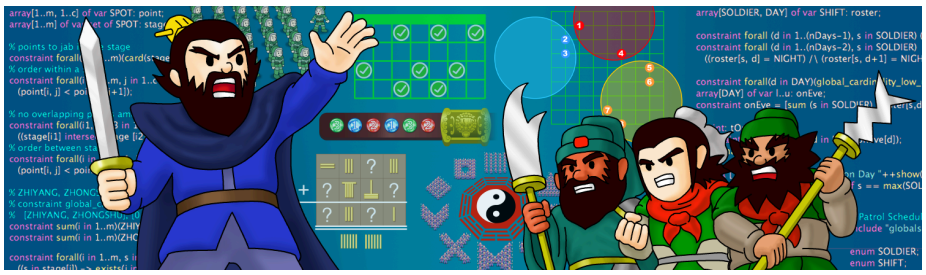
Beauty Trap: Part 2

Basic Modeling for Discrete Optimization: Assignment 3



Problem Statement

Wang Yun plots to help defeat Dong Zhou. He sets out to have both Dong Zhou and his best fighter Lü Bu fall for his foster daughter Diao Chan. Diao Chan is a remarkable beauty. When Lü Bu is invited to Wang Yun's house she performs a dance of seduction in order to trap him into love. This is the dance trap part of the "beauty trap".

Diao Chan must plan the most seductive dance possible. During each phase of the dance she must choose what her legs are doing, what her arms are doing and what her face is doing. There are constraints on sequences of possible actions for legs, arms and face.

Since Lü Bu is easily bored she must also choose the length of the dance to be most attractive, the longer it is, the more interesting it has to be. Also, there are upper limits on how many times she can use the same move, otherwise Lü Bu's boredom will be overwhelming.

The moves she can make with her legs are: *spin*, *leap*, *waltz*, *curtsey*, *prep*(are) for a leap, and *stand*. She must *prep* before any *leap*. Directly after a *spin* she can only *curtsey*, *prep* or *stand*. Directly after a *leap* she can only *spin*, *waltz*, or *stand*. She can *waltz* at most three times in a row. She cannot *prep* directly after a *curtsey*. Finally, in between any *waltz* and a following *curtsey* there must be a *stand*.

The moves she can make with her arms are *beckon*, hands *out*, hands *up*, hands *wrapped* around her body, and *neutral*. She can *beckon* only directly after *out* or *up* (and hence not as the first move). She can *wrapped* only directly after *beckon* or *neutral*, including the possibility that *wrapped* is the first move (since the previous move can be considered *neutral*). Furthermore, she cannot do any of the two same moves in a row except *neutral*.

The facial gestures she can make are *smile*, *wink*, *batt*(ing) her eyelids, *think*(ing), *glow* with beauty, or *blank*. She cannot make more than two of the same gestures in a row except *blank*. She cannot *think* directly after *smile*(ing) or *batt*(ing) her eyelids.

The combination of her legs move and arms move at each step determines

the value of her dance. The combination of her arms move and facial gesture at each step determines the enticement that she achieves.

Some combinations of legs move and arms moves are impossible. Similarly, some combinations of arms move and face would be very off-putting and hence must be avoided.

After the dance ends she must stay in the base position *stand*, *neutral*, and *blank*.

Her aim is to maximize the seductive power of the dance, which is given by the value of the dance, plus the enticements of the dance minus the boredom level of Lü Bu multiplied by the length of the dance.

Data Format Specification

The input form for Dance Trap are files named `data/dancetrap_*.dzn`. In these files,

- `maxlen` is the maximum length of the dance,
- `boredom` the boredom value of Lü Bu,
- `dance_value` an 2D array mapping a leg move plus an arm move to a dance value (which is negative for disallowed combinations),
- `entice_value` an 2D array mapping an arm move plus a facial gesture to an enticement value (which is negative for disallowed combinations),
- `maxlegs` is an array for each leg move giving the maximum number of times it can be used,
- `maxarms` is a similar array for arms moves,
- `maxface` is a similar array for facial gestures.

It is guaranteed that dance value of the combination *stand* and *neutral* is 0. It is guaranteed that enticement value of the combination *neutral* and *blank* is 0. Furthermore, it is guaranteed that the maximum usages of each of the null moves: *stand*, *neutral*, and *blank* is at least `maxlen`, hence doing nothing for the whole dance is always possible.

