Evolutionary Computation: Method Categorization

Andrew Kusiak,
Intelligent Systems Laboratory
2139 Seaman's Center
The University of Iowa
Iowa City, Iowa 52242-1527
andrew-kusiak@uiowa.edu
http://www.icaen.uiowa.edu/~ankusiak
Tel: 319-335-5934 Fax: 319-335-5669

General Optimization Algorithms

• Enumerative schemes (implicit methods): Each possible solution is evaluated

• Deterministic algorithms

• Stochastic algorithms

Deterministic Algorithms

• Greedy
• Hill climbing
• Branch and bound
• Depth-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

Evolutionary Computation Techniques

- Genetic programming
- Learning classifier systems

Evolutionary Computation

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

Search Strategies

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

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.

Search Strategies

- The \((\mu + \lambda)\) strategy leads to search space exploration
- The \((\mu, \lambda)\) strategy leads to search space exploitation

Evolutionary Computation Algorithms

<table>
<thead>
<tr>
<th>Eval Alg Type</th>
<th>Representation</th>
<th>Evolutionary Operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eval Programming</td>
<td>Real-values</td>
<td>Mutation and ((\mu + \lambda)) selection alone</td>
</tr>
<tr>
<td>Eval Strategy</td>
<td>Real-values and strategy parameters</td>
<td>Mutation, recombination, and ((\mu + \lambda)) or ((\mu, \lambda)) selection</td>
</tr>
<tr>
<td>Gen Algorithm</td>
<td>Historically binary, nowadays real-values common</td>
<td>Mutation, recombination, and selection</td>
</tr>
<tr>
<td>Genetic Programming</td>
<td>Learning Classifier Systems</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Historically binary:</strong></td>
<td><strong>Historically binary:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Mutation, recombination:</strong></td>
<td><strong>Mutation, recombination:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Gen Algorithm:</strong></td>
<td><strong>Gen Algorithm:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Nowadays:</strong></td>
<td><strong>Nowadays:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>and selection:</strong></td>
<td><strong>and selection:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Real values common:</strong></td>
<td><strong>Real values common:</strong></td>
<td></td>
</tr>
</tbody>
</table>

- **Genetic programming (GP)**
  - It generalizes Genetic Algorithm
  - Design orientation vs problem solving orientation of GA

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