Genetic Programming

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CONTENTS

Introduction

Genetic Programming

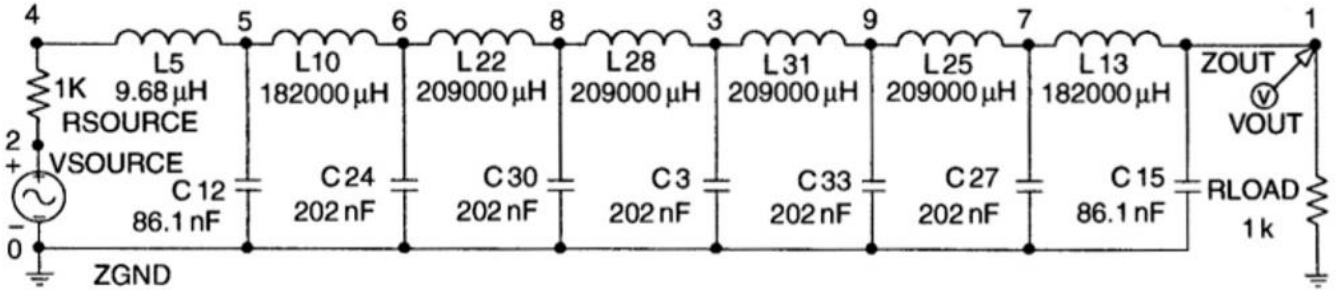
GP can automatically synthesize both

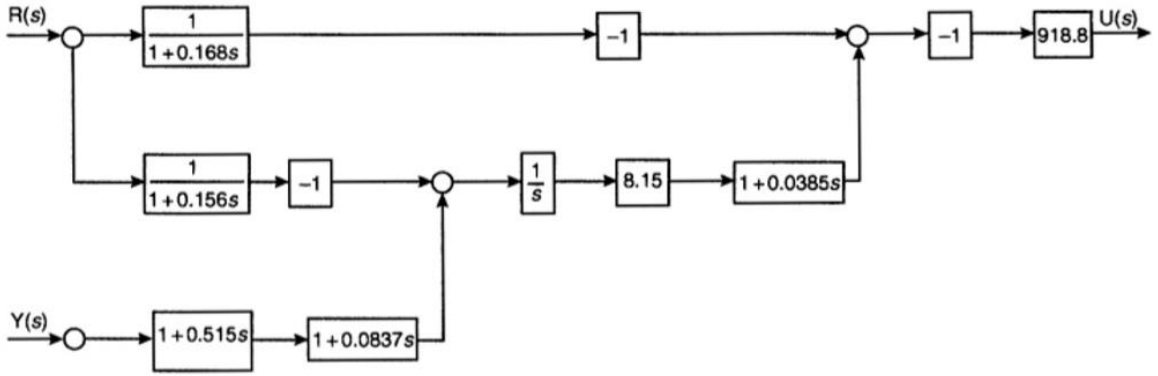
a graphical structure (the topology)

