the dictionary of not neighborhoods {node: (dx,ax)}

notaneighbors(*node*)
Renders the set of absorbed not in-neighbors of a node.

notdneighbors(*node*)
Renders the set of not dominated out-neighbors of a node.

omax(*L*, *Debug=False*)
epistemic disjunction for bipolar outranking characteristics computation

omin(*L*, *Debug=False*)
epistemic conjunction for bipolar outranking characteristics computation

optimalRankingByChoosing(*Odd=True*, *CoDual=False*, *Comments=False*, *Debug=False*, *Limited=None*)
Renders a ranking by choosing result when progressively eliminating all chordless (odd only by default) circuits with rising valuation cut levels.

Parameters:

- CoDual = False (default)/True
- Limited = proportion (in [0,1]) * (max - med) of valuationdomain (default = None)

Returns the highest correlated rankingByChoosing with self or codual of self, depending on the CoDual flagg.

outDegrees()
renders the median cut outdegrees

outDegreesDistribution()
Renders the distribution of outdegrees.

plusirredundant(*U*)
Generates all +irredundant choices of a digraph.

powerset(*U*)
Generates all subsets of a set.

readPerrinMisset(*file*)
read method for 0-1-char-coded MISs from perrinMIS.c curd.dat file.

readPerrinMissetOpt(*file*)
read method for 0-1-char-coded MISs from perrinMIS.c curd.dat file.

readabsvector(*x*, *relation*)
Parameter: action x absorbent in vector.

readdomvector(*x*, *relation*)
Parameter: action x dominant out vector.

recodeValuation(*newMin=-1.0*, *newMax=1.0*, *Debug=False*)
Recodes the characteristic valuation domain according to the parameters given.

Note: Default values gives a normalized valuation domain

save(*fileName='tempdigraph'*, *option=None*, *DecimalValuation=True*)
Persistent storage of a Digraph class instance in the form of a python source code file

saveCSV(*fileName='tempdigraph'*, *Normalized=True*, *Dual=True*, *Converse=False*, *Diagonal=False*, *Debug=False*)
Persistent storage of a Digraph class instance in the form of a csv file.

saveXMCDA(*fileName='temp'*, *relationName='R'*, *category='random'*, *subcategory='valued'*, *author='digraphs Module (RB)'*, *reference='saved from Python'*, *valuationType='standard'*, *servingD3=False*)
save digraph in XMCDA format.

saveXMCDA2 (*fileName='temp', fileExt='xmcda2', Comments=True, relationName='R', relationType='binary', category='random', subcategory='valued', author='digraphs Module (RB)', reference='saved from Python', valuationType='standard', digits=2, servingD3=False*)
save digraph in XMCDA format.

saveXML (*name='temp', category='general', subcategory='general', author='digraphs Module (RB)', reference='saved from Python'*)
save digraph in XML format.

savedre (*name='temp'*)
save digraph in nauty format.

sharp (*x, y*)
Paramaters: choice characteristic values. Renders the sharpest of two characteristic values x and y.

sharpvec (*v, w*)
Paramaters: choice characteristic vectors. Renders the sharpest of two characteristic vectors v and w.

showActions ()
presentation methods for digraphs actions

showAll ()

showAutomorphismGenerators ()
Renders the generators of the automorphism group.

showBadChoices (*Recompute=True*)
Characteristic values for potentially bad choices.

showChoiceVector (*ch*)
show procedure for annotated bipolar choices

showChordlessCircuits ()
show methods for (chordless) circuits in a Digraph. Dummy for showCircuits().

showCircuits ()
show methods for circuits observed in a Digraph instance.

showComponents ()

showGoodChoices (*Recompute=True*)
Characteristic values for potentially good choices.

showHTMLRelationTable ()
Launches a browser window with the colored relation table of self.

showInteractiveGraph ()
Save the graph and all needed files for the visualization of an interactive graph generated by the exportD3() function. For best experience make sure to use Firefox, because other browser restrict the loading of local files.

showMIS (*withListing=True*)

Prints all maximal independent choices: Result in self.misset.

showMIS_AH (*withListing=True*)
Prints all MIS using the Hertz method. Result saved in self.hertzmisset.

showMIS_HB2 (*withListing=True*)
Prints all MIS using the Hertz-Bisdorff method. Result saved in self.newmisset.

showMIS_RB (*withListing=True*)
Prints all MIS using the Bisdorff method. Result saved in self.newmisset.

showMIS_UD (*withListing=True*)
Prints all MIS using the Hertz-Bisdorff method. Result saved in self.newmisset.

showMaxAbsIrred (*withListing=True*)

Computing maximal -irredundant choices: Result in self.absirset.

showMaxDomIrred (*withListing=True*)

Computing maximal +irredundant choices: Result in self.domirset.

showMinAbs (*withListing=True*)

Prints minimal absorbent choices: Result in self.absset.

showMinDom (*withListing=True*)

Prints all minimal dominant choices: Result in self.domset.

showNeighborhoods ()
Lists the gamma and the notGamma function of self.

showOrbits (*InChoices*, *withListing=True*)
Prints the orbits of Choices along the automorphisms of the digraph self.

showOrbitsFromFile (*InFile*, *withListing=True*)
Prints the orbits of Choices along the automorphisms of the digraph self by reading in the 0-1 misset file format.

showPreKernels (*withListing=True*)

Printing dominant and absorbent preKernels: Result in self.dompreKernels and self.abspreKernels

showRankingByBestChoosing (*rankingByBestChoosing=None*)
A show method for self.rankinByBestChoosing result.

> **Warning:** The self.computeRankingByBestChoosing(CoDual=False/True) method instantiating the self.rankingByBestChoosing slot is pre-required !

showRankingByChoosing (*rankingByChoosing=None*)
A show method for self.rankinByChoosing result.

> **Warning:** The self.computeRankingByChoosing(CoDual=False/True) method instantiating the self.rankingByChoosing slot is pre-required !

showRankingByLastChoosing (*rankingByLastChoosing=None*, *Debug=None*)
A show method for self.rankinByChoosing result.

> **Warning:** The self.computeRankingByLastChoosing(CoDual=False/True) method instantiating the self.rankingByChoosing slot is pre-required !

showRelation ()
prints the relation valuation in ##.## format.

showRelationTable (*Sorted=True*, *IntegerValues=False*, *actionsSubset=None*, *relation=None*, *ndigits=2*, *ReflexiveTerms=True*)
prints the relation valuation in actions X actions table format.

showRubisBestChoiceRecommendation (*Comments=False*, *Debug=False*)
Renders the RuBis best choice recommendation.

showRubyChoice (*Comments=False*)
dummy for showRubisChoice() older versions compatibility

showShort ()
concise presentation method for genuine digraphs.

showSingletonRanking (*Comments=True*, *Debug=False*)
Calls self.computeSingletonRanking(comments=True,Debug = False). Renders and prints the sorted bipolar net determinatation of outrankingness minus outrankedness credibilities of all singleton choices. res = ((netdet,sigleton,dom,absorb)+)

showStatistics ()
Computes digraph statistics like order, size and arc-density.

showdre ()
Shows relation in nauty format.

singletons ()
list of singletons and neighborhoods [(singx1, +nx1, -nx1, not(+nx1 or -nx1)),....]

size ()
Renders the number of validated non reflexive arcs

sizeSubGraph (*choice*)
Output: (size, undeterm,arcDensity). Renders the arc density of the induced subgraph.

strongComponents (*setPotential=False*)
Renders the set of strong components of self.

symDegreesDistribution ()
Renders the distribution of symmetric degrees.

topologicalSort (*Debug=False*)
If self is acyclic, adds topological sort number to each node of self and renders ordered list of nodes. Otherwise renders None. Source: M. Golumbic Algorithmic Graph heory and Perfect Graphs, Annals Of Discrete Mathematics 57 2nd Ed. , Elsevier 2004, Algorithm 2.4 p.44.

weakAneighbors (*node*)
Renders the set of absorbed in-neighbors of a node.

weakCondorcetWinners ()
Renders the set of decision actions x such that self.relation[x][y] >= self.valuationdomain['med'] for all y != x.

weakDneighbors (*node*)
Renders the set of dominated out-neighbors of a node.

weakGammaSets ()
Renders the dictionary of neighborhoods {node: (dx,ax)}

worstRanks ()
renders worst possible ranks from outdegrees account

zoomValuation (*zoomFactor=1.0*)
Zooms in or out, depending on the value of the zoomFactor provided, the bipolar valuation of a digraph.

class digraphs.**DualDigraph** (*other*)
Bases: digraphs.Digraph

Instantiates the dual Digraph object of a given other Digraph instance.

The relation constructor returns the dual of self.relation with formula: relationOut[a][b] = Max - self.relation[a][b] + Min where Max (resp. Min) equals valuation maximum (resp. minimum).

class `digraphs.`**`EmptyDigraph`**(*order=5*, *valuationdomain=(-1.0, 1.0)*)
Bases: `digraphs.Digraph`

Parameters: order > 0 (default=5); valuationdomain =(Min,Max).

Specialization of the general Digraph class for generating temporary empty graphs of given order in {-1,0,1}.

class `digraphs.`**`EquivalenceDigraph`**(*d1*, *d2*, *Debug=False*)
Bases: `digraphs.Digraph`

Instantiates the logical equivalence digraph of two bipolar digraphs d1 and d2 of same order. Returns None if d1 and d2 are of different order

`computeCorrelation`()
Renders the global bipolar correlation index resulting from the pairwise equivalence valuations.

class `digraphs.`**`FusionDigraph`**(*dg1*, *dg2*, *operator='o-min'*)
Bases: `digraphs.Digraph`

Instantiates the epistemic fusion of two given Digraph called dg1 and dg2.

Parameter:

- operator = "o-min" | "o-max" (epistemic conjunctive or dijunctive fusion)

class `digraphs.`**`GridDigraph`**(*n=5*, *m=5*, *valuationdomain={'max': 1.0, 'min': -1.0}*, *hasRandomOrientation=False*, *hasMedianSplitOrientation=False*)
Bases: `digraphs.Digraph`

Parameters: n,m > 0; valuationdomain ={'min':m, 'max':M}.

Specialization of the general Digraph class for generating temporary Grid digraphs of dimension n times m.

Default instantiation (5 times 5 Grid Digraph): n = 5, m=5, valuationdomain = {'min':-1.0,'max':1.0}.

Randomly orientable with hasRandomOrientation=True (default=False).

`showShort`()

class `digraphs.`**`IndeterminateDigraph`**(*other=None*, *order=5*, *valuationdomain=(-1.0, 1.0)*)
Bases: `digraphs.Digraph`

Parameters: order > 0; valuationdomain =(Min,Max). Specialization of the general Digraph class for generating temporary empty graphs of order 5 in {-1,0,1}.

class `digraphs.`**`KneserDigraph`**(*n=5*, *j=2*, *valuationdomain={'max': 1.0, 'min': -1.0}*)
Bases: `digraphs.Digraph`

Parameters:

n > 0; n > j > 0;
valuationdomain ={'min':m, 'max':M}.

Specialization of the general Digraph class for generating temporary Kneser digraphs

Default instantiation as Petersen graph: n = 5, j = 2, valuationdomain = {'min':-1.0,'max':1.0}.

`showShort`()

class `digraphs.`**`MedianExtendedDigraph`**(*digraph=None*, *Level=None*)
Bases: `digraphs.Digraph`

Parameters: digraph + beta cut level between Med and Max.

Specialisation of Outranking relation.

constructRelation (*relationin*, *Level*)
Parameters: relation and cut level. Renders the polarised relation.

class digraphs.**PolarisedDigraph** (*digraph=None*, *level=None*, *KeepValues=True*, *AlphaCut=False*, *StrictCut=False*)
Bases: digraphs.Digraph

Renders the polarised valuation of digraph:

- If AlphaCut = True a genuine one-sided True-oriented cut is operated.
- If StrictCut = True, the cut level value is not included.

class digraphs.**PreferenceDigraph** (*digraph*)
Bases: digraphs.Digraph

Initiates the valued difference S(a,b) - S(b,a) of a Digraph instance.

class digraphs.**Preorder** (*other*, *direction='best'*)
Bases: digraphs.Digraph

Instantiates the associated preorder from a given Digraph called other.

Instantiates as other.__class__ !

Copies the case given the description, the criteria and the evaluation dictionary into self.

class digraphs.**RandomDigraph** (*order=9*, *arcProbability=0.5*, *hasIntegerValuation=True*, *Bipolar=False*)
Bases: digraphs.Digraph

Specialization of the general Digraph class for generating temporary crisp (irreflexive) random digraphs.

***Parameters*:**

- order (default = 10);
- arc_probability (in [0.,1.], default=0.5)
-

class digraphs.**RandomFixedDegreeSequenceDigraph** (*order=7*, *degreeSequence=[3, 3, 2, 2, 1, 1, 0]*)
Bases: digraphs.Digraph

Parameters: order=n and degreeSequence=[degree_1, ... ,degree_n]>

Specialization of Digraph class for random symmetric instances with fixed degree sequence.

class digraphs.**RandomFixedSizeDigraph** (*order=7*, *size=14*)
Bases: digraphs.Digraph

Parameters: order and size

Specialization of Digraph class for random fixed size instances.

class digraphs.**RandomRegularDigraph** (*order=7*, *degree=2*)
Bases: digraphs.Digraph

Parameters: order and degree.

Specialization of Digraph class for random regular symmetric instances.

class digraphs.**RandomTournament** (*order=10*, *ndigits=2*, *isCrisp=True*, *valuationDomain=None*)
Bases: digraphs.Digraph

Parameter: order = n > 0

Specialization of the general Digraph class for generating temporary weak tournaments

class `digraphs.RandomTree`(*numberOfNodes=5*, *ndigits=2*, *hasIntegerValuation=True*)

Bases: `digraphs.Digraph`

Random generator for trees, using random Pruefer codes

Parameter: numerOfNodes

`prufer_to_tree`(*a*)

class `digraphs.RandomValuationDigraph`(*order=9*, *ndigits=2*, *Normalized=False*, *hasIntegerValuation=False*)

Bases: `digraphs.Digraph`

Specialization of the general Digraph class for generating temporary uniformly valued random digraphs.

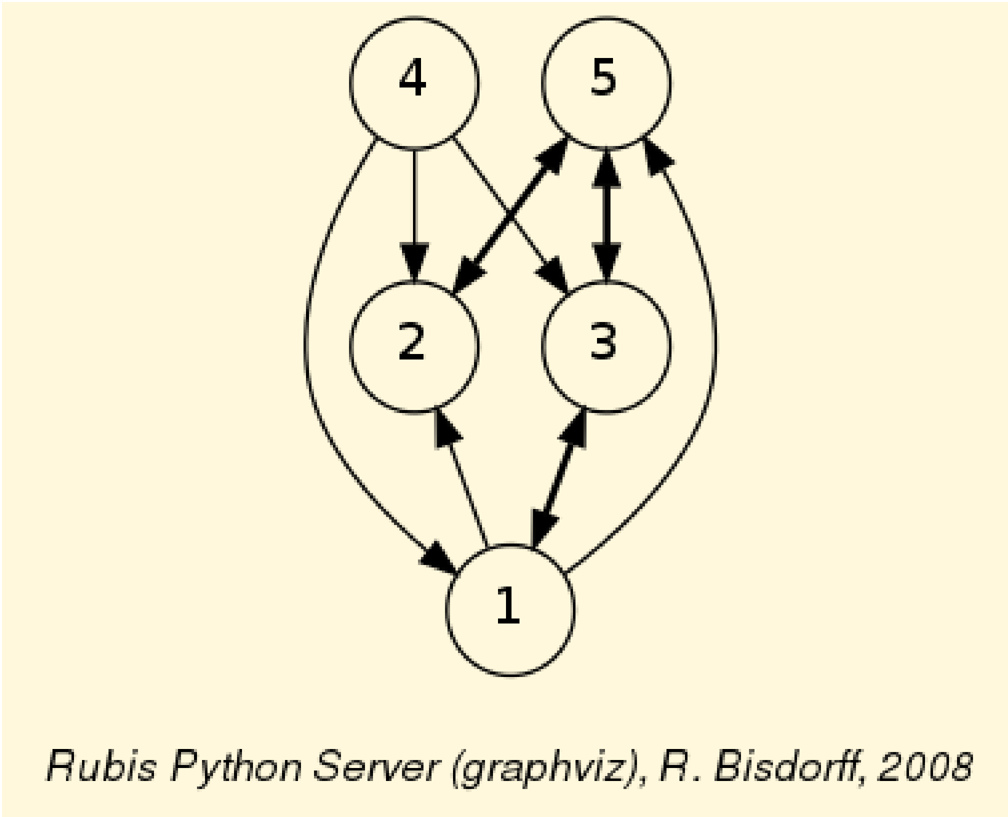
***Parameters*:**

- order > 0, number of arcs;
- ndigits > 0, number of digits if hasIntegerValuation = True; Otherwise, decimal precision.
- Normalized = True (r in [-1,1], r in [0,1] if False/default);
- hasIntegerValuation = False (default).

