Savings, Savings, Savings

by

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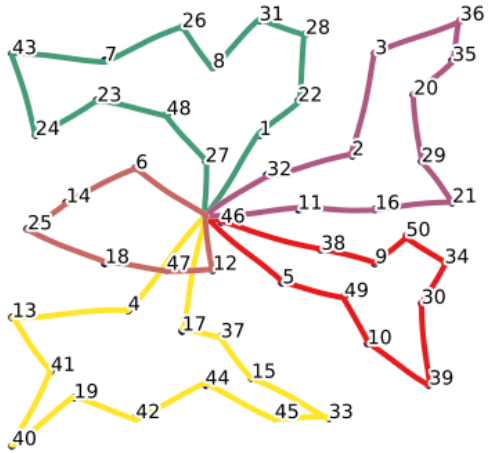
Overview

- cvrp problem
- implementation details
- improvement procedures
- random savings
- genetic algorithm
- tabu search
- QA

The Problem

Capacitated Vehicle Routing

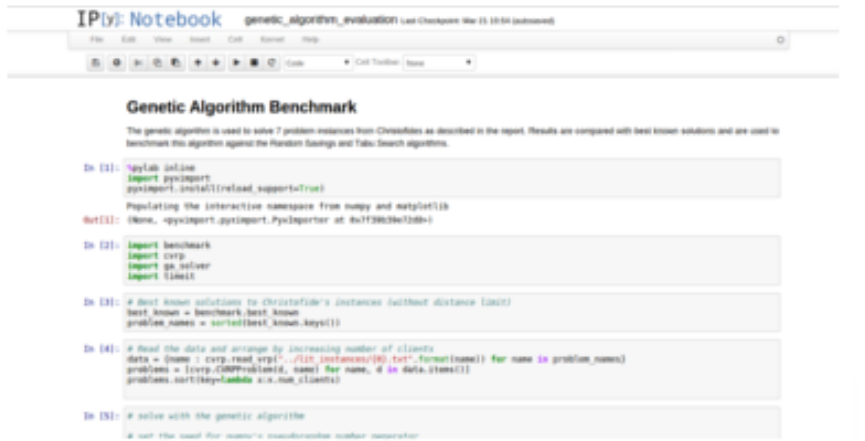


$$\text{minimize} \quad \sum_{route \in solution} distance(route)$$

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

Implementation

Implementation Details



Implementation Details

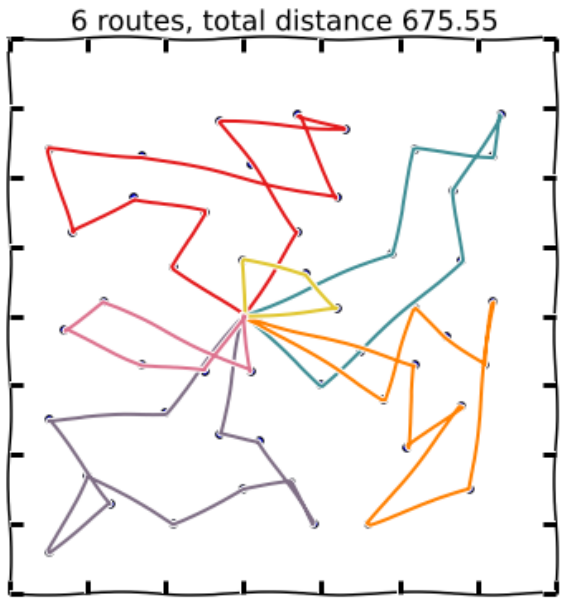
- reuse basic operators
- modularity
- concise

