CC484 – Constraint Satisfaction Genetic Programming

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Outline (1/1)

- What is GP?
- Biological concepts
- Flowchart of GP
  - Population
  - Fitness Function
  - Selection
  - Genetic Operators
- Research Points.
- Applications

What is GP? (1/1)

- Genetic Programming (GP) has been highly successful as a technique for getting computers to automatically solve problems without having to tell them explicitly how to do it.

- GP is considered a branch of Genetic Algorithms.

Previous work (1/1)

- Friedberg – 1950.
- Lynn Cramer – 1980.
- John Koza – 1990.

Fig. 1. John Koza

Inspiration of GP (1/1)

- In GP, hundreds or thousands of individuals are genetically bred.
- It has its inspiration from Darwinian Theory.
- Darwinism is a term used for evolution and natural selection.

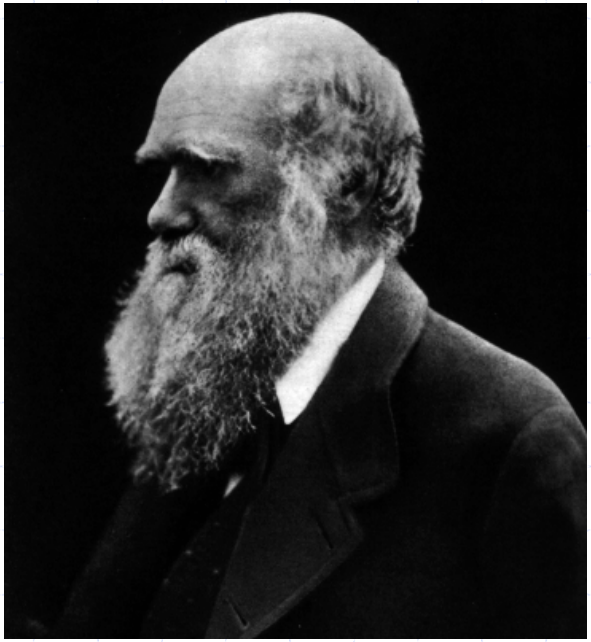


Fig. 2. Charles Darwin

Evolution and Natural Selection (1/1)

- What is Evolution?

  Evolution = COOL!

- What is Natural Selection?

  Natural Selection = COOL!

Some biological concepts (1/5)

- **Deoxyribonucleic acid (DNA)** is a nucleic acid that contains the genetic instructions specifying the biological development of all cellular forms of life.
- DNA is often referred to as molecule of **heredity**.
- During reproduction, DNA is replicated and **transmitted** to the offspring.

Some biological concepts (2/5)

- DNA is encoded with four bases, which can be abbreviated **A, T, C and G**.
- A strand of DNA contains **genes**.
- The DNA is normally packed in the form of one or more large macromolecules called **chromosomes**.

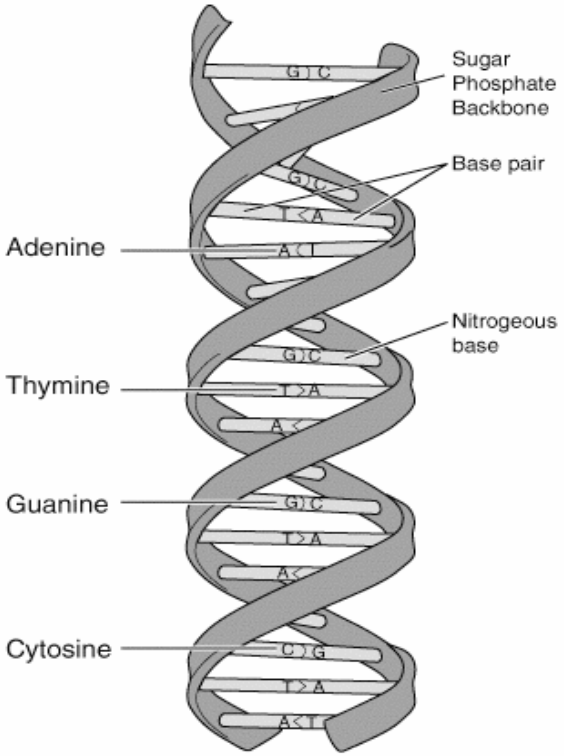


Fig. 3. Structure of DNA.

Some biological concepts (3/5)

- Each **gene** is able to occupy a single position in the chromosome.
- The **genome** of an organism is the whole hereditary information of an organism that is encoded in the DNA.
- An individual is a member of a population.
- **Many Individuals = Population**.

