MIC'17

Introducing biased randomization in GRASP

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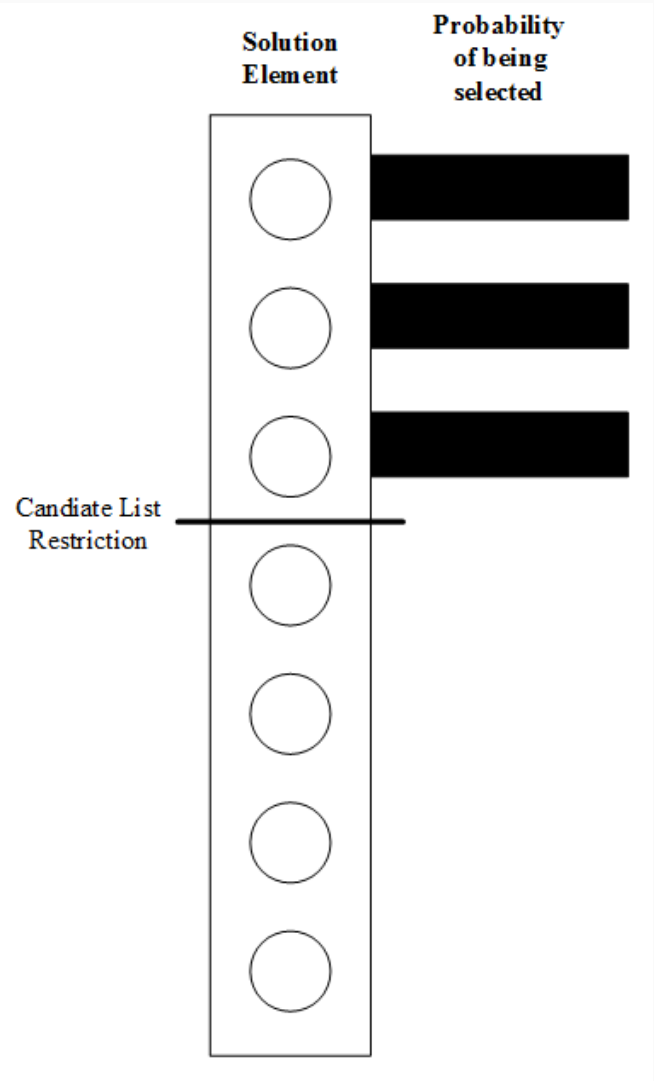
Greedy Randomized Adaptive Search Procedure

```
1 Function GRASP(α, c, 𝒩)
2 |   while stopping criterion not reached do
3 |   |   x ← Construct-Greedy-Randomized-Solution(α);
4 |   |   x ← LocalSearch(x, 𝒩);
5 |   |   if k = 1  or  c'x > c'x_b then
6 |   |   |   x_b ← x
7 |   return (x_b);
```

