Crowdsourcing Societal Tradeoffs
Homework 3

February 9, 2015

Due: February 20, 2015

Please see the rules for homework on the course website, and contact Rupert, Markus, and/or Vince with any questions.

0. Installing the GNU linear programming kit.

You can find the GNU linear programming kit on the Web (`https://www.gnu.org/software/glpk/`). You are free to install it on your own computer. If you have trouble, below are some instructions for installing glpk on your login.oit.duke.edu user space that might be helpful (but could be a little tedious, so you are encouraged to try installing on your own machine first). If you still have trouble, please let us know. After you have successfully installed everything you are highly encouraged to check out the "examples" directory for examples of how to use the modeling language, as well as the examples from class which are on the course website.

Instructions for getting onto OIT computers

Of course, your first option is to work at a computer on campus. Otherwise, using ssh, login to your account on a Duke OIT machine and do your work there. Here is a good manual on how to do this on Duke's network.

`http://www.cs.duke.edu/~alvy/courses/Remote_Access.pdf`

You will have to work from the command line, but if you don't already know how this is a great time to learn! Here is a good tutorial for some of the basics.

`http://www.cs.duke.edu/~alvy/courses/unixtut/`

It may also be good to work from a command line text editor, like vim or emacs.

Installation Instructions for GLPK

Individual students need to install GLPK in their login.oit.duke.edu user spaces with the following commands:

```
mkdir ~/glpk
cd ~/glpk
wget ftp://ftp.gnu.org/gnu/glpk/glpk-4.47.tar.gz
tar -xzvf glpk-4.47.tar.gz
cd glpk-4.47
./configure
make
```

The program can then be run from the following directory.

`~/glpk/glpk-4.47/examples`

If you want to solve an LP/MIP expressed using the modeling language, navigate to the above directory and type

`./glpsol --math`

You will also need to specify the file that you want to solve, e.g.

`./glpsol --math problem.mod`

and you will also need to specify a name for a file in which the output will be stored, preceded by –output. So, typing

`./glpsol --math problem.mod --output problem.out`

will instruct the solver to solve the LP/MIP problem.mod, and put the solution in a new file called problem.out.

You will need an editor to read and edit files. One such editor is emacs (but any text editor will do). For example, typing

```
emacs problem.out
```

will allow you to read the output file.

1. Variations on the Kemeny Rule.

The Kemeny rule values agreeing with an edge in proportion to the weight on that edge. But we might also say that agreeing with high-weight edges is even more important. For example, we could say that agreeing with an edge of weight w is actually worth w^2 points, or even w^3 points. Or, we could go the other direction, and say that agreeing with high-weight edges is a little more important than agreeing with low-weight edges, but not quite in proportion to the weight. For example, we could say that agreeing with an edge of weight w is actually worth $w^{1/2}$ points, or even $w^{1/3}$ points. In general, for every α, we could consider the rule K^α that gives w^α points for agreeing with an edge of weight w.

a) Which rule is K^0?

b) Modify the Kemeny integer linear program from the course website so that it can compute K^α. (Note that while you can't take powers of a *variable* in an integer linear program because the result would no longer be linear, it is perfectly fine to take powers of *parameters*.) Turn in the mathematical formulation of the integer linear program, and the modeling language formulation.

c) For the example weighted pairwise election graph we did in class (used to illustrate Kemeny and Slater on the voting slides), run glpsol to evaluate the rule for each of $\alpha = 1/3, 1/2, 2, 3$. Compare the solutions to those found in class, and explain intuitively why these are the right solutions. What is the precise value of α at which the solution changes?