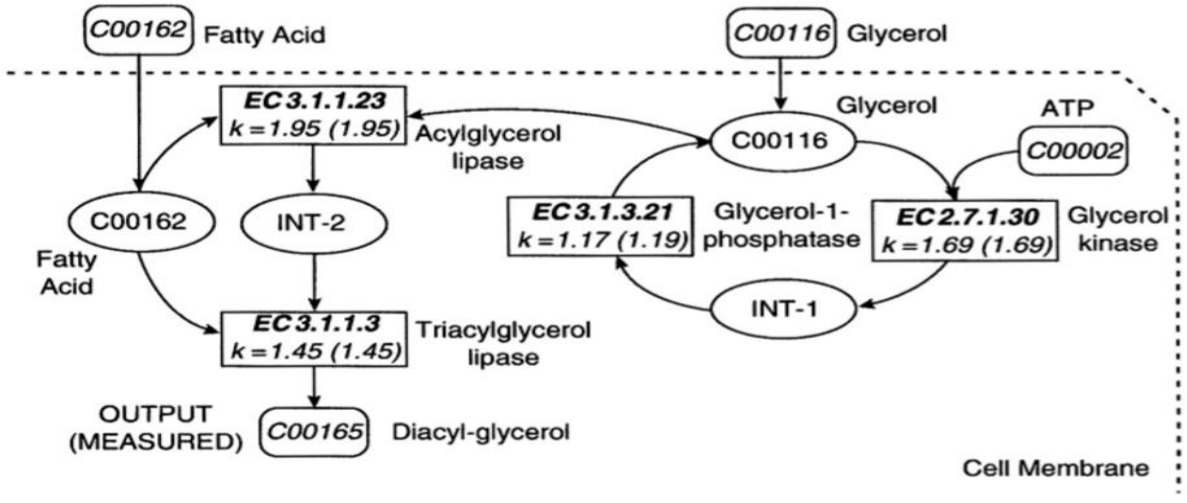
and a set of optimal or near-optimal

numerical values for each element of

- analog electrical circuits
- Controllers
- antennas
- networks of chemical reactions







Genetic Programming

- It’ s a global optimization search algorithm
- It’ s simple and robust
- It’ s suitable to solve nonlinear complex problems

Feature of Genetic Programming:

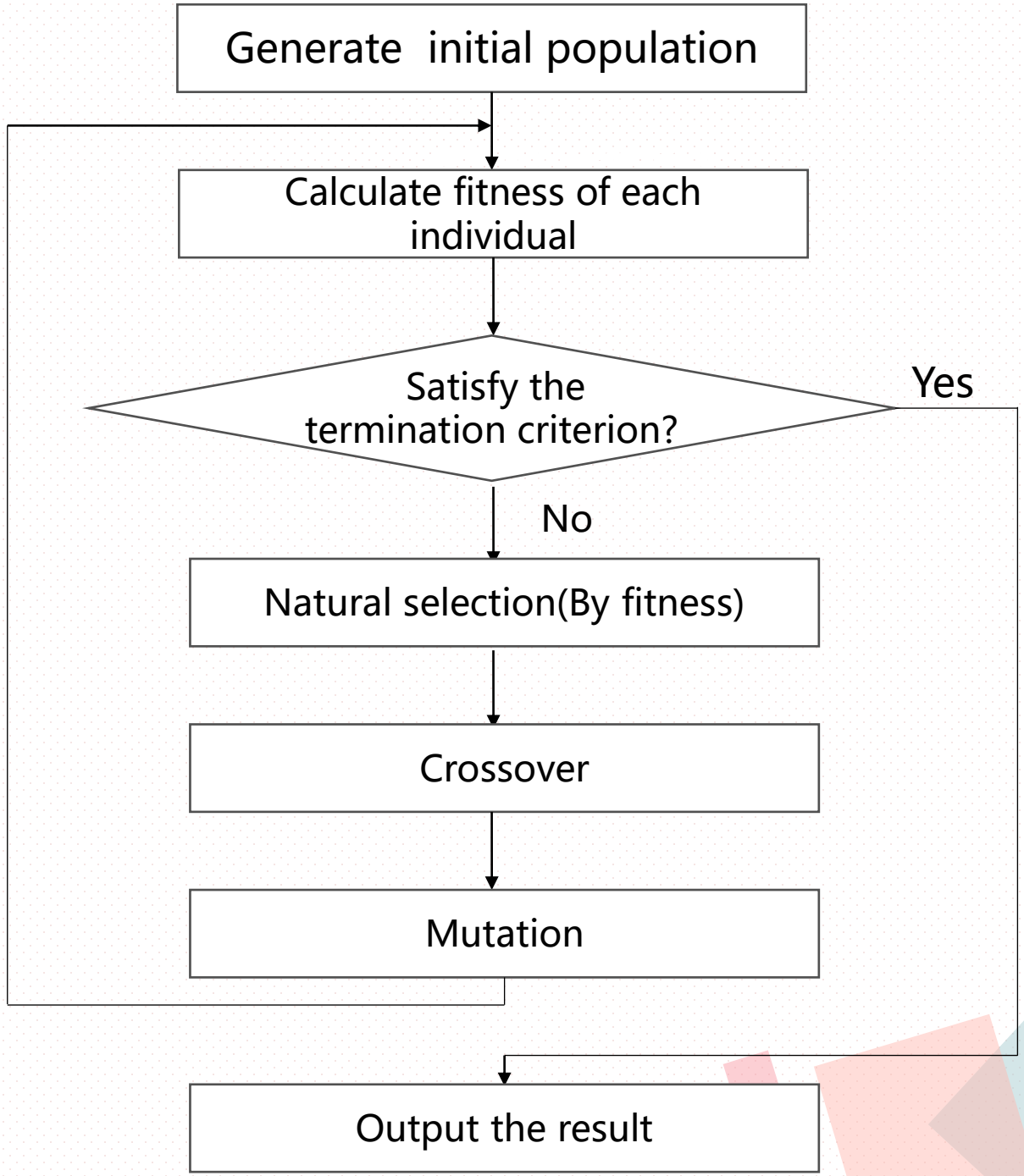
- basic unit of evolution is the new algorithm and its parameters
- GP is usually represented by tree structure, which is relatively complex.
- the length (depth) of individuals in each generation of GP is generally different, even between individuals in the same generation.
- the resources consumed by GP are uncontrollable