Construct Greedy Randomized Solution

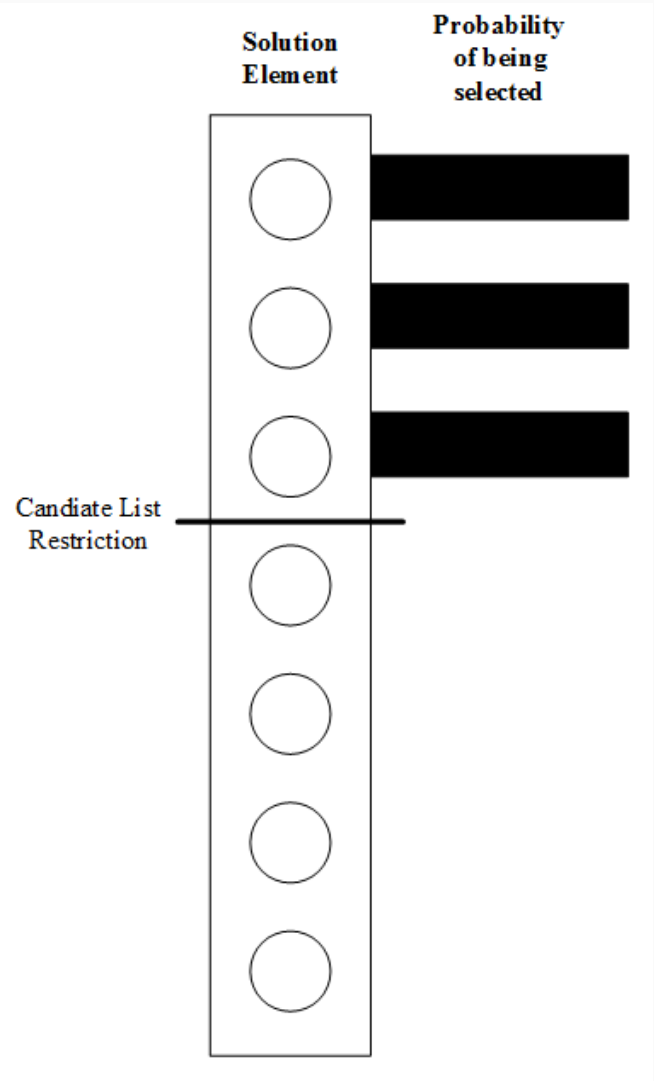
```
1  Function Construct-Greedy-Randomized-Solution(α)
2      s ← ∅;
3      initialize candidate set: CL ← E;
4      order the Candidate List (CL) elements according to c(·) ;
5      while solution s is not complete do
6          c_min ← min_{x∈CL}{c(x)};
7          c_max ← max_{x∈CL}{c(x)};
8          thr ← c_min + α(c_max − c_min);
9          RCLsize ← |{x ∈ CL: c(x) ≤ thr}|;
10         pos ← UniformRand(1, 2, ..., RCLsize) ;
11         s ← s ∪ {CL[pos]};
12         CL ← CL \ {CL[pos]};
13         Reorder CL;
14     return s;
```

Construction phase



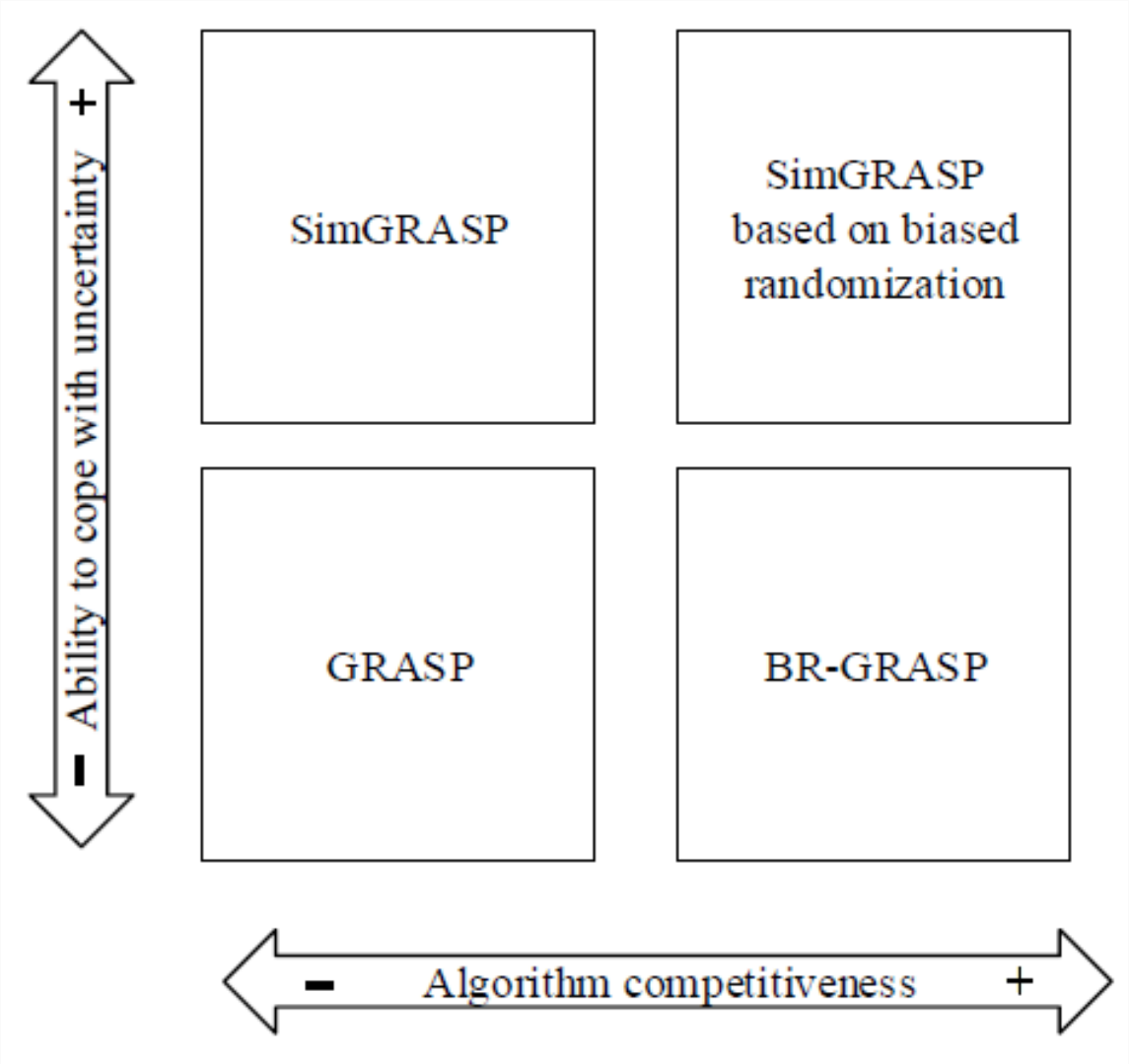
- Not all candidates can be selected;

