Savings, Savings, Savings

by

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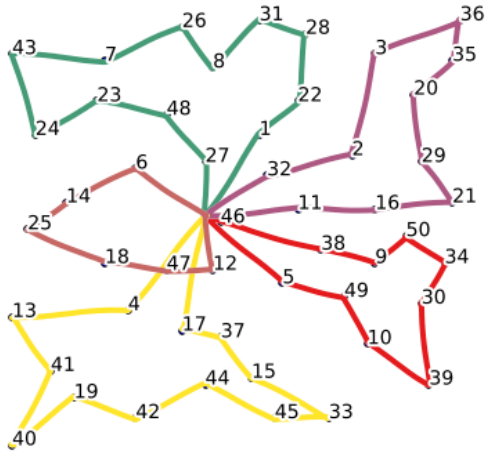
Overview

- cvrp problem
- implementation details
- improvement procedures
- construction procedure
- genetic algorithm
- tabu search
- QA

The Problem

Capacitated Vehicle Routing

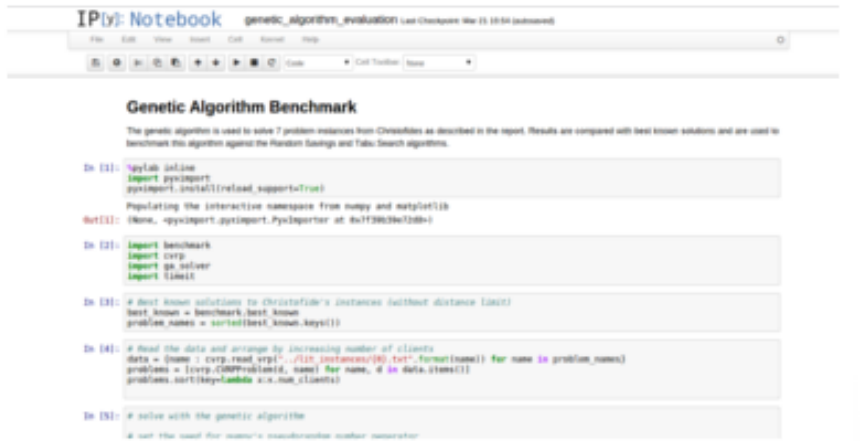


$$\text{minimize} \quad \sum_{route \in solution} distance(route)$$

$$\text{subject to} \quad weight(route) \leq vehicle\ capacity$$

Implementation

Implementation Details



Implementation Details

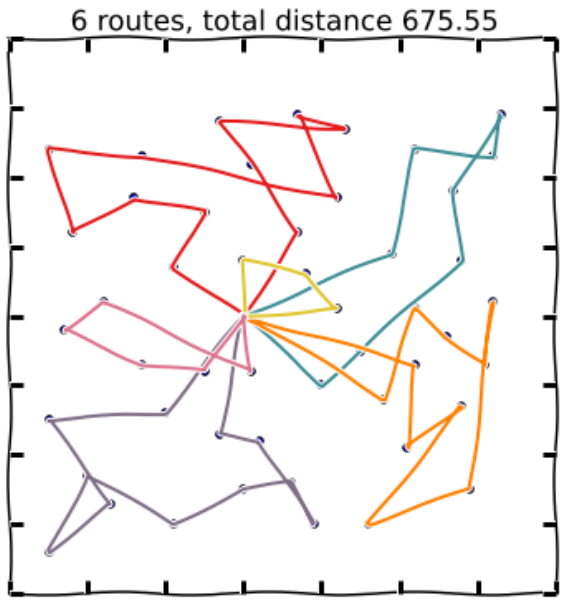
- reuse basic operators
- modularity
- concise

