Fuzzy fitness assignment in an Interactive Genetic Algorithm for a cartoon face search

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10/08/2009
Outline

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About the paper

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- It is published in “**Advances in Fuzzy Systems – Application and Theory**”, Vol. 7, 1997

- **Editors:**
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  - Takanori Shibata
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What is an IGA?

- IGA stands for Interactive Genetic Algorithm
- An IGA is a GA whose fitness is determined with human intervention.
  - Searching for a target according to user’s subjective factors
- Applications
  - Criminal suspect search
  - Cartoon face search
  - ...
Cartoon face space

- Each face has 12 parameters corresponding to facial components (eyes, hair, mouth, ...)
- Each component has 3 bits of variable range
- A face $F$ can be assigned to a point in the 12 dimensional face-space:
  - $F = (f_0, f_1, f_2, ..., f_{11})$ ($f_{\text{min}} \leq f_i \leq f_{\text{max}}$)
- Origin of the space:
  - $O = (o_0, o_1, o_2, ..., o_{11})$ ($o_i = [f_{\text{min}} + f_{\text{max}}]/2$)
Cartoon face space (cont.)

- Extreme faces, i.e. $F_{\text{min}}$ and $F_{\text{max}}$

- Average face, i.e. $O$ (the origin of the space)
Facial difference: Distance

- Any two faces, A and B, can be connected by a straight line; the length of the line is the Euclidean distance:

\[ AB = |A - B| = \sqrt{\sum (a_i - b_i)^2} \]

- It is used to rank “similarity” between faces.
Facial difference: Angle

- To stipulate more facial differences, we use the angle between two faces:

\[ \overrightarrow{AOB} = \cos^{-1} \frac{(A-O) \cdot (B-O)}{AO \cdot BO} \]

- In addition to distance, angle is also used to rank “similarity” between faces.
Example: Angle between faces

Target face

A direction perpendicular to the "target–average" direction

Average face (origin)

Angle = 30

The face antipodal to the target face

Angle = 180
Fitness assignment

- Experiments show that it is tiresome for the user to rate all the faces.
- Therefore, the user needs to identify just the closest face (winner face) to the target face.

\[
\text{fitness} = \begin{cases} 
1.0 & \text{the face selected by the user} \\
? & \text{the other faces}
\end{cases}
\]
Fuzzy fitness assignment

- Fuzzy fitness assignment strategy is used to rate the other faces:

- Sample fuzzy rule:
  
  If (**Distance** is *small*) and (**Angle** is *small*) and (**Gen.** is *any*)
  
  Then (**Fitness** is *large*)
Sample fuzzy rule set

- The bar symbol “-” is a symbol that matches any of linguistic labels.

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
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<tbody>
<tr>
<td>Distance</td>
<td>Angle</td>
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</table>
Fuzzy membership functions

- Fuzzy membership functions set up for three inputs (distance, angle and generation), and singleton output functions.
Fuzzy membership functions

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The Genetic Algorithm parameters used in experiments:

<table>
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<th>GA parameters</th>
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<td>Population number</td>
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<tr>
<td>Chromosome length</td>
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<td>Crossover method</td>
<td>Simplex$^{10}$</td>
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<td>Simplex crossover rate</td>
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<tr>
<td>Mutation rate</td>
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<td>Number of elites to survive</td>
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Sample results

- 10th generation
- 30th generation