Construction phase



- Not all candidates can be selected;
- the selection distribution is uniform.

Aim


SimGRASP
SimGRASP based on biased randomization
GRASP
BR-GRASP
+
Ability to cope with uncertainty
-
-
Algorithm competitiveness
+

Introducing Biased Randomized

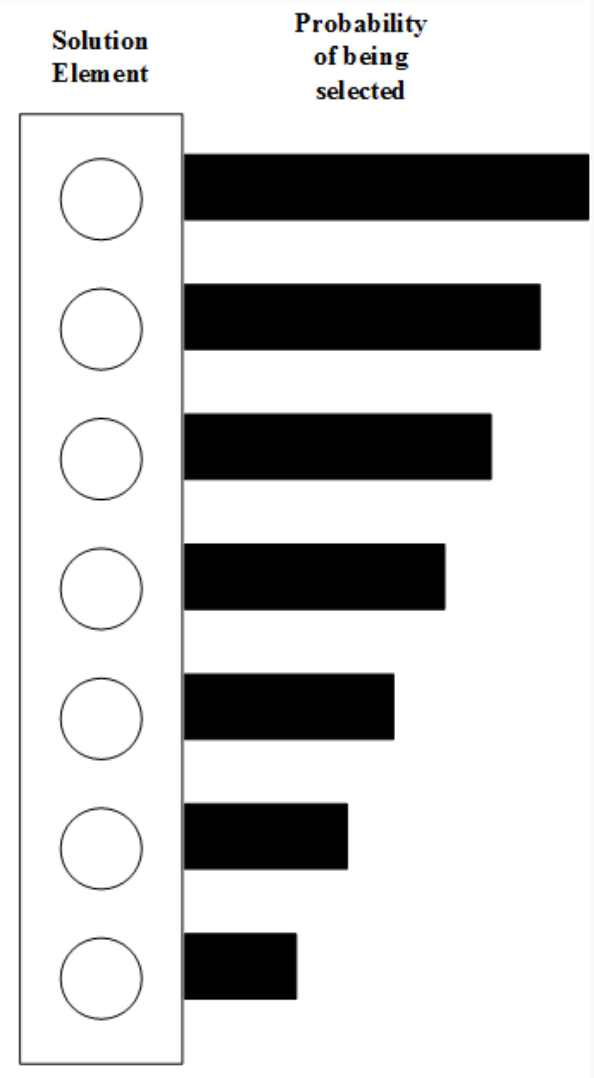
Biased randomization (Bresina, 1996; Juan et al., 2013) uses a skewed probability function that assigns selection probabilities to all elements

