Today's goals

We will look more at the top end of the process of visual perception and try and find computational principles.

Vision – the story so far …

We have seen that visual perception/cognition is served by many small, slow units (neurons)…
that there is a lot of hierarchical neural architecture …
that there are receptive fields that look like feature detectors, but might not be …
that the visual world gets topographically imported into the brain …
that line-based invariances seem crucial …
and that bottom-up, data-driven processing may be supplemented by top-down information and goals.
Today's readings

Fine-coding and coarse-coding
There are hemispheric styles of processing. They are not simple dichotomies. Rather, it is a productive division of labour between different specialisms and between different approaches to the same problem. Brown and Kosslyn (1993) used a response-time task in which participants responded to a qualitative task (is the dot above or below the line?) or a quantitative task (is the dot a little way or a long way away from the line?)
LH = qualitative; RH = quantitative …

Fine-coding and coarse-coding
Fine-coding and coarse-coding can be conceived of in terms of receptive fields.

In coarse-coding any one representational unit (e.g. neuron) responds to a broader range of stimuli in the world.
Lateralization in fish vision

Crossover at the optic chiasm is complete.

Degree of lateralization is determined by experience of predation.

The idea of invariances shares a lot with Gestalt principles (Koffka, 1935):

- Similarity
- Proximity
- Good continuation
- Continuity
- Pragnanz

Gestalt principles are generalisations about the effects of "good forms" in vision.

Vision is a hard problem

Does a computer have to know that telephones don't usually float in space?
Vision is a hard problem

When we try to proceduralize visual recognition – to model it computationally – we understand all of the assumptions made along the way. Do humans have hands that are the same size?

“World knowledge”


 (#isa #BillClinton #UnitedStatesPresident)

 (#genls #Tree-ThePlant #Plant)

 How do we represent and use “world knowledge” (cf. Lenat & Guha, 1989)?

Recurrence in the visual system

Felleman & Van Essen (1991)
Topographic mapping in V1 is affected by real-world understanding of size (Murray et al., 2006).

Perceptual constancy

The viewer adjusts perceived luminance in the light of experience (Adelson, 1999).
Perceptual constancy

The viewer adjusts perceived luminance in the light of experience (Adelson, 1999).

There are also constancies of shape, size, colour, etc.
Coping with slowness of neurons

Neurons are slow. Vision cannot work by a lot of sequential computations.

One response is “population coding”, in which whole populations fire at once and encode something particular. There is no shortage of neurons.

Another response is using top-down knowledge-driven processing.

Mathematical perspectives on perception

Similar ideas have surfaced and resurfaced within Cognitive Science, from Helmholtz (1860) to Neisser’s (1967) “analysis by synthesis” to Dayan et al.’s “Helmholtz Machine” to Grush’s (2004) emulation to Friston et al.’s “predictive coding” and “the free energy principle”.

They are driven by advances in mathematics and in neuroscience.

Mathematical perspectives on perception

They all have in common the idea that the individual’s brain generates an internal model of the external cause and the bodily reaction and makes predictions about what will happen next.

Successful prediction is perception.

There is a critical role for the error between the incoming signal and the prediction.

Reducing that error is successful perception/cognition.
"A critique of pure vision"
Churchland, Ramachandran & Sejnowski (1994)

They criticize the standard view of "pure vision", abstracted away from movement.

"no obvious replacement term for "hierarchy" suggests itself, and a new set of concepts adequate to describing interactive systems is needed" (p. 27).

They suggest an alternative heterarchical, interactive view – "interactive vision".

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The "grandmother cell"
Lashley's (1950) "Mass Action Principle" regarding learning: learning is distributed – as "engrams".

Earlier in the course, we have seen connectionist models involving this principle.

[Diagram of neural network]

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How to recognize Jennifer Anniston

[Image of Jennifer Anniston]
What does it mean to have such sparse response characteristics?

The case of DF

A dissociation can occur, between preserved and impaired functions.
This can be a clue to the functional architecture of cognition.

DF has bilateral, ventral stream brain damage from CO poisoning (Goodale & Milner, 2004). The dorsal stream is intact.

DF cannot identify figure from ground, visually segment objects or identify lines and edges.
But her grasping of objects is good.
(This is the opposite of optic ataxia.)
The case of DF

The dorsal stream has been characterised as "where" and as "perception for action". But there is interaction between the two streams and the debate continues with regard to grasping affordances (cf. Mon-Williams & Bingham, 2011).

Affordances
Gibson (1977)

A jug invites being picked up by its handle.

Amodal representations
Lambon-Ralph, Matthew & Patterson (2008)
Simultagnosia

Challenges

To test computational principles in real implementations.
To identify processing preferences and specialisms in particular brain architectures.
To engage therapeutically with visual impairment.
To keep pinning the mathematical advances down to the philosophical distinctions.

References

References
http://www.youtube.com/watch?v=3ur7WjPprss