Evolutionary Computation: Method Categorization

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General Optimization Algorithms

Explicit methods
- Enumerative schemes where each possible solution is evaluated

Explicit methods
- Deterministic algorithms
- Stochastic algorithms

Deterministic Algorithms

- Greedy
- Hill climbing
- Branch and bound
- Depth-first
- Breadth-first
- Best-first
- Calculus-based

Stochastic Algorithms

- Random search
- Simulated annealing
- Monte Carlo
- Tabu search
- Evolutionary computation

Greedy Algorithms

- Locally optimal choices are made
- Assumption is made that sub-optimal solutions are always part of the global solution

Hill-climbing Algorithms

- Based on irrevocable strategy of expanding the most promising node
**Branch-and-Bound Algorithms**
- A bound is computed at each node to determine if the node is promising.

**Random Search Algorithms**
- The simplest stochastic search strategy
- A number of stochastic solutions is evaluated and the best solution is chosen.

**Simulated Annealing Algorithms**
- Based on an annealing analogy, where a liquid is heated and then gradually cooled until it freezes
- Hill-climbing chooses the best move from a node picked by SA at random
- The move probability decreases around the global optimum

**Monte Carlo Algorithms**
- Random search where any selected trial solution is independent of the previous solutions
- The current best solution is stored as a comparator

**Tabu Search Algorithms**
- Involves a meta-strategy to avoid being stuck in a local optimum
- Keeps a record of visited solutions and the path used to reach them
- Often integrated with other optimization methods

**Evolutionary Computation**
- Stochastic search methods, which computationally simulate the natural evolutionary process
- New research area, however, associated techniques have existed for about 40 years
Evolutionary Computation

Algorithms

• Genetic algorithms (GA)
• Evolution strategies (ES)
• Evolutionary programming (EP), known as EAs

Techniques

• Genetic programming
• Learning classifier systems

Evolutionary Computation

• Based on the survival of the fittest individual
• Different selection strategies
• Tournament selection - a common selection strategy

Search Strategies

\[ \mu = \text{number of parents} \]
\[ \lambda = \text{number of offspring (children)} \]

The \((\mu + \lambda)\) strategy selects the best \(\mu\) individuals from both parents and children.

The \((\mu, \lambda)\) strategy selects the best \(\mu\) individuals from the children population only.

Evolutionary Computation

Algorithms

**Typology**

<table>
<thead>
<tr>
<th>Evol Alg Type</th>
<th>Representation</th>
<th>Evolutionary Operators</th>
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</thead>
<tbody>
<tr>
<td>Real Programming (Same as EA)</td>
<td>Real-values</td>
<td>Mutation and ((\mu + \lambda)) selection</td>
</tr>
<tr>
<td>Search Strategy</td>
<td>Real-value and strategy parameters</td>
<td>Mutation, crossover, and ((\mu + \lambda), (\mu, \lambda)) selection</td>
</tr>
<tr>
<td>Gen Algorithm</td>
<td>Historically binary. Nowadays</td>
<td>Mutation, crossover, and selection</td>
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</tbody>
</table>
Genetic Programming

- Generalizes genetic algorithm
- Has design orientation vs problem solving orientation of GA

Learning Classifier Systems

- Combine GA with reinforcement learning and other learning concepts (e.g., Q learning)
- Other classifier variations, e.g., XCS

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