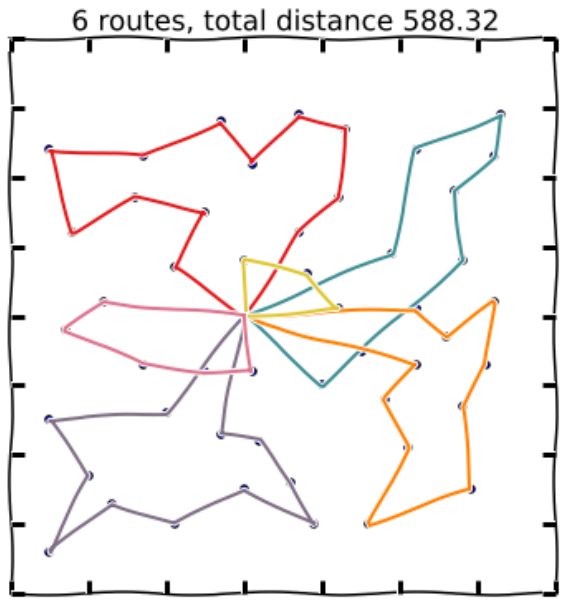
Improvement

2-opt descent

- uses common 2-opt operator
- calculates all possible 2-opt for each iteration
- chooses the best available

2-opt example

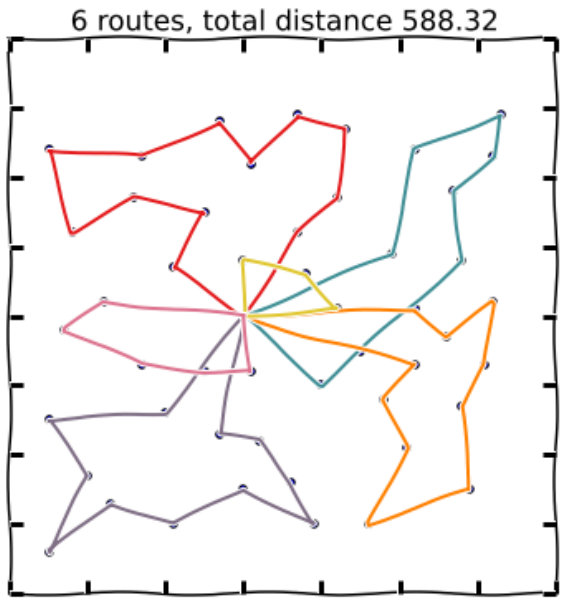


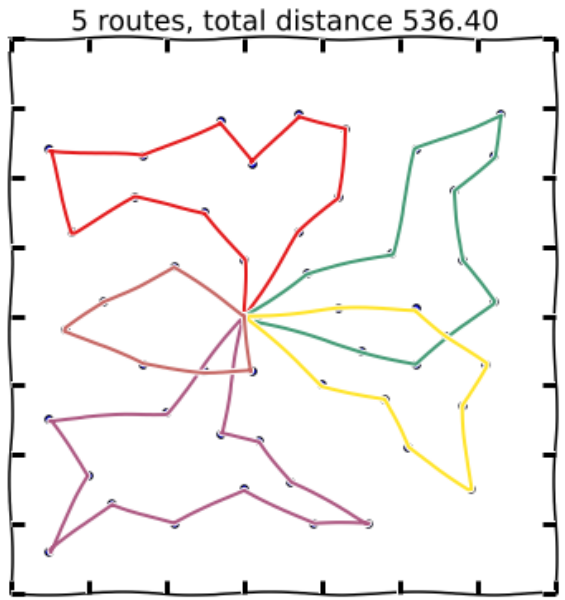


λ_1-interchange definition

- λ-interchange, Osman, 1991
- exchange of customers between routes
- only feasible exchanges (capacity constraint)
- insertion (1, 0) and (0, 1) or interchange (1, 1)
- chooses the best option at each iteration
- apply 2-opt descent on routes implicated

