AI Applications in Genetic Algorithms

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Works Cited

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Overview

1. What is Genetics?
2. What are Genetic Algorithms?
3. Brief History of Genetic Algorithms?
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What is Genetics?

- Genetics is the study of Genes and Heredity.
- Genes are made up of sequences of DNA
- How offspring share traits with their parents
- Each person has a unique set of genes - this determines the features and characteristics present in each individual
- Even though our DNA is largely the same, the existence of slight variances from person to person makes us all different.
- Parents will pass on certain genes, mutations can cause some genes to change

http://learn.genetics.utah.edu/content/basics/

What are Genetic Algorithms?

Genetic Algorithms is the process of improving AI by having them replicate evolution. The points are placed into nodes that represent an iteration of the AI and then are randomly selected and paired together to have child nodes who host an assortment of rules from both nodes. These nodes are then randomly selected again and paired until eventually an optimal solution is found.

The rules it follows are: *Selection Rule*, which chooses nodes to carry over to a next generation; *Crossover Rules*, combining two nodes to create an improved node; *Mutation Rule*, which randomly alters the code passed down to the next generation.

https://www.mathworks.com/discovery/genetic-algorithm.html
https://www.mathworks.com/help/gads/what-is-the-genetic-algorithm.html?requestedDomain=www.mathworks.com

History of Genetic Algorithms

The start of genetic algorithms began in 1953 by Nils Barricelli and the goal was initially to create artificial life. Barricelli created the first genetic algorithm which was later picked up in 1957 by biologist Alexander Fraser to study the path of evolution.

While it was intended to study evolution and genetics, computer scientists found that genetic algorithms were methods to solve complex problems and optimization.

Genetic algorithms have an advantage over traditional methods because they use a wide range of candidate solutions to optimize a problem rather than looking for a single solution.

https://www.whitman.edu/Documents/Academics/Mathematics/2014/carrjk.pdf page 17

History (Cont.)

In 1975, John Holland published a book called *Adaption in Natural and Artificial Systems*, which outlines the more recent specifics of genetic algorithms

The idea of a population was a major innovation to the field

In lieu of evolutionary computations, these genetic algorithms uses genetic operators to determine the changes that a new population will have

In more recent years, the boundaries between this original definition of genetic algorithms and their evolutionary siblings have blurred

http://www.boente.eti.br/fuzzy/ebook-fuzzy-mitchell.pdf

Genetic Algorithms Process

Genetic Algorithms initialize a large amount of nodes, known as population of genes to create a viable set that will be broken down into the most optimal solution.

Genetic Algorithms apply a fitness algorithm to judge the quality of the population. The fitness algorithm is unique to the application it is applied to. Earlier iterations of the Genetic Algorithm have an extremely low fitness while later iterations are extremely fit.

https://cs.stanford.edu/people/eroberts/courses/soco/projects/1997-98/genetic-algorithms/algo.html

Genetic Algorithms Process (CONT.)

Genetic algorithms use genetic operators to gear the algorithm towards a correct solution.

There are three genetic operators *Selection, Crossover,* and *Mutation.*

Selection operators tells the algorithm what properties a candidate solution should have to be considered a *good* or *better* solution. Selection is analogous to the *fitness* property found in evolution.

Crossover operators tells the algorithm what properties a candidate solution should adopt from its parent solution in order to find the best combination solution.

Mutation operators allows candidate solutions to create genetic diversity and widen the pool of possible candidate solutions. Mutation operators are an integral part of genetic algorithms because they add complexity to the pool of candidate solutions, making it possible to solve complex problems.