Example python3 session:

```
>>> from digraphs import RandomValuationDigraph
>>> dg = RandomValuationDigraph(order=5,Normalized=True)
>>> dg.showAll()
*----- show detail -------------*
Digraph          : randomValuationDigraph
*---- Actions ----*
['1', '2', '3', '4', '5']
*---- Characteristic valuation domain ----*
{'max': Decimal('1.0'), 'min': Decimal('-1.0'),
 'med': Decimal('0.0'), 'hasIntegerValuation': False}
* ---- Relation Table -----
  S   |  '1'    '2'    '3'    '4'     '5'
 -----|-----------------------------------
  '1' |  0.00   0.28   0.46  -0.66   0.90
  '2' | -0.08   0.00  -0.46  -0.42   0.52
  '3' |  0.84  -0.10   0.00  -0.54   0.58
  '4' |  0.90   0.88   0.90   0.00  -0.38
  '5' | -0.50   0.64   0.42  -0.94   0.00
*--- Connected Components ---*
1: ['1', '2', '3', '4', '5']
Neighborhoods:
  Gamma     :
'4': in => set(), out => {'1', '2', '3'}
'5': in => {'1', '2', '3'}, out => {'2', '3'}
'1': in => {'4', '3'}, out => {'5', '2', '3'}
'2': in => {'4', '5', '1'}, out => {'5'}
'3': in => {'4', '5', '1'}, out => {'5', '1'}
  Not Gamma :
'4': in => {'5', '1', '2', '3'}, out => {'5'}
'5': in => {'4'}, out => {'4', '1'}
'1': in => {'5', '2'}, out => {'4'}
'2': in => {'3'}, out => {'4', '1', '3'}
'3': in => {'2'}, out => {'4', '2'}

>>> dg.exportGraphViz()
```



class digraphs.**RandomWeakTournament**(*order=10*, *ndigits=2*, *hasIntegerValuation=False*, *weaknessDegree=0.25*, *Comments=False*)

Bases: digraphs.Digraph

Parameter: order = n > 0

Specialization of the general Digraph class for generating temporary bipolar-valued weak tournaments

class digraphs.**StrongComponentsCollapsedDigraph**(*digraph=None*)

Bases: digraphs.Digraph

Reduction of Digraph object to its strong components.

showComponents()

class digraphs.**SymmetricPartialDigraph**(*digraph*)

Bases: digraphs.Digraph

Renders the symmetric part of a Digraph instance.

..caution:

```
The not symmetric links of relationIn are all put to the meadian characteristics value!.
```

class digraphs.**WeakCocaDigraph**(*digraph=None*, *comment=None*)

Bases: digraphs.Digraph

Parameters: Stored or memory resident digraph instance.

Specialization of general Digraph class for instantiation of weak chordless odd circuits augmented digraphs.

addWeakCircuits(*comment=None*)

Augmenting self with self.weakCircuits.

closureWeakChordlessOddCircuits(*comment=None*)
Closure of cdordless odd circuits extraction.

showCircuits()
show methods for chordless odd circuits in CocaGraph

class digraphs.**XMCDA2Digraph**(*fileName='temp'*)
Bases: digraphs.Digraph

Specialization of the general Digraph class for reading stored XMCDA-2.0 formatted digraphs. Using the inbuilt module xml.etree (for Python 2.5+).

Param: fileName (without the extension .xmcda).

showAll()

class digraphs.**XMCDADigraph**(*fileName='temp'*)
Bases: digraphs.Digraph

Specialization of the general Digraph class for reading stored XMCDA formatted digraphs. Using the inbuilt module xml.etree (for Python 2.5+).

Param: fileName (without the extension .xmcda).

showAll()

class digraphs.**XMLDigraph**(*fileName='testsaveXML'*)
Bases: digraphs.Digraph

Specialization of the general Digraph class for reading stored XML formatted digraphs. Using the inbuilt module xml.etree (for Python 2.5+).

Param: fileName (without the extension .xml).

class digraphs.**XMLDigraph24**(*fileName='testsaveXML'*)
Bases: digraphs.Digraph

Specialization of the general Digraph class for reading stored XML formatted digraphs.

showAll()

class digraphs.**XORDigraph**(*d1, d2, Debug=False*)
Bases: digraphs.Digraph

Instantiates the XOR digraph of two bipolar digraphs d1 and d2 of same order.

digraphs.**all_perms**(*str*)

class digraphs.**kChoicesDigraph**(*digraph=None, k=3*)
Bases: digraphs.Digraph

Parameters:

digraph := Stored or memory resident digraph instance
k := cardinality of the choices

Specialization of general Digraph class for instantiation of chordless odd circuits augmented digraphs.

computeRelation(*relation*)
computing the relation on kChoices

digraphs.**powerset**(*S*)
Power set generator iterator.

Parameter S may be any object that is accepted as input by the set class constructor.

Back to the *Introduction*

1.2.3 graphs module

A tutorial with coding examples is available here: *Working with the graphs module*

class `graphs.Graph` (*fileName=None, Empty=False, numberOfVertices=7, edgeProbability=0.5*)

Bases: `builtins.object`

Graph class implementation with a vertices and an edges dictionary and a gamma function (dictionary) from vertices to subsets of vertices.

Example python3 session:

```
>>> from graphs import Graph
>>> g = Graph(numberOfVertices=5,edgeProbability=0.5)
>>> g.showShort()
*----- show short --------------*
*---- short description of the graph ----*
Name             :  'random'
Vertices         :  ['v1', 'v2', 'v3', 'v4', 'v5']
Valuation domain :  {'med': 0, 'max': 1, 'min': -1}
Gamma function   :
v1 -> ['v4']
v2 -> []
v3 -> ['v4']
v4 -> ['v1', 'v3']
v5 -> []
```

`chordlessPaths` (*Pk, v0, Comments=False, Debug=False*)

recursice chordless precycle (len > 3) construction: Pk is the current pre chordless cycle v0 is the initial vertex of the precycle vn is the last vertex of the precycle

`computeChordlessCycles` (*Comments=True, Debug=False*)

Renders the set of all chordless cycles observed in a Graph intance.

`depthFirstSearch` (*Debug=False*)

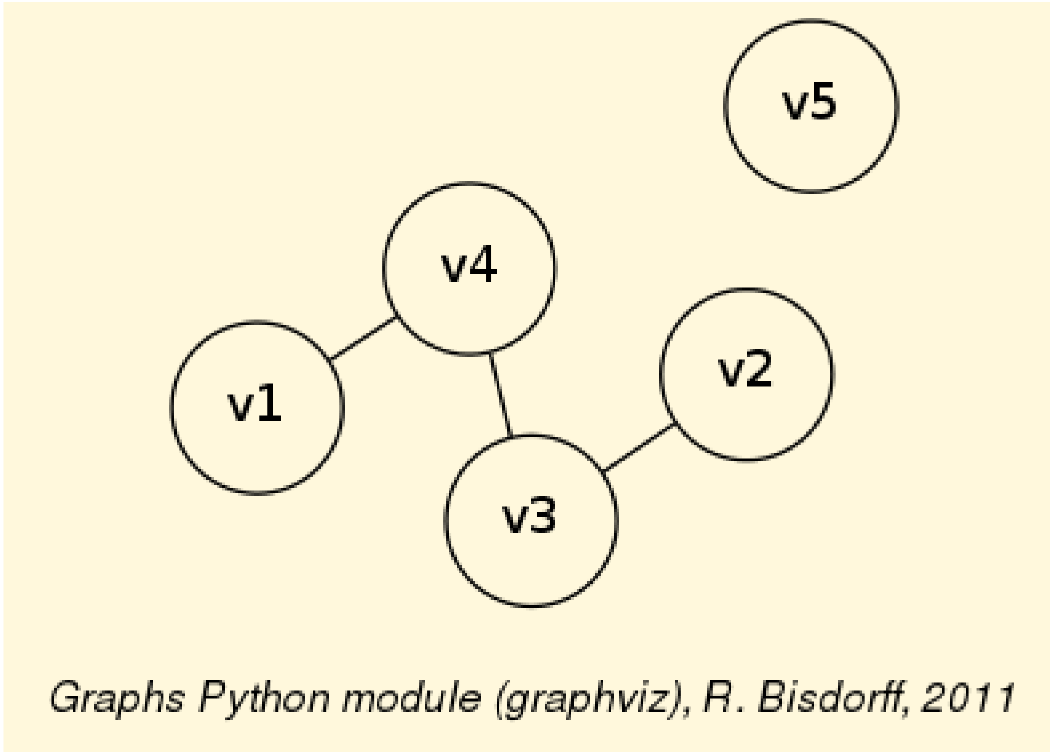
Depth first search through a graph

`exportGraphViz` (*fileName=None, noSilent=True, graphType='png', graphSize='7, 7'*)

Exports GraphViz dot file for graph drawing filtering.

Example:

```
>>> g = Graph(numberOfVertices=5,edgeProbability=0.3)
>>> g.exportGraphViz('randomGraph'))
```



gammaSets (*Debug=False*)
renders the gamma function as dictionary

graph2Digraph ()
Converts a Graph object into a Digraph object.

save (*fileName='tempGraph'*, *Debug=False*)
Persistent storage of a Graph class instance in the form of a python source code file.

saveEdges (*fileName='graphEdges'*, *Agrum=False*, *Decimal=True*)
Saving graph instances as list of edges, ie node node on each line for enumChordlessCycles C++/agrum progam.

showShort ()
Generic show method for Graph instances.

class graphs.**GridGraph** (*n=5*, *m=5*, *valuationMin=-1*, *valuationMax=1*)
Bases: `graphs.Graph`

Specialization of the general Graph class for generating temporary Grid graphs of dimension n times m.

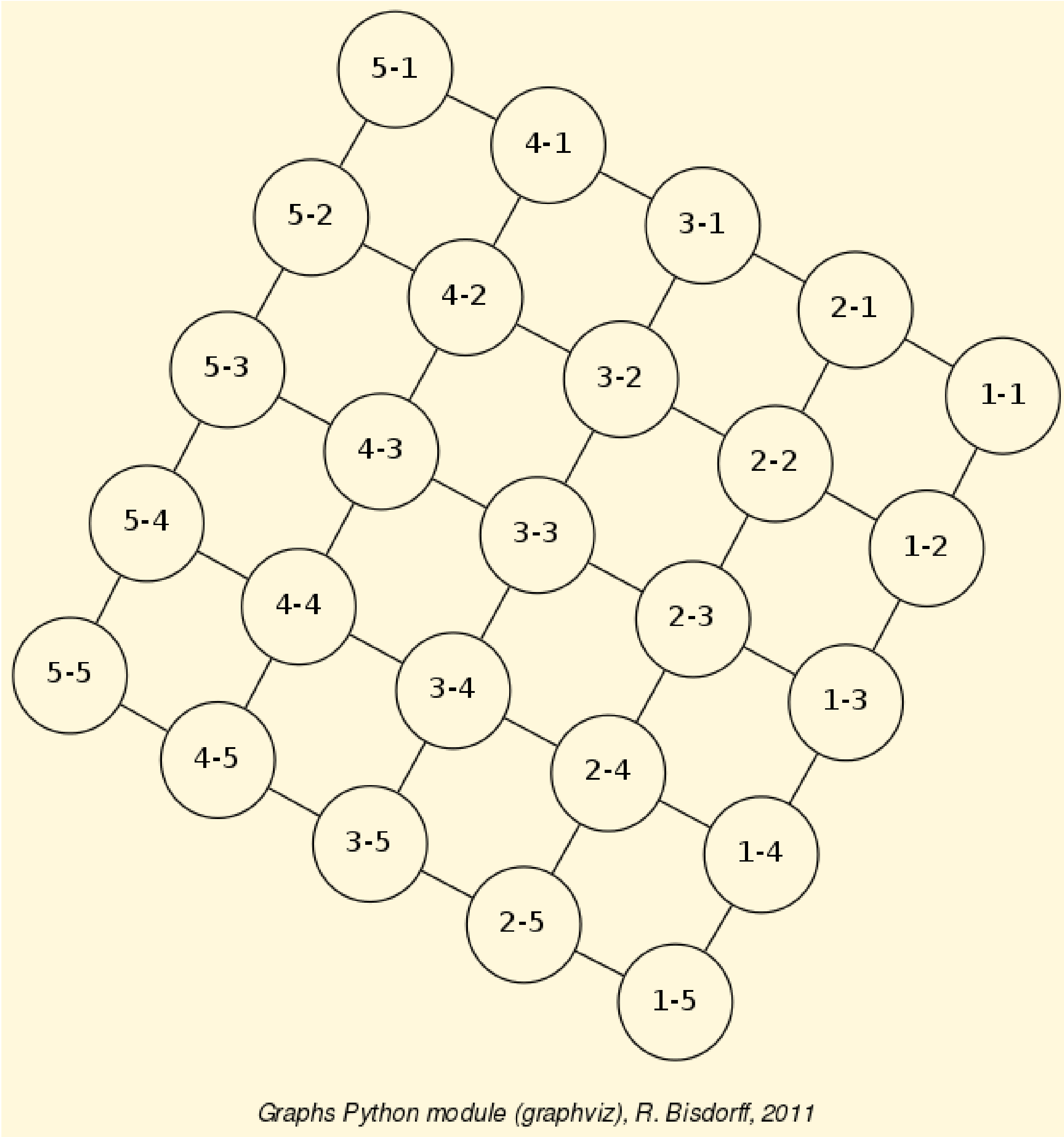
***Parameters*:**

- n,m > 0
- valuationDomain ={'min':m, 'max':M}

Default instantiation (5 times 5 Grid Digraph):

- n = 5,
- m=5,
- valuationDomain = {'min':-1.0,'max':1.0}.

Example of 5x5 GridGraph instance:



showShort()

class graphs.**IsingModel**(*g*, *beta=0*, *nSim=None*, *Debug=False*)

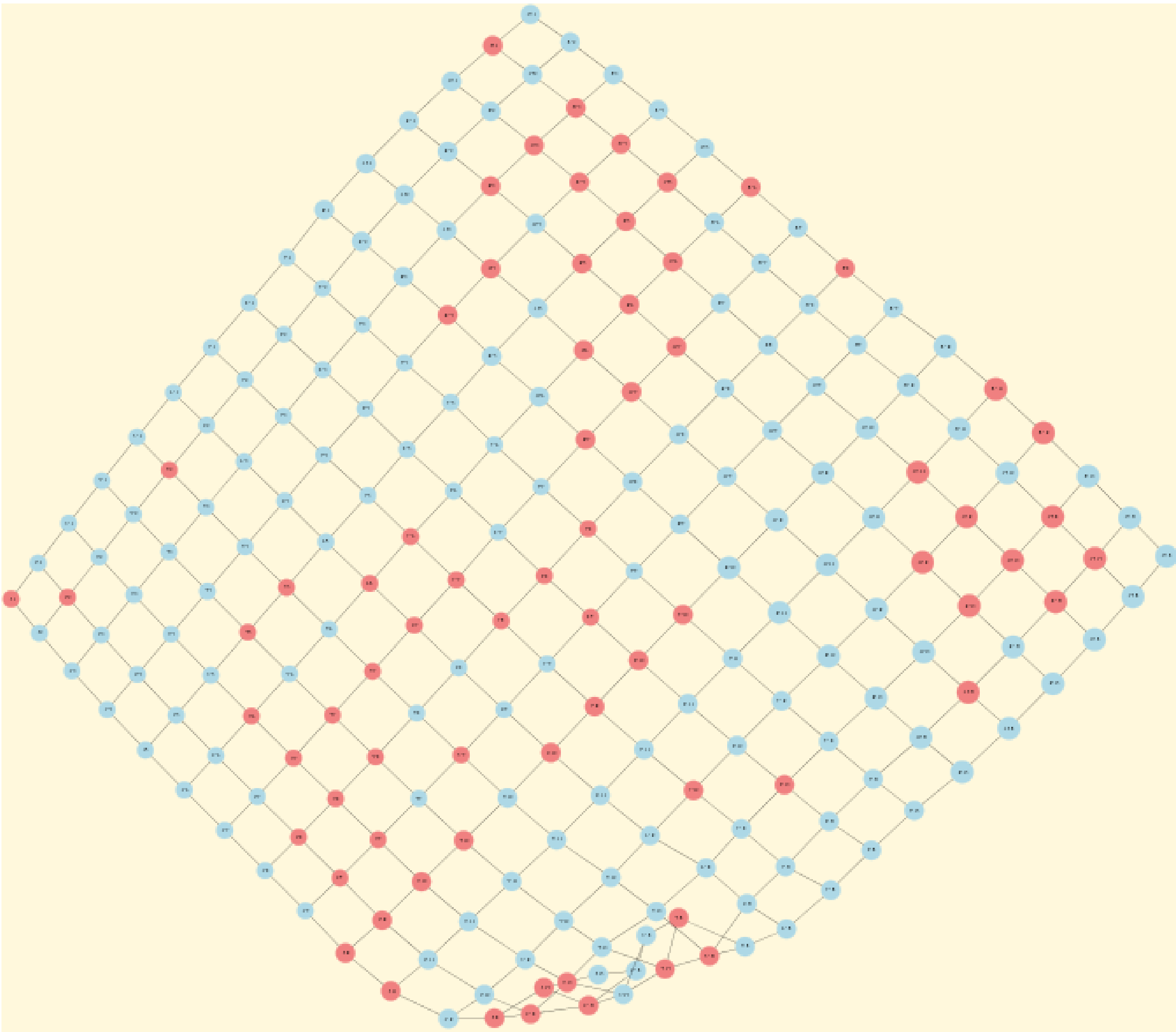
Bases: graphs.Graph

Specialisation of a Gibbs Sampler for the Ising model

Example:

```
>>> g = GridGraph(n=15,m=15)
>>> g.showShort()
*----- show short --------------*
Grid graph    :   grid-6-6
n             :   6
m             :   6
```

```
order         :  36
>>> im = IsingModel(g,beta=0.3,nSim=100000,Debug=False)
Running a Gibbs Sampler for 100000 step !
>>> im.exportGraphViz(colors=['lightblue','lightcoral'])
*---- exporting a dot file for GraphViz tools ---------*
Exporting to grid-15-15-ising.dot
fdp -Tpng grid-15-15-ising.dot -o grid-15-15-ising.png
```



computeSpinEnergy()
Spin energy H(c) of a spin configuration is H(c) = -sum_{{x,y} in self.edges}[spin_c(x)*spin_c(y)]

exportGraphViz(*fileName=None, noSilent=True, graphType='png', graphSize='7,7', edgeColor='black', colors=['gold', 'lightblue']*)
Exports GraphViz dot file for Ising models drawing filtering.