λ_1-interchange example



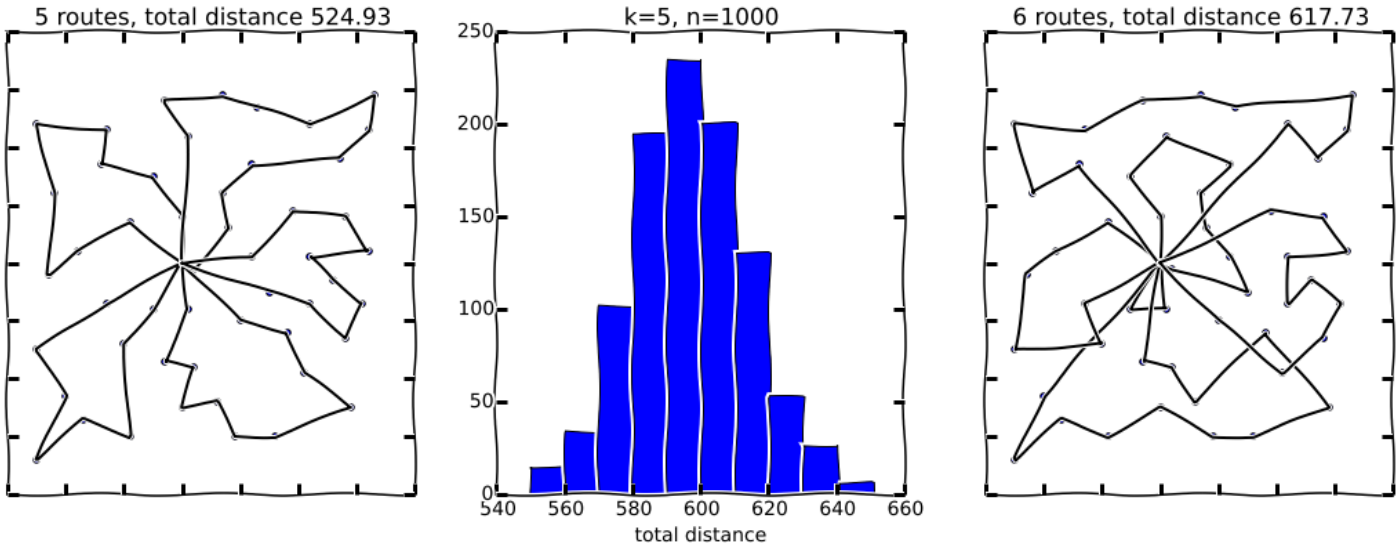


Construction

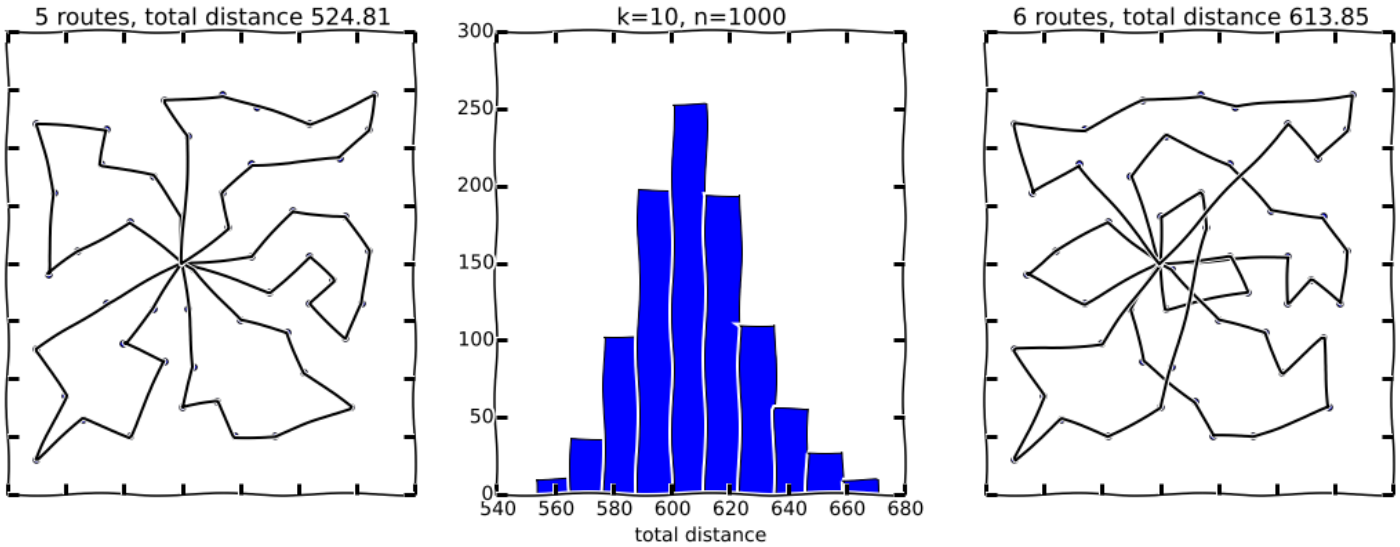
Random Savings Definition

- iterated local search
- variant of parallel savings
- at each iteration select randomly from top k best savings
- $k{=}1 \rightarrow$ normal parallel savings
- once finished, apply improvement method

Random Savings, k=5



