Tiling

- Tiling by cones
- Tiling by retinal ganglion cells
 - midget vs. parasol (parvo/magno)
 - foveated sampling

Efficient coding model of retina

(Karklin & Simoncelli 2012)





С

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Cones sample the light intensity distribution over the joint domain of space and wavelength $I(x, y, \lambda)$



5 arcmin



Human - cone spectral sensitivities



Cones sample the light intensity distribution over the joint domain of space and wavelength $I(x, y, \lambda)$



Tiling by retinal ganglion cells

Cone vs. retinal ganglion cell spacing as a function of eccentricity



Smoothing and subsampling by retinal ganglion cells



Parvo- and Magno-cell dendritic field diameter as a function of eccentricity





(Horwitz, 2020)



Parvo and Magno cells encode complementary aspects of spatio-temporal structure



Ocko, S., Lindsey, J., Ganguli, S., & Deny, S. The emergence of multiple retinal cell types through efficient coding of natural movies. *NeurIPS 2018*.

Foveated sampling

Active vision in jumping spiders



(Wayne Maddison)



(Bair & Olshausen, 1991)



Weakly electric fish



Non-conductor



Foveated sampling



Retinal ganglion cell spacing as a function of eccentricity

 $\Delta E \approx .01(|E|+1)$



Letter size vs. eccentricity (Anstis, 1974)







times its threshold height.

Human eye movements during viewing of an image



Yarbus (1967)

DOI:10.1068/p2935

The roles of vision and eye movements in the control of activities of daily living

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Learning the glimpse window sampling array (Cheung, Weiss & Olshausen, 2017)



Scene

- Network is trained to correctly classify the digit in the scene.
- To do this it must find a digit and move its glimpse window to that location.







Example MNIST scenes

Evolution of the sampling array during training



Learned sampling arrays for different conditions



Translation only (Dataset 1)



Translation only (Dataset 2)



Translation & zoom (Dataset 1)



Translation & zoom (Dataset 2)

Comparison to primate retina





Model

Eccentricity

Comparison to primate retina



A FOVEATED RETINA-LIKE SENSOR

USING CCD TECHNOLOGY

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A Foveated Image Sensor in Standard CMOS Technology

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