NOC – EVOLUTION OF CODE

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Evolution of Code – Nature of Code

The Generic Algorithm, Part I: Creating a Population

Create a population of randomly generated elements called "DNA". In field of generic algorithms, we have two important concepts:

- **Genotype: This is what gets passed down generation to generation (Heritage).**
- **Phenotype: This is the expression of data. How we choose to express the module.**

Genotype	Phenotype
Int c = 255;	
Int c = 127;	
Int c = 0;	

Same Genotype	Different Phenotype (line length)
Int c = 255;	
Int c = 127;	
Int c = 0;	

More specific description would be:

Create a population of N elements, each with randomly generated DNA

The Generic Algorithms, Part II: Selection

Here, Darwinian principle of selection is applied as followed:

1. ***Evaluate fitness***

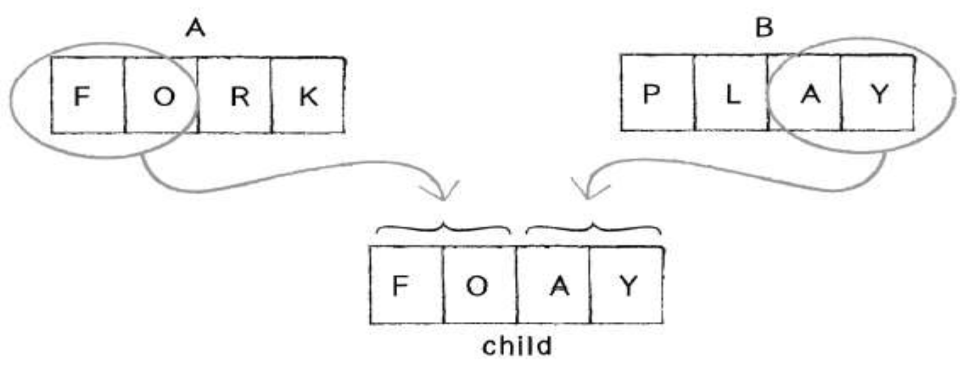
   Fitness, is an overall score given to each element, describing its similarity level with the desired target.
2. ***Create a mating pool***

   Once fitness is calculated, we must make a (as we call) *mating pool* using a probabilistic method. Basically, a weighed wheel of fortune.

The Generic Algorithms, Part III: Reproduction

Now that we have chosen two or more parents using our *mating pool*, we must pass their DNA to a newly made element. How we do this:

1. **Crossover**
   An algorithm that determines how the DNA genes are passed from parents to child.



There are various algorithms to implement *Crossover*. Implementations have not been mentioned here.

2. **Mutation**
   Mutation maintains some variation when DNA is inherited. This ensures the population variation in future generations.

Setup Sudo-Code:

SETUP:

Step 1: ***Initialize***. Create a population of N elements, each with randomly generated DNA.

LOOP:

Step 2: ***Selection***. Evaluate the fitness of each element of the population and build a mating pool.

Step 3: ***Reproduction***. Repeat N times:

a) Pick two parents with probability according to relative fitness.
b) Crossover—create a "child" by combining the DNA of these two parents.
c) Mutation—mutate the child's DNA based on a given probability.
d) Add the new child to a new population.

Step 4. Replace the old population with the new population and return to Step 2.

Crossover Implementation:

```
// Crossover, creates a new genes array using the two parents
    DNA crossover(DNA partner) {
```

```
      int midPoint = (int)random(genes.length);  // Random location in genes array
      DNA child = new DNA(genes.length);  // Create child DNA

      // Inherit from patner and self
      for (int i = 0; i < genes.length; i++)
        if (i < midPoint)
          child.genes[i] = this.genes[i];
        else
          child.genes[i] = partner.genes[i];

      return child;
    }
```

Mutation Implementation:

```
// Mutate genes based on the given probability
    void mutate(float mutationRate) {
      for (int i = 0; i < genes.length; i++)
        if (random(1) < mutationRate) {
          this.genes[i] = PVector.random2D();
          this.genes[i].mult(random(0, maxForce));
        }
    }
```

Accept Reject Implementation (Weighted Probability):

```
// Accept Reject algorithm for calculating weighted probability
    Rocket acceptReject(float maxFitness) {
      int safe = 0;  // In we couldn't find the appropriate parent, then giveup (Throw error)
      while (safe < 1000) {

        Rocket partner = population[(int)random(population.length)];  // Choose a random Rocke
t
        float prob = random(maxFitness);

        if (prob < partner.getFitness())
          return partner;

        safe++;
      }
      return null;
    }
```

Natural Selection Implementation:

```
// selection
    void generate() {
```

```
      float maxFitness = getMaxFitness();

      Rocket[] newPopulation = new Rocket[population.length];
      for (int i = 0; i < population.length; i++) {

        // Choose two fittest parents' DNAs
        DNA parent1_DNA = acceptReject(maxFitness).dna;
        DNA parent2_DNA = acceptReject(maxFitness).dna;

        DNA child_DNA = parent1_DNA.crossover(parent2_DNA);  // Inherit genes
        child_DNA.mutate(mutationRate);  // Mutate genes

        newPopulation[i] = new Rocket(new PVector(width / 2, height + 20), child_DNA);
      }
      population = newPopulation;  // Replace the old generation with the new one
      generations++;
    }
```

Mating Pool Implementation:

```
// Generate a mating pool
  void selection() {
    // Clear the ArrayList
    matingPool.clear();

    // Calculate total fitness of whole population
    float maxFitness = getMaxFitness();

    // Calculate fitness for each member of the population (scaled to value between 0 and 1)
    // Based on fitness, each member will get added to the mating pool a certain number of tim
es
    for (int i = 0; i < population.length; i++) {
      float fitnessNormal = map(population[i].getFitness(), 0, maxFitness, 0, 1);
      int n = (int) (fitnessNormal * 100);  // Arbitrary multiplier
      for (int j = 0; j < n; j++) {
        matingPool.add(population[i]);
      }
    }
  }
```

*Credits: These implementations are used in “Shakespeare Monkey Typer” and “AutonomousRockets” inspired from NOC by Daniel Shiffman.