Machine Learning CS579

FacePrints, Maze Solver and Genetic algorithms

by Jacob Blumberg

Presentation Outline

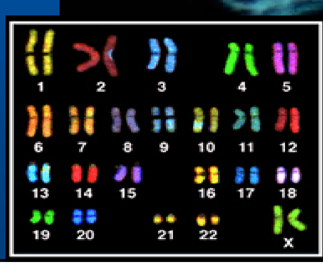
- **Brief reminder genetic algorithms**
- **FacePrints a system that evolves faces**
- **Improvements and future work**
- **Maze Solver**
- **Summary**
- **Demo of Maze Solver**

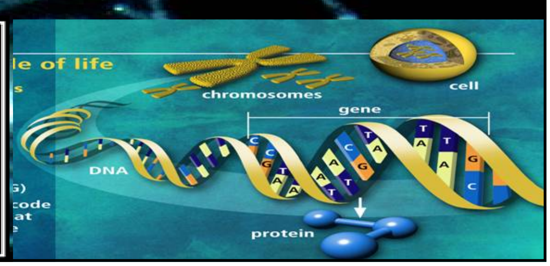
Brief Introduction

- What are genetic algorithms?
  - A search techniques to attempt find optimal solutions according to a fitness function
- Why use them?
  - To solve hard problems with medium epistasis
  - Very robust
- Huge variations of methods

Components Involved:

- Population of Hypothesis / Chromosomes
  - Represented as Binary Strings
- Fitness / Evaluation Function
- Genetic Operators:
  - Crossover
  - Mutation





Encoding a Problem
Representing a Hypothesis

- Each chromosome is composed of a set of genes
- Each gene must then be encoded into binary
- The genes are then concatenated to form a chromosome
- Careful how you represent your problem
  - Invalid chromosomes?
  - Related Genes should be next to each other
- Finding the best set of genes is equivalent to finding the best solution

Basic Process

Generate a initial population of hypotheses
Compute Fitness of each hypothesis
While the population has not converged
    For (population-size ÷ 2)
        Select two hypotheses from the old generation for matting
        Uses genetic operators on this pair to create offspring
        Compute the fitness of the two offspring
        Add the offspring to the new generation

Uniform Crossover

- Generate a uniformly random crossover mask
- For the first offspring
  - If 1 in the mask use the first parent
  - If 0 n the mask use the second parent
- For the second offspring do the exact opposite
- Eliminates the problem of ordering genes well
- Works as well as 2-point crossover

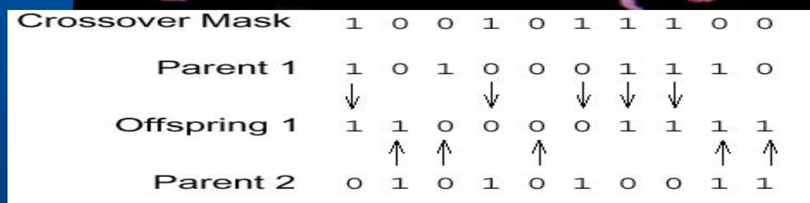


Figure 2: Uniform Crossover

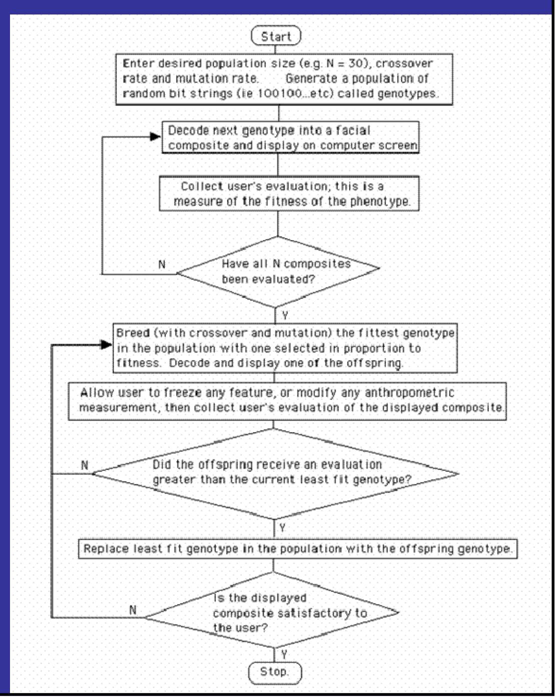
FacePrints by Dr. Victor Johnston Psychology at NMSU