Introducing Biased Randomized

Biased randomization (Bresina, 1996; Juan et al., 2013) uses a skewed probability function that assigns selection probabilities to all elements

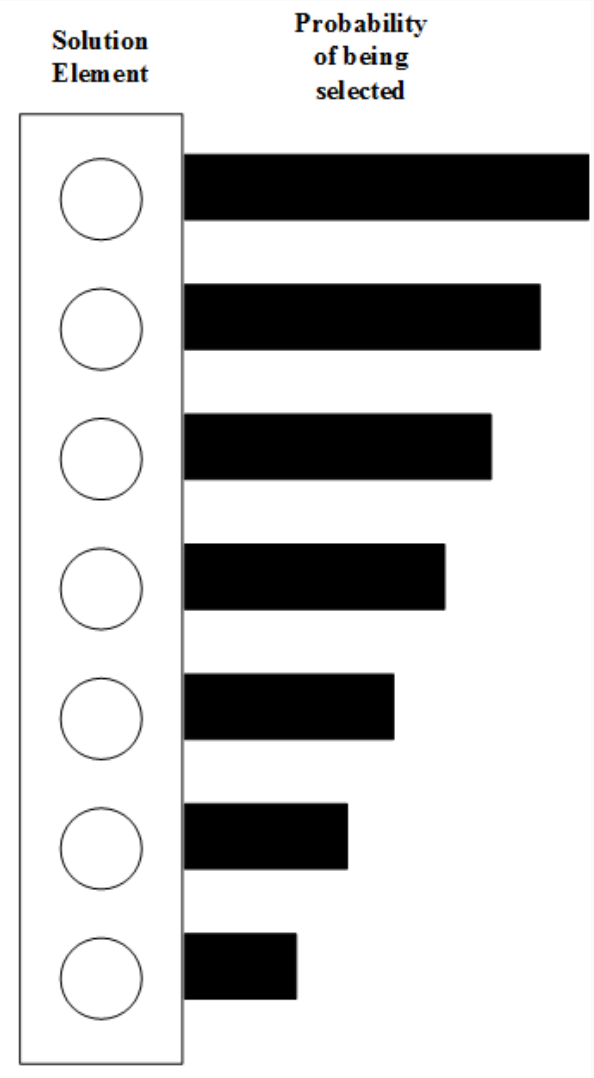
1 **Function** `Biased-Construction`(D, β)
2 $s \leftarrow \emptyset$;
3 initialize candidate set: CL $\leftarrow$ E;
4 order the Candidate List (CL) elements according to $c(\cdot)$;
5 **while** *solution* s *is not complete* **do**
6 Randomly select $pos \in \{1, \ldots, |CL|\}$ according to distribution $D(\beta)$;
7 $s \leftarrow s \cup \{CL[pos]\}$;
8 $CL \leftarrow CL \setminus \{CL[pos]\}$;
9 Reorder CL;
10 **return** s;

