

Optimization for Non-Mathematicians

Drawing Graphs with Graphviz

MATLAB itself offers no possibility to draw graphs as in [Figure 1](#). For this reason we use the open source software **Graphviz** in this class. Graphviz consists of a series of executable programs (`dot`, `neato`, `fdp`, `sfdp`, `twopi` and `circo`) for the layout of graphs. These differ in the algorithms used to place the nodes.¹

There exists a MATLAB interface for Graphviz named `graphViz4Matlab`, which does not offer access to all capabilities, but is sufficient for our purpose. Especially for this class `graphViz4Matlab` has been equipped with several extensions² by us, which meanwhile have been included in the official version. In addition, a high level interface function `Graph` has been written, which further simplifies the usage of `graphViz4Matlab`.³

Installation of `graphViz4Matlab` and `Graph`

For the installation the following steps are necessary (*only once*). Please login under **Linux** in the MRZ computer pool.

- (a) Download the latest version of `graphViz4Matlab` by typing in the console:

```
svn checkout http://graphviz4matlab.googlecode.com/↔  
    svn/trunk/ graphViz4Matlab
```

The downloaded content can then be found in the subdirectory `graphViz4Matlab` (of the current directory).

- (b) Download the file `Graph.m` from the [homepage of the lecture](#) and save it in the above mentioned directory `graphViz4Matlab`.
- (c) For the transformation of adjacency to incidence matrices and vice versa we use the two files `adj2inc.m` and `inc2adj.m`. These can be found on the [homepage of the lecture](#) and also have to be saved in the directory `graphViz4Matlab`.
- (d) Download the file `setup_graph.sh` from the [homepage of the lecture](#) and save it in your home directory.

Subsequently you should follow the steps below *in every session* in which you would like to use `graphViz4Matlab`:

¹Anyone who is interested in more details will find the documentation for **Graphviz** under <http://www.graphviz.org/Documentation.php>, see e.g., the document [Using Graphviz as a library](#) (Drawing graphs with Graphviz).

²These concern the possibility to adjust the line style of the edges (`-edgeLineStyle`) and to attach labels to the edges (`-edgeLabels`).

³`Graph` enables us to draw a graph based on its incidence matrix ([Definition 13.4](#)), which is also used in the lecture. Since `graphViz4Matlab` expects an adjacency matrix ([Definition 13.3](#)), the incidence matrix is transformed first. Moreover the interface `Graph` facilitates the use of node and edge labels.

- (a) Execute the script `setup_graph.sh`, which sets several paths for Graphviz and `graphViz4Matlab`. To this end, type in the console:

```
source setup_graph.sh
```

The script will query the version of `dot` (one of the programs out of Graphviz suite); the output should look like:

```
dot - graphviz version 2.28.0 (20110708.1347)
```

- (b) Start MATLAB.

By calling (typing) `graphViz4Matlab` in the MATLAB window you should now see an example graph. Furthermore try the example programs `graphViz4MatlabDEMO1`, `graphViz4MatlabDEMO2` and `graphViz4MatlabDEMO3`.

Using Graph

First we generate the incidence matrix of a graph which we would like to draw — as seen in [Figure 1](#) top left. Then we call our Graph interface of `graphViz4Matlab`:

```
% Generate the incidence matrix for a transportation
% network with m = 9 nodes and n = 11 edges
A = ...
[ -1 -1  0  0  0  0  0  0  0  0  0; ...
  0  0 -1 -1  0  0  0  0  0  0  0; ...
  0  0  0  0 -1 -1  0  0  0  0  0; ...
  1  0  1  0  1  0 -1 -1 -1  0  0; ...
  0  1  0  1  0  1  1  0  0 -1 -1; ...
  0  0  0  0  0  0  0  1  0  0  0; ...
  0  0  0  0  0  0  0  0  1  0  0; ...
  0  0  0  0  0  0  0  0  0  1  0; ...
  0  0  0  0  0  0  0  0  0  0  1];

% Draw the graph
h = Graph(A);
```

The return value `h` is a handle for the generated `graphViz4Matlab` object.⁴ Next we show how to change the standard labels $1, 2, \dots, m$ of the nodes to individual labels (see [Figure 1](#) top right):

```
% Set the node labels for the production sites,
% storage sites and points of sale
nodelabels = {'P1', 'P2', 'P3', 'Z1', 'Z2', 'V1', 'V2', 'V3', '↔
             V4'};

% Redraw the graph
h = Graph(A, h, nodelabels);
```

⁴We use the handle, among other things, to be able to overwrite the graph described by `h` in its window. This prevents a new window to be opened upon every call of `Graph`.

The edges can be labeled in a similar way (Figure 1 center left):

```
% Set additional edge labels
edgelabels = [0.8; 2.0; 2.5; 1.0; 1.2; 2.0; 1.0; 1.0; ↵
             1.0; 1.0; 1.0];
h = Graph(A,h,nodelabels,edgelabels);
```

Using the handle `h` we have access to the node positions and can change them to modify the default layout. As an example, we rotate the generated graph by 135 degree and scale it down slightly, so that it fits completely into the picture (Figure 1 center right):

```
% Set node positions XY manually
% Here: rotate graph about 135 degree
alpha = 135 * pi / 180;
R = [cos(alpha), -sin(alpha); sin(alpha), cos(alpha)];
XY = h.getNodePositions();
XY = XY - 0.5;           % shift to origin
XY = (R * XY')';       % rotate
XY = XY * 0.8;         % scale on 80%
XY(:,1) = XY(:,1) + 0.5; % shift back
XY(:,2) = XY(:,2) + 0.4; % shift back
h.setNodePositions(XY);
```

Finally we show the usage of two different layouts (Figure 1 bottom left and right), here again without edge labels.⁵

```
% Redraw the graph with tree layout
h = Graph(A,h,nodelabels,[],'-layout',Treelayout);
```

```
% Redraw the graph with circle layout
h = Graph(A,h,nodelabels,[],'-layout',Circlelayout);
```

You can find out about available layouts by `h.layouts` or in Table 1.