Some biological concepts (4/5)

- The **phenotype** of an individual is its total physical appearance and constitution.
- The **genotype** is the genetic composition of an individual.
- The **fitness** of an individual refers to individual's ability to propagate its genes.
- **Reproduction** is the biological process by which new individuals are produced.

Some biological concepts (5/5)

- **Reproduction**:
  - Sexual (two individuals)
  - Asexual (one individual)
- **Selection** is based in the fitness of each individual.

Flowchart for GP (1/1)

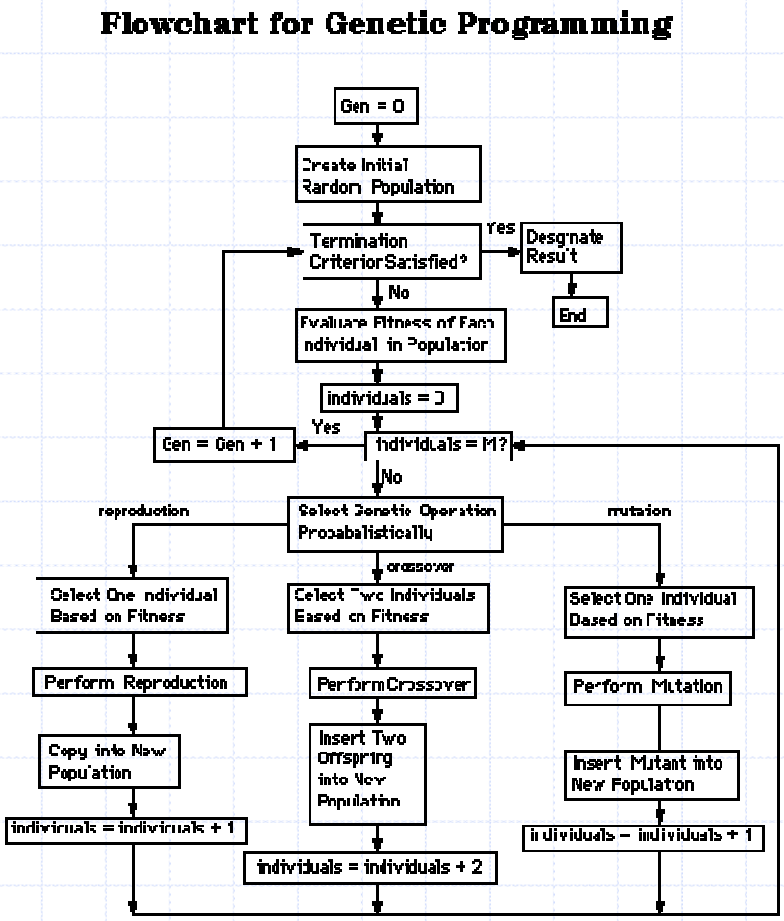


Fig. 4. Flowchart for the GP Paradigm

Terminal and Functional Sets (1/1)

- The **functions** in the function set may include: arithmetic operations (+, -, *, /), mathematical functions (sin, cos, exp), Boolean operations (and, or, not), and more.
- The **terminals** are typically either variable atoms or constant atoms.

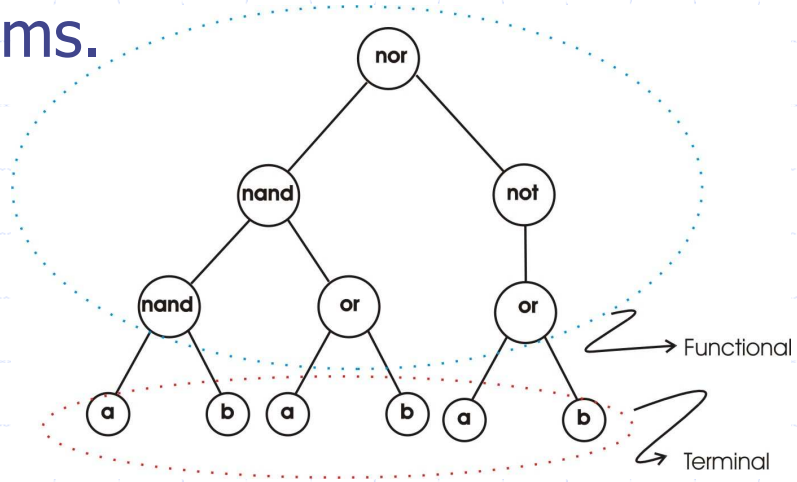


Fig. 5. A typical individual in GP.

Closure and Sufficiency (1/1)

- The **closure** that each of the functions in the function set be able to accept, as its arguments, any value and data type that may be possible returned by any function.
- The **sufficiency** requires that the terminal and functional sets be capable of expressing a solution to the problem.