http://www.doc.ic.ac.uk/~nd/surprise_96/journal/vol1/hmw/article1.html

Example Code of an Genetic Algorithm

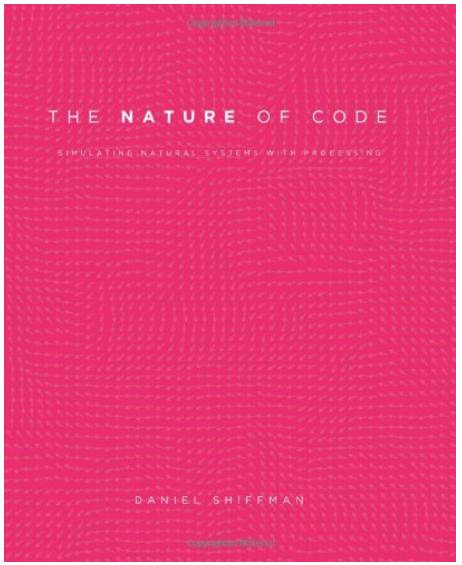
```
function DNA(genes) {
  // Recieves genes and create a dna object
  if (genes) {
    this.genes = genes;
  }
  // If no genes just create random dna
  else {
    this.genes = [];
    for (var i = 0; i < lifespan; i++) {
      // Gives random vectors
      this.genes[i] = p5.Vector.random2D();
      // Sets maximum force of vector to be applied to a rocket
      this.genes[i].setMag(maxforce);
    }
  }
```

```
// Performs a crossover with another member of the species
this.crossover = function(partner) {
  var newgenes = [];
  // Picks random midpoint
  var mid = floor(random(this.genes.length));
  for (var i = 0; i < this.genes.length; i++) {
    // If i is greater than mid the new gene should come from this partner
    if (i > mid) {
      newgenes[i] = this.genes[i];
    }
    // If i < mid new gene should come from other partners gene's
    else {
      newgenes[i] = partner.genes[i];
    }
  }
  // Gives DNA object an array
  return new DNA(newgenes);
}
```

https://github.com/CodingTrain/Rainbow-Code/blob/master/CodingChallenges/CC_29_SmartRockets/dna.js

Example Code of an Genetic Algorithm

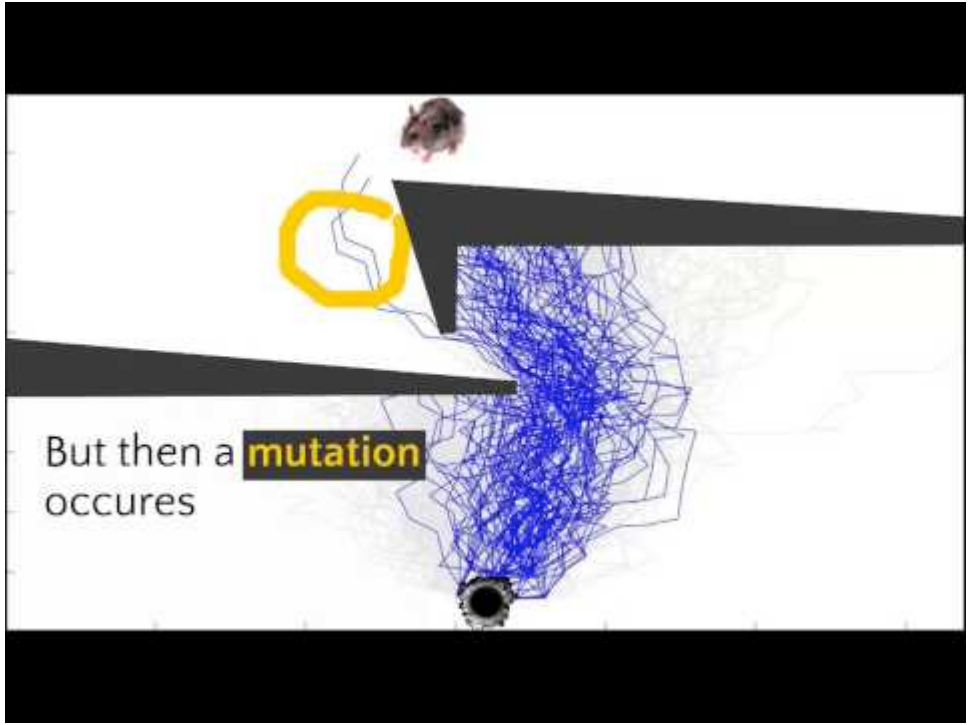
```
// Adds random mutation to the genes to add variance.
this.mutation = function() {
  for (var i = 0; i < this.genes.length; i++) {
    // if random number less than 0.01, new gene is then random vector
    if (random(1) < 0.01) {
      this.genes[i] = p5.Vector.random2D();
      this.genes[i].setMag(maxforce);
    }
  }
}
```