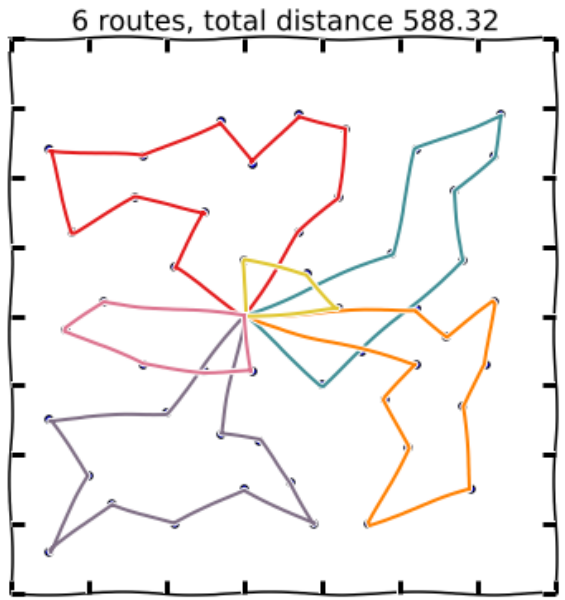
Improvement

2-opt descent

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

2-opt example

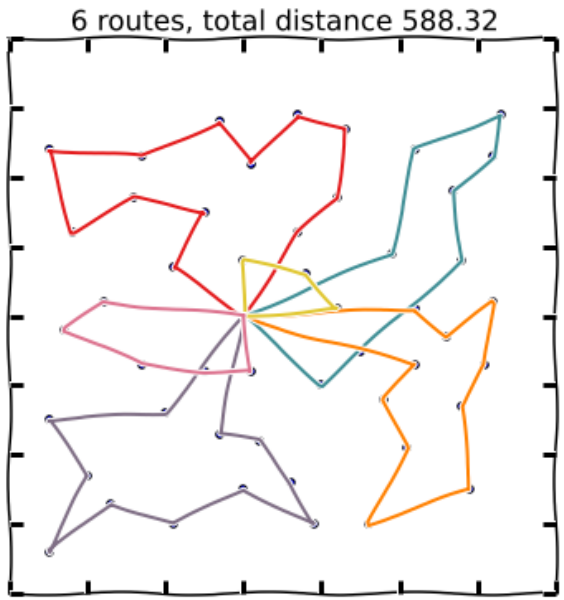


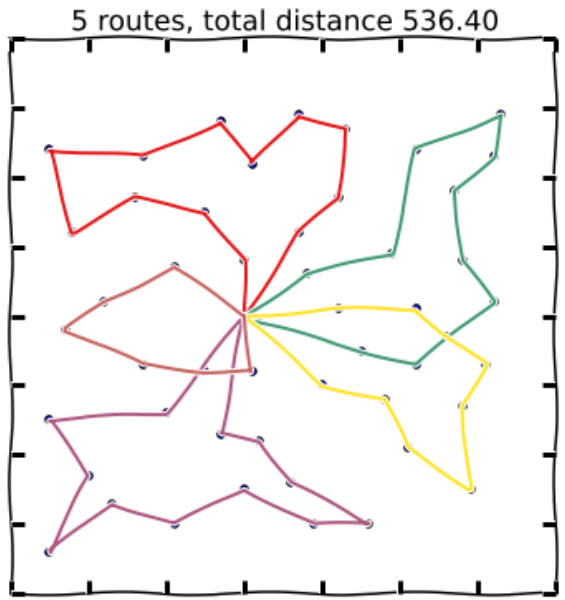


1-interchange definition

- 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

1-interchange example