Introducing Biased Randomization



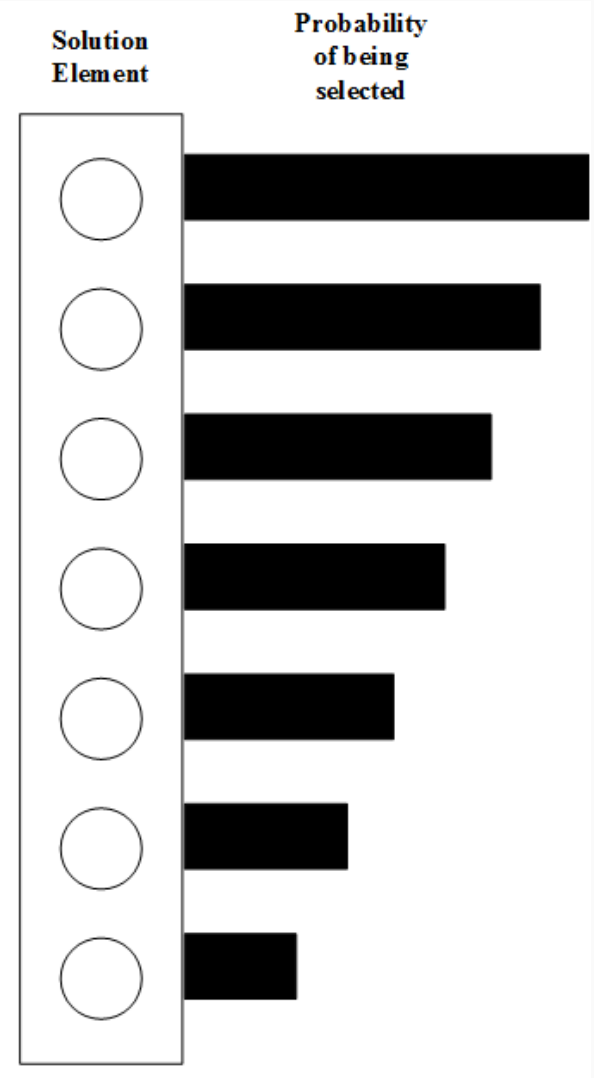
- All candidates can be selected;

Introducing Biased Randomization



- All candidates can be selected;
- different distribution can be used, i.e., triangular, geometric.

Introducing Biased Randomization



- All candidates can be selected;
- different distribution can be used, i.e., triangular, geometric.
- simpler implementation!