The data declarations and decisions are hence:

```
enum LEGS = {spin, leap, waltz, curtsey, prep, stand};
enum ARMS = {beckon, out, up, wrapped, neutral};
enum FACE = {smile, wink, batt, think, glow, blank};

int: maxlen;
set of int: STEP = 1..maxlen;
array[LEGS] of int: maxlegs;
array[ARMS] of int: maxarms;
array[FACE] of int: maxface;
```

```
constraint assert(maxlegs[stand] >= maxlen, "maxlegs[stand] smaller than maxlen"
constraint assert(maxarms[neutral] >= maxlen, "maxarms[neutral] smaller than max
constraint assert(maxface[blank] >= maxlen, "maxface[blank] smaller than maxlen"
array[LEGS,ARMS] of int: dance_value;
array[ARMS,FACE] of int: entice_value;
constraint assert(dance_value[stand,neutral] = 0, "incorrect dance_value array")
constraint assert(entice_value[neutral,blank] = 0, "incorrect entice_value array
int: boredom; % how bored each step makes the viewer

var STEP: len;
array[STEP] of var LEGS: legs;
array[STEP] of var ARMS: arms;
array[STEP] of var FACE: face;
```

An example data file is

```
maxlen = 10;
boredom = 8;
dance*value = [| -1, 5, 3, 2, 2
| 2, 4, 2, -1, 1
| 4, 4, 0, -1, 2
| 5, 1, -1, 2, 2
| 0, 0, 0, 0, 0
| 2, 1, 1, 2, 0 |];
entice_value = [| 4, 6, 5, -1, 3, -1
| 3, 2, 3, 3, 1, 1
| 2, 4, 5, 4, -1, 0
| 5, 3, 2, 5, 6, 0
| 4, 2, 1, 4, -1, 0 |];
maxlegs = [3, 3, 6, 2, 4, 20];
maxarms = [3, 3, 3, 3, 20];
maxface = [5, 2, 2, 7, 3, 20];
```

which allows a dance of at most length 10, the boredom factor is 8, and e.g. she can use *waltz* at most 6 times, and *curtsey* at most 2. A solution for this data file (which is not necessarily the best) is given by the following assignment.

```
len = 9;
legs = [stand, stand, spin, curtsey, spin, curtsey, waltz, waltz, spin, stand];
arms = [wrapped, up, out, beckon, out, beckon, out, beckon, wrapped, neutral];
face = [glow, batt, smile, batt, smile, wink, smile, wink, glow, blank];
objective = 4;
```

Notice how the dance is only length 9, and in step 10 she is base position. You can check that the dance meets all the constraints, and has an objective value of 4 calculated as summing the dance value at each step `[2, 1, 5, 5, 5, 5, 4, 4, 2, 0]` and the enticement value at each step `[6, 5,`

`3, 5, 3, 6, 3, 6, 6, 0]` and subtracting `8 * 9` for boredom.

As the **interface to the grader**, your model should contain variable declarations for `len`, `legs`, `arms`, and `face`, and it must calculate the correct objective value. Note that you are allowed to use `::output_only` variable declarations, if you want to use a different point of view.

Instructions

Edit the provided `mzn` model files to solve the problems described above. Your implementations can be tested locally by using the **Run + Check** icon in the MiniZinc IDE. Once you are confident that you have solved the problem, submit your solution for grading.

Technical Requirements To complete this assignment you will a new version of the MiniZinc Bundle (`http://www.minizinc.org`). Your submissions to the Coursera grader are currently checked using MiniZinc version 2.6.1.

Handin This assignment contains 5 solution submissions and 1 model submissions. For solution submissions, we will retrieve the best/last solution the solver has found using your model and check its correctness and quality. For model submissions, we will retrieve your model file (.mzn) and run it on some hidden data to perform further tests.

From the MiniZinc IDE, the **Submit to Coursera** icon can be used to submit assignment for grading. Follow the instructions to apply your MiniZinc model(s) on the various assignment parts. You can submit multiple times and your grade will be the best of all submissions.[1]. You can track the status of your submission on the **programming assignments** section of the course website.

[1] Please limit your number of submissions and test on your local machine first to avoid congestion on the Coursera servers