- System to evolve faces based on human evaluation
- Create the most attractive, healthiest, ect. Male or Female face
- Recreate a sketch of a criminal from an eye witness

Encoding of a human face

- Any unique face can be found in a Multidimensional “Face-Space”
- The Cartesian dimensions corresponds to the shapes and position of facial features
- Each face is represented by 10 numbers
- Five numbers to specify the shape of each feature (hair, eye, nose, mouth, and chin)
- Five numbers to specify the unique proportions of each feature, specified by its values on the five-position axis.

Flow chart of FacePrints

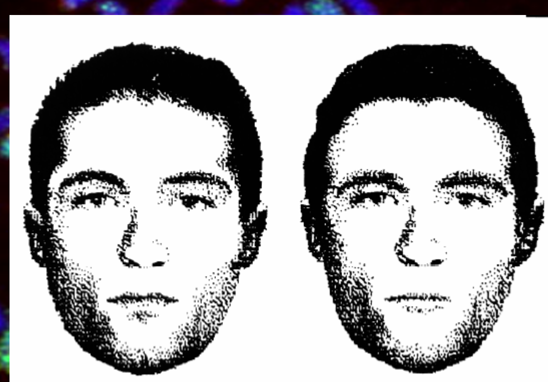


Genetic Properties of FacePrints

- Initially Random Population
- Fitness is provided by a human
- Uniform Crossover
- Single bit mutation
- Offspring are evaluated as they are created
- Termination based on a perfect fitness or after 200 evaluating faces

FacePrints Fighting Crime

- Replaces a sketch artist
- Reconstructs a face after a crime
- Fitness: how close the face is to the actual face seen

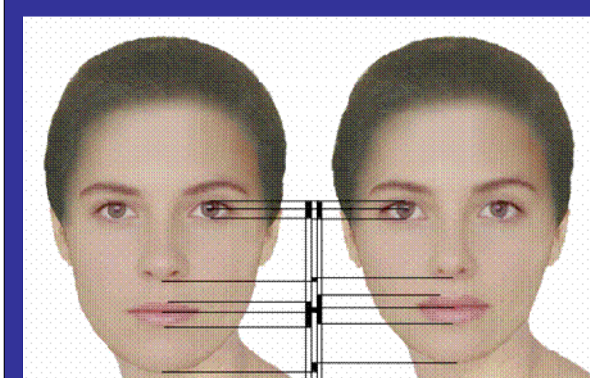


Human Facial Beauty

- Beauty is view as arbitrary and non-important
- The average face in a population is perceived to be most attractive
- Studies using FacePrints have shown the opposite
- Results explained by Darwin’s sexual selection

Characteristics of Attractiveness

- Shorter Narrow Jaw
- Wider eyes
- Raised thin eyebrows
- Full lips

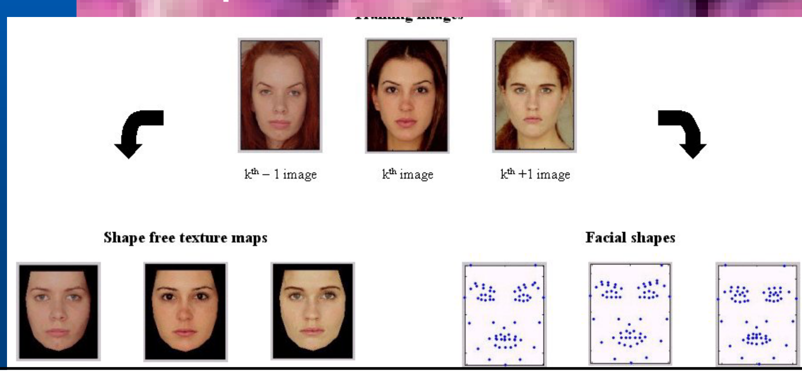


Improvements in Representing Faces

- Every Face is variation of the average face
- Weighted set of components of the major sources of variance
- Principal Component Analysis
  - Uses the important Eigenvectors as a new basis to compress the information
- Shape and texture components

