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Evolutionary Algorithms - Study Guide

What are evolutionary algorithms?

Evolutionary algorithms are a style of optimization inspired by the study of genetics and evolution. A population of solutions are proposed for a given problem. The best solutions are held aside, and the rest are removed. Then, by introducing changes through crossover and/or mutation, the algorithm explores the search space. If we don't introduce any new genetic material (through mutation), the process will tend to stagnate due to a limited gene pool.

What kinds of evolutionary algorithms are out there? (Here are just a few)

- **Genetic algorithm**: formulate a string of numbers (traditionally binary) to represent a genome and iteratively improve based on a fitness function in order to solve a problem.
- **Evolution Strategies**: genetic algorithm with a vector of real numbers
- **Genetic programming**: genetic algorithms applied to generating programs.
- **Neuroevolution**: genetic programming applied to neural networks

What are the steps in an evolutionary algorithm?

4 steps:

1. **Initialization**: create an initial population of solutions.
2. **Selection**: members are evaluated based on a fitness function
3. **Genetic Operators**: ('A' or 'A and B')
   A) mutation: vary the genes based on random noise
   B) crossover: swap genes between successful members of the population
   (repeat steps 2 and 3 until...)
4. **Termination**: end after reaching max runtime or a threshold of performance

What are the advantages of evolutionary algorithms over other methods?

- Evolutionary algorithms cover a large search space
- Highly creative approaches
- Doesn't require a gradient

What kinds of problems are evolutionary algorithms suited for?

- Problems where there is a large search space for solutions
- Problems where you can't calculate a gradient
- Black box engineering: problems where you don't have a very informative model
- Quantum computing: designing quantum algorithms can be counter-intuitive

How can evolutionary algorithms be combined with neural networks?

- The weights can be trained with an evolutionary algorithm (conventional neuroevolution)
- Neural Architecture search: can be used to find optimal Neural Net architectures
- Use a Neural Network to get the features and evolution to get the policy

Further information

Introduction to Evolutionary Algorithms

An introduction to Evolutionary Algorithms - Dr. Shahin Rostami

Multi-Objective Problems - Dr. Shahin Rostami

What exactly are genetic algorithms and what sort of problems are they good for?

Evolutionary algorithms: A critical review and its future prospects (2016, pay-wall)

Evolutionary-Neural Hybrid Agents for Architecture Search (2019, under review)

Meet some of the researchers

Jeff Clune

Kenneth Stanley

Wolfgang Banzhaf

Lee Spector

Publications of Dr. A.E. Eiben