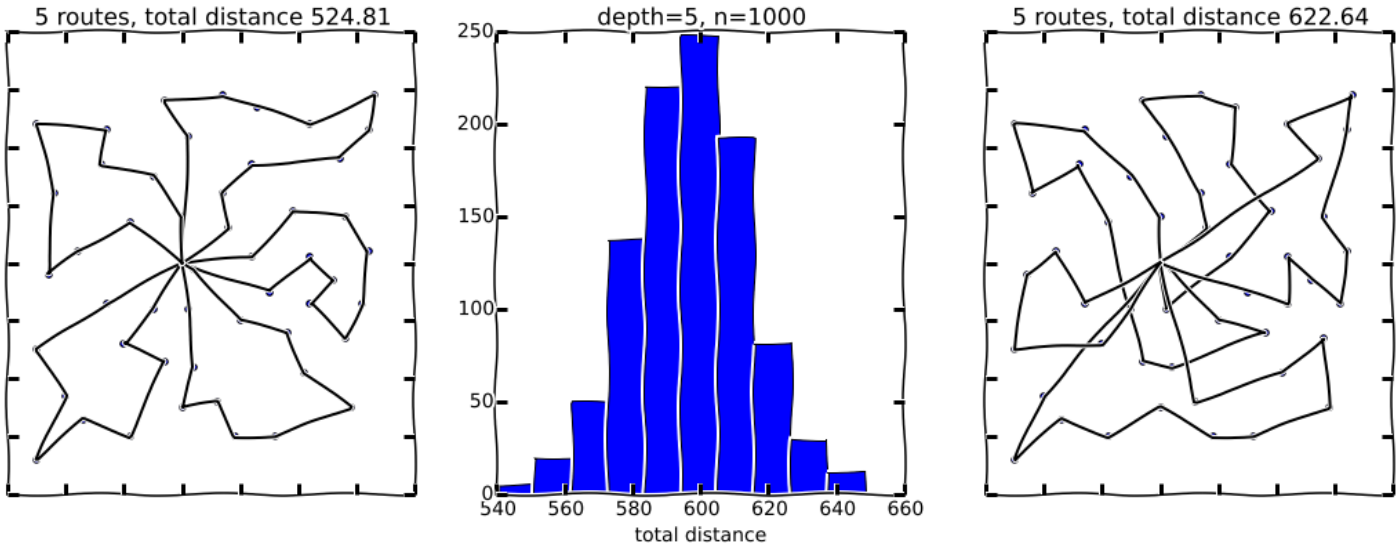


Random Savings

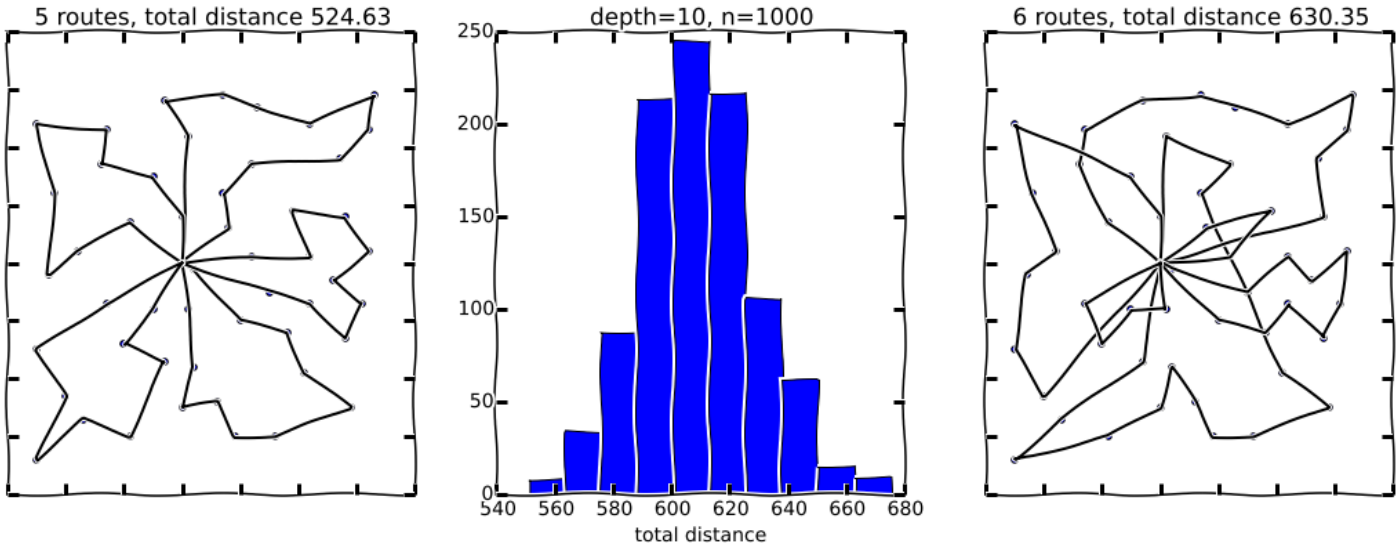
Random Savings Definition

- iterated local search
- variant of parallel savings
- select randomly from top *depth* moves
- *depth*=1 $\rightarrow$ normal parallel savings
- once finished, apply improvement method