Details of GP

Details of GP

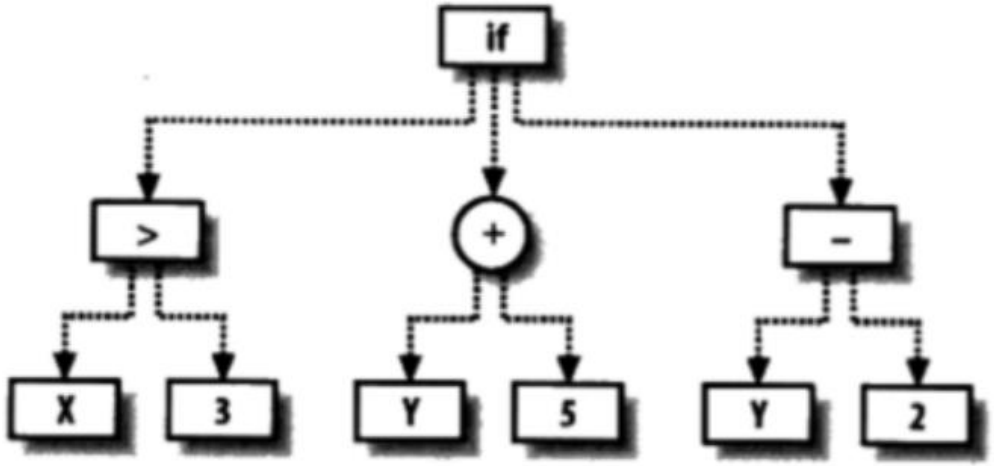
The procedure of GP includes:

- Natural selection
- Crossover
- Mutation
- Gene duplication
- Gene deletion



Generate initial population

- Generate initial population: the population of programs is usually generated randomly



Calculate fitness

- Calculate fitness: the fitness measures the problem-solving ability of the individual
- Fitness function: a function that calculates the fitness of individuals in a population. It shouldn’ t be to complex, or too much time will be wasted in calculating fitness.

Natural selection

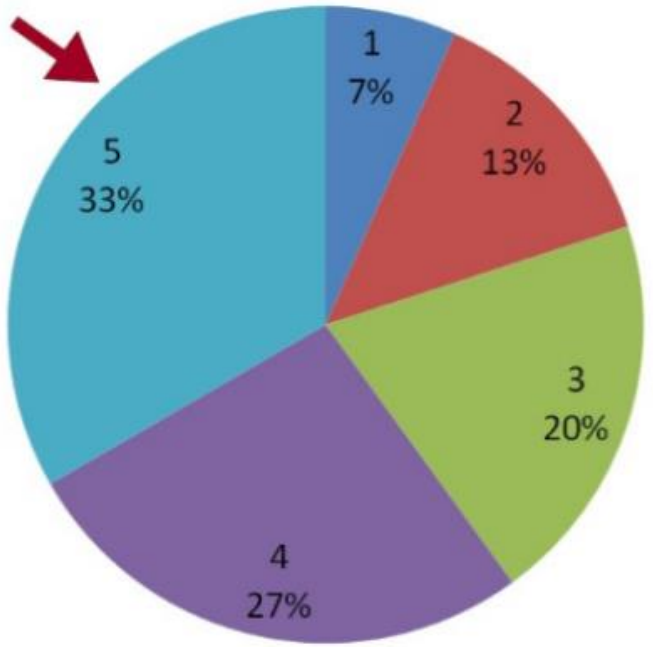
There are two ways to do natural selection:

