

不做任何假设，随机算法，全局搜索  
用适应度近似法解决计算复杂度障碍  
收敛性没问题，需要无穷时间

## 优点

- 易于并行parallelized，基于种群的搜索
- 易跳出局部最优local optima
- 适用性广（人工智能落地关键），不用调参

- *non-differentiable problems*
- *problems without explicit objective function formulation*
- *problems with multiple objective functions*

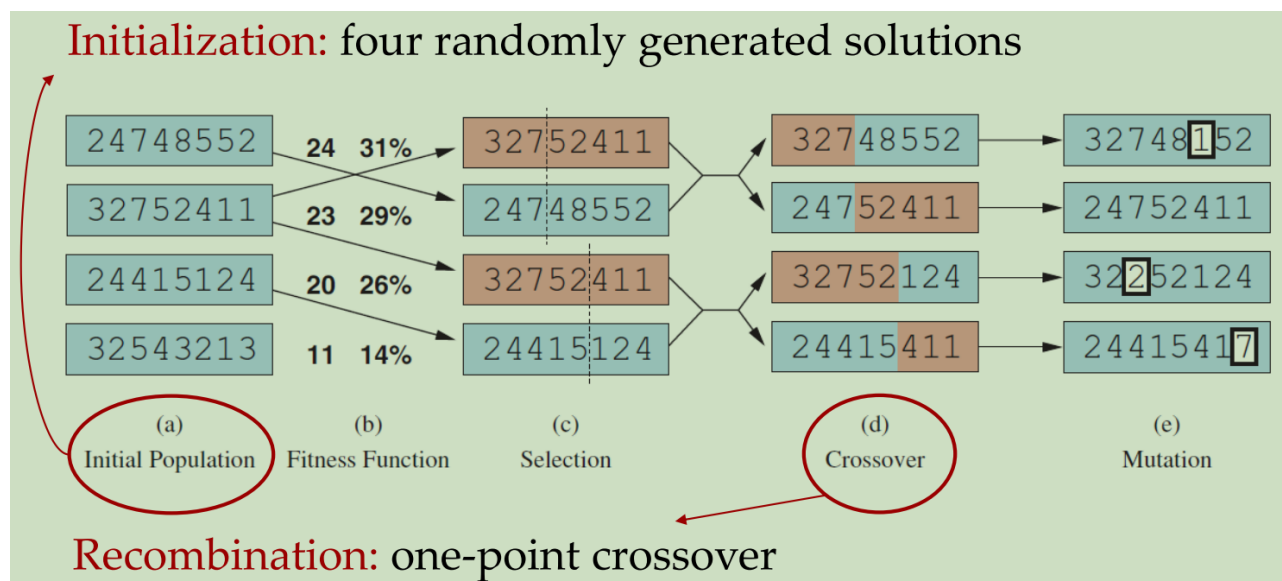
## 缺点

- 可解释性不强
- 效率低，但有加速方法

- *utilizing modern computer facilities*
- *combining with local search*
- *using the machine learning techniques*


## 例子--八皇后

用8个皇后所在行数作为8位编码



- 交叉Crossover
- 变异Mutation: 当前解随机扰动
- 幸存者survivor selection: 父代和子代淘汰一半

## 起源




### Genetic Algorithms (GA)

for optimization in discrete domains

[J. H. Holland. *Outline for a logical theory of adaptive systems*. JACM, 1962]

J. H. Holland  
1929-2015

University of Michigan




### Evolutionary Strategies (ES)

for optimization in continuous domains

[I. Rechenberg. *Cybernetic solution path of an experimental problem*. 1965]

I. Rechenberg  
1934-

Technical University of Berlin



### Evolutionary Programming (EP)

for optimizing finite state machines (agents)