Random Savings, *depth* $= 5$



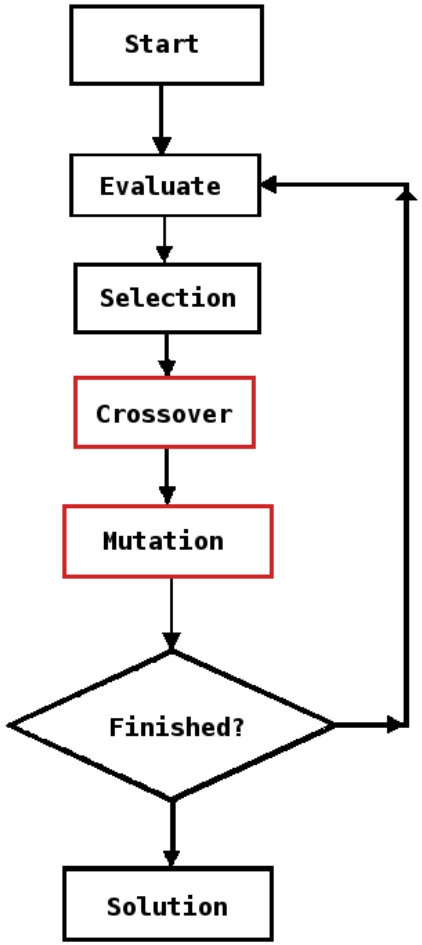
Random Savings, $depth = 10$



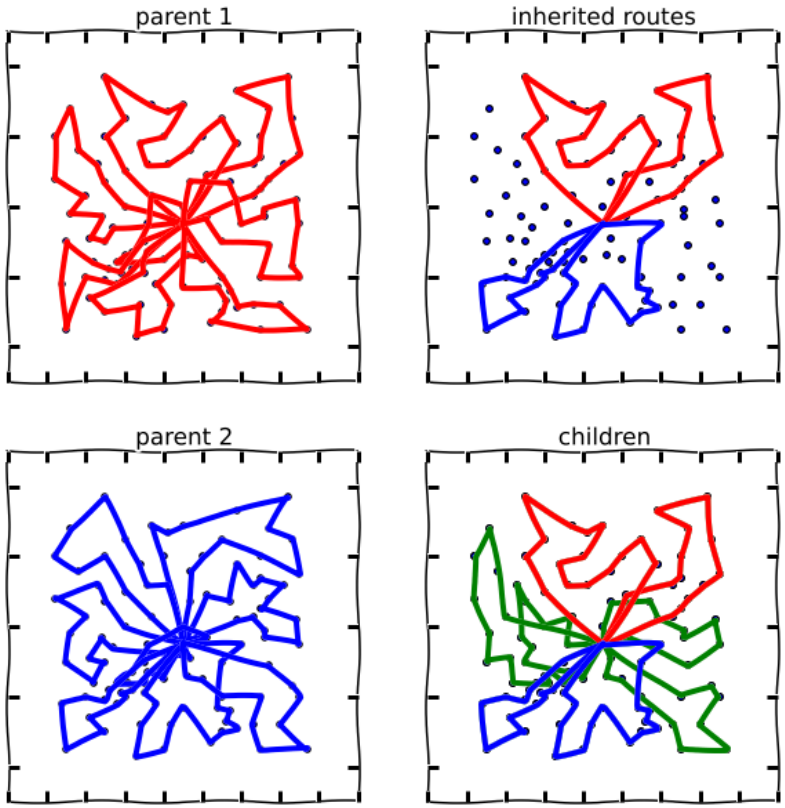
Best result in 60 secs

Genetic Algorithm

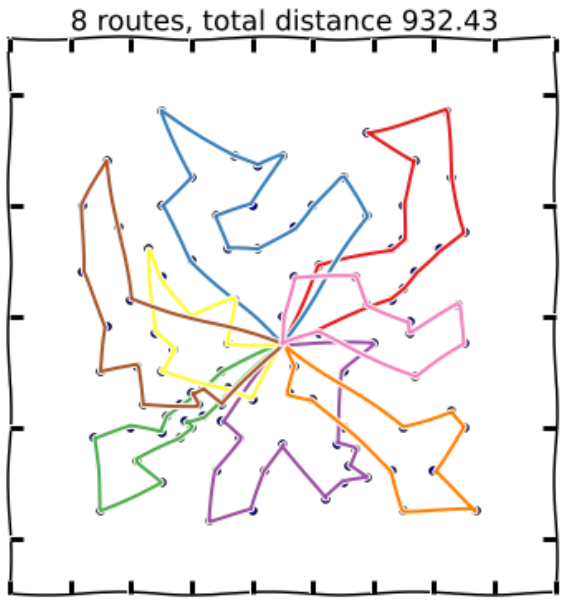
Overview

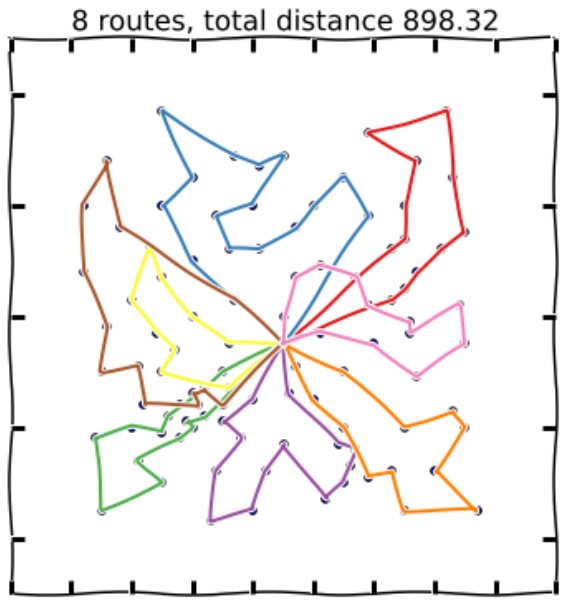

Start
Evaluate
Selection
Crossover
Mutation
Finished?
Solution

Crossover



Mutation example





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

Neighbourhood Structure

- 1-interchange
- only feasible solutions