https://i.gr-assets.com/images/S/compressed.photo.goodreads.com/books/1363560350i/17622418._UY200_.jpg

https://github.com/CodingTrain/Rainbow-Code/blob/master/CodingChallenges/CC_29_SmartRockets/dna.js

Genetic Algorithms in ACTION



https://youtu.be/XcinBPhgT7M?t=22s

Scheduling

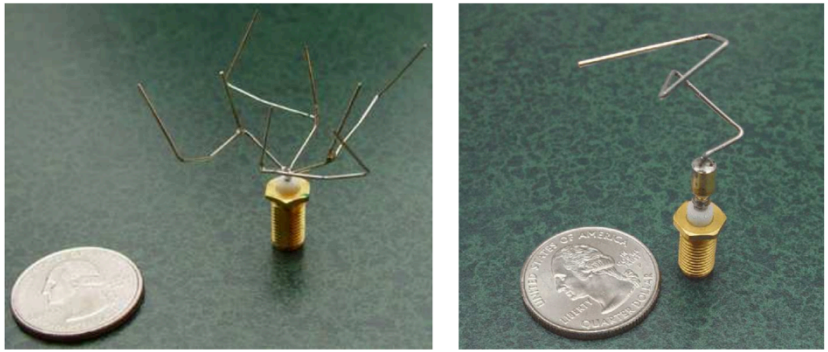
- A very practical application
- Applies to many different situations
- Seems like a relatively simple problem, but due to the existence of both hard and soft constraints means it is a NP-complete problem
- Hard constraints such as two tests can’t be in the same room at the same time
- Soft constraints such as fatigue/ morale of workers

http://www.talkorigins.org/faqs/genalg/genalg.html#examples:routing

The Evolved Antenna

NASA developed an evolved antenna design using genetic algorithms to find the most optimal radiation patterns for use on the ST5 spacecraft.

Compared to standard antenna designs, the evolved antenna designs were 80% efficient with one antenna and 93% efficiency with two antennas.



(a) (b)

http://www.jeffreythompson.org/blog/wp-content/uploads/2015/05/GeneticallyGrownAntennas_NASA-web-1024x441.jpg

https://ti.arc.nasa.gov/m/pub-archive/1244h/1244%20(Hornby).pdf

OpenAI Dota 2 Bot

OpenAI is a project of Elon Musk to see whether a bot would be able to beat a professional player in the game Dota 2.

The bot was not told any basic rules of the game, and was let loose on Dota 2 servers to learn basic techniques. Eventually the bot was able to perform high level techniques consistently. Eventually several pro players were versed in a 1v1 competition and had consistently beaten every player it was up against.

https://www.inverse.com/article/35449-elon-musk-dota-2-openai-the-international-dendi-1v1

Genetic Algorithms in StarCraft

A program called Evolution Chamber uses genetic algorithms to find the perfect tactics for the game StarCraft.

It starts by allowing the user to set up a list of basic actions

It runs a genetic algorithm with these actions as chromosome. The algorithm run many cycles to find the best population strategy.

https://www.wired.com/2010/11/genetic-algorithms-starcraft/

https://www.theverge.com/2017/4/19/15353282/download-starcraft-1-free-brood-war-blizzard

Limitations

- Speed is highly depended on the initial population
- Takes days to find a solution
- The solution may not be the best solution

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.9245&rep=rep1&type=pdf

QUESTIONS

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