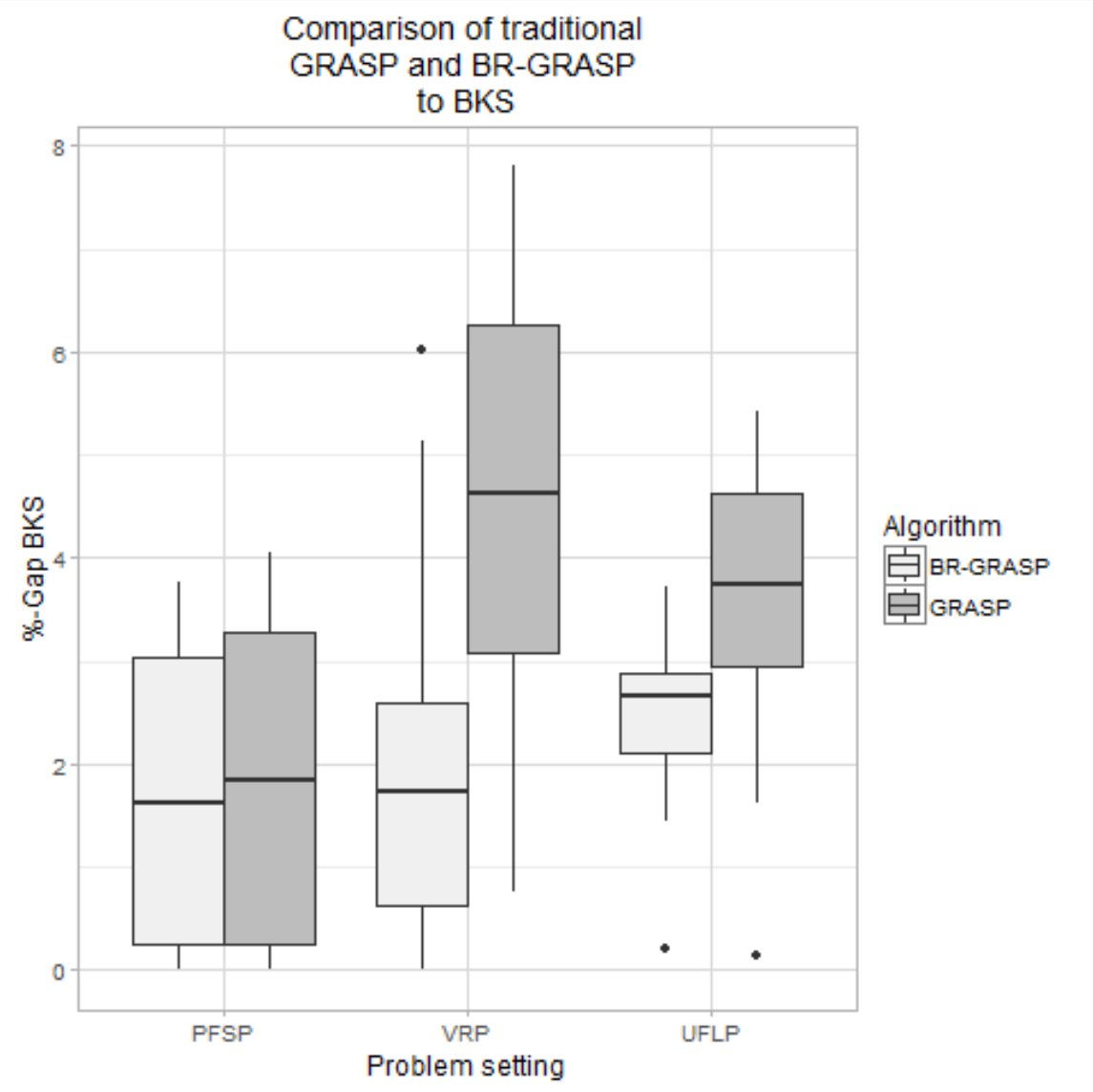
Experimental settings

Vehicle Routing Problem benchmark set for the capacitated VRP proposed by Augerat et al. (1998)

Uncapacitate Facility Location Problem benchmark instances are the ones originally proposed by Ahn et al. (1988)

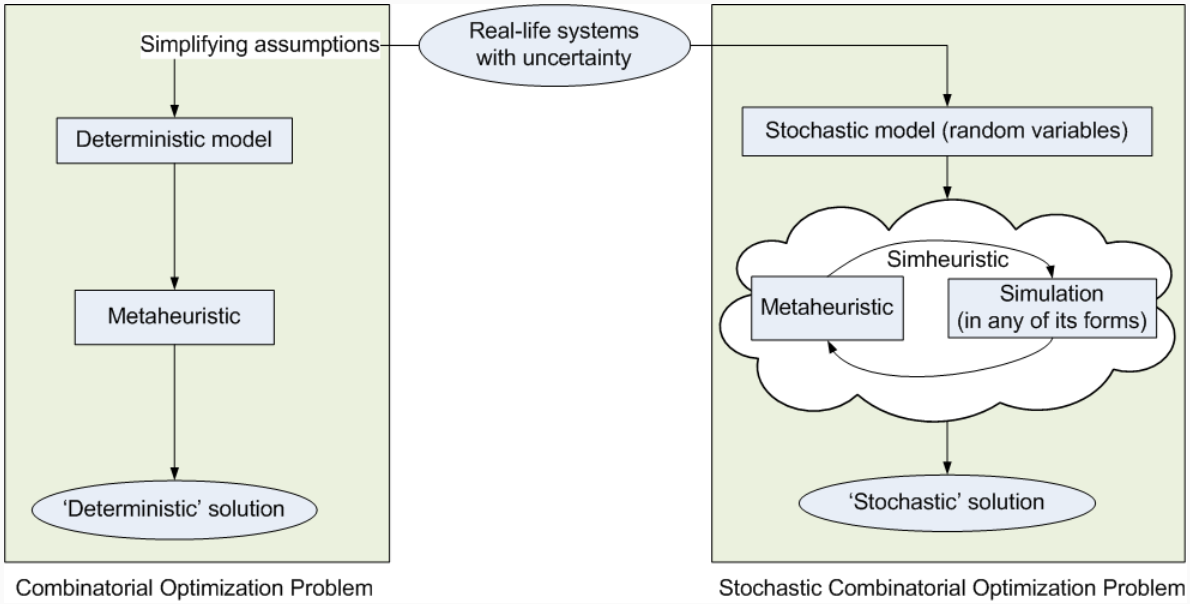
Permutation Flow Shop Problem benchmark instances proposed by Taillard (1993)