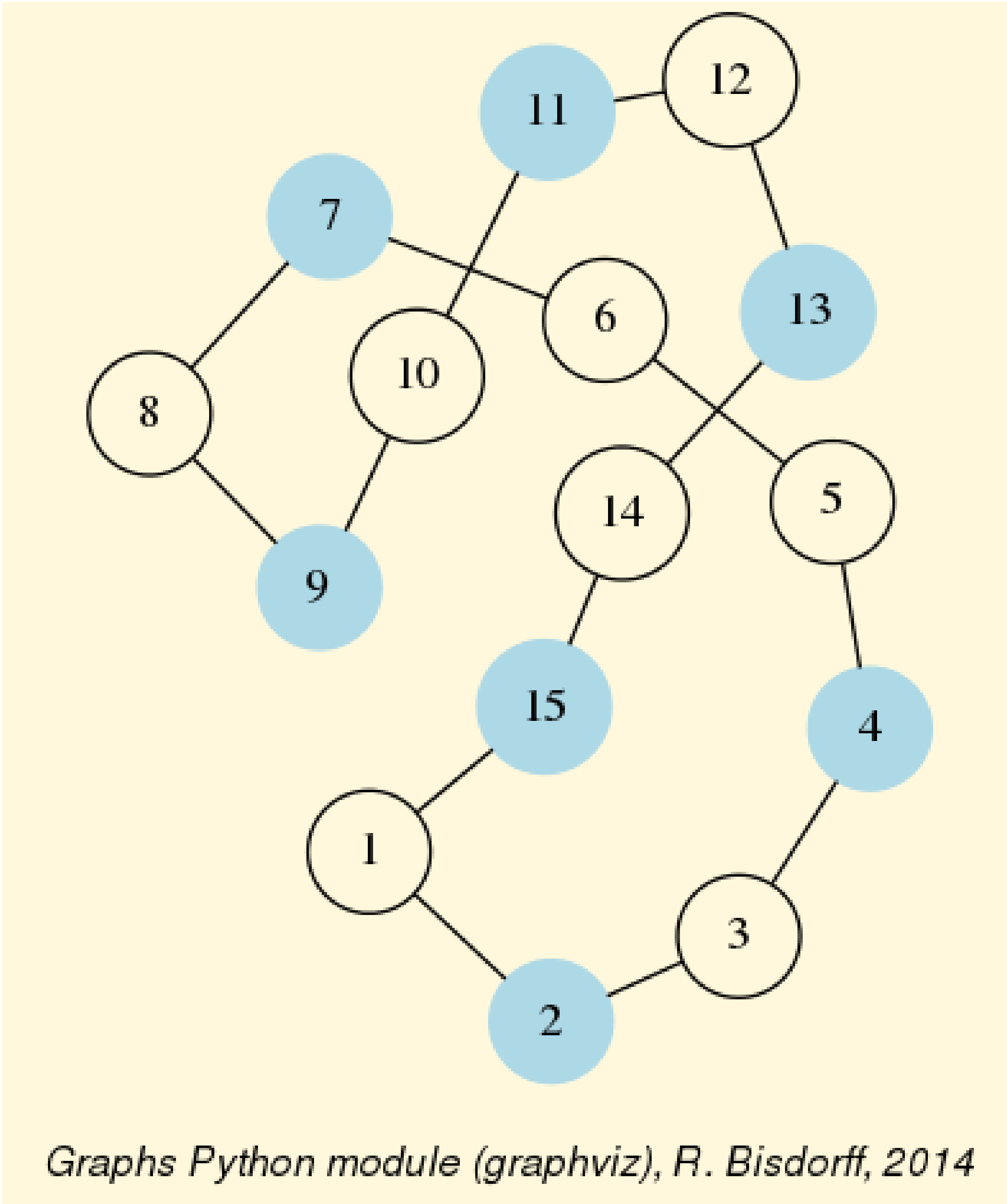
generateSpinConfiguration(*beta=0, nSim=None, Debug=False*)

class graphs.**MISModel**(*g, nSim=None, maxIter=20, Debug=False*)
Bases: `graphs.Graph`

Specialisation of a Gibbs Sampler for the hard code model, that is a random MIS generator.

Example:

```
>>> from digraphs import CirculantDigraph
>>> dg = CirculantDigraph(order=15)
>>> g = dg.digraph2Graph()
>>> g.showShort()
*---- short description of the graph ----*
Name             : 'c15'
Vertices         :  ['1', '10', '11', '12', '13', '14',
                     '15', '2', '3', '4', '5', '6', '7',
                     '8', '9']
Valuation domain :  {'med': 0, 'min': -1, 'max': 1}
Gamma function   :
1 -> ['2', '15']
10 -> ['11', '9']
11 -> ['10', '12']
12 -> ['13', '11']
13 -> ['12', '14']
14 -> ['15', '13']
15 -> ['1', '14']
2 -> ['1', '3']
3 -> ['2', '4']
4 -> ['3', '5']
5 -> ['6', '4']
6 -> ['7', '5']
7 -> ['6', '8']
8 -> ['7', '9']
9 -> ['10', '8']
>>> mis = MISModel(g)
Running a Gibbs Sampler for 1050 step !
>>> mis.checkMIS()
{'2','4','7','9','11','13','15'}  is maximal !
>>> mis.exportGraphViz()
*---- exporting a dot file for GraphViz tools ---------*
Exporting to c15-mis.dot
fdp -Tpng c15-mis.dot -o c15-mis.png
```



checkMIS (*Comments=True*)

Verify maximality of independent set.

Note: Returns three sets: an independent choice, the covered vertices, and the remaining uncovered vertices. When the last set is empty, the independent choice is maximal.

---

exportGraphViz (*fileName=None, noSilent=True, graphType='png', graphSize='7, 7', misColor='lightblue'*)

Exports GraphViz dot file for MIS models drawing filtering.

generateMIS (*Reset=True, nSim=None, Comments=True, Debug=False*)

class `graphs.`**`MetropolisChain`** (*g, probs=None*)

Bases: `graphs.Graph`

Specialisation of the graph class for implementing a generic Metropolis Markov Chain Monte Carlo sampler with a given probability distribution probs = {'v1': x, 'v2': y, ...}

Usage example:

```
>>> g = Graph(numberOfVertices=5,edgeProbability=0.5)
>>> g.showShort()
*---- short description of the graph ----*
Name             : 'randomGraph'
Vertices         :  ['v1', 'v2', 'v3', 'v4', 'v5']
Valuation domain :  {'max': 1, 'med': 0, 'min': -1}
Gamma function   :
v1 -> ['v2', 'v3', 'v4']
v2 -> ['v1', 'v4']
v3 -> ['v5', 'v1']
v4 -> ['v2', 'v5', 'v1']
v5 -> ['v3', 'v4']
>>> probs = {}
>>> n = g.order
>>> i = 0
>>> verticesList = [x for x in g.vertices]
>>> verticesList.sort()
>>> for v in verticesList:
...     probs[v] = (n - i)/(n*(n+1)/2)
...     i += 1
>>> met = MetropolisChain(g,probs)
>>> frequency = met.checkSampling(verticesList[0],nSim=30000)
>>> for v in verticesList:
...     print(v,probs[v],frequency[v])
v1 0.3333 0.3343
v2 0.2666 0.2680
v3 0.2    0.2030
v4 0.1333 0.1311
v5 0.0666 0.0635
>>> met.showTransitionMatrix()
* ---- Transition Matrix -----
  Pij  | 'v1'    'v2'    'v3'    'v4'    'v5'
  -----|-----------------------------------
  'v1' |  0.23   0.33    0.30    0.13    0.00
  'v2' |  0.42   0.42    0.00    0.17    0.00
  'v3' |  0.50   0.00    0.33    0.00    0.17
  'v4' |  0.33   0.33    0.00    0.08    0.25
  'v5' |  0.00   0.00    0.50    0.50    0.00
```

MCMCtransition(*si*, *Debug=False*)

checkSampling(*si*, *nSim*)

computeTransitionMatrix()

saveCSVTransition(*fileName='transition'*, *Debug=False*)
Persistent storage of the transition matrix in the form of a csv file.

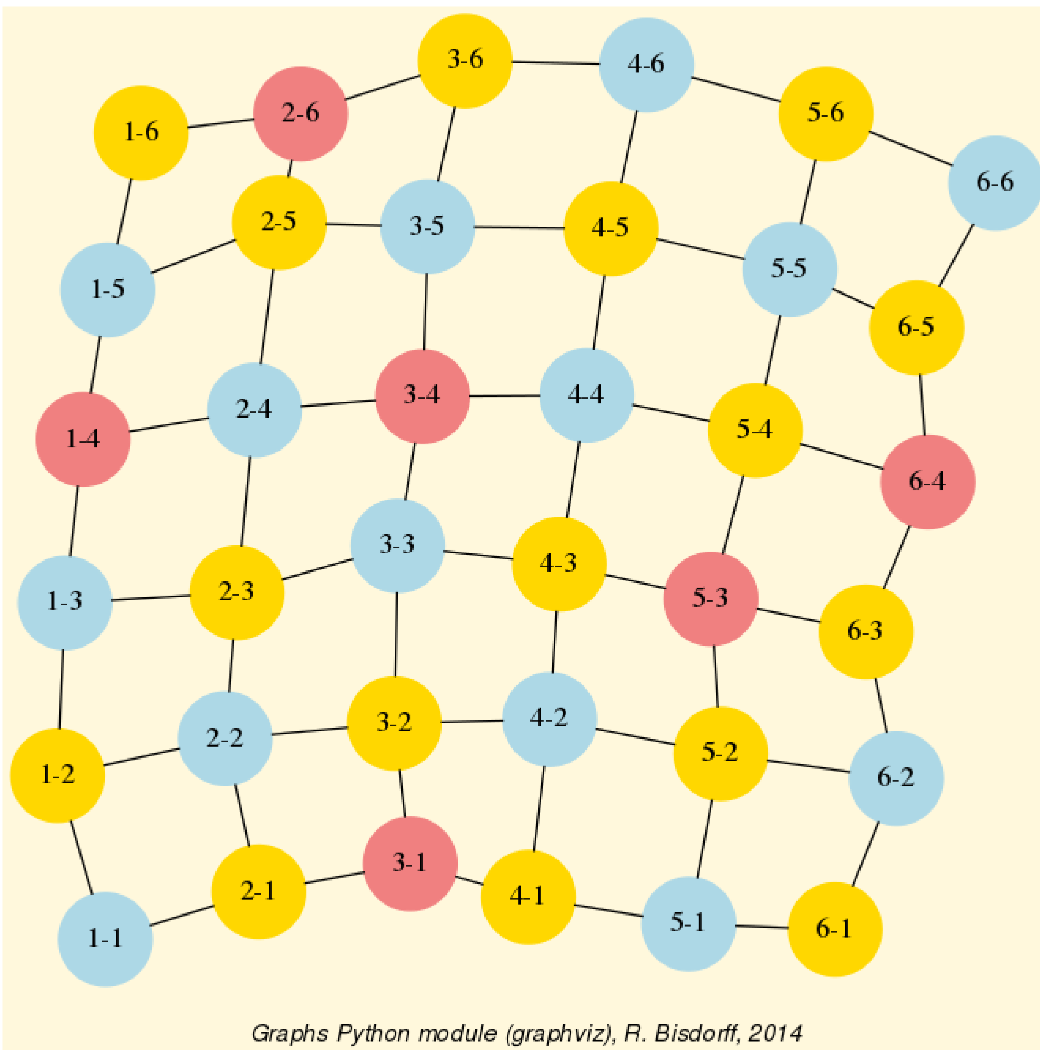
showTransitionMatrix(*Sorted=True*, *IntegerValues=False*, *vertices=None*, *relation=None*, *ndigits=2*, *ReflexiveTerms=True*)
Prints on stdout the transition probabilities in vertices X vertices table format.

class graphs.**Q_Coloring**(*g, colors=['gold', 'lightcoral', 'lightblue'], nSim=None, maxIter=20, Comments=True, Debug=False*)
Bases: `graphs.Graph`

Generate a q-coloring of a Graph instance via a Gibbs MCMC sampler in nSim simulation steps (default = len(graph.edges)).

Example 3-coloring of a grid 6x6 :

```
>>> g = GridGraph(n=6,m=6)
>>> g.showShort()
>>> g.exportGraphViz()
*----- show short --------------*
Grid graph    :  grid-6-6
n             :  6
m             :  6
order         :  36
>>> qc = Q_Coloring(g,colors=['gold','lightblue','lightcoral'])
Running a Gibbs Sampler for 630 step !
>>> qc.checkFeasibility()
The q-coloring with 3 colors is feasible !!
>>> qc.exportGraphViz()
*---- exporting a dot file for GraphViz tools ---------*
Exporting to grid-6-6-qcoloring.dot
fdp -Tpng grid-6-6-qcoloring.dot -o grid-6-6-qcoloring.png
```



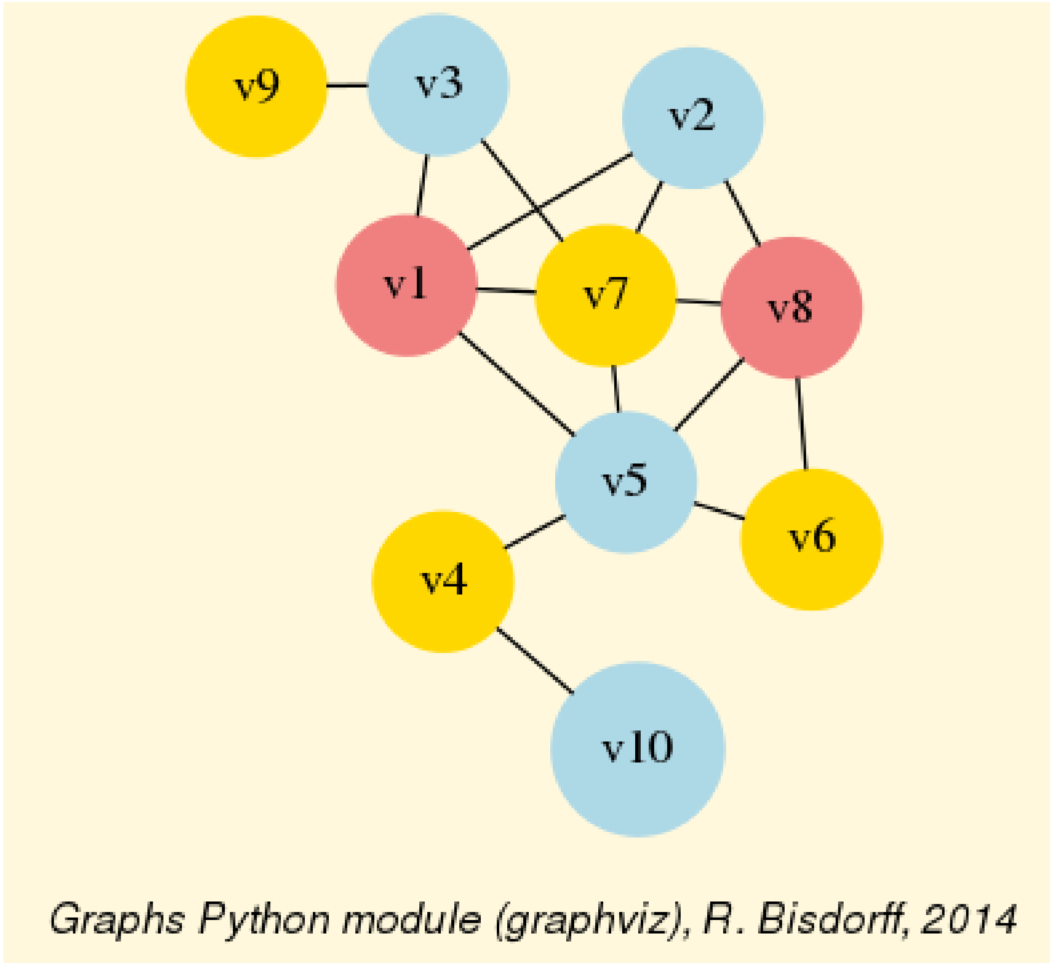
checkFeasibility(*Comments=True*, *Debug=False*)

exportGraphViz (*fileName=None*, *noSilent=True*, *graphType='png'*, *graphSize='7, 7'*)

Exports GraphViz dot file for q-coloring drawing filtering.

