Optimization and Simulation
Simulation Exercise 6: Project II

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The Exercise: Simulation based Optimization

- Optimization of Sioux Falls Network in reaction to supply or demand changes
  - In your case reduction of supply
    - Converting certain number of roads to pedestrian only
  - Propose an optimal combination of changes using Simulated Annealing

Encoding a Solution

- Let x be a vector of zeros and ones
  - $x(i) = 0$ means that road i is open
  - $x(i) = 1$ means that road i is closed
- The dimension of vector x is 1 x [total number of links]
- Feasible set X contains all solutions where
  - At least one link is open
  - Every open link reaches every other open link

Simulation of Road Closures

- For a given vector x, the function `[NewScenario, valid] = ClosureRoads(x, orgainalScenario)` creates a corresponding scenario and checks its validity
- First, it sets
  - `LAMBDA` (demand from outside) for all closed roads to zero
  - `MU` (service rate, link capacity) for all closed roads to zero
  - All `TURNS` into all closed roads to zero

Simulation of Road Closures

- Second, it checks network connectivity (and sets the value of `valid`)
- Third, if `valid`, it re-normalizes by
  - Distributing the removed `LAMBDA` to all open links in the block
  - Scaling all `TURNS` out of an open link to sum up to one

Example of Valid Road Closure

TRANSP-OR

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

The Optimization Problem

- Objective: Make optimal use of the open roads

$$\min_{x \in X} \sum_i (1 - x(i)) \cdot |\mathrm{E}\{y(i)\} \cdot L - l(i)|$$

where

  - $l(i)$ is the length of link i
  - L is the length of a vehicle
  - $E\{.\}$ is the expected value
  - $y(i)$ is the simulated peak number of vehicles on the link

- Evaluate based on scenario

```
NewSiouxFalls(0.0025)
```

Vanilla Solution

- Implement the objective function
- Implement a (feasible) random solution variation
- Start with all roads being open
  - Run Simulated Annealing
    - Slow, but seems to generate improvements
- The all-zero starting point is very poor
  - Good solution will have excessive links removed
- Start with a feasible random initial solution

Vanilla Solution

- The objective function is stated in terms of expectations $E\{y(i)\}$
  - Simulation is random
  - To evaluate one solution
    - Needs to average over many simulation runs

Vanilla Solution

- Hint:
  - Search first with a `scale` smaller than 0.0025 and high C value
    - Greedy search on random objective function
    - Not optimal, but will get you somewhere
  - Refine search with a scale closer to 0.0025 and reasonable C value
  - Eventually, reduce the variance of the best solutions and select

Vanilla Solution

- Optimization my tend to get stuck
  - The objective function of the currently best solution is random
  - If it is low by chance, this solution is kept for very long
- Cure: Re-compute the objective function of the current solution every time it is not changed

Project Questions

- What is the optimal road closing strategy?
- What is the expected objective function value?
  - What is the variance?
- What exact solution approach did you choose? Why?
- *In addition to that, group specific questions will be sent via email to each group, shortly*