

Metaheuristic Search

Overview

- Today we'll overview [Metaheuristic Search Algorithms](#)
- We'll consider a number of specific algorithms but will focus primarily on [genetic algorithms](#)

Metaheuristic Definition

- *“A **metaheuristic** is a set of concepts that can be used to define heuristic methods that can be applied to a wide set of different problems. In other words, a metaheuristic can be seen as a general algorithmic framework which can be applied to different optimization problems with relatively few modifications to make them adapted to a specific problem” [MHN17]*

[MHN17] Metaheuristic Network. Website: <http://www.metaheuristics.net/> (Last accessed: Oct. 17, 2017).

Metaheuristic Algorithm [ZBB10]

Algorithm 4.1: Abstract algorithmic framework for **metaheuristics**

Create one or several start solutions e.g. by problem specific heuristic(s)

```
while termination criterion not satisfied do  
    if intensify then  
        | Create new solution by intensification step;  
    else  
        | Create new solution by diversification step;  
    end  
    Update best found solution (if necessary);  
end  
return Best found solution;
```

[ZBB10] Gunther Zapfel, Roland Braune, Michael Bogl. "Metaheuristic Search Concepts: A Tutorial with Applications to Production and Logistics." 2010.

Metaheuristic Algorithm [ZBB10]

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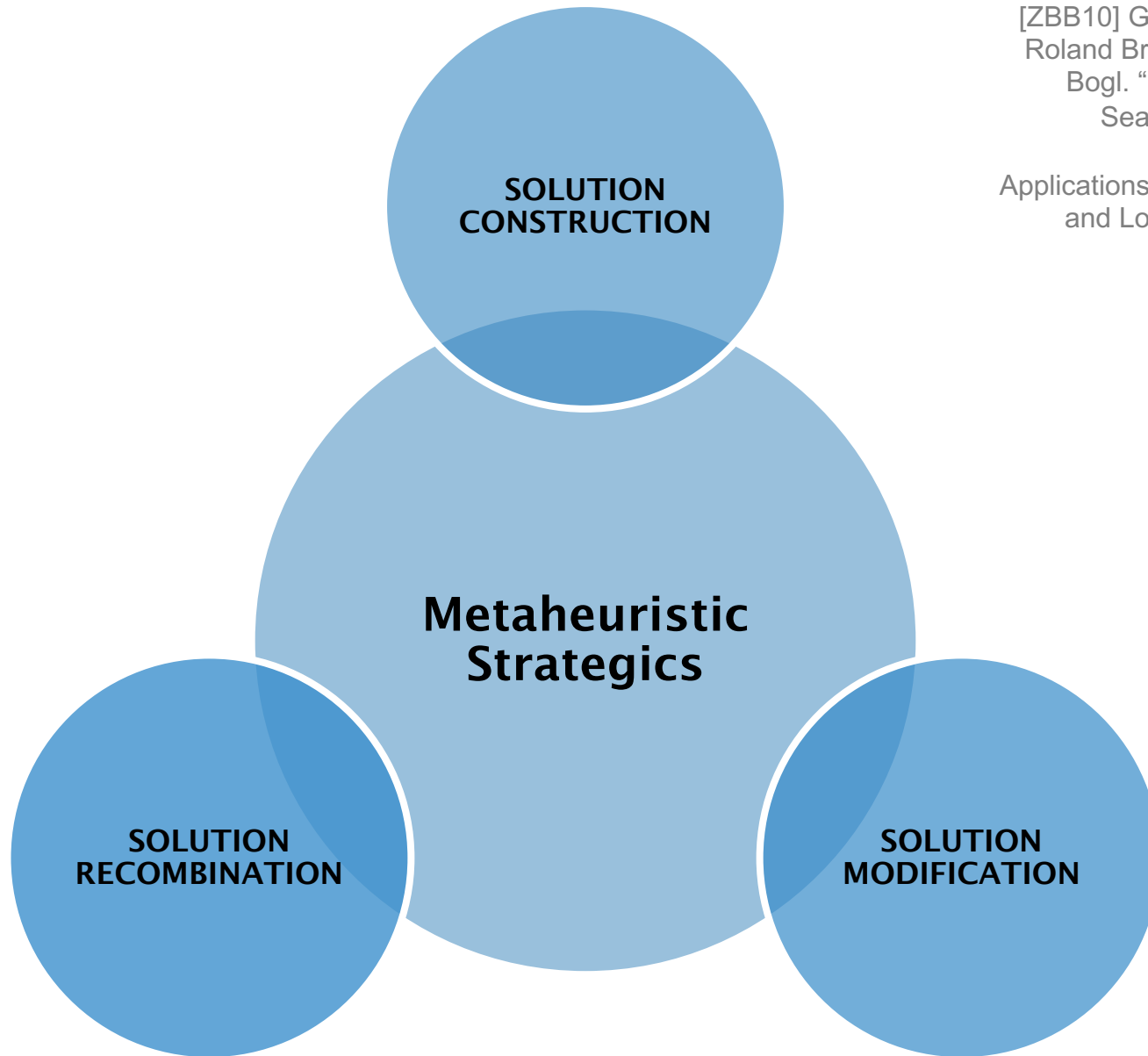
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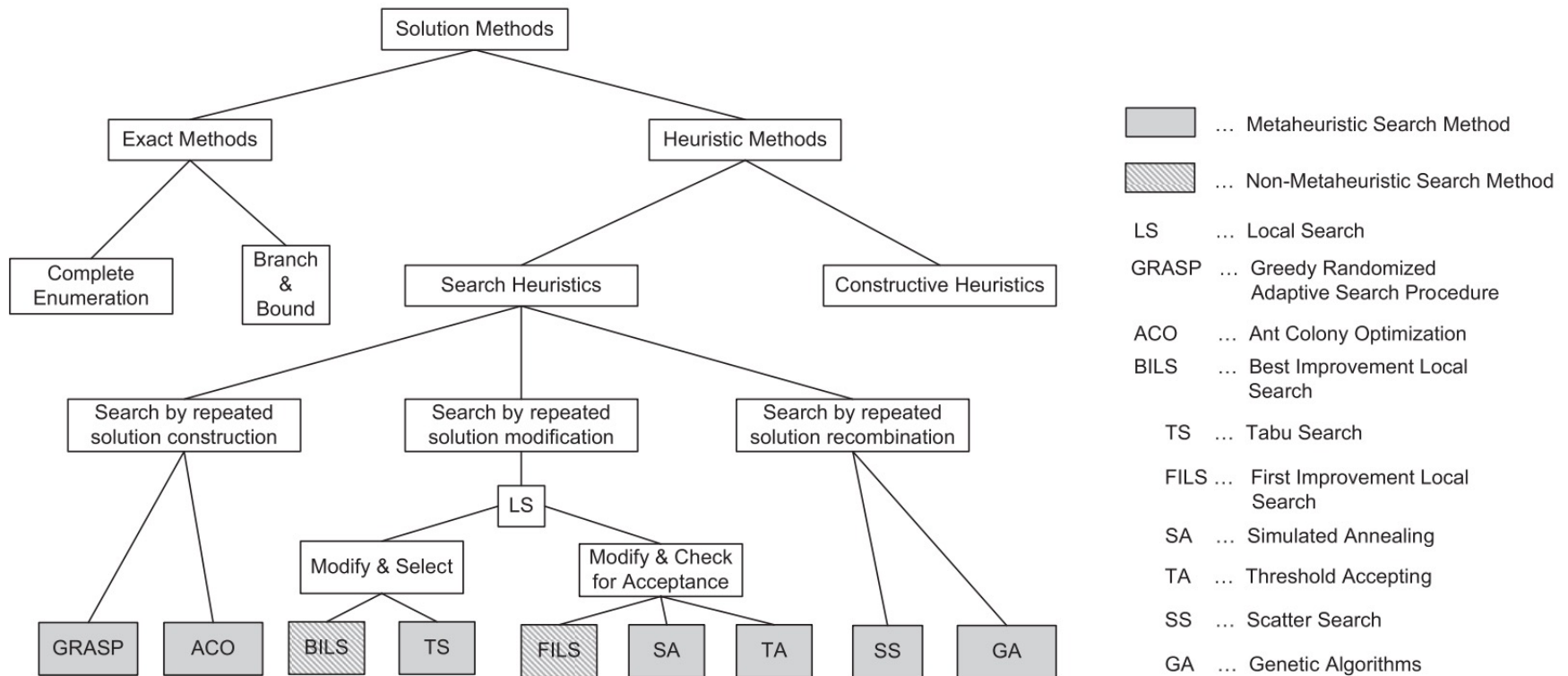
2 key concepts – **intensification & diversification**. These need to be **balanced!**