Results


Comparison of traditional
GRASP and BR-GRASP
to BKS
%-Gap BKS
0
2
4
6
8
PFSP
VRP
UFLP
Problem setting
Algorithm
BR-GRASP
GRASP

SimGRASP

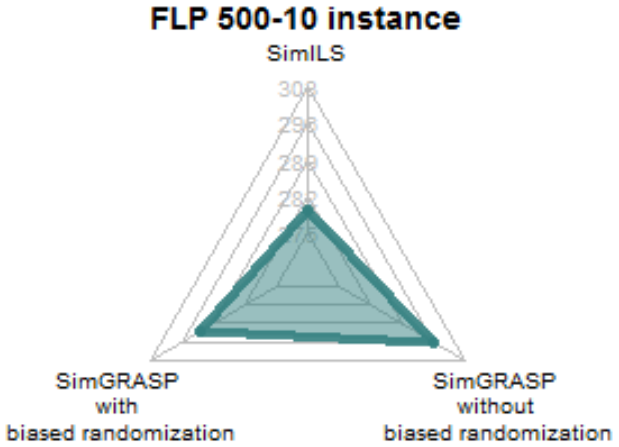
- Traditional optimization techniques are only capable of solving simplified (deterministic) problem settings
- Real life systems are characterized by some extend of uncertainty ($\Rightarrow$ stochasticity)
- Simheuristics (Juan et al., 2015) integrate simulation in any of its form into metaheuristic frameworks
- These optimization-driven algorithms rely on efficient solution methodologies for deterministic problem settings

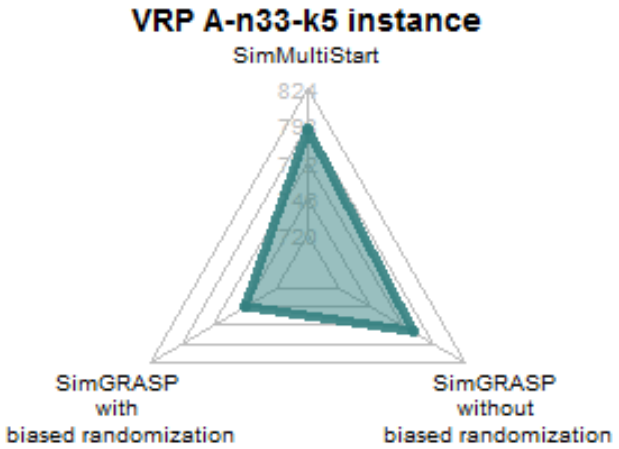


Introducing simulation

```
1  Function SimGRASP(Stochastic COP)
2      Transform stochastic COP into deterministic counterpart;
3      while stopping criterion not reached do
4          s** ← Biased-Construction(·);
5          s** ← LocalSearch(s**);
6          (s**, sf(s**), statistics) ← Simulation(s**, short)
8          add(s**, EliteSolutions)
10     foreach solution s ∈ EliteSolutions do
12         (s, sf(s), statistics) ← Simulation(s, long)
14     return EliteSolutions;
```

Results





Problem	%-gap
PFSP	0.37
VRP	-9.81
UFLP	1.36

Conclusions and future work

- Biased randomization and simulation have been introduced in GRASP
- Biased randomization is competitive respect to the RCL
- Simulation gives to GRASP the ability to cope with uncertainty
- Future work:
  - Further hybridization of the GRASP: Reactive-BR-GRASP, ...
  - Comparison of SimGRASP with other simheuristic algorithms
  - Use simulation to guide the SimGRASP

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(**E** **N** **D**)

Thank you.