Your next steps should be:

- (a) Read `help Graph`.
- (b) Try the different buttons which you can see in the plot window of the graph. Also move some nodes in the graph and query the new node positions.
- (c) Read `help graphViz4Matlab`.
- (d) Experiment with different layouts for the graph by using some options of `graphViz4Matlab` which have not been mentioned above, e.g., the coloring of edges and / or nodes.

⁵All arguments starting from the fifth are passed on from our interface `Graph` to `graphViz4Matlab`, see also `help Graph` and `help graphViz4Matlab`.

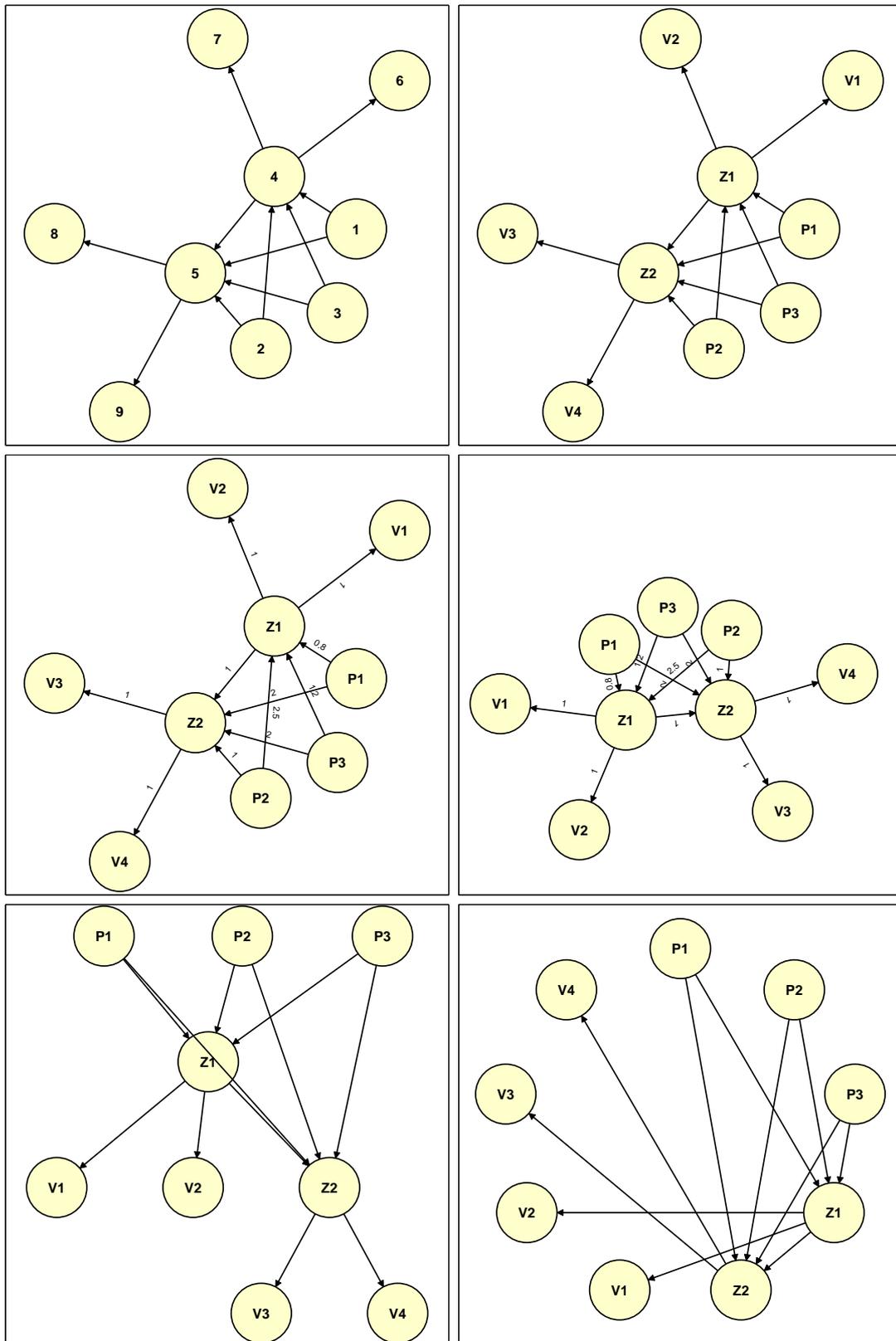


Figure 1: In the top left figure you see the standard layout of the graph. Top right: node labels have been assigned. Center left: edge labels have been set in addition. Center right: the node positions have been changed manually. The two figures on the bottom show the graph in the Treelayout and Circlelayout, respectively.

parameter -layout in graphViz4Matlab	Graphviz routine
Gvizlayout	neato
Treelayout	dot
Radiallayout	twopi
Circularlayout	circo
Springlayout	fdp
Circlelayout	—
Gridlayout	—
Randlayout	—

Table 1: available layouts in graphViz4Matlab and their counterparts in Graphviz