Example:

```
>>> g = Graph(numberOfVertices=10,edgeProbability=0.4)
>>> g.showShort()
*---- short description of the graph ----*
Name : 'randomGraph'
Vertices :  ['v1','v10','v2','v3','v4','v5','v6','v7','v8','v9']
Valuation domain :  {'max': 1, 'min': -1, 'med': 0}
Gamma function   :
v1 -> ['v7', 'v2', 'v3', 'v5']
v10 -> ['v4']
v2 -> ['v1', 'v7', 'v8']
v3 -> ['v1', 'v7', 'v9']
v4 -> ['v5', 'v10']
v5 -> ['v6', 'v7', 'v1', 'v8', 'v4']
v6 -> ['v5', 'v8']
v7 -> ['v1', 'v5', 'v8', 'v2', 'v3']
v8 -> ['v6', 'v7', 'v2', 'v5']
v9 -> ['v3']
>>> qc = Q_Coloring(g,nSim=1000)
Running a Gibbs Sampler for 1000 step !
>>> qc.checkFeasibility()
The q-coloring with 3 colors is feasible !!
>>> qc.exportGraphViz()
*---- exporting a dot file for GraphViz tools ---------*
Exporting to randomGraph-qcoloring.dot
fdp -Tpng randomGraph-qcoloring.dot -o randomGraph-qcoloring.png
```



generateFeasibleConfiguration(*Reset=True*, *nSim=None*, *Debug=False*)

showConfiguration()

class graphs.**RandomGraph**(*order=5*, *edgeProbability=0.4*)

Bases: graphs.Graph

Random instances of the Graph class

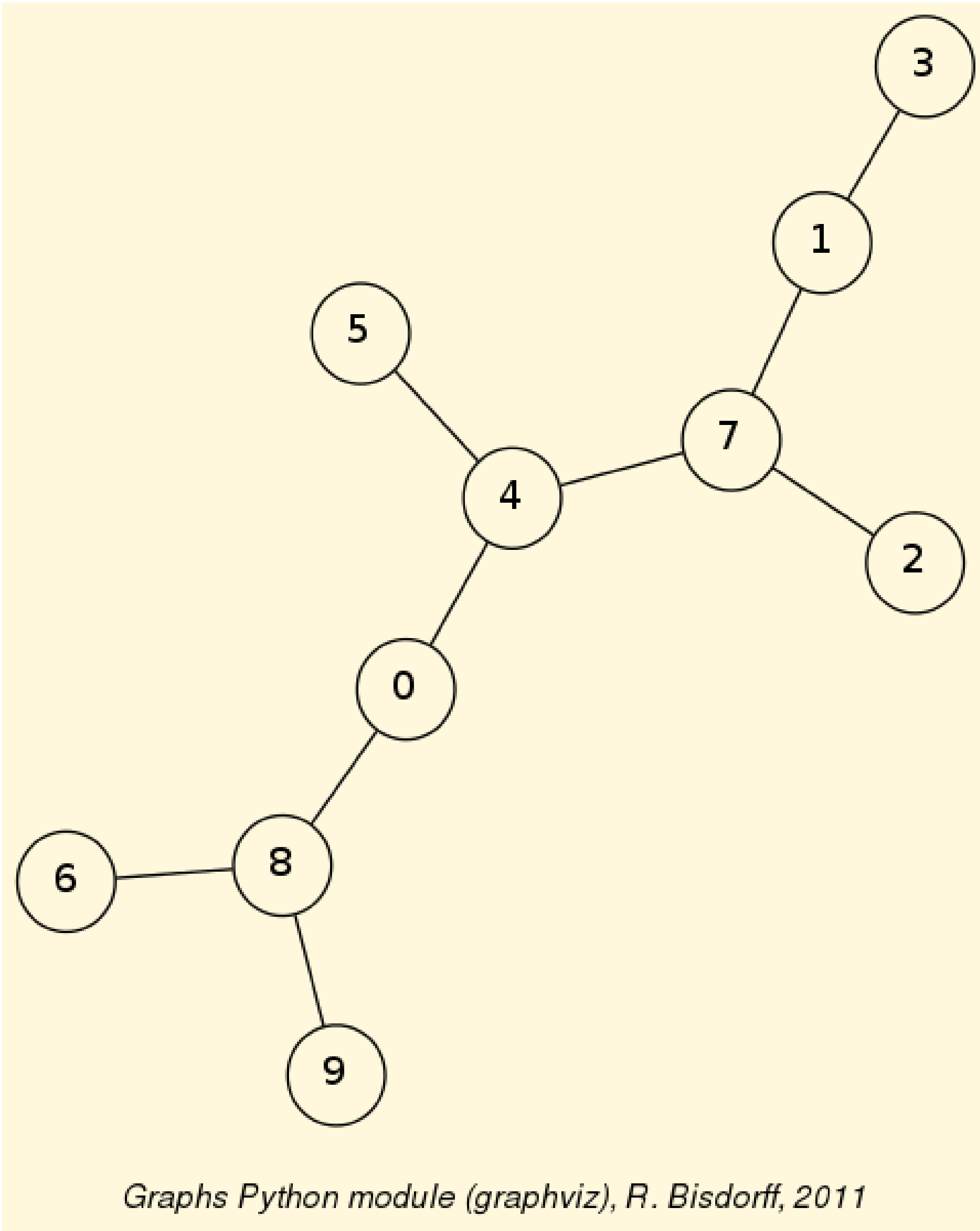
Parameters:

- order (positive integer)
- edgeProbability (in [0,1])

class graphs.**RandomTree**(*order=None*, *prueferCode=None*, *myseed=None*, *Debug=False*)

Bases: graphs.Graph

Random instance of a tree generated from a random Prüfer code.



class `graphs.`**`TriangularGraph`**(*n=5*, *m=5*, *valuationMin=-1*, *valuationMax=1*)

Bases: `graphs.Graph`

Specialization of the general Graph class for generating temporary triangular graphs of dimension n times m.

***Parameters*:**

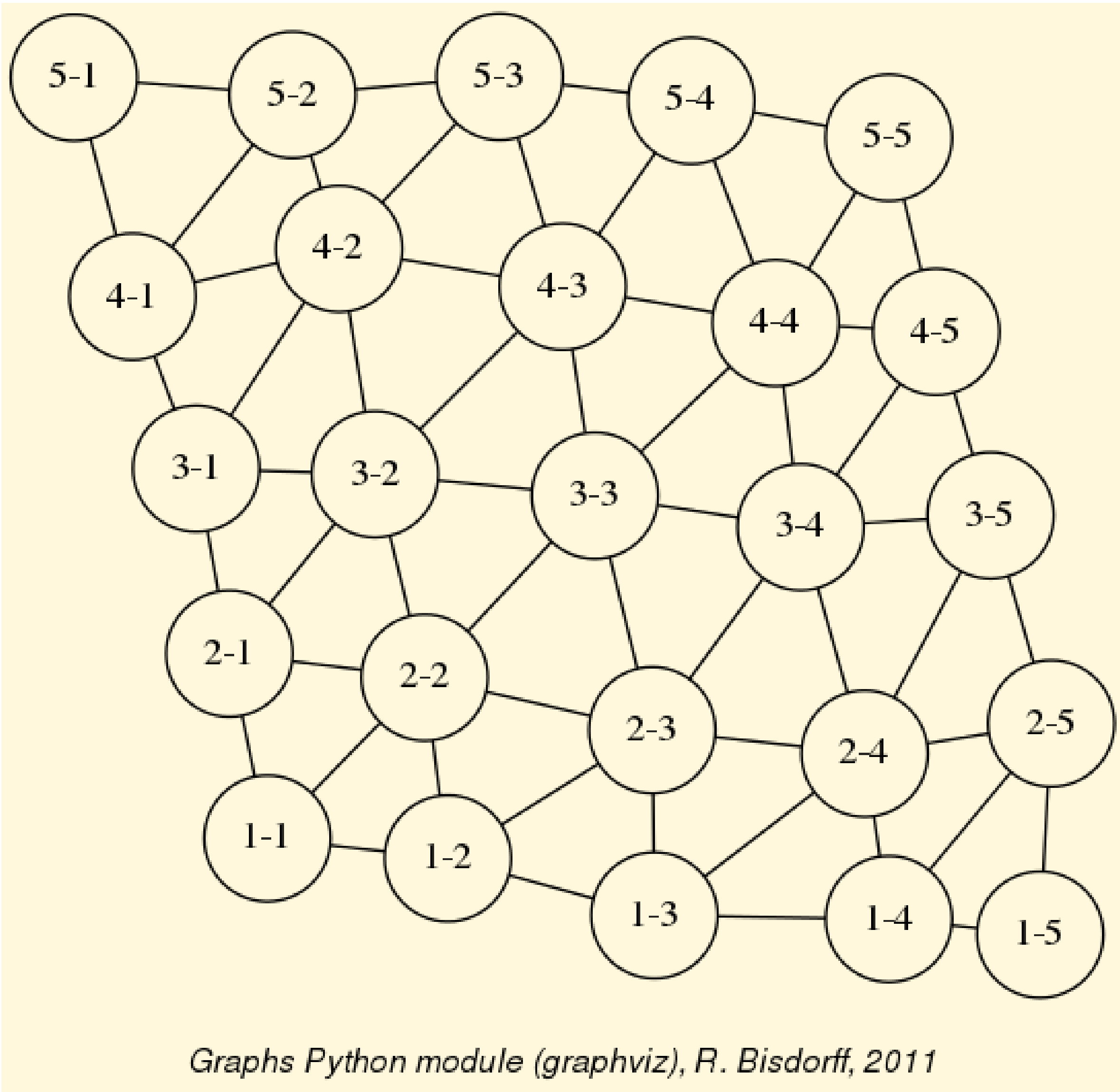
- n,m > 0

- valuationDomain ={'min':m, 'max':M}

Default instantiation (5 times 5 Trinagular Digraph):

- n = 5,
- m=5,
- valuationDomain = {'min':-1.0,'max':1.0}.

Example of 5x5 GridGraph instance:



showShort()

Back to the *Introduction*

1.2.4 perfTabs module

class `perfTabs.`**`FullRandomPerformanceTableau`**(*numberOfActions=None*, *numberOfCriteria=None*, *weightDistribution=None*, *weightScale=None*, *integerWeights=True*, *commonScale=None*, *commonThresholds=None*, *commonMode=None*, *valueDigits=2*, *Debug=False*)

Bases: `perfTabs.PerformanceTableau`

Full automatic generation of random performance tableaux

`showAll`()

Show fonction for performance tableau of full random outranking digraph.

class `perfTabs.`**`NormalizedPerformanceTableau`**(*argPerfTab=None*, *lowValue=0*, *highValue=100*, *coalition=None*, *Debug=False*)

Bases: `perfTabs.PerformanceTableau`

specialsation of the PerformanceTableau class for constructing normalized, 0 - 100, valued PerformanceTableau instances from a given argPerfTab instance.

class `perfTabs.`**`OldXMCDAPerformanceTableau`**(*fileName='temp'*)

Bases: `perfTabs.PerformanceTableau`

Specialization of the general PerformanceTableau class for reading stored XMCDA formatted instances. Using the inbuilt module xml.etree (for Python 2.5+).

Param: fileName (without the extension .xml or .xmcda).

class `perfTabs.`**`PartialPerformanceTableau`**(*inPerfTab*, *actionsSubset=None*, *criteriaSubset=None*)

Bases: `perfTabs.PerformanceTableau`

Constructor for partial performance tableaux.

class `perfTabs.`**`PerformanceTableau`**(*filePerfTab=None*, *isEmpty=False*)

Bases: `builtins.object`

A general class for tacling MCDA performance tableaux.

`computeActionCriterionPerformanceDifferences`(*refAction*, *refCriterion*, *comments=False*, *Debug=False*)

computes the performances differences observed between the reference action and the others on the given criterion

`computeActionCriterionQuantile`(*action*, *criterion*, *Debug=False*)

renders the quantile of the performance of action on criterion

`computeActionQuantile`(*action*, *Debug=True*)

renders the overall performance quantile of action

`computeCriterionPerformanceDifferences`(*c*, *Comments=False*, *Debug=False*)

Renders the ordered list of all observed performance differences on the given criterion.

`computeDefaultDiscriminationThresholds`(*quantile={'weakVeto': 60, 'pref': 20, 'veto': 80, 'ind': 10}*, *Debug=False*, *Comments=False*)

updates the discrimination thresholds with the percentiles from the performance differences. Parameters: quantile = {'ind': 10, 'pref': 20, 'weakVeto': 60, 'veto: 80}.

computeMinMaxEvaluations (*criteria=None*, *actions=None*)
: renders minimum and maximum performances on each criterion in dictionary form: {'g': {'minimum': x, 'maximum': x}}

computeNormalizedDiffEvaluations (*lowValue=0.0*, *highValue=100.0*, *withOutput=False*, *Debug=False*)
: renders and csv stores (withOutput=True) the list of normalized evaluation differences observed on the family of criteria Is only adequate if all criteria have the same evaluation scale. Therefore the performance tableau is normalized to 0.0-100.0 scales.

computePerformanceDifferences (*Comments=False*, *Debug=False*, *NotPermanentDiffs=True*)
: Adds to the criteria dictionary the ordered list of all observed performance differences.

computeQuantilePreorder (*Comments=True*, *Debug=False*)
: computes the preorder of the actions obtained from decreasing majority quantiles. The quantiles are recomputed with a call to the self.computeQuantileSort() method.

computeQuantileSort ()
: shows a sorting of the actions from decreasing majority quantiles

computeQuantiles (*Debug=False*)
: renders a quantiles matrix action x criterion with the performance quantile of action on criterion

computeThresholdPercentile (*criterion*, *threshold*, *Debug=False*)
: computes for a given criterion the quantile of the performance differences of a given constant threshold.

computeVariableThresholdPercentile (*criterion*, *threshold*, *Debug=False*)
: computes for a given criterion the quantile of the performance differences of a given threshold.

computeWeightPreorder ()
: renders the weight preorder following from the given criteria weights in a list of increasing equivalence lists of criteria.

computeWeightedAveragePerformances (*isNormalized=False*, *lowValue=0.0*, *highValue=100.0*, *isListRanked=False*)
: Compute normalized weighted average scores Normalization transforms by default all the scores into a common 0-100 scale. A lowValue and highValue parameter can be provided for a specific normalisation.

csvAllQuantiles (*fileName='quantiles'*)
: save quantiles matrix criterionxaction in CSV format

hasOddWeightAlgebra (*Debug=False*)
: Verify if the given criteria[self]['weight'] are odd or not. Return a Boolen value.

htmlPerformanceTable (*isSorted=True*, *ndigits=2*)
: Renders the performance table citerion x actions in html format.

normalizeEvaluations (*lowValue=0.0*, *highValue=100.0*, *Debug=False*)
: recode the evaluations between lowValue and highValue on all criteria

save (*fileName='tempperftab'*, *isDecimal=True*, *valueDigits=2*)
: Persistant storage of Performance Tableaux.

saveXMCDA (*fileName='temp'*, *category='New XMCDA Rubis format'*, *user='digraphs Module (RB)'*, *version='saved from Python session'*, *variant='Rubis'*, *valuationType='standard'*, *servingD3=True*)
: save performance tableau object self in XMCDA format.

saveXMCDA2 (*fileName='temp'*, *category='XMCDA 2.0 format'*, *user='digraphs Module (RB)'*, *version='saved from Python session'*, *title='Performance Tableau in XMCDA-2.0 format.'*, *variant='Rubis'*, *valuationType='bipolar'*, *servingD3=True*, *isStringIO=False*, *stringNA='NA'*, *comment='produced by saveXMCDA2()'*, *hasVeto=True*) save performance tableau object self in XMCDA 2.0 format.

saveXMCDA2String(*fileName='temp'*, *category='XMCDA 2.0 format'*, *user='digraphs Module (RB)'*, *version='saved from Python session'*, *title='Performance Tableau in XMCDA-2.0 format.'*, *variant='Rubis'*, *valuationType='bipolar'*, *servingD3=True*, *comment='produced by stringIO()'*, *stringNA='NA'*)
save performance tableau object self in XMCDA 2.0 format. !!! obsolete: replaced by the isStringIO in the saveXMCDA2 method !!!

saveXML(*name='temp'*, *category='standard'*, *subcategory='standard'*, *author='digraphs Module (RB)'*, *reference='saved from Python'*)
save temporary performance tableau self in XML format.

saveXMLRubis(*name='temp'*, *category='Rubis'*, *subcategory='new D2 version'*, *author='digraphs Module (RB)'*, *reference='saved from Python'*)
save temporary performance tableau self in XML Rubis format.

showAll()
Show fonction for performance tableau

showAllQuantiles()
renders a html string showing the table of the quantiles matrix action x criterion

showCriteria(*IntegerWeights=False*, *Debug=False*)
print Criteria with thresholds and weights.

showEvaluationStatistics()
renders the variance and standard deviation of the values observed in the performance Tableau.

showHTMLPerformanceTableau(*isSorted=True*, *ndigits=2*)
shows the html version of the performance tableau in a browser window.

showPerformanceTableau(*sorted=True*, *ndigits=2*)
Print the performance Tableau.

showQuantileSort(*Debug=False*)
Wrapper of computeQuantilePreorder() for the obsolete showQuantileSort() method.

showStatistics()
show statistics concerning the evaluation distributions on each criteria.

class perfTabs.**RandomCBPerformanceTableau**(*numberOfActions=None*, *numberOfCriteria=None*, *weightDistribution=None*, *weightScale=None*, *integerWeights=True*, *commonScale=None*, *commonThresholds=None*, *commonPercentiles=None*, *commonMode=None*, *valueDigits=2*, *Debug=False*, *Comments=False*)
Bases: perfTabs.PerformanceTableau

Full automatic generation of random Cost versus Benefit oriented performance tableaux.