- Tournament Selection : Tournament selection randomly selected a certain number of individuals from the group, compared their fitness, and the one with the highest fitness was selected as parent for the next step of genetic operations.
- Roulette Wheel Selection

Natural selection

- Roulette Wheel Selection : The probability of an individual being selected is proportional to its fitness. The formula of Roulette Wheel Selection is:

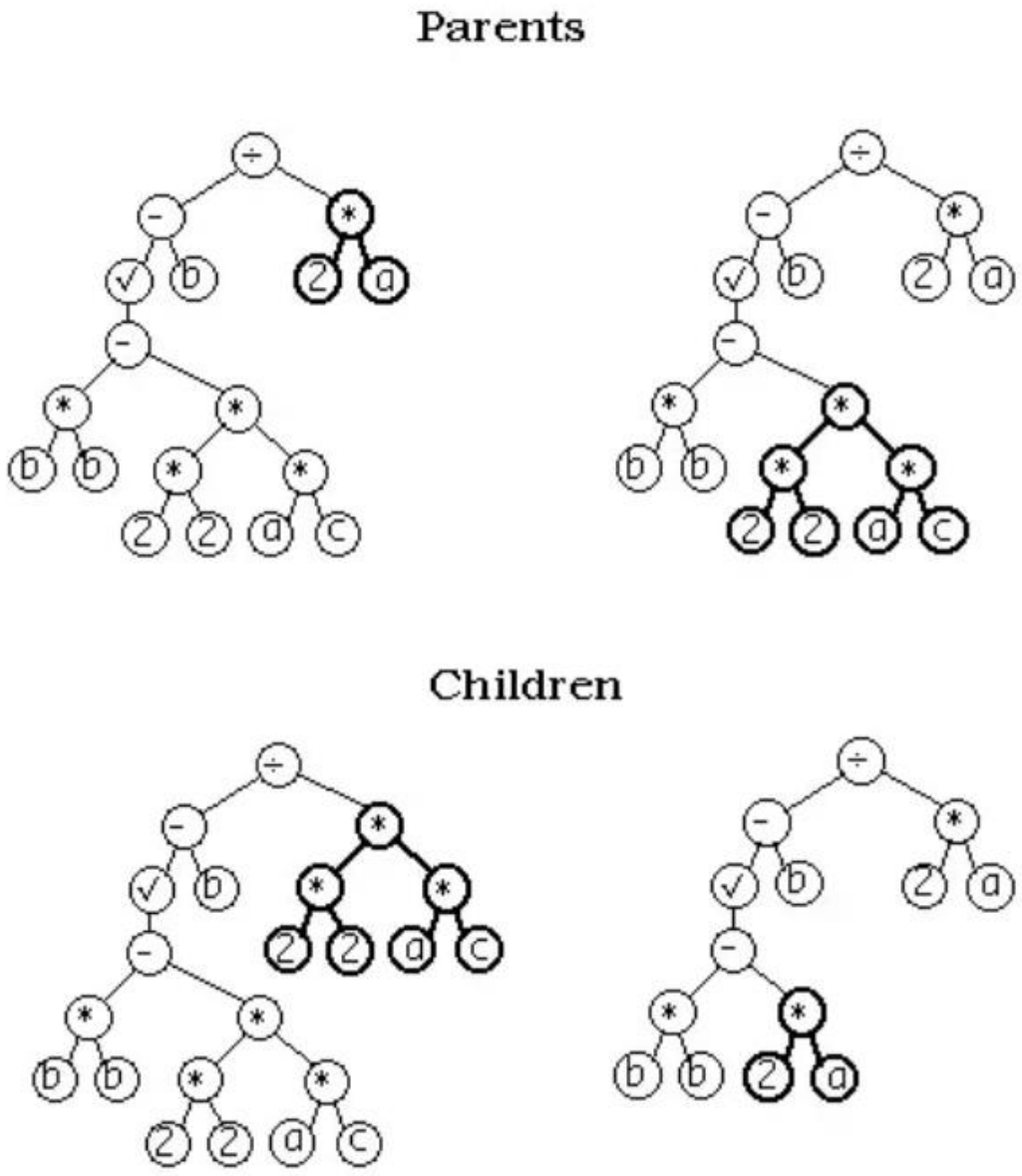
$$P_i = \frac{f_i}{\sum_{k=1}^{N} f_k}$$



