Object recognition

Purposes

-classes

-individual instances

-“stimulus equivalence”

Simple biological systems

Learning and classification

Models and representation

Template matching

techniques

problems

Feature analysis

- **Hubel & Wiesel's "feature detectors"**

- **Pandemonium system**

  Selfridge (1959)

  Lindsay & Norman (1972)

- **Context ?**

Structural descriptions

- **Features**

- **Relationships**

  -2D

  -3D

- **From 2 $\frac{1}{2}$ D to 3D descriptions**

Volumetric representation & modular organisation

- **Generalised cones**

  Marr & Nishihara (1978)

  - contour generators

  - contour segmentation

- **Superquadratics (Pentland (1986))**

Recognition by components (RBC)

- **Geons**

(I. Biederman (1987) Recognition by components: a theory of human image understanding. Psychological Review 94, 115-147)

- viewpoint invariance

- non-accidental properties

- canonical views

Recognition by components theory

- image of a complex object segmented into **geons**

  -breakpoints at matched concavities

  - the segmented regions are convex or simply concave

- contours are coded by their viewpoint invariant properties (VIPs), e.g.

  -edges straight or curved

  -pairs of edges parallel or not

  -vertices formed at co-terminations

- the VIP coded features activate the closest fitting geon

- objects represented by geons and their relationships

The model claims to solve the following fundamental problems in object recognition:

- **viewpoint invariance (w.r.t. translation, size and viewpoint)**

- **grouping (organisation) of image elements into appropriate parts**

- **a basis of determining invariant object centred relations**

- **a basis for computing the similarity and equivalence of object images**

- **Grouping of components achieved through "phase locking" of the oscillatory activity of cells tuned to oriented image edges**

- **Phase locking (or fast enabling links: FELs) between pairs of**

  - colinear

  - co-terminating

  - parallel adjacent cells

- **Sets of FELs emerge from "learning experience" (individual or evolutionary)**

- **strength of a FEL between two units is a function of probability that both units are active when images are presented to the retina**

Model based recognition

Bottom - up techniques

- **start from a 2D image**
- **derive descriptions**
- **match descriptions with the model**

Top-down techniques

- **start from a model (3D based)**
- **look for instances of a model in an image**

  -Lowe (1987)

  -Sullivan et al (1989)

View-based recognition

- **Store a number of views of the object**
- **Look for instances of the views in an image**

Point distribution model (PDM) - a statistical model of shape

- Views of an object, or a class of objects, are statistically similar
- A statistical model of a shape of a class of objects can be built from shape examples
- Principal component analysis (PCA) used as a technique

The steps of the algorithm

- Label matching points in a training set of object shapes
- Align the training set
- Compute the “mean shape”
- Find the modes of variation in shape (eigenvectors)
- Any shape in the model can be approximated from its mean and variance
- New examples of shapes can be generated

Point distribution model

- Captures typical shape
- Allows variability
- Can be computed directly from a training set