Parameters:

If numberOfActions == None, a uniform random number between 10 and 31 of cheap, neutral or advantageous actions (equal 1/3 probability each type) actions is instantiated

If numberOfCriteria == None, a uniform random number between 5 and 21 of cost or benefit criteria (1/3 respectively 2/3 probability) is instantiated

weightDistribution := {'equiobjectives'|'fixed'|'random'|'equisignificant' (default = 'equisignificant')}

default weightScale for 'random' weightDistribution is 1 - numberOfCriteria

commonScale parameter is obsolete. The scale of cost criteria is cardinal or ordinal (0-10) with proabailities 1/4 respectively 3/4, whereas the scale of benefit criteria is ordinal or cardinal with probabilities 2/3, respectively 1/3.

All cardinal criteria are evaluated with decimals between 0.0 and 100.0 wheras all ordinal criteria are evaluated with integers between 0 and 10.

commonThresholds is obsolete. Preference discrimination is specified as percentiles of concerned performance differences (see below).

CommonPercentiles = {'ind':5, 'pref':10, ['weakveto':90,] 'veto':95} are expressed in percents (reversed for vetoes) and only concern cardinal criteria.

> **Warning:** Minimal number of decision actions required is 3 !

class `perfTabs.`**`RandomCoalitionsPerformanceTableau`**(*numberOfActions=None, numberOfCriteria=None, weightDistribution=None, weightScale=None, integerWeights=True, commonScale=None, commonThresholds=None, commonMode=None, valueDigits=2, Coalitions=True, VariableGenerators=True, OrdinalScales=False, Debug=False, RandomCoalitions=False, vetoProbability=None, Electre3=True*)

Bases: `perfTabs.PerformanceTableau`

Full automatic generation of performance tableaux with random coalitions of criteria

Parameters:

numberOf Actions := 20 (default)

number of Criteria := 13 (default)

weightDistribution := 'equisignificant' (default with all weights = 1.0), 'random', 'fixed' (default w_1 = numberOfCriteria-1, w_{i!=1} = 1

weightScale := [1,numerOfCriteria[(random default), [w_1, w_{i!=1] (fixed)

integerWeights := True (default) / False

commonScale := (0.0, 100.0) (default)

commonThresholds := [(1.0,0.0),(2.001,0.0),(8.001,0.0)] if OrdinalSacles, [(0.10001*span,0),(0.20001*span,0.0),(0.80001*span,0.0)] with span = commonScale[1] - commonScale[0].

commonMode := ['triangular',50.0,0.50] (default), ['uniform',None,None], ['beta', None,None] (three alpha, beta combinations (5.8661,2.62203) chosen by default for high('+'), medium ('~') and low ('-') evaluations.

valueDigits := 2 (default, for cardinal scales only)

Coalitions := True (default)/False, three coalitions if True

VariableGenerators := True (default) / False, variable high('+'), medium ('~') or low ('-') law generated evaluations.

OrdinalScales := True / False (default)

Debug := True / False (default)

RandomCoalitions = True / False (default) zero or more than three coalitions if Coalitions == False.

vetoProbability := x in]0.0-1.0[/ None (default), probability that a cardinal criterion shows a veto preference discrimination threshold.

Electre3 := True (default) / False, no weakveto if True (obsolete)

class `perfTabs.`**`RandomPerformanceTableau`**(*numberOfActions=None, numberOfCriteria=None, weightDistribution=None, weightScale=None, integerWeights=True, commonScale=[0.0, 100.0], commonThresholds=[(10.0, 0.0), (20.0, 0.0), (80.0, 0.0)], commonMode=None, valueDigits=2, Debug=False*)

Bases: `perfTabs.PerformanceTableau`

Specialization of the PerformanceTableau class for generating a temporary random performance tableau.

Parameters:

actions := nbr of actions,

criteria := number criteria,

scale := [Min,Max],

thresholds := [q,p,v],

mode = [| ('uniform',None,None) | ('normal',mu,sigma) | ('triangular',mode,None) | ('beta',mode,(alpha,beta)],

weightDistribution := equivalent|random|fixed

Code example::

```
>>> from perfTabs import RandomCBPerformanceTableau
>>> t = RandomCBPerformanceTableau(numberOfActions=3,numberOfCriteria=1)
>>> t.actions
    {'a02': {'comment': 'RandomCBPerformanceTableau() generated.', 'type': 'advantageous',
    'a03': {'comment': 'RandomCBPerformanceTableau() generated.', 'type': 'advantageous', '
    'a01': {'comment': 'RandomCBPerformanceTableau() generated.', 'type': 'neutral', 'name'
>>> t.criteria
    {'g01': {'comment': 'Evaluation generator: triangular law with variable mode (m) and pr
    'performanceDifferences': [Decimal('21.84'), Decimal('25.49'), Decimal('47.33')],
    'scale': (0.0, 100.0),
    'minimalPerformanceDifference': Decimal('21.84'),
    'preferenceDirection': 'max',
    'weight': Decimal('1'),
    'randomMode': ['triangular', 50.0, 0.5],
                   'name': 'random cardinal benefit criterion',
                   'maximalPerformanceDifference': Decimal('47.33'),
                   'thresholds': {'ind': (Decimal('22.205'), Decimal('0.0')),
                                  'veto': (Decimal('45.146'), Decimal('0.0')),
                                  'pref': (Decimal('22.570'), Decimal('0.0'))},
    'scaleType': 'cardinal'}
    }

>>> t.evaluation
    {'g01': {'a02': Decimal('94.22'),
             'a03': Decimal('72.38'),
             'a01': Decimal('46.89')
            }
    }
```

class `perfTabs.`**`RandomRankPerformanceTableau`**(*numberOfActions=None, numberOfCriteria=None, weightDistribution=None, weightScale=None, commonThresholds=None, integerWeights=True, Debug=False*)

Bases: `perfTabs.PerformanceTableau`

Specialization of the PerformanceTableau class for generating a temporary random performance tableau.

class `perfTabs.`**`RandomS3PerformanceTableau`**(*numberOfActions=None*, *numberOfCriteria=None*, *weightDistribution=None*, *weightScale=None*, *integerWeights=True*, *commonScale=None*, *commonThresholds=None*, *commonMode=None*, *valueDigits=2*, *Coalitions=True*, *VariableGenerators=True*, *OrdinalScales=False*, *Debug=False*, *RandomCoalitions=False*, *vetoProbability=None*, *Electre3=True*)

Bases: `perfTabs.RandomCoalitionsPerformanceTableau`

Obsolete dummy class for backports.

class `perfTabs.`**`XMCDA2PerformanceTableau`**(*fileName='temp'*, *HasSeparatedWeights=False*, *HasSeparatedThresholds=False*, *stringInput=None*)

Bases: `perfTabs.PerformanceTableau`

Specialization of the general PerformanceTableau class for reading stored XMCDA 2.0 formatted instances with exact decimal numbers. Using the inbuilt module xml.etree (for Python 2.5+).

Parameters:

fileName (without the extension .xml or .xmcda) HasSeparatedWeights - XMCDA 2.0.0 encoding (default = False) HasSeparatedThresholds - XMCDA 2.0.0 encoding (default = False) stringInput (default = None)

class `perfTabs.`**`XMCDAPerformanceTableau`**(*fileName='temp'*)

Bases: `perfTabs.PerformanceTableau`

Specialization of the general PerformanceTableau class for reading stored XMCDA formatted instances with exact decimal numbers. Using the inbuilt module xml.etree (for Python 2.5+).

Param: fileName (without the extension .xml or .xmcda).

class `perfTabs.`**`XMLPerformanceTableau`**(*fileName='testperftabXML'*)

Bases: `perfTabs.PerformanceTableau`

Specialization of the general PerformanceTableau class for reading stored XML formatted instances.

class `perfTabs.`**`XMLRubisPerformanceTableau`**(*fileName='rubisPerformanceTableau'*)

Bases: `perfTabs.PerformanceTableau`

Specialization of the general PerformanceTableau class for reading stored XML formatted instances. Using the inbuilt module xml.etree (for Python 2.5+).

Param: fileName (without the extension .xml).

`stripsplit`(*th*)

extract thresholds new Python 3 compatible version

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1.2.5 outrankingDigraphs module

class `outrankingDigraphs.`**`BipolarIntegerOutrankingDigraph`**(*argPerfTab=None*, *coalition=None*, *hasBipolarVeto=True*, *hasSymmetricThresholds=True*)

Bases: `outrankingDigraphs.BipolarOutrankingDigraph`, `perfTabs.PerformanceTableau`

Parameters:

performanceTableau (fileName of valid py code) optional, coalition (sublist of criteria)

Specialization of the standard OutrankingDigraph class for generating bipolar integer-valued outranking digraphs.

savePy2Gprolog(*name='temp'*)
save digraph in gprolog version

showRelation()
prints the relation valuation in ##.## format.

class outrankingDigraphs.**BipolarOutrankingDigraph**(*argPerfTab=None*, *coalition=None*, *hasNoVeto=False*, *hasBipolarVeto=True*, *Normalized=False*)
Bases: outrankingDigraphs.OutrankingDigraph, perfTabs.PerformanceTableau

Specialization of the standard OutrankingDigraph class for generating new bipolar ordinal-valued outranking digraphs.

Parameters:

performanceTableau (fileName of valid py code)

optional, coalition (sublist of criteria)

computeCriterionRelation(*c*, *a*, *b*, *hasSymmetricThresholds=True*)
Compute the outranking characteristic for actions x and y on criterion c.

computeSingleCriteriaNetflows()
renders the Promethee single criteria netflows matrix M

criterionCharacteristicFunction(*c*, *a*, *b*, *hasSymmetricThresholds=True*)
Renders the characteristic value of the comparison of a and b on criterion c.

saveSingleCriterionNetflows(*fileName='tempnetflows.prn'*, *delimiter=' '*, *Comments=True*)
Delimited save of single criteria netflows matrix

class outrankingDigraphs.**BipolarPreferenceDigraph**(*argPerfTab=None*, *coalition=None*)
Bases: outrankingDigraphs.BipolarOutrankingDigraph, perfTabs.PerformanceTableau

Parameters:

performanceTableau (fileName of valid py code)

optional, coalition (sublist of criteria)

Specialization of the standard BipolarOutrankingDigraph class for generating new bipolar ordinal-valued outranking digraphs.

computeSingleCriteriaNetflows()
renders the Promethee single criteria netflows matrix M

criterionCharacteristicFunction(*c*, *a*, *b*, *hasSymmetricThresholds=True*)
Renders the characteristic value of the comparison of a and b on criterion c.

saveSingleCriterionNetflows(*fileName='tempnetflows.prn'*, *delimiter=' '*, *Comments=True*)
Delimited save of single criteria netflows matrix

class outrankingDigraphs.**DissimilarityOutrankingDigraph**(*filePerfTab=None*)
Bases: outrankingDigraphs.OutrankingDigraph, perfTabs.PerformanceTableau

Parameters: performanceTableau (fileName of valid py code)

Specialization of the OutrankingDigraph class for generating temporary dissimilarity random graphs

showAll()
specialize the general showAll method for the dissimilarity case

class `outrankingDigraphs.`**`Electre3OutrankingDigraph`**(*argPerfTab=None*, *coalition=None*, *hasNoVeto=False*)

Bases: `outrankingDigraphs.OutrankingDigraph`, `perfTabs.PerformanceTableau`

Parameters:

performanceTableau (fileName of valid py code)

optional, coalition (sublist of criteria)

Specialization of the standard OutrankingDigraph class for generating bipolar uniform-valued outranking digraphs.

`computeCriterionRelation`(*c*, *a*, *b*, *hasSymmetricThresholds=False*)

compute the outranking characteristic for actions x and y on criterion c.

`computeVetos`(*cutLevel=None*, *realVetosOnly=False*)

prints all veto situations observed in the OutrankingDigraph instance.

`showVetos`(*cutLevel=None*, *realVetosOnly=False*, *Comments=True*)

prints all veto situations observed in the OutrankingDigraph instance.

class `outrankingDigraphs.`**`EquiSignificanceMajorityOutrankingDigraph`**(*argPerfTab=None*, *coalition=None*, *hasNoVeto=False*)

Bases: `outrankingDigraphs.BipolarOutrankingDigraph`, `perfTabs.PerformanceTableau`

Parameters: performanceTableau (fileName of valid py code)

Specialization of the general OutrankingDigraph class for temporary outranking digraphs with equisignificant criteria.

class `outrankingDigraphs.`**`MedianBipolarOutrankingDigraph`**(*argPerfTab=None*, *coalition=None*, *percentile=(1, 2)*, *Debug=False*)

Bases: `outrankingDigraphs.BipolarOutrankingDigraph`, `perfTabs.PerformanceTableau`

Parameters: performanceTableau (fileName of valid py code)

optional: coalition (sublist of criteria) percentile as rational (n,d) for instance (50,100) or (1,2) renders Q2, (1,4) = Q1 (1,10) = D1, (3,4) = Q3

Specialization of the standard OutrankingDigraph class for generating a median bipolar outranking digraph.

class `outrankingDigraphs.`**`MultiCriteriaDissimilarityDigraph`**(*perfTab=None*, *filePerfTab=None*)

Bases: `outrankingDigraphs.OutrankingDigraph`, `perfTabs.PerformanceTableau`

Parameters: performanceTableau (fileName of valid py code)

Specialization of the OutrankingDigraph class for generating temporary multiple criteria based dissimilarity graphs.

class `outrankingDigraphs.`**`NewRobustOutrankingDigraph`**(*filePerfTab=None*, *Debug=False*, *hasNoVeto=True*)

Bases: `outrankingDigraphs.BipolarOutrankingDigraph`, `perfTabs.PerformanceTableau`

Parameters: performanceTableau (fileName of valid py code)

Specialization of the general OutrankingDigraph class for new robustness anaylsis.

class `outrankingDigraphs.`**`OrdinalOutrankingDigraph`**(*argPerfTab=None*, *coalition=None*, *hasNoVeto=False*)

Bases: `outrankingDigraphs.OutrankingDigraph`, `perfTabs.PerformanceTableau`

Parameters: performanceTableau (fileName of valid py code)

Specialization of the general OutrankingDigraph class for temporary ordinal outranking digraphs

class `outrankingDigraphs.`**`OutrankingDigraph`**(*argPerfTab=None*, *coalition=None*, *hasNoVeto=False*)

Bases: `digraphs.Digraph`, `perfTabs.PerformanceTableau`

Abstract class for methods common to all outranking digraphs

`computeAMPLData`(*OldValuation=False*)
renders the ampl data list

`computeActionsCorrelations`()
renders the comparison correlations between the actions

`computeCriteriaCorrelationDigraph`()
renders the ordinal criteria correlation digraph

`computeCriteriaCorrelations`()
renders the comparison correlations between the criteria

`computeCriterionRelation`(*c*, *a*, *b*)
compute the outranking characteristic for actions x and y on criterion c.

`computePairwiseComparisons`(*hasSymmetricThresholds=True*)
renders pairwise comparison parameters for all pairs of actions

`computePairwiseCompleteComparison`(*a*, *b*, *c*)
renders pairwise complete comparison parameters for actions a and b on criterion c.

`computeQuantileSortRelation`(*Debug=False*)
Renders the bipolar-valued relation obtained from the self quantile sorting result.

`computeSingletonRanking`(*Comments=False*, *Debug=False*)
Renders the sorted bipolar net determinatation of outrankingness minus outrankedness credibilities of all singleton choices.

res = ((netdet,singleton,dom,absorb)+)

`computeVetoesStatistics`(*level=None*)
renders the cut level vetos in dictionary format: vetos = {'all': n0, 'strong: n1, 'weak':n2}.

`computeVetosShort`()
renders the number of vetoes and real vetoes in an OutrankingDigraph.

`computeWeightsConcentrationIndex`()
Renders the Gini concentration index of the weight distribution

Based on the triangle summation formula.

`convertEvaluationFloatToDecimal`()
Convert evaluations from obsolete float format to decimal format

`convertWeightFloatToDecimal`()
Convert significance weights from obsolete float format to decimal format.

`defaultDiscriminationThresholds`(*quantile={'weakVeto': 60, 'pref': 20, 'veto': 80, 'ind': 10}*, *Debug=False*, *comments=False*)
updates the discrimination thresholds with the percentiles from the performance differences.