Initialization of individuals (1/1)

- The "**full**" method involves creating trees for which the length of every nonbacktracking path between an endpoint and the root is equal to the specified maximum depth.
- The "**grow**" method involves growing trees that are variably shaped.
- The "**ramped half-and-half method**" is mixed method of full method and grow method.

Genotype-Phenotype (1/1)

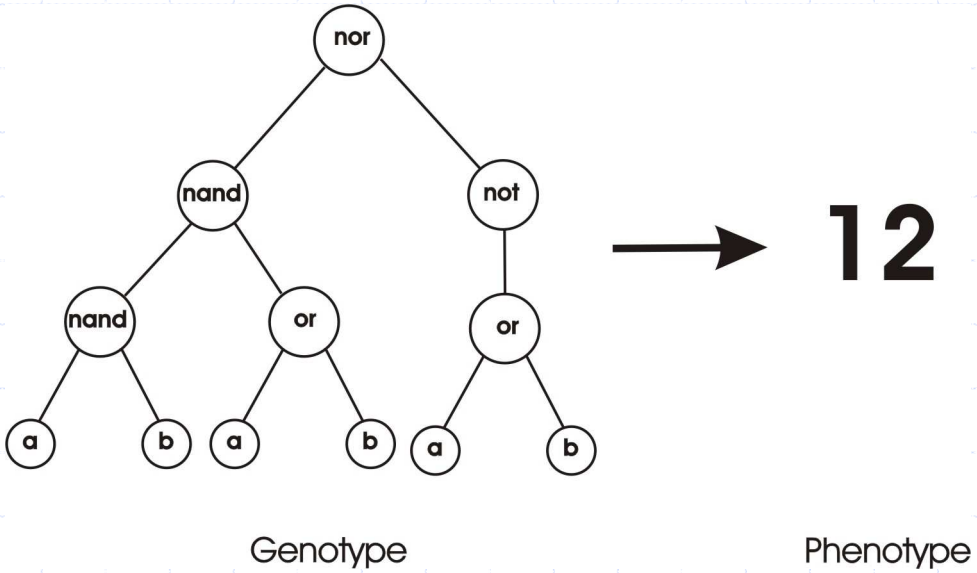


Fig. 6. Genotype-Phenotype of an Individual.

Selection (1/1)

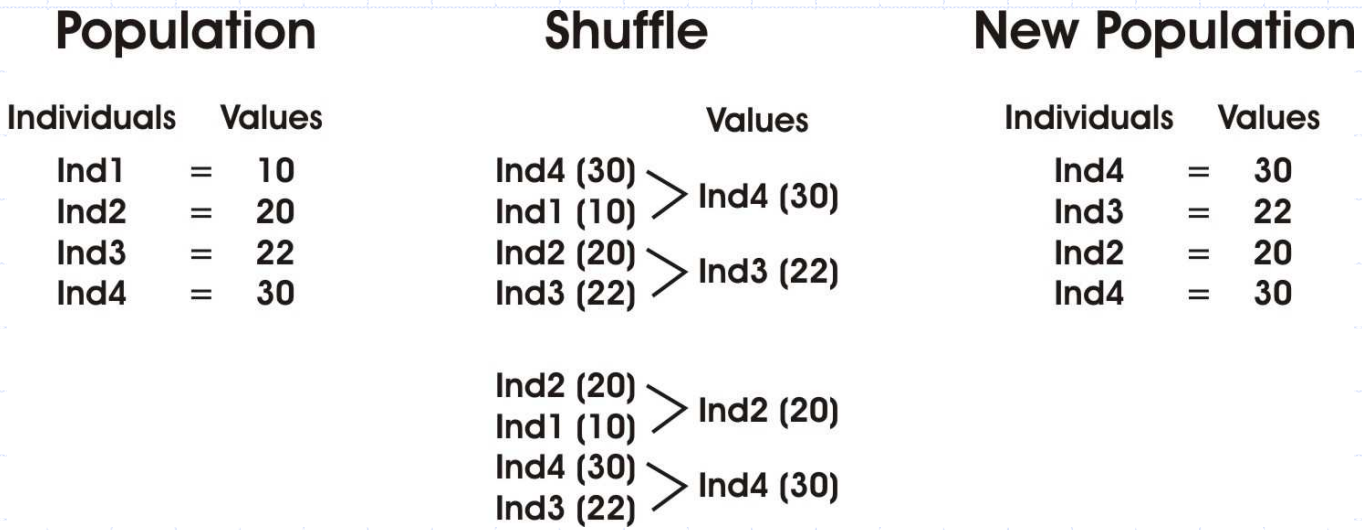


Fig. 7. Tournament Selection.