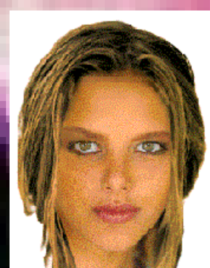
Appearance Model

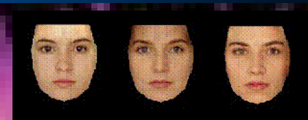
- 100 high quality photos of Caucasian females
- Compact, able to create random plausible faces
- 200-400 bits per chromosome



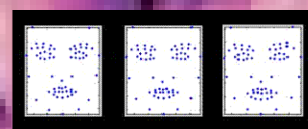
Creating Synthesized Faces

- Texture maps are warped to the corresponding shapes

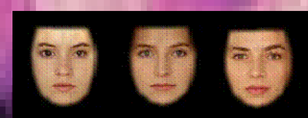




Synthesized, shape free, texture maps



Synthesized face shapes



Synthesized faces

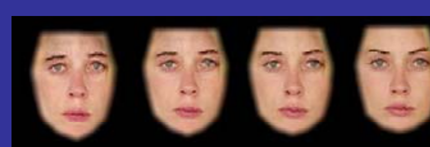
Preliminary Results

Evolve a known face from an average face

Evolve a attractive face

Modification constrained by parameters

(a) Steps in evolutionary process Target face



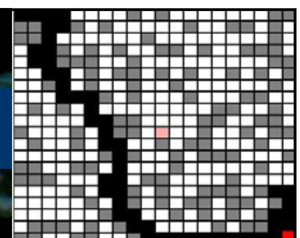
(b) Attractiveness evolution

(c) Original face.
Random perturbations on the appearance model parameters.

Potential uses in Surgery

- Two important modifications
  - 3-D facial appearance
    - Virtually Reality, viewing and rotating?
    - 3-D facial scanners
  - Controlled variations
    - Modify faces based on what is possible
    - Relationship between parameters and surgical procedures.

Maze Solver



- Uses a genetic algorithm to find a path through a maze.
- Chromosomes consist of a string of directions (N)orth, (S)outh, (E)ast, (W)est
  - Eg. “NSNEWSENNNSSSEW”
- Initializes population w/ randomly generated paths (may not be valid)
- Paths are fixed length
- Crossover only creates one offspring

Crossover Methods

- 1 Point crossover
- 2 Point crossover
- Truncate Section

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Before Crossing
    Index        0 1 2 3 4 5 6 7 8
    Parent1      E W S E W S E W S
    Parent2      N N N N N N N N N

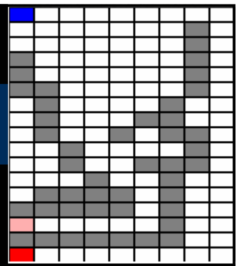
After Crossing using index1 = 2 index2 = 3
    Index        0 1 2 3 4 5 6 7 8
    Child        E W W S E W S N N
```

- Uniform Crossover
- Random – (pick a method a random)

Procedure

1. Select percentage of survivors, i.e. the genes with the highest fitness
2. Add new (random) genes to survival population
3. Cross survivor population to create the next generation
4. Mutate some of the next generation
5. 'Optimize'
6. Evaluate
7. Sort according to weight (only to help the survivor selection)
8. Show best fit genes (only to see how the GA evaluates)
9. Resolve Crowding
10. Mutate Maze if option is chosen

Optimizations



- Optimizations
  - Loop truncation and redundant step elimination
- Dead End Detection
  - Bombs if fitness is not increase in 4 generations
- Locked chromosomes

Evaluation

- Cartesian Distance Fitness function
- Walks the path specified in the chromosome.
  - Ignores direction and moves to the next gene if the direction leads it into a wall or block
  - Kills the chromosome if it reaches a bomb
  - Terminates if the end is reached.

Crowding

- Premature Convergence
- Over-dominate chromosome gets copied over and over even though it is not the best
- Force mutation with-in a radius of the best chromosome. (adjacent)

References

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Summary

- Genetic algorithms are very robust and are vastly different among problems
- FacePrints creates a way to evolve a face based on a fitness function defined by a human
  - Used in police station and potentially in doctor offices
- Maze Solver, finds a path through a random maze. A good visualization tool to understand genetic algorithms.