Individual	Fitness
1	1.0
2	2.0
3	3.0
4	4.0
5	5.0

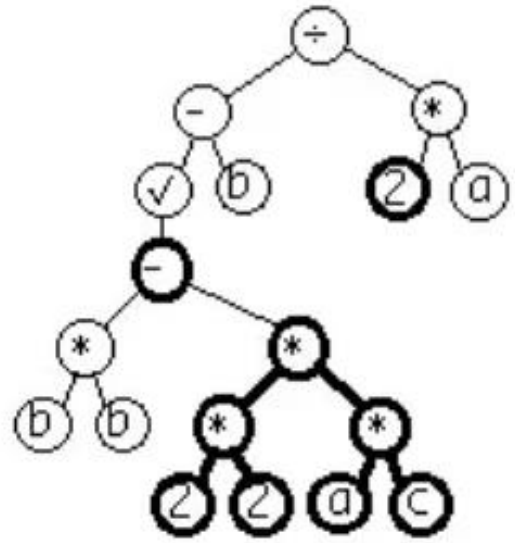
Crossover

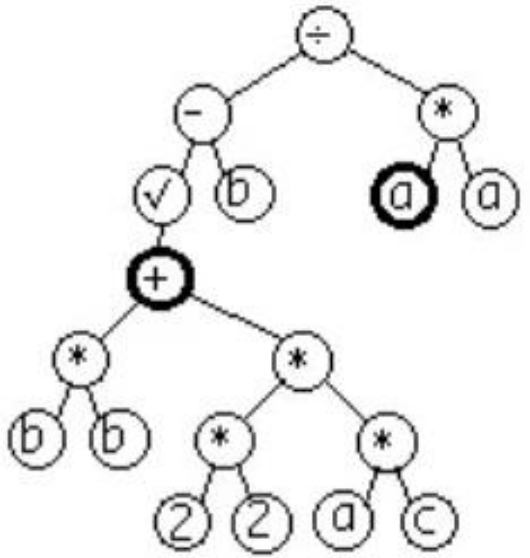
- Crossover: create a new offspring program for the new population by recombining randomly chosen parts of two selected programs.

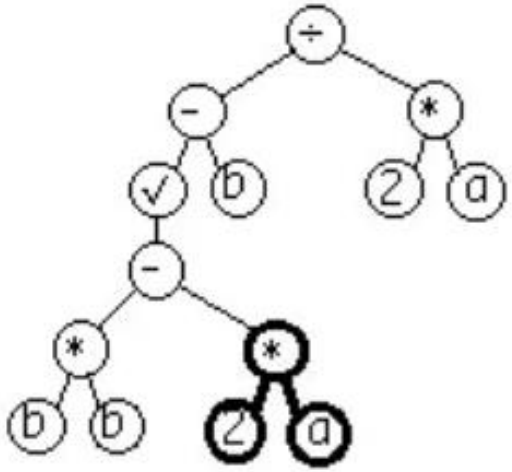


Mutation

- Mutation: Create one new offspring program for the new population by randomly mutating a randomly chosen part of the selected program.
- Mutation can be viewed as an undirected local search mechanism.







Advantages and disadvantages

Advantages and disadvantages

Advantages:

- Strong universality. It can be applied to continuous variables and discrete variables;
- No derivative information is required, so the continuous and differentiable properties of fitness functions are not required;
- Parallel search can be done in a wide range of solution spaces;
- The probability of falling into local optimality is very small;
- Highly parallelized and easy to integrate with other optimization methods;

Disadvantages:

- The convergence rate of convex optimization problems is slow;
- A large number of individuals in the search space is needed to search for the optimal solution.
- It takes a lot of experience to design coding methods, fitness functions, and mutation rules.