Crossover Operator (1/1)

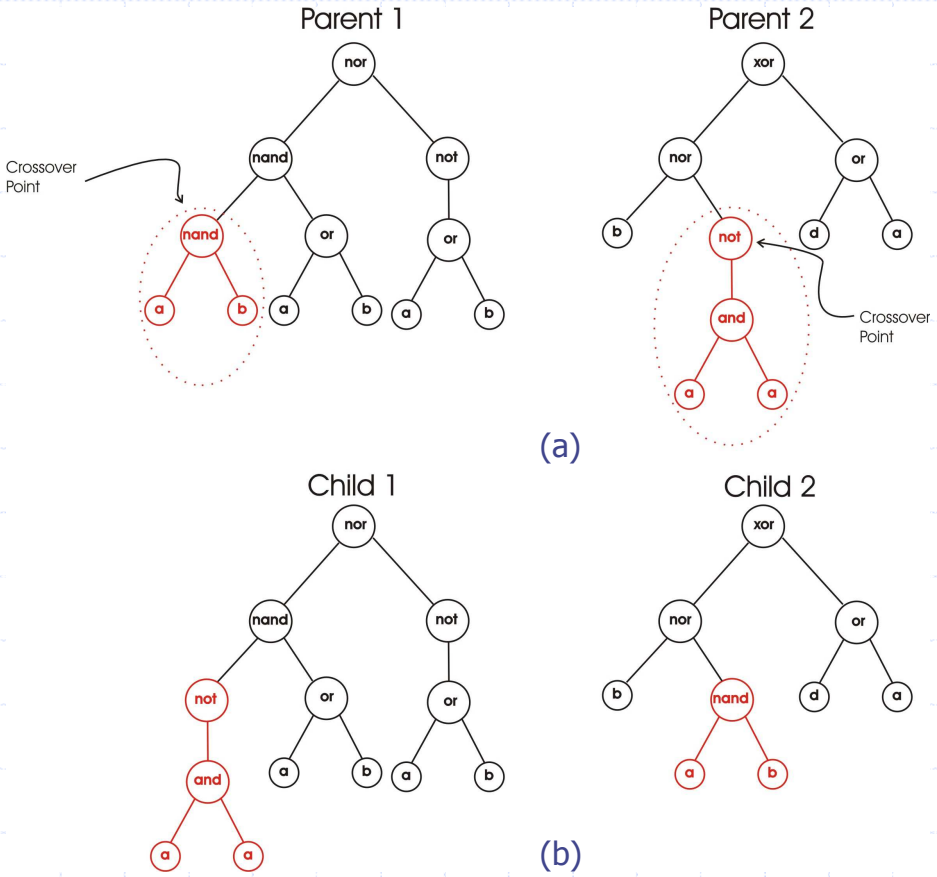


Fig. 8.Two parents before applying the crossover operator (a) and the children obtained after applying the crossover operator (b).

Mutation Operator (1/1)