[ZBB10] Gunther Zapfel, Roland Braune, Michael Bogl. “Metaheuristic Search Concepts: A Tutorial with Applications to Production and Logistics.” 2010.

[ZBB10] Gunther Zapfel,
Roland Braune, Michael
Bogl. "Metaheuristic
Search Concepts:
A Tutorial with
Applications to Production
and Logistics." 2010.



Taxonomy of Optimization Approaches [ZBB10]



[ZBB10] Gunther Zapfel, Roland Braune, Michael Bogl. "Metaheuristic Search Concepts: A Tutorial with Applications to Production and Logistics." 2010.

Local vs. Global Search

- **Local Search**

- Local in scope
- The solution is a local optima (i.e. a neighbour of the starting candidate solution) which is found by making iterative local changes

- **Global Search**

- Global in scope
- The solution is a global optima (i.e. over the entire set of possible solutions) which is found by iterative making changes that cover the entire solution space (e.g., possibly over a set of candidate solutions)

Metaheuristics – Solution Construction

Ant Colony Optimization

- Probabilistic search
- Models problem as graph-based path finding

Greedy Randomized Adaptive Search Procedure (GRASP)

- Involves ranking potential solutions using a greedy function

Metaheuristics – Solution Modification

Hill Climbing

- Simpler local search than the below methods
- Incrementally tries to improve the solution by making a change to an element of the candidate solution (within a neighbourhood)

Tabu Search

- A local search that iteratively explores neighbours
- Allows worsening moves in iterative process
- Includes prohibitions preventing solutions to be revisited

Simulated Annealing

- Models optimization problem as heating a material
- As the algorithm progresses the temperature is lowered at a slow rate

Metaheuristics – Solution Recombination

Genetic Algorithms

- Work with populations of individuals (often strings)
- Involve reproduction, crossover and mutation
- Involve a fitness function that is evaluated each iteration of the algorithm

Metaheuristic Search

Summary

- Today we conducted a high-level overview of **metaheuristic search algorithms**

Up Next

- Neural networks, deep learning

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References

- [ZBB10] Gunther Zapfel, Roland Braune, Michael Bogl. “Metaheuristic Search Concepts: A Tutorial with Applications to Production and Logistics.” 2010.