Random Savings, k=10



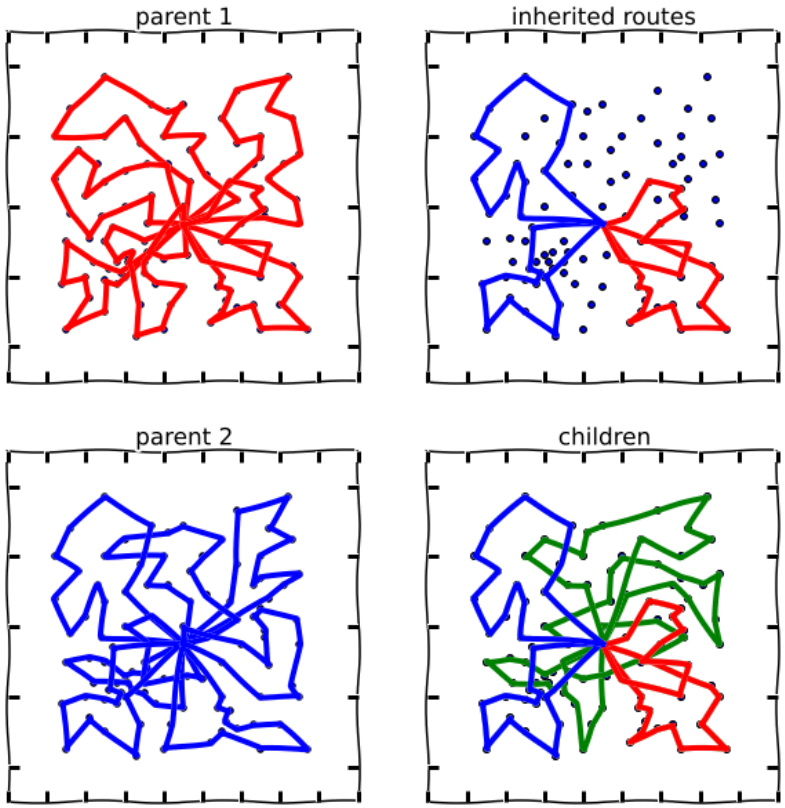
Best result in 60 secs

Genetic Algorithm

Crossover Description

1. arrange routes by angle of centroid to depot
2. choose $\frac{n}{4}$ contiguous routes from parent 1
3. choose at most $\frac{n}{4}$ contiguous non-intersecting routes from parent 2
4. assign routes to the rest of clients using parallel savings