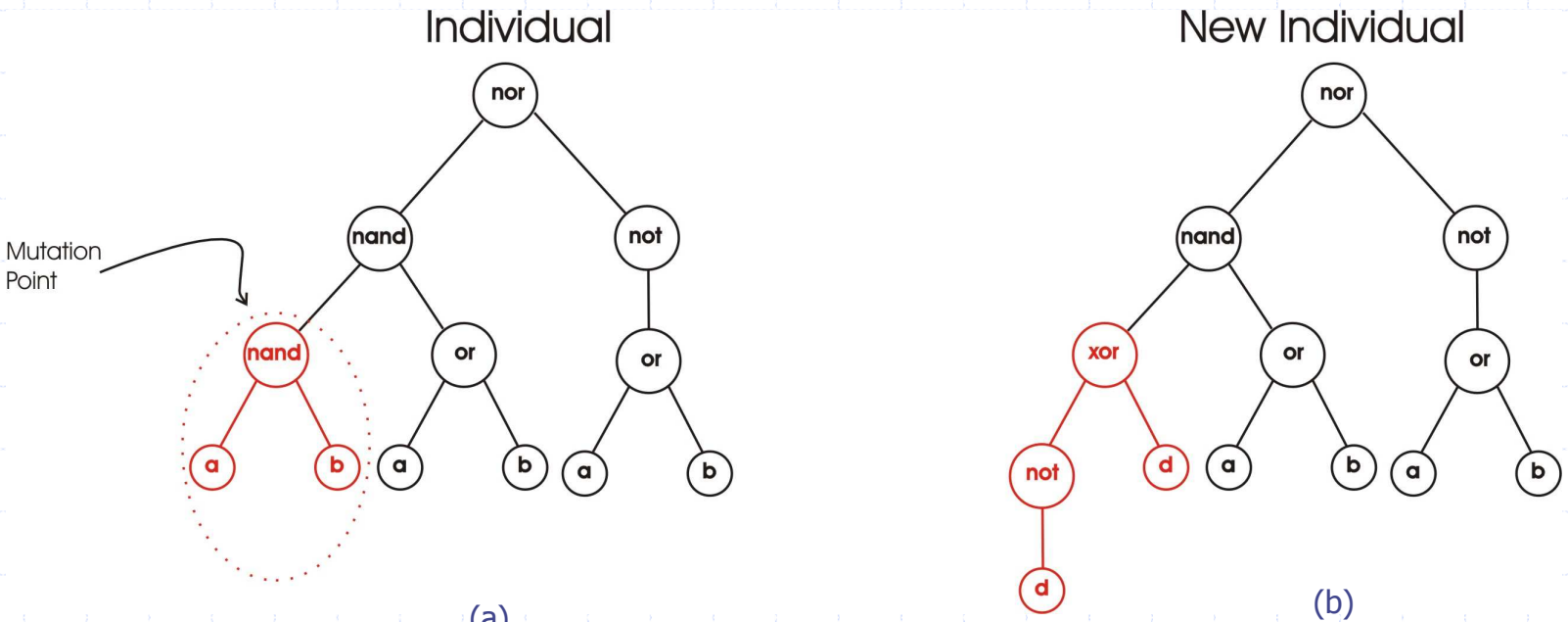
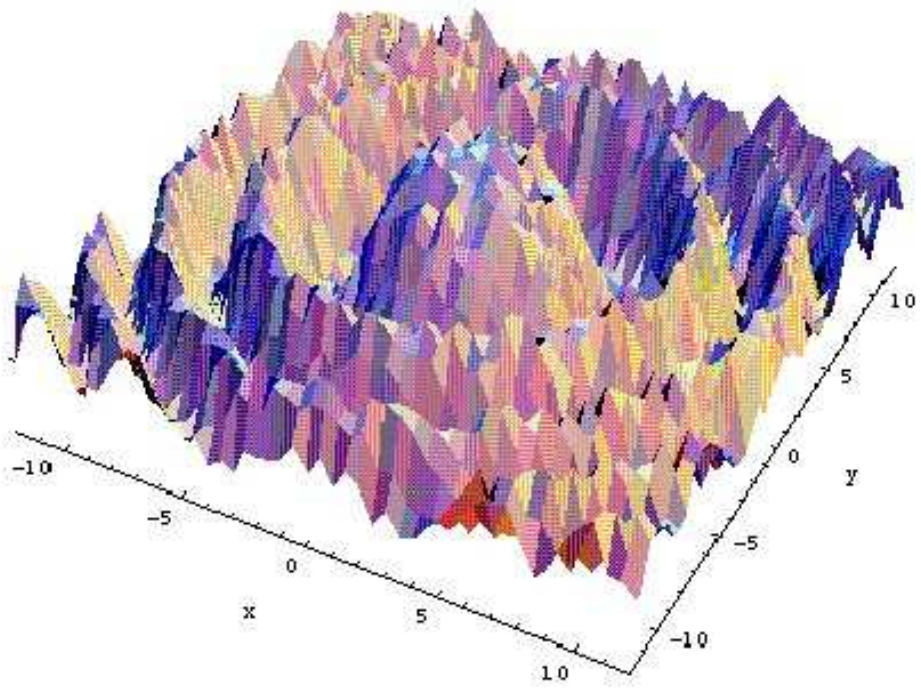


Fig. 9. One individual before applying the mutation operator (a) and the new individual obtained after applying the mutation operator (b).

Search Space (1/1)



Research Points (1/1)

- Introns.
- Bloat.
- New genetic operators.
- Mapping genotype-phenotype.
- Neutral Networks.

Applications (1/1)

- Robotics.
- Analysis of signals. (video)
- Generation of music.
- Compression of images.
- Tracking.

References (1/1)

- John Koza (1992), *Genetic Programming: On the Programming of Computers by Means of Natural Selection*.
- Banzhaf, W., Nordin, P., Keller, R.E., Francone, F.D. (1997), *Genetic Programming: An Introduction: On the Automatic Evolution of Computer Programs and Its Applications*, Morgan Kaufmann
- William Langdon and Riccardo Poli (2002), *Foundations of Genetic Programming.*