Pattern Recognition

• Why is pattern recognition important?
  – Humans’ ability to recognize patterns is what separates us most from machines

• Models of pattern recognition
  – Templates
  – Features
  – Structural analysis
The Mystery of Pattern Recognition
Plumes of smoke pour from the World Trade Center buildings in New York Tuesday. Some people have seen the face of Satan in the plume of smoke. AP PHOTO

Satan seen in smoke plume

Associated Press

NEW YORK — Several newspapers that printed an Associated Press photo of fire consuming a World Trade Center tower received calls from readers Wednesday saying they saw a strange shape in the smoke.

Some readers said they could identify eyes, a nose, a mouth and horns in the black and gray clouds — and they wondered if the photo had been manipulated to include a satanic face.

Vin Alabiso, an AP vice president and the executive photo editor, said the photo was untouched. Readers were reacting to natural indentations in the smoke clouds, he said Wednesday.

"AP has a very strict written policy which prohibits the alteration of the content of a photo in any way," he said. "The smoke in this photo combined with light and shadow has created an image which readers have seen in different ways."
Templates

- Match observed object to stored images
  - “A” is recognized by matching it to stored photograph-like image of previously seen “A”s

- Problems
  - Too many templates needed
    - One template for “A” is probably not enough
    - Need a template for “A” with a specific size, orientation, color, etc.
    - Can this problem be solved with pre-processors?
  - Ignores intuition that objects are composed of smaller parts
Templates

(a) Input: A, Template: A

(b) Input: L, Template: L

(c) Input: L, Template: L

(d) Input: A, Template: A

(e) Input: A, Template: A

(f) Input: A, Template: A

(g) Input: A, Template: A

(h) Input: A, Template: A
Feature Analysis

• Recognize an object by breaking it down into features
  – “A” is recognized by combining evidence for \(+ - + /\)

• Evidence for feature analysis
  – Neural feature detectors have been found
  – Simple and conjunctive feature search tasks
    • Simple features are detected in parallel, but combining features requires attention to be moved across an image in a serial manner
    • Asymmetries in feature search
  – Illusory conjunction
| Features          | A | E | F | H | I | L | T | K | M | N | V | W | X | Y | Z | B | C | D | G | J | O | P | Q | R | S | U |
| Straight          |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| horizontal       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| vertical         |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| diagonal/        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| diagonal\        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Curve            |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| closed           |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| open vertical    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| open horizontal  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Intersection     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Redundancy       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| cyclic change    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| symmetry         |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Discontinuity    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| vertical         |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| horizontal       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

Note: The table cells contain symbols that represent the presence or absence of specific features in the alphabets.
Simple feature search

Look for an “O”
Simple feature search

Look for something red
Conjunctive feature search

Look for a red “O”
Conjunctive feature search

Look for a red “O”
Disjunctive and conjunctive feature search tasks
# The Cleveland Font

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Feature search asymmetries

It is easier to find X among Ys than Y among Xs if X has an extra feature compared to Y.

Find the O

Find the Q
Figure A and B show patterns of lines. In Figure A, the lines are oriented in various directions within a square. In Figure B, the lines are also oriented in different directions but within a more irregular shape. The patterns suggest that the lines are intended to form a specific visual effect or representation.
When attention cannot be used to bind features together because displays are too fast, then features free-float independently, and may incorrectly recombine with each other.
Structural Analysis

• Represent parts, and relations between parts

• Geon theory
  – A fixed number of primitive geometric components
  – Composed in different arrangements to create all objects

• Evidence for geons
  – Object recognition is hard if object cannot be analyzed into geons
Combining geons to create objects

36 geons in all
Relations between parts is important
Recognition is easier when geons can be recovered