Parameters: quantile = {'ind': 10, 'pref': 20, 'weakVeto': 60, 'veto: 80}.

export3DplotOfActionsCorrelation(*plotFileName='correlation', Type='pdf', Comments=False, bipolarFlag=False, dist=True, centeredFlag=False*)
use Calmat and R for producing a png plot of the principal components of the the actions ordinal correlation table.

export3DplotOfCriteriaCorrelation(*plotFileName='correlation', Type='pdf', Comments=False, bipolarFlag=False, dist=True, centeredFlag=False*)
use Calmat and R for producing a plot of the principal components of the criteria ordinal correlation table.

saveActionsCorrelationTable(*fileName='tempcorr.prn', delimiter=' ', Bipolar=True, Silent=False, Centered=False*)
Delimited save of correlation table

saveCriteriaCorrelationTable(*fileName='tempcorr.prn', delimiter=' ', Bipolar=True, Silent=False, Centered=False*)
Delimited save of correlation table

saveXMCDA2RubisChoiceRecommendation(*fileName='temp', category='Rubis', subcategory='Choice Recommendation', author='digraphs Module (RB)', reference='saved from Python', comment=True, servingD3=False, relationName='Stilde', graphValuationType='bipolar', variant='standard', instanceID='void', stringNA='NA'*)
save complete Rubis problem and result in XMCDA 2.0 format with unicode encoding.

saveXMCDAOutrankingDigraph(*fileName='temp', category='Rubis', subcategory='Choice Recommendation', author='digraphs Module (RB)', reference='saved from Python', comment=True, servingD3=False, relationName='Stilde', valuationType='bipolar', variant='standard', instanceID='void'*)
save complete Rubis problem and result in XMCDA format with unicode encoding.

saveXMLRubisOutrankingDigraph(*name='temp', category='Rubis outranking digraph', subcategory='Choice recommendation', author='digraphs Module (RB)', reference='saved from Python', noSilent=False, servingD3=True*)
save complete Rubis problem and result in XML format with unicode encoding.

showAll()
specialize the general showAll method with criteria and performance tableau output

showCriteriaCorrelationTable(*isReturningHTML=False*)
prints the criteriaCorrelationIndex in table format

showCriteriaHierarchy()
shows the Rubis clustering of the ordinal criteria correlation table

showCriterionRelationTable(*criterion, actionsSubset=None*)
prints the relation valuation in actions X actions table format.

showPairwiseComparison(*a, b, hasSymetricThresholds=True, Debug=False, isReturningHTML=False, hasSymmetricThresholds=True*)
renders the pairwise comprison parameters on all criteria in html format

showPairwiseComparisonsDistributions()
show the lt,leq, eq, geq, gt distributions for all pairs

showPerformanceTableau()
Print the performance Tableau.

showRelationTable(*IntegerValues=False*, *actionsSubset=None*, *Sorted=True*, *hasLPDDenotation=False*, *hasLatexFormat=False*, *hasIntegerValuation=False*, *relation=None*)
prints the relation valuation in actions X actions table format.

showShort()
specialize the general showShort method with the criteria.

showSingletonRanking(*Comments=True*, *Debug=False*)
Calls self.computeSingletonRanking(comments=True,Debug = False). Renders and prints the sorted bipolar net determinatation of outrankingness minus outrankedness credibilities of all singleton choices. res = ((netdet,sigleton,dom,absorb)+)

showVetos(*cutLevel=None*, *realVetosOnly=False*)
prints all veto situations observed in the OutrankingDigraph instance.

class `outrankingDigraphs.`**PolarisedOutrankingDigraph**(*digraph=None*, *level=None*, *KeepValues=True*, *AlphaCut=False*, *StrictCut=False*)
Bases: `digraphs.PolarisedDigraph`, `outrankingDigraphs.OutrankingDigraph`, `perfTabs.PerformanceTableau`

polarised Digraph instance for Outranking Digraphs.

class `outrankingDigraphs.`**RandomBipolarOutrankingDigraph**(*numberOfActions=7*, *numberOfCriteria=7*, *weightDistribution='random'*, *weightScale=[1, 10]*, *commonScale=[0.0, 100.0]*, *commonThresholds=[(10.0, 0.0), (20.0, 0.0), (80.0, 0.0), (80.0, 0.0)]*, *commonMode=('uniform', None, None)*, *hasBipolarVeto=True*, *Normalized=False*)
Bases: `outrankingDigraphs.BipolarOutrankingDigraph`, `perfTabs.PerformanceTableau`

Parameters:

n := nbr of actions, p := number criteria,

scale := [Min,Max], thresholds := [h,q,v]

Specialization of the OutrankingDigraph class for generating temporary Digraphs from random performance tableaux.

class `outrankingDigraphs.`**RandomElectre3OutrankingDigraph**(*numberOfActions=7*, *numberOfCriteria=7*, *weightDistribution='random'*, *weightScale=[1, 10]*, *commonScale=[0.0, 100.0]*, *commonThresholds=[(10.0, 0.0), (20.0, 0.0), (80.0, 0.0)]*, *commonMode=['uniform', None, None]*)
Bases: `outrankingDigraphs.Electre3OutrankingDigraph`, `perfTabs.PerformanceTableau`

Parameters:

n := nbr of actions, p := number criteria, scale := [Min,Max],

thresholds := [h,q,v]

Specialization of the OutrankingDigraph class for generating temporary Digraphs from random performance tableaux.

class `outrankingDigraphs.`**`RandomOutrankingDigraph`**(*numberOfActions=7, numberOfCriteria=7, weightDistribution='random', weightScale=[1, 10], commonScale=[0.0, 100.0], commonThresholds=[(10.0, 0.0), (20.0, 0.0), (80.0, 0.0), (80.0, 0.0)], commonMode=('uniform', None, None), hasBipolarVeto=True, Normalized=False*)

Bases: `outrankingDigraphs.RandomBipolarOutrankingDigraph`

Dummy for obsolete RandomOutrankingDigraph Class

class `outrankingDigraphs.`**`RobustOutrankingDigraph`**(*filePerfTab=None, Debug=False, hasNoVeto=True*)

Bases: `outrankingDigraphs.BipolarOutrankingDigraph`, `perfTabs.PerformanceTableau`

Parameters: performanceTableau (fileName of valid py code)

Specialization of the general OutrankingDigraph class for robustness anaylsis.

`saveAMPLDataFile`(*name='temp', Unique=False, Comments=True*)
save the ampl reverse data for cplex

`saveXMLRubisOutrankingDigraph`(*name='temp', category='Rubis outranking robustness digraph', subcategory='Choice recommendation', author='digraphs Module (RB)', reference='saved from Python', comment=True, servingD3=True*)
save complete robust Rubis problem and result in XML format with unicode encoding.

`showRelationTable`()
specialisation for integer values

class `outrankingDigraphs.`**`RubisRestServer`**(*host='http://leopold-loewenheim.uni.lu/cgi-bin/xmlrpc_cgi.py', Debug=False*)

Bases: `xmlrpc.client.ServerProxy`

xmlrpc-cgi Proxy Server for accessing on-line a Rubis Rest Solver.

Parameters:

- performanceTableau (fileName of valid XMCDA2 code, required)
- coalition (sublist of criteria, optional)

Example Python3 session:

```
>>> from outrankingDigraphs import RubisRestServer
>>> solver = RubisRestServer()
>>> solver.ping()
*************************************************
* This is the Leopold-Loewenheim Apache Server  *
* of the University of Luxembourg.             *
* Welcome to the Rubis XMCDA 2.0 Web service    *
* R. Bisdorff (c) 2009-2013                    *
* November 2013, version REST/D4 1.1           *
*************************************************
>>> from perfTabs import RandomCBPerformanceTableau
>>> t = RandomCBPerformanceTableau(numberOfActions=5,numberOfCriteria=7)
>>> solver.submitProblem(t)
The problem submission was successful !
```

```
Server ticket: l4qfAP0RfBBvyjsL
>>> solver.viewSolution()
Created new window in existing browser session.
>>> solver.saveXMCDA2Solution()
The solution request was successful.
Saving XMCDA 2.0 encoded solution in file Solutionl4qfAP0RfBBvyjsL.xml
>>> ...
```

ping (*Debug=False*)

saveXMCDA2Solution (*fileName=None*, *Debug=False*)
Save the solution in XMCDA 2.0 encoding.

showSolution (*ticket=None*, *valuation=None*)
Show XMCDA 2.0 solution in a default browser window. The valuation parameter may set the correct style sheet.

Parameter:

- valuation: 'bipolar' or 'robust'. By default the valuation type is set automatically at problem submission.

submitProblem (*perfTab*, *valuation='bipolar'*, *hasVeto=True*, *argTitle='XMCDA 2.0 encoding'*, *Debug=False*)
Submit PerformanceTableau class instances.

Parameter:

- valuation: 'bipolar', 'robust', 'integer'

submitXMCDA2Problem (*fileName*, *valuation=None*, *Debug=False*)
Submit stored XMCDA 2.0 encoded performance tableau.

> **Warning:** An <_.xml> file extension is assumed !

class outrankingDigraphs.**StochasticBipolarOutrankingDigraph** (*argPerfTab=None*, *sampleSize=50*, *samplingSeed=None*, *distribution='triangular'*, *spread=1.0*, *likelihood=0.9*, *coalition=None*, *hasNoVeto=False*, *hasBipolarVeto=True*, *Normalized=False*, *Debug=False*, *SeeSampleCounter=False*)

Bases: outrankingDigraphs.BipolarOutrankingDigraph

Stochastic bipolar outranking digraph base on multiple criteria of uncertain significance.

The digraph's bipolar valuation represents the median of sampled outranking relations with a sufficient likelihood (default = 90%) to remain positive, repectively negative, over the possible criteria significance ranges.

Each criterion i' significance weight is supposed to be a triangular random variables of mode w_i in the range 0 to 2*w_i.

Parameters:

- argPerfTab: PerformanceTableau instance or the name of a stored one. If None, a random instance is generated.

- sampleSize: number of random weight vectors used for Monte Carlo simulation.
- distribution: {triangular|uniform|beta(2,2)|beta(12,12)}, probability distribution used for generating random weights
- spread: weight range = weight mode +- (weight mode * spread)
- likelihood: 1.0 - frequency of valuations of opposite sign compared to the median valuation.
- other standard parameters from the BipolarOutrankingDigraph class (see documentation).

computeCDF (*x*, *y*, *rValue*)
computes by interpolation the likelihood of a given rValue with respect to the sampled r(x,y) valuations.

Parameters:

- action key x
- action key y
- r(x,y)

showRelationStatistics (*argument='likelihoods'*, *actionsSubset=None*, *hasLatexFormat=False*)
prints the relation statistics in actions X actions table format.

showRelationTable (*IntegerValues=False*, *actionsSubset=None*, *hasLPDDenotation=False*, *hasLatexFormat=False*, *hasIntegerValuation=False*, *relation=None*)
specialising BipolarOutrankingDigraph.showRelationTable() for stochstic instances.

class outrankingDigraphs.**UnanimousOutrankingDigraph** (*argPerfTab=None*, *coalition=None*, *hasNoVeto=False*)
Bases: outrankingDigraphs.OutrankingDigraph, perfTabs.PerformanceTableau

Parameters: performanceTableau (fileName of valid py code)

Specialization of the general OutrankingDigraph class for temporary unanimous outranking digraphs

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1.2.6 votingDigraphs module

class votingDigraphs.**ApprovalVotingProfile** (*fileVotingProfile=None*)
Bases: votingDigraphs.VotingProfile

A specialised class for approval voting profiles

Structure:

```
candidates = {'a':  ,'b':  ,'c', ..., ...}
voters = {'1':{'weight':1.0},'2':{'weight':1.0}, ...}
## each specifies the subset of candidates he approves on
approvalBallot = {
    '1' : ['b'],
    '2' : ['a','b'],
    ...
    }
```

computeBallot (*approvalEquivalence=False*, *disapprovalEquivalence=False*)
Computes a complete ballot from the approval Ballot.

Parameters: approvalEquivalence=False, disapprovalEquivalence=False.

save (*name='tempAVprofile'*)
Persistant storage of an approval voting profile.

Parameter: name of file (without <.py> extension!).

showResults()
Renders the votes obtained by each candidates.

class votingDigraphs.**CondorcetDigraph**(*argVotingProfile=None*, *approvalVoting=False*, *coalition=None*, *majorityMargins=False*, *hasIntegerValuation=False*)

Bases: digraphs.Digraph

Specialization of the general Digraph class for generating bipolar-valued marginal pairwise majority difference digraphs.

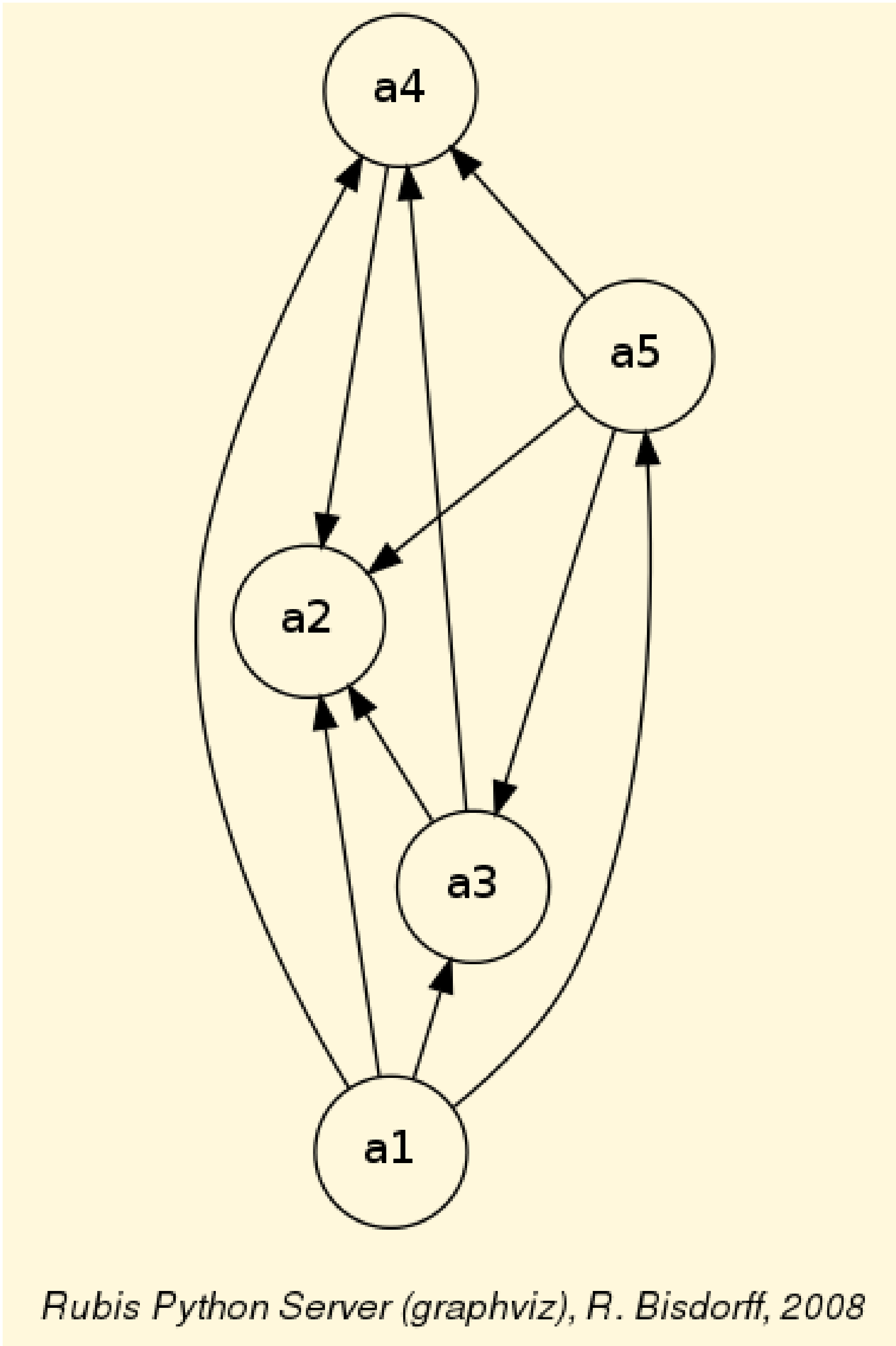
Parameters:

stored voting profile (fileName of valid py code) or voting profile object

optional, coalition (sublist of voters)

Example Python3 session

```
>>> from votingDigraphs import *
>>> v = RandomLinearVotingProfile(numberOfVoters=101,numberOfCandidates=5)
>>> v.showLinearBallots()
v101(1.0):   ['a5', 'a1', 'a2', 'a4', 'a3']
v100(1.0):   ['a4', 'a1', 'a5', 'a3', 'a2']
v89(1.0):    ['a4', 'a5', 'a1', 'a2', 'a3']
v88(1.0):    ['a3', 'a2', 'a5', 'a1', 'a4']
v87(1.0):    ['a5', 'a2', 'a4', 'a3', 'a1']
v86(1.0):    ['a5', 'a3', 'a1', 'a4', 'a2']
v85(1.0):    ['a5', 'a3', 'a2', 'a4', 'a1']
v84(1.0):    ['a3', 'a1', 'a2', 'a4', 'a5']
...
...
>>> g = CondorcetDigraph(v,hasIntegerValuation=True)
>>> g.showRelationTable()
* ---- Relation Table -----
 S   |  'a1'  'a2'   'a3'   'a4'  'a5'
-----|------------------------------------------------------------
'a1' |   -     33     9      11    21
'a2' |  -33    -     -19     -1    -5
'a3' |  -9     19    -       5     -1
'a4' |  -11    1      -5     -     -9
'a5' |  -21    5       1     9      -
>>> g.computeCondorcetWinner()
['a1']
>>> g.exportGraphViz()
*---- exporting a dot file dor GraphViz tools ---------*
Exporting to rel_randLinearProfile.dot
dot -Grankdir=BT -Tpng rel_randLinearProfile.dot -o rel_randLinearProfile.png
```



computeArrowRaynaudRanking(*linearOrdered=True*, *Debug=False*)
Renders a ranking of the actions following Arrow&Raynaud's rule.

computeCondorcetWinner()
compute the Condorcet winner(s) renders always a, potentially empty, list

computeKohlerRanking (*linearOrdered=True*, *Debug=False*)
Renders a ranking of the actions following Kohler's rule.

constructApprovalBallotRelation (*hasIntegerValuation=False*)
Renders the votes differences between candidates on the basis of an approval ballot.

constructBallotRelation (*hasIntegerValuation*)
Renders the marginal majority between candidates on the basis of a complete ballot.

constructMajorityMarginsRelation (*hasIntegerValuation=True*)
Renders the marginal majority between candidates on the basis of an approval ballot.

class votingDigraphs.**LinearVotingProfile** (*fileVotingProfile=None*, *numberOfCandidates=5*, *numberOfVoters=9*)

Bases: votingDigraphs.VotingProfile

A specialised class for linear voting profiles

Structure:

```
candidates = {'a': ,'b':  ,'c', ..., ...}
voters = {'1':{'weight':1.0},'2':{'weight':1.0}, ...}
## each specifies a a ranked list of candidates
## from the best to the worst
linearBallot = {
    '1' : ['b','c','a', ...],
    '2' : ['a','b','c', ...],
    ...
    }
```

Sample Python3 session

```
>>> from votingDigraphs import *
>>> v = RandomLinearVotingProfile(numberOfVoters=5,numberOfCandidates=3)
>>> v.showLinearBallots()
voters(weight)        candidates rankings
v4(1.0):      ['a1', 'a2', 'a3']
v5(1.0):      ['a1', 'a2', 'a3']
v1(1.0):      ['a2', 'a1', 'a3']
v2(1.0):      ['a1', 'a2', 'a3']
v3(1.0):      ['a1', 'a3', 'a2']
>>> v.computeRankAnalysis()
{'a1': [4.0, 1.0, 0],
 'a2': [1.0, 3.0, 1.0],
 'a3': [0, 1.0, 4.0]}
>>> v.computeUninominalVotes()
{'a1': 4.0, 'a3': 0, 'a2': 1.0}
>>> v.computeSimpleMajorityWinner()
['a1']
>>> v.computeBordaScores()
{'a1': 6.0, 'a3': 14.0, 'a2': 10.0}
>>> v.computeBordaWinners()
['a1']
>>> v.computeInstantRunoffWinner()
['a1']
```

computeBallot ()
Computes a complete ballot from the linear Ballot.

computeBordaScores ()
compute Borda scores from the rank analysis

computeBordaWinners()
compute the Borda winner from the Borda scores, ie the list of candidates with the minimal Borda score.

computeInstantRunoffWinner(*Comments=False*)
compute the instant runoff winner from a linear voting ballot

computeRankAnalysis()
compute the number of ranks each candidate obtains

computeSimpleMajorityWinner(*Comments=False*)
compute the winner in a uninominal Election from a linear ballot

computeUninominalVotes(*candidates=None*, *linearBallot=None*)
compute uninominal votes for each candidate in candidates sublist and restricted linear ballots

save(*name='templinearprofile'*)
Persistant storage of a linear voting profile.