Tabu List

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

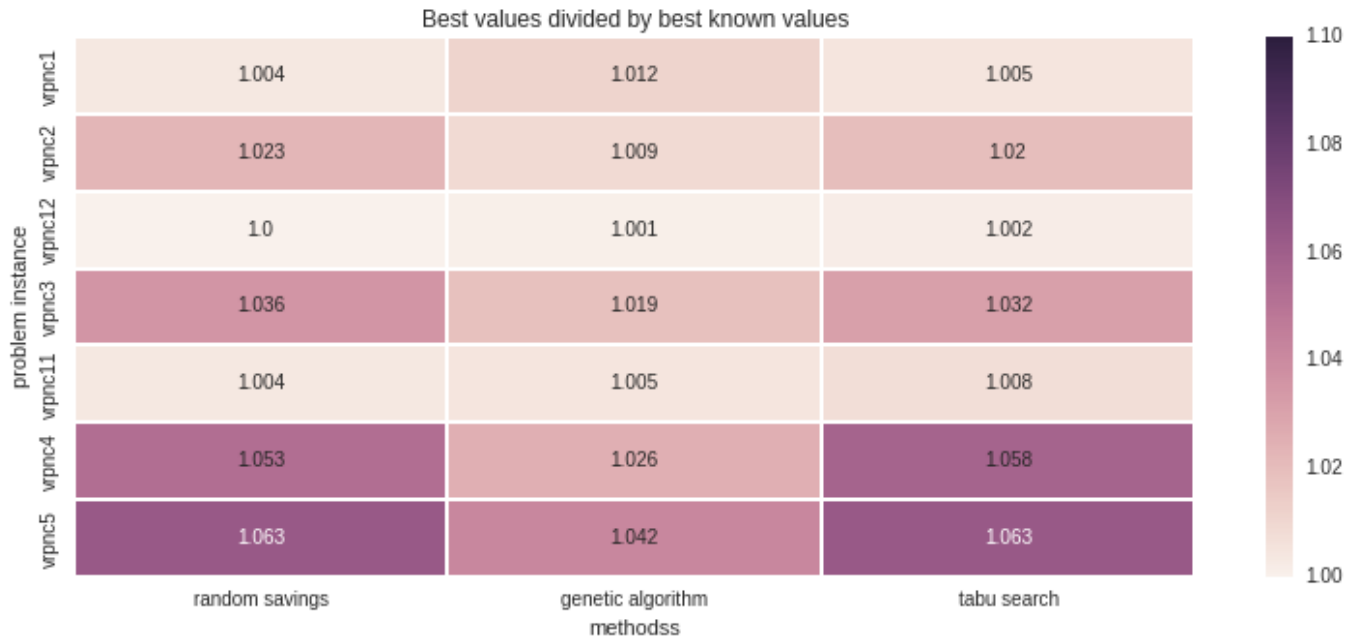
Diversification by Multi-Start

- 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

Comparison


Best values divided by best known values
problem instance
wrpnc1
wrpnc2
wrpnc12
wrpnc3
wrpnc11
wrpnc4
wrpnc5
1004
1012
1005
1023
1009
102
10
1001
1002
1036
1019
1032
1004
1005
1008
1053
1026
1058
1063
1042
1063
random savings
genetic algorithm
tabu search
methodss
1.10
1.08
1.06
1.04
1.02
1.00

QA