# Optimization and Simulation

## Simulation project II

## Optimization of Sioux Falls Network

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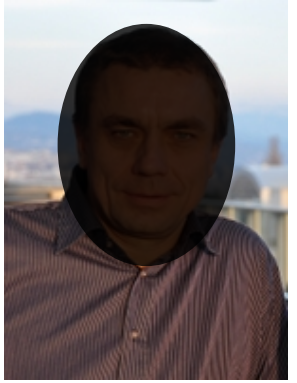
# Goals

Full application of a simulation example

- use variance reduction techniques
- use simulation for complex optimization problems

# Overview

Optimization of Sioux Falls Network in reaction to supply changes.



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] = CloseRoads (x, originalScenario)

creates a corresponding scenario and checks its validity

Always pass as input the original scenario with all roads open

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

# The Optimization Problem

Objective: identify the set *x** with at least 30 closed links that minimizes the objective function.

Objective function example: average-queue-length in the open links of the entire city

$$\min_{x \epsilon X} \frac{\sum_i E\{f(i)\}}{\sum_i 1 - x(i)}$$

where

- *E{.}* is the expected value
- *f(i)* is the simulated average-queue-length number of vehicles on link *i* evaluated at solution *x*

- Evaluate based on scenario NewSiouxFalls(0.0025)

# Finding the solution

- Implement the objective function
- Implement a (feasible) random solution variation
- Implement a cooling strategy
- Start with a feasible random initial solution. At least 30 closed links

# Finding the solution

The objective function is stated in terms of expectations *E{f(i)}*

Simulation is random, to evaluate one solution:

- Needs to average over many simulation runs

# Finding the solution

In the case of computational time problems:

- Use variance reduction techniques
- Search first with a scale smaller than 0.0025
- Refine search with a scale closer to 0.0025

# Simulation Project II

# Individual group question

Given the presence of pedestrian roads, re-evaluate the consequences on traffic conditions of the two alternative projects of “Simulation Project I”

- At least 30 links should be closed
- The links involved in the project should remain open

Use Simulated Annealing to identify the best road closure solution for each project, and suggest the best alternative given your objective function.

# Prize question

To evaluate which consulting company is *really* the best, Mayor M. gives an identical task to all the companies.

Starting from a city without any infrastructural project, find the best road closure solution (at least 30 closed links) that minimize the average-queue-length .

Report:

- The mean of the average-queue-length with all road open $q_o$
- The mean of the average-queue-length, with at least 30 closed roads, for your best solution $q_c$
- The % increase in average-queue-length for your best solution $\Delta = (q_c - q_o)/q_o$

# Prize question

The company with the smaller % increase Δ will receive a *prestigious* award from Mayor M.

# Project presentation

# Contents

- Summary Simulation Project I (problem, objective function, indexes, …)
- Simulated Annealing strategy (neighbor search strategy, cooling strategy, …)
- Variance reductions techniques
- Results (closed road, index values, …)
- Suggested best alternative
- Prize question indexes and results $q_o$, $q_c$, $\Delta$

# Code

Send me the code of this and previous laboratories, and the presentation by email (same day of the presentation)