Parameter: name of file (without <.py> extension!).

showLinearBallots()
show the linear ballots

class `votingDigraphs.`**RandomApprovalVotingProfile**(*numberOfVoters=9*, *numberOfCandidates=5*, *minSizeOfBallot=1*, *maxSizeOfBallot=2*)
Bases: `votingDigraphs.ApprovalVotingProfile`

A specialized class for approval voting profiles.

generateRandomApprovalBallot(*minSizeOfBallot*, *maxSizeOfBallot*)
Renders a randomly generated approval ballot.

class `votingDigraphs.`**RandomLinearVotingProfile**(*seed=None*, *numberOfVoters=9*, *numberOfCandidates=5*)
Bases: `votingDigraphs.LinearVotingProfile`

A specialized class for random linwear voting profiles.

generateRandomLinearBallot(*seed*)
Renders a randomly generated linear ballot.

class `votingDigraphs.`**RandomVotingProfile**(*numberOfVoters=9*, *numberOfCandidates=5*, *hasRandomWeights=False*, *maxWeight=10*, *seed=None*, *Debug=False*)
Bases: `votingDigraphs.VotingProfile`

A subclass for generating random voting profiles.

generateRandomBallot(*seed*, *Debug=False*)
Renders a randomly generated approval ballot from a shuffled list of candidates for each voter.

class `votingDigraphs.`**VotingProfile**(*fileVotingProfile=None*)
Bases: `builtins.object`

A general class for storing voting profiles.

General structure:

```
candidates = {'a': ...,'b': ...,'c': ...,  ... }
voters = {
'1':{'weight':1.0},
'2':{'weight':1.0},
...,
}
```

```
ballot = {      # voters x candidates x candidates
    '1': {      # bipolar characteristic {-1,0,1} of each voter's
          'a': { 'a':0,'b':-1,'c':0, ...},   # pairwise preferences
          'b': { 'a':1,'b':0, 'c':1, ...},
          'c': { 'a':0,'b':-1,'c':0, ...},
          ...,
    },
    '2': { 'a': { 'a':0, 'b':0, 'c':1, ...},
           'b': { 'a':0, 'b':0, 'c':1, ...},
           'c': { 'a':-1,'b':-1,'c':0, ...},
           ...,
    },
    ...,
}
```

save (*name='tempVprofile'*)
Persistant storage of an approval voting profile.

showAll (*WithBallots=True*)
Show method for <VotingProfile> instances.

showVoterBallot (*voter*, *hasIntegerValuation=False*)
Show the actual voting of a voter.

Back to the *Introduction*

1.2.7 sortingDigraphs module

class sortingDigraphs.**OptimalQuantilesSortingDigraph** (*argPerfTab=None*, *minQuantiles=4*, *maxQuantiles=50*, *LowerClosed=True*, *PrefThresholds=True*, *hasNoVeto=False*, *minValuation=-100.0*, *maxValuation=100.0*, *outrankingType='bipolar'*, *Prudent=False*, *Threading=False*, *Debug=False*)

Bases: sortingDigraphs.QuantilesSortingDigraph

Specialisation of the QuantilesSortingDigraph Class for optimal sorting of alternatives into quantiles delimited ordered classes.

class sortingDigraphs.**QuantilesSortingDigraph** (*argPerfTab=None*, *limitingQuantiles=None*, *LowerClosed=True*, *PrefThresholds=True*, *hasNoVeto=False*, *minValuation=-1.0*, *maxValuation=1.0*, *outrankingType='bipolar'*, *CompleteOutranking=True*, *Threading=False*, *Debug=False*)

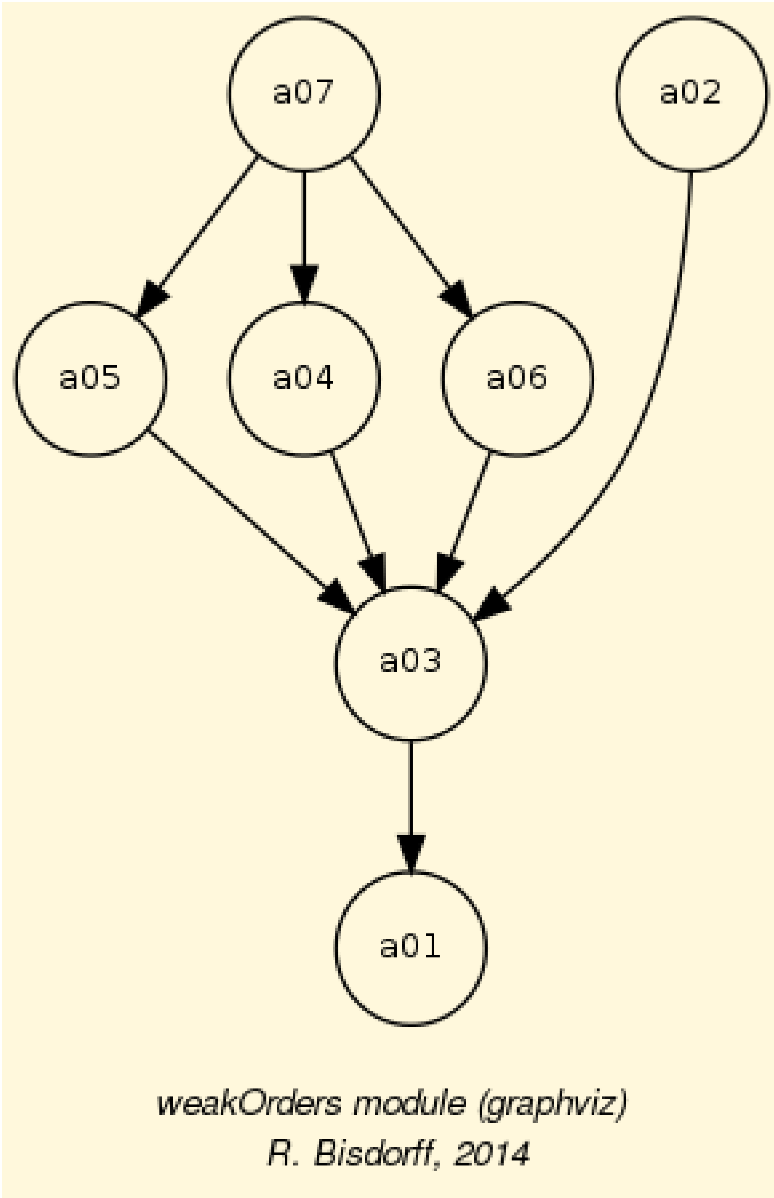
Bases: sortingDigraphs.SortingDigraph, weakOrders.WeakOrder

Specialisation of the sortingDigraph Class for sorting of alternatives into quantiles delimited ordered classes.

Note: We generally require an PerformanceTableau instance or a valid filename. If none is given, then a default profile with the limiting quartiles Q0,Q1,Q2, Q3 and Q4 is used on each criteria. By default lower closed limits of categories are supposed to be used in the sorting.

Example Python3 session:

```
>>> from sortingDigraphs import *
>>> t = RandomCBPerformanceTableau(numberOfActions=7,numberOfCriteria=5,
...                                 weightDistribution='equiobjectives')
>>> qs = QuantilesSortingDigraph(t,limitingQuantiles=10)
>>> qs.showSorting()
*--- Sorting results in descending order ---*
[0.90 - <[:         []
[0.80 - 0.90[:      []
[0.70 - 0.80[:      []
[0.60 - 0.70[:      ['a02', 'a07']
[0.50 - 0.60[:      ['a02', 'a04', 'a05', 'a06']
[0.40 - 0.50[:      []
[0.30 - 0.40[:      []
[0.20 - 0.30[:      ['a03']
[0.10 - 0.20[:      ['a01']
[0.00 - 0.10[:      []
>>> qs.exportGraphViz('quantilesSorting')
```



computeSortingRelation(*categoryContents=None*, *Debug=False*)
constructs a bipolar sorting relation using the category contents.

showActionCategories(*action*, *Debug=False*, *Comments=True*)
Renders the union of categories in which the given action is sorted positively or null into. Returns a tuple : action, lowest category key, highest category key, membership credibility !

showActionsSortingResult(*actionSubset=None*)
shows the quantiles sorting result all (default) of a subset of the decision actions.

showSorting(*Reverse=True*, *isReturningHTML=False*, *Debug=False*)
Shows sorting results in decreasing or increasing (Reverse=False) order of the categories. If isReturningHTML is True (default = False) the method returns a htlm table with the sorting result.

showWeakOrder(*Descending=True*)
Specialisation for QauntilesSortingDigraphs.

class `sortingDigraphs.`**`SortingDigraph`**(*argPerfTab=None*, *argProfile=None*, *scaleSteps=5*, *minValuation=-100.0*, *maxValuation=100.0*, *isRobust=False*, *hasNoVeto=False*, *lowerClosed=True*, *Threading=False*, *Debug=False*)

Bases: `outrankingDigraphs.BipolarOutrankingDigraph`, `perfTabs.PerformanceTableau`

Specialisation of the digraphs.BipolarOutrankingDigraph Class for Condorcet based multicriteria sorting of alternatives.

Besides a valid PerformanceTableau instance we require a sorting profile, i.e.:

- a dictionary <categories> of categories with 'name', 'order' and 'comment'
- a dictionary <criteriaCategoryLimits> with double entry:

  [criteriakey][categoryKey] containing a ['minimum'] and a ['maximum'] value in the scale of the criterion respecting the order of the categories.

Template of required data:

```
self.categories = {'c01': { 'name': 'week','order': 0,
                          'comment': 'lowest category',},
                   'c02': { 'name': 'ok','order': 1,
                          'comment': 'medium category',},
                   'c03': { 'name': 'good','order': 2,
                          'comment': 'highest category',},
                   'c04': { 'name': 'excellent','order': 3,
                          'comment': 'highest category',},
}
self.criteriaCategoryLimits['lowerClosed'] = True # default
self.criteriaCategoryLimits[g] = {
        'c01': {'minimum':0, 'maximum':25},
        'c02': {'minimum':25, 'maximum':50},
        'c03': {'minimum':50, 'maximum':75},
        'c04': {'minimum':75, 'maximum':120},
 }
```

A template named tempProfile.py is providied in the digraphs module distribution.

Note: We generally require a performanceTableau instance and a filename where categories and a profile my be read from. If no such filename is given, then a default profile with five, equally spaced, categories is used on each criteria. By default lower-closed limts of categories are supposed to be used in the sorting.If no performance tableau instance is given, a standard random instance with 10 actions and 13 criteria is generated by default.

Example Python3 session

```
>>> from sortingDigraphs import SortingDigraph
>>> s = SortingDigraph() %% Based on a random performance tableau
>>> [x for x in s.actions]
['a07', 'a06', 'a05', 'a04', 'a03', 'a02', 'a01', 'a10', 'a09', 'a08']
>>> s.showSorting()
*--- Sorting results in descending order ---*
]> - 100]:   []
]100 - 80]:  ['a03', 'a09']
]80 - 60]:   ['a02', 'a04', 'a05', 'a06', 'a07', 'a08']
]60 - 40]:   ['a01', 'a10']
]40 - 20]:   []
]20 - 0]:    []
>>> s.showSortingCharacteristics('a10')
x  in  K_k    r(x >= m_k)   r(x < M_k)  r(x in K_k)
```

```
a10 in [0-20[    100.00      -85.98       -85.98
a10 in [20-40[    85.98      -49.53       -49.53
a10 in [40-60[    49.53       20.56        20.56
a10 in [60-80[   -20.56       34.58       -20.56
a10 in [80-100[  -34.58      100.00       -34.58
a10 in [100-<[  -100.00      100.00      -100.00
>>> from outrankingDigraphs import BipolarOutrankingDigraph
>>> g = BipolarOutrankingDigraph(s)
>>> g.computeOrdinalCorrelation(s)
{'determination': Decimal('0.24382139148494288681204569O4'),
'MedianCut': False,
'correlation': Decimal('0.6482112436115843270868824533')}
>>>
```

computeCategoryContents(*Reverse=False*, *Comments=False*)
Computes the sorting results per category.

computeSortingCharacteristics(*action=None*, *Comments=False*)
Renders a bipolar-valued bi-dictionary relation representing the degree of credibility of the assertion that "action x in A belongs to category c in C", ie x outranks low category limit and does not outrank the high category limit.

computeSortingRelation(*categoryContents=None*, *Debug=False*)
constructs a bipolar sorting relation using the category contents.

computeWeakOrder(*Descending=True*, *Debug=False*)
Specialisation for QuantilesSortingDigraphs.

exportDigraphGraphViz(*fileName=None*, *bestChoice=set()*, *worstChoice=set()*, *noSilent=True*, *graphType='png'*, *graphSize='7, 7'*)
export GraphViz dot file for digraph drawing filtering.

exportGraphViz(*fileName=None*, *direction='decreasing'*, *noSilent=True*, *graphType='png'*, *graphSize='7, 7'*, *fontSize=10*, *Debug=False*)
export GraphViz dot file for weak order (Hasse diagram) drawing filtering from SortingDigraph instances.

getActionsKeys(*action=None*)
extract normal actions keys()

htmlCriteriaCategoryLimits(*tableTitle='Category limits'*)
Renders category minimum and maximum limits for each criterion as a html table.

orderedCategoryKeys(*Reverse=False*)
Renders the ordered list of category keys based on self.categories['order'] numeric values.

saveProfilesXMCDA2(*fileName='temp'*, *category='XMCDA 2.0 format'*, *user='sortinDigraphs Module (RB)'*, *version='saved from Python session'*, *title='Sorting categories in XMCDA-2.0 format.'*, *variant='Rubis'*, *valuationType='bipolar'*, *isStringIO=False*, *stringNA='NA'*, *comment='produced by saveProfilesXMCDA2()'*)
Save profiles object self in XMCDA 2.0 format.

showCriteriaCategoryLimits()
Shows category minimum and maximum limits for each criterion.

showOrderedRelationTable(*direction='decreasing'*)
Showing the relation table in decreasing (default) or increasing order.

showSorting(*Reverse=True*, *isReturningHTML=False*)
Shows sorting results in decreasing or increasing (Reverse=False) order of the categories. If isReturningHTML is True (default = False) the method returns a htlm table with the sorting result.

showSortingCharacteristics(*action=None*)
Renders a bipolar-valued bi-dictionary relation representing the degree of credibility of the assertion that "action x in A belongs to category c in C", ie x outranks low category limit and does not outrank the high category limit.

