第七章 进化计算

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第七章 进化计算

Outline

Part Ⅰ: Biological Inspiration to Search

1. Major Agents of Genetic Change in Individuals:
    - **Recombination**
    - **Mutation**
2. 进化机制可以分为 **自然选择**、**重组**、**突变** 三种类型
3. **Evolutionary Computation**:

> Adoption of the evolutionary paradigm to computation and other problems can help us find optimal solutions

Part Ⅱ: DNA Computing

1. DNA acts as a massive memory, but complementary bases react with each other can be used to compute things.
2. Uniqueness of DNA:
    - Extremely dense information storage.

> The 1 gram of DNA can hold about 1x1014 MB of data.

- Enormous parallelism.

  > contain trillions of strands. 3X10^14

- Extraordinary energy efficiency.

  > 2 x 10^19 operations per joule.

3. DNA计算

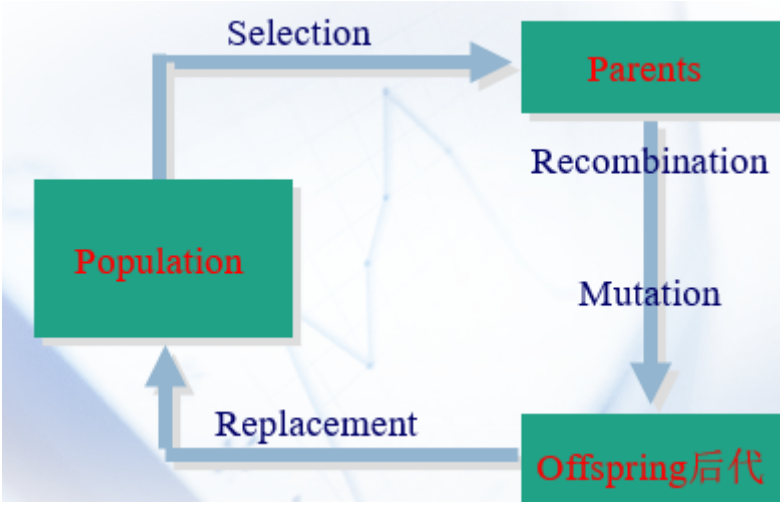
Part Ⅲ: What is Evolutionary Computation?

1. The Metaphor between **evolution** and **search**

   > Environment -> Problem
   > Individual -> Candidate Solution
   > Fitness -> Quality(Value or Cost)

2. 进化机制可以分为 **自然选择**、**重组**、**突变** 三种类型

3. The Evolutionary Cycle



4. 典型进化算法
   确定问题的表达方式，基因型还是表现型，编码方式

```
BEGIN
  INITIALISE population with random candidate solutions;
  EVALUATE each candidate;
  REPEAT UNTIL ( TERMINATION CONDITION is satisfied ) DO
    1 SELECT parents;
    2 RECOMBINE pairs of parents;
    3 MUTATE the resulting offspring;
    4 EVALUATE new candidates;
    5 SELECT individuals for the next generation;
  OD
END
```

5. 五个要素factor
   >**Representation** Genotypic vs. Phenotypicv
   >**Fitness Evaluation**
   >**Genetic Operations**
   > - Recombination
   > - Mutationv
   > **Selection Strategies**
   > - Parent Selection
   > - Survivor Selection初始化终止方案
   > **Initialization\Termination Schemes**
6. 突变exploration和选择exploitation的平衡

   > 选择太多会导致局部最优解
   > 突变太多会导致不收敛
7. 如何设计一个进化算法?

   > Step1. Design a representation
   > Step2. Design a way of mapping a genotype to a phenotype (not necessarily)
   > Step3. Design a fitness function
   > Step4. Design suitable genetic operators: mutation and/or recombination
   > Step5. Decide how to select parents and survivors
   > Step6. Decide how to initialise a population and when to stop the algorithm
8. Example: 8 Queen

Part IV : Evolutionary Algorithms

1. Genetic algorithms
2. Evolutionary Programming
   - 主要特点

     > 表现型观点
     > 只存在突变不存在重组
     > 进化发生在个体上
     > 先产生新的群体，然后在新旧两个群体上平等选择

   - 理论基础

     > One point in the search space stands for a species, not for an individual and there can be no crossover between species

   - 选择算子

     > Parent selection(一个父代个体通过突变产生一个子代个体)
     > Survivor selection（随机型q-竞争法）

   - Example application: evolving checkers players
3. Evolutionary Strategies
   - 进化策略主要特点

     > applied to numerical optimazation
     > fast, good optimizer for real-valued optimazation, relatively much throry
     > self-adaptation of (mutation) parameters standard
     > 自然选择按照确定的方式执行，有别于遗传算法和进化规划中的随机选择方式

   - 进化策略的不同形式
     - (1+1)-ES, only mutation
     - (u + 1)-ES, mutation and recombination
     - (u + λ)-ES, mutation and recombination
   - 进化策略中的遗传操作
     - 重组
       - 离散重组
       - 中值重组
       - 混杂重组
     - 变异
       - 简单突变算子
       - 二元突变算子

- 三元突变算子

$$\begin{cases}\sigma_i' = \sigma_i \cdot \exp\left(\tau' \cdot N(0,1) + \tau \cdot N_i(0,1)\right) \\ \alpha_{ij}' = \alpha_{ij} + \beta \cdot N_j(0,1) \\ x_i' = x_i + z_i\end{cases}$$

- 选择

> 严格按照适应度大小选择

- 算法流程

> Step1 确定问题的表达方式
> Step2 随机生成初始种群，计算其中每个个体的适应度
> Step3 用以下操作生成新群体，实现进化：
> Step3-1. 选择某种重组方式进行个体重组
> Step3-2. 选择某种突变方式对重组后的个体进行突变
> Step3-3. 计算新个体适应度 Step3-3. 选择适应度最高的前若干个优良个体组成下一代群体
> Step4 反复执行Step3，直到终止条件满足，从群体中选择最优个体作为最优解。这里，终止条件与进化规划算法的终止条件类似。