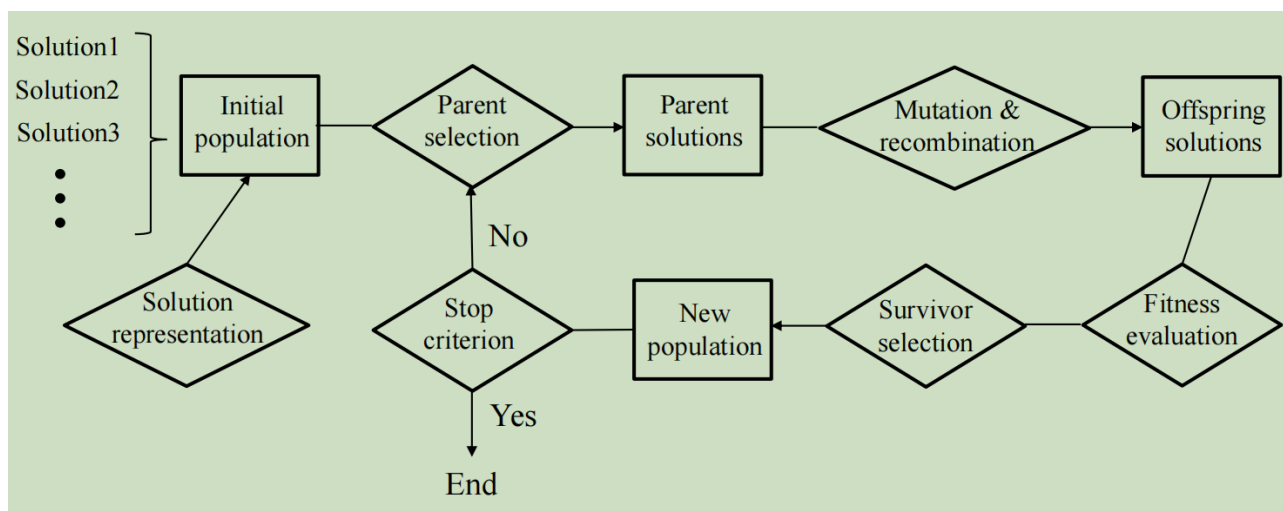
[L. J. Fogel, A. J. Owens, M. J. Walsh. *Artificial Intelligence through Simulated Evolution*. 1966]

L. J. Fogel  
1928-2007

University of California, Los Angeles

90年代合并成EC: 演化计算

通过交叉变异和自然选择维持解的质量



## population

- Size of population: the number of contained genotypes基因型

fitness适应度, 评价得分

genotypes代表种群多样性

一个fitness可以对应多个优化对象phenotypes表现型

一个phenotypes可以对应多个genotypes

genotype用01编码表示便于交叉变异

## survive selection

- fitness based: 选fitness最高的
- age based: 只要子代offspring, 抛弃所有父代parent

## 背包问题

Population size	500
Initialization	Random
Parent selection	Tournament selection with size 2
Recombination	One-point crossover
Recombination prob.	70%
Mutation	Bit-wise mutation
Mutation prob.	$1/n$
Number of offspring	500
Survival selection	Age based
Termination condition	No improvement in last 25 generations

Select two solutions from the population uniformly at random, and choose the better one as a parent solution

**one-point crossover:** Select one point randomly, and exchange the parts of the parents after that point

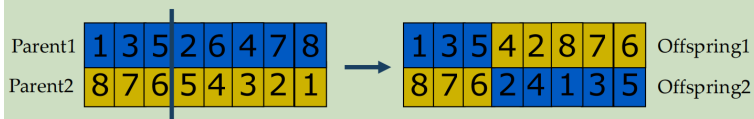
**Bit-wise mutation:** Flip each bit of a solution with probability  $1/n$

## 八皇后问题

Representation	Permutation
Population size	100
Initialization	Random
Parent selection	Best 2 out of random 5
Recombination	Cut-and-crossfill crossover
Mutation	Swap
Mutation prob.	80%
Number of offspring	2
Survival selection	Fitness based
Termination condition	Reach the best fitness or 10,000 fitness evaluations

### Cut-and-crossfill crossover:

1. Select a crossover point randomly;
2. Cut both parents into two segments at this point;
3. Copy the first segment of parent 1 into offspring 1 and the first segment of parent 2 into offspring 2;
4. Scan parent 2 after the crossover point and fill the second segment of offspring 1 with values from parent 2, skipping those that it already contains
5. Do the same for parent 1 and offspring 2



### Swap 80%

Swap values of two randomly chosen positions



算法运行100次再画一个平均图像

参数有很大影响

只要结果可以评价，就可以用演化算法