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1.2.8 linearOrders module

class linearOrders.**ExtendedPrudentDigraph**(*other*, *prudentBetaLevel=None*, *CoDual=False*, *Debug=False*)
Bases: digraphs.Digraph

Instantiates the associated extended prudent codual of the digraph enstance. Instantiates as other.__class__ ! Copies the case given the description, the criteria and the evaluation dictionary into self.

class linearOrders.**KemenyOrder**(*other*, *orderLimit=7*, *Debug=False*)
Bases: linearOrders.LinearOrder

instantiates the exact Kemeny Order from a given bipolar-valued Digraph instance of small order

class linearOrders.**KohlerOrder**(*other*, *coDual=True*, *Debug=False*)
Bases: linearOrders.LinearOrder

instantiates the Kohler Order from a given bipolar-valued Digraph instance

class linearOrders.**LinearOrder**(*file=None*, *order=7*)
Bases: digraphs.Digraph

abstract class for digraphs which represent linear orders.

computeKemenyIndex(*other*)
renders the Kemeny index of the self.relation (linear order) compared with a given bipolar-valued relation of a compatible other digraph (same nodes or actions).

computeOrder()
shows the linear order of an instance of the LinearOrcer class

exportDigraphGraphViz(*fileName=None*, *bestChoice=set()*, *worstChoice=set()*, *noSilent=True*, *graphType='png'*, *graphSize='7, 7'*)
export GraphViz dot file for digraph drawing filtering.

exportGraphViz(*fileName=None*, *isValued=True*, *bestChoice=set()*, *worstChoice=set()*, *noSilent=True*, *graphType='png'*, *graphSize='7, 7'*)
export GraphViz dot file for linear order drawing filtering.

htmlOrder()
returns the html encoded presentation of a linear order

class linearOrders.**NetFlowsOrder**(*other*, *coDual=False*, *Debug=False*)
Bases: linearOrders.LinearOrder

instantiates the net flows Order from a given bipolar-valued Digraph instance

class linearOrders.**PrincipalOrder**(*other*, *Colwise=True*, *imageType=None*, *plotFileName='principalOrdering'*, *Debug=False*)
Bases: linearOrders.LinearOrder

instantiates the order from the scores obtained by the first princiapl axis of the eigen deomposition of the covariance of the outdegrees of the valued digraph 'other'.

class `linearOrders.`**`RandomLinearOrder`**(*numberOfActions=10, Debug=False, OutrankingModel=False*)

Bases: `linearOrders.LinearOrder`

Instantiates random linear orders

class `linearOrders.`**`RankedPairsOrder`**(*other, coDual=False, Cpp=False, isValued=False, isExtendedPrudent=False, Debug=False*)

Bases: `linearOrders.LinearOrder`

instantiates the Extended Prudent Ranked Pairs Order from a given bipolar-valued Digraph instance

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1.2.9 weakOrders module

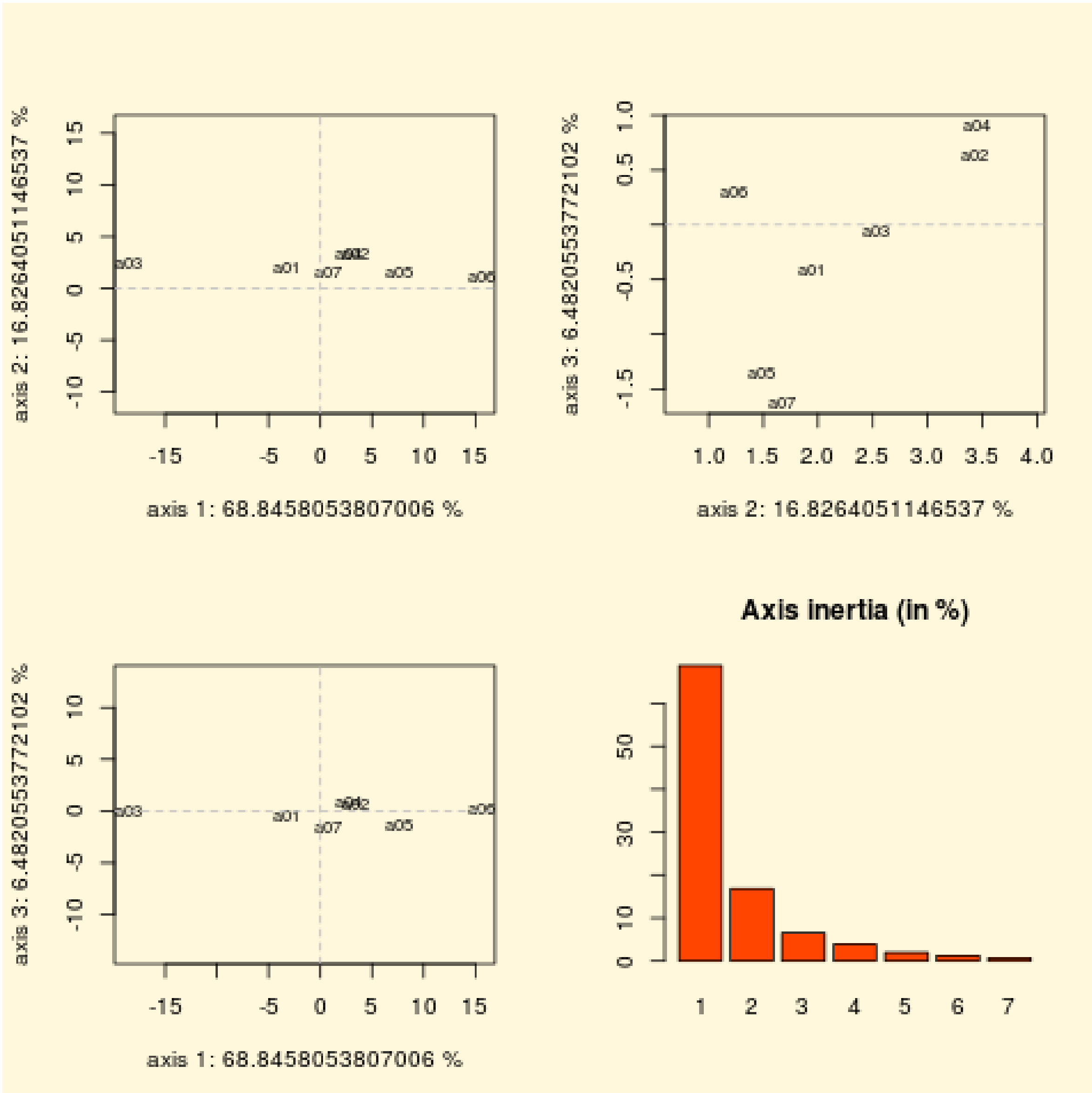
class `weakOrders.`**`PrincipalInOutDegreesOrdering`**(*other, fusionOperator='o-max', imageType=None, plotFileName=None, Threading=True, Debug=False*)

Bases: `weakOrders.WeakOrder`

Specialization of abstract WeakOrder class for ranking by fusion of the principal orders of the variance-covariance of in- (Colwise) and outdegrees (Rowwise).

Example Python3 session with same outranking digraph g as shown in the RankingByChoosingDigraph example session (see below).

```
>>> from weakOrders import PrincipalInOutDegreesOrdering
>>> pro = PrincipalInOutDegreesOrdering(g,imageType="png",\
                plotFileName="proWeakOrdering")
>>> pro.showWeakOrder()
Ranking by Choosing and Rejecting
 1st ranked ['a06'] (1.00)
   2nd ranked ['a05'] (1.00)
     3rd ranked ['a02'] (1.00)
       4th ranked ['a04'] (1.00)
       4th last ranked ['a04'] (1.00)
     3rd last ranked ['a07'] (1.00)
   2nd last ranked ['a01'] (1.00)
 1st last ranked ['a03'] (1.00)
>>> pro.showPrincipalScores(ColwiseOrder=True)
List of principal scores
Column wise covariance ordered
action       colwise         rowwise
a06          15.52934        13.74739
a05          7.71195         4.95199
a02          3.40812         0.70554
a04          2.76502         0.15189
a07          0.66875         -1.77637
a01          -3.19392        -5.36733
a03          -18.51409       -21.09102
```



computeWeakOrder (*ColwiseOrder=False*)
: Specialisation for PrincipalInOutDegreesOrderings.

exportGraphViz (*fileName=None*, *direction='ColwiseOrder'*, *Comments=True*, *graphType='png'*, *graphSize='7, 7'*, *fontSize=10*)
: Specialisation for PincipalInOutDegrees class.

  direction = "Colwise" (best to worst, default) | "Rowwise" (worst to best)

showPrincipalScores (*ColwiseOrder=False*, *RowwiseOrder=False*)
: showing the principal in- (Colwise) and out-degrees (Rowwise) scores.

showWeakOrder (*ColwiseOrder=False*)
: Specialisation for PrincipalInOutDegreesOrderings.

class weakOrders.**QsRbcWeakOrdering**(*argPerfTab=None*, *limitingQuantiles=None*, *LowerClosed=True*, *PrefThresholds=True*, *hasNoVeto=False*, *minValuation=-1.0*, *maxValuation=1.0*, *outrankingType='bipolar'*, *Threading=True*, *cores=None*, *Comments=True*, *Debug=False*)

Bases: weakOrders.WeakOrder, sortingDigraphs.SortingDigraph

Refinig a quantiles sorting result with a ranking-by-choosing of the local quantile equivalence classes of less than 50 items. For larger quantile equivalence classes, Tideman's ranked pairs heuristic is used insted.

***Parameter*:**

- limitingQuantiles are set by default to len(actions)//2 for outranking digraph orders below 200. For higher orders, centiles are used by default.
- threading is on by default for cpu with more than 2 cores.

Note: The weakording is instantiated as strict ordering! And for larger orders a consistent size of several Giga bytes cpu memory is required.

---

computeQsRbcRanking(*DescendingOrder=True*, *Comments=False*, *Debug=False*)

Render the ranking result of QsRbcWeakOrdering constructor

computeWeakOrder(*DescendingOrder=True*, *Comments=False*, *Debug=False*)

specialisation of the showWeakOrder method

showActionCategories(*action*, *Debug=False*, *Comments=True*)

Renders the union of categories in which the given action is sorted positively or null into. Returns a tuple : action, lowest category key, highest category key, membership credibility !

showActionsSortingResult(*actionSubset=None*)

shows the quantiles sorting result all (default) of a subset of the decision actions.

showOrderedRelationTable(*direction='decreasing'*, *originalRelation=False*)

Showing the relation table in decreasing (default) or increasing order.

showQsRbcRanking(*DescendingOrder=True*)

show the ranking-by-sorting refinement of the quantiles sorting result

class weakOrders.**RankingByBestChoosingDigraph**(*digraph*, *Normalized=True*, *CoDual=False*, *Debug=False*)

Bases: weakOrders.RankingByChoosingDigraph

Specialization of abstract WeakOrder class for computing a ranking by best-choosing.

showWeakOrder()

Specialisation of showWeakOrder() for ranking-by-best-choosing results.

class weakOrders.**RankingByChoosingDigraph**(*other*, *fusionOperator='o-max'*, *CoDual=False*, *Debug=False*, *CppAgrum=False*, *Threading=True*)

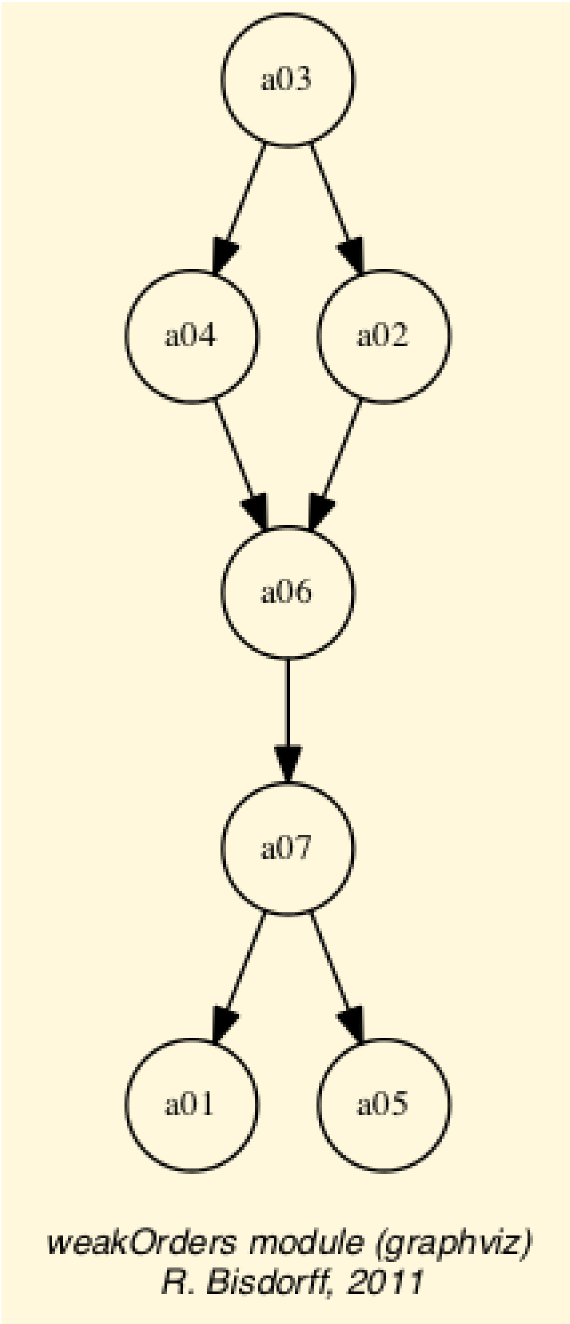
Bases: weakOrders.WeakOrder

Specialization of the abstract WeakOrder class for ranking-by-Rubis-choosing orderings.

Example python3 session:

```
>>> from outrankingDigraphs import *
>>> t = RandomCBPerformanceTableau(numberOfActions=7,\
          numberOfCriteria=5,\
          weightDistribution='equiobjectives')
>>> g = BipolarOutrankingDigraph(t,Normalized=True)
```

```
>>> g.showRelationTable()
* ---- Relation Table -----
  S    |   'a01'  'a02'  'a03'  'a04'  'a05'  'a06'  'a07'
 -----|-----------------------------------------------------------
'a01' |   +0.00  -1.00  -1.00  -0.33  +0.00  +0.00  +0.00
'a02' |   +1.00  +0.00  -0.17  +0.33  +1.00  +0.33  +0.67
'a03' |   +1.00  +0.67  +0.00  +0.33  +0.67  +0.67  +0.67
'a04' |   +0.33  +0.17  -0.33  +0.00  +1.00  +0.67  +0.67
'a05' |   +0.00  -0.67  -0.67  -1.00  +0.00  -0.17  +0.33
'a06' |   +0.33  +0.00  -0.33  -0.67  +0.50  +0.00  +1.00
'a07' |   +0.33  +0.00  -0.33  -0.67  +0.50  +0.17  +0.00
>>> from weakOrders import RankingByChoosingDigraph
>>> rbc = RankingByChoosingDigraph(g)
>>> rbc.showWeakOrder()
Ranking by Choosing and Rejecting
  1st ranked ['a03'] (0.47)
   2nd ranked ['a02', 'a04'] (0.58)
    3rd ranked ['a06'] (1.00)
    3rd last ranked ['a06'] (1.00)
   2nd last ranked ['a07'] (0.50)
  1st last ranked ['a01', 'a05'] (0.58)
>>> rbc.exportGraphViz('weakOrdering')
*---- exporting a dot file for GraphViz tools ---------*
Exporting to converse-dual_rel_randomCBperftab.dot
dot -Grankdir=BT -Tpng converse-dual_rel_randomCBperftab.dot
   -o weakOrdering.png
```




```
>>> rbc.showOrderedRelationTable(direction="decreasing")
* ---- Relation Table -----
  S    |  'a03'  'a04'  'a02'  'a06'  'a07'  'a01'  'a05'
 -----|------------------------------------------------------------
'a03' |   -      0.33   0.17   0.33   0.33   1.00   0.67
'a04' |  -0.33    -     0.00   0.67   0.67   0.33   1.00
'a02' |  -0.17   0.00    -     0.33   0.67   1.00   0.67
'a06' |  -0.33  -0.67  -0.33    -     0.17   0.33   0.17
'a07' |  -0.33  -0.67  -0.67  -0.17    -     0.33   0.33
'a01' |  -1.00  -0.33  -1.00  -0.33  -0.33    -     0.00
'a05' |  -0.67  -1.00  -0.67  -0.17  -0.33   0.00    -
```

computeRankingByBestChoosing (*Forced=False*)
Dummy for blocking recomputing without forcing.

computeRankingByLastChoosing (*Forced=False*)
Dummy for blocking recomputing without forcing.

showRankingByChoosing (*rankingByChoosing=None*)
Dummy for showWeakOrder method

class `weakOrders.`**RankingByLastChoosingDigraph** (*digraph*, *Normalized=True*, *CoDual=False*, *Debug=False*)
Bases: `weakOrders.RankingByChoosingDigraph`

Specialization of abstract WeakOrder class for computing a ranking by rejecting.

showWeakOrder ()
Specialisation of showWeakOrder() for ranking-by-last-choosing results.

class `weakOrders.`**RankingByPrudentChoosingDigraph** (*digraph*, *CoDual=False*, *Normalized=True*, *Odd=True*, *Limited=0.2*, *Comments=False*, *Debug=False*, *SplitCorrelation=True*)
Bases: `weakOrders.RankingByChoosingDigraph`

Specialization for ranking-by-rejecting results with prudent single elimination of chordless circuits. By default, the cut level for circuits elimination is set to 20% of the valuation domain maximum (1.0).

class `weakOrders.`**WeakOrder** (*file=None*, *order=7*)
Bases: `digraphs.Digraph`

Abstract class for weak orderings' specialized methods.

exportDigraphGraphViz (*fileName=None*, *bestChoice=set()*, *worstChoice=set()*, *noSilent=True*, *graphType='png'*, *graphSize='7, 7'*)
export GraphViz dot file for digraph drawing filtering.

exportGraphViz (*fileName=None*, *direction='best'*, *noSilent=True*, *graphType='png'*, *graphSize='7, 7'*, *fontSize=10*)
export GraphViz dot file for weak order (Hasse diagram) drawing filtering.

showOrderedRelationTable (*direction='decreasing'*, *originalRelation=False*)
Showing the relation table in decreasing (default) or increasing order.

showRankingByChoosing (*actionsList=None*, *rankingByChoosing=None*)
Dummy name for showWeakOrder() method

showWeakOrder (*rankingByChoosing=None*)
A show method for self.rankinByChoosing result.

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REFERENCES

See Copyright

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