Biological and Computational Vision

Lecture 7
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www.ini.unizh.ch/~kiper/comp_vis/index.html
Sharpness of tuning depends on number of subfields

De Valois & De Valois (1990)
Albrecht (1978)
Back to the model of perceptual sensitivity
Perceptual and neural sensitivity: data from a monkey

De Valois & De Valois (1990)
Selectivity for stimulus orientation and direction

Hubel and Wiesel (1968)
in Wandell (1995)
Selectivity in V1 is extremely sharp
Retinotopy
Cortical representation measured with 2-deoxy-glucose
Cortical magnification

Methods:
- fMRI
- estimate from strokes + primate cells
- microstimulation in a blind volunteer
- PET in 5 observers

Engel et al. (1994) in Wandell (1995)
Schwartz et al. (1988)
Frederick and Schwartz (1990)
After Hubel & Wiesel (1962) in Nicholls et al. (1992)
Orientation columns measured with optical imaging

Bonhoeffer and Grinvald (1991) in Nicholls et al. (1992)
The “ice-cube” model of Hubel and Wiesel

Orientation and ocular dominance columns

Obermayer and Blasdel, 1983
Linear model of V1 simple cells

Responses are a weighted average of the stimulus intensity, where the receptive field is the map of the weights.
The linear model
For a linear cell, knowing the receptive field is knowing everything.
Dependence of responses on orientation
For simple cells, knowing the receptive field is knowing spatial frequency tuning.
Nonlinearities in V1 responses
Linear model:

Linear systems $L(x)$ obey

- homogeneity: $L(ax) = a L(x)$
- superposition: $L(x+y) = L(x) + L(y)$
A basic nonlinearity: Thresholding

Thresholding is a fundamental property of neurons where they fire when the membrane potential reaches a certain threshold. The diagram illustrates how the membrane potential (Potential) is compared to a threshold value. If the potential exceeds the threshold, the neuron fires (Firing rate). The graphs show the actual and predicted firing rates over time (Time s).
A violation of homogeneity: Saturation
Saturation depends on contrast

Carandini, Heeger & Movshon (1996)
A violation of superposition: Masking
A nonlinear model of V1 simple cells
Adaptation
Adaptation in a V1 neuron

Maffei, Fiorentini and Bisti, 1973
Contrast adaptation controls V1 neuron sensitivity

![Contrast adaptation controls V1 neuron sensitivity](image)
Learning
Hebbian learning

Das, 1997
Evidence for Hebbian learning in V1

Fregnac et al., 1992, in Das, 1997