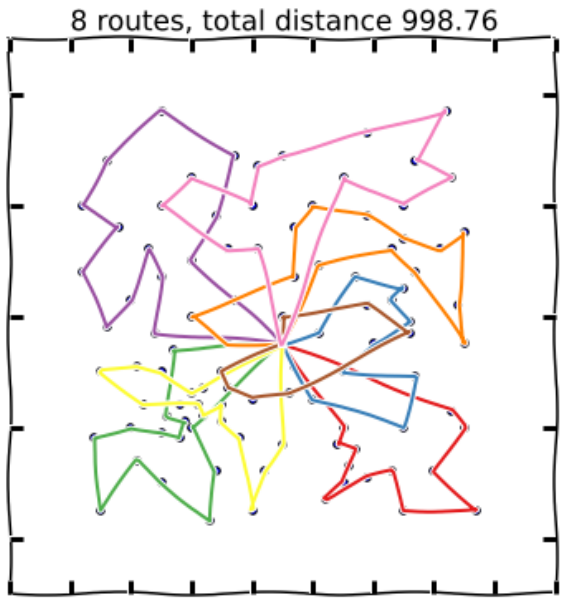
Crossover example

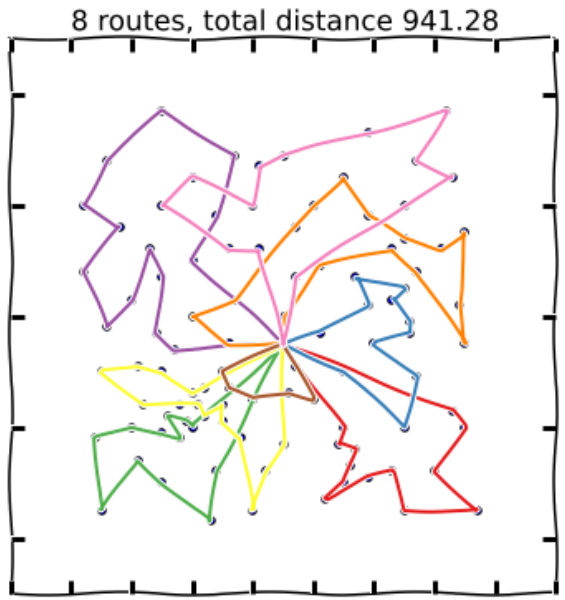


Mutation Description

- reuse the λ_1-interchange operator
- use a fixed (in this case 5) number of iterations
- serves as local exploration and changes clusters of clients

Mutation example





Genetic Algorithm Parameters

- number of generations
- population size
- elitism (percentage of transfer)
- recombination probability
- mutation probability
- k for random savings

Results


Genetic algorithm best values divided by best known values
problem instance
vrpnc1 0 min 41 sec
vrpnc2 1 min 15 sec
vrpnc12 2 min 24 sec
vrpnc3 2 min 41 sec
vrpnc11 4 min 22 sec
vrpnc4 5 min 28 sec
vrpnc5 9 min 17 sec
1.016 1.016 1.016 1.012 1.016
1.017 1.009 1.021 1.023 1.02
1.001 1.001 1.001 1.001 1.001
1.024 1.019 1.022 1.02 1.022
1.005 1.007 1.008 1.008 1.008
1.026 1.026 1.034 1.042 1.033
1.042 1.046 1.049 1.049 1.045
1 2 3 4 5
replicate
1.10
1.08
1.06
1.04
1.02
1.00

Tabu Search

Tabu Search Description

- Neighbourhood Structure
- Tabu List
- Diversification

Neighbourhood Structure

- λ_1-interchange
- only feasible solutions

Tabu List

- avoid reversing a move
- remember pairs $(\mathit{client},\ \mathit{route})$
- $\mathit{max}\{7,\ -40 + 9.6 \times \mathit{ln}(n \times v)\}$

Diversification by Multi-Start

- takes a parameter called *patience*
- patience replenish after a new best is found
- patience runs out $\rightarrow$ random savings

Best Results in 60 sec

Overall Performance

Overall Performance

- complexity : [RS, GA, Tabu]
- speed: [Tabu, RS, GA]
- quality: [GA/Tabu, RS]

QA