

Modeling the Nature of Center-Surround Interactions in Early Visual Cortex

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Outline

- 1 Introduction
 - Early Visual Cortex
 - Image Decomposition
- 2 Center-Surround Interactions
 - Divisive Normalization Model
- 3 Results and Discussion
- 4 Conclusion and References

Motivation

- Does interaction radius varies across spatial frequencies in center-surround interaction?

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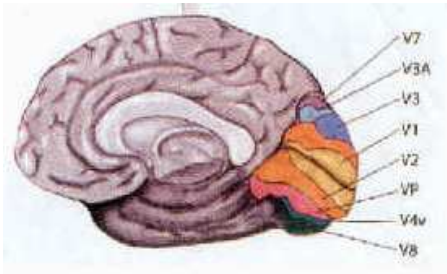
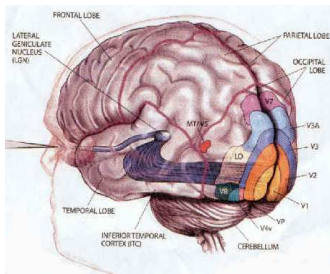
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Visual Perception

- involves mainly
- capturing the image with the eyes,
- recognizing and interpreting

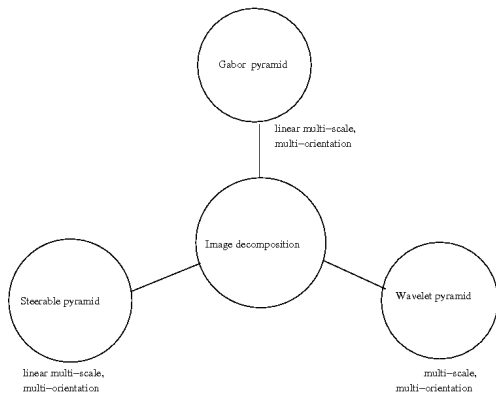
Visual Field



Definition and the need for decomposing images

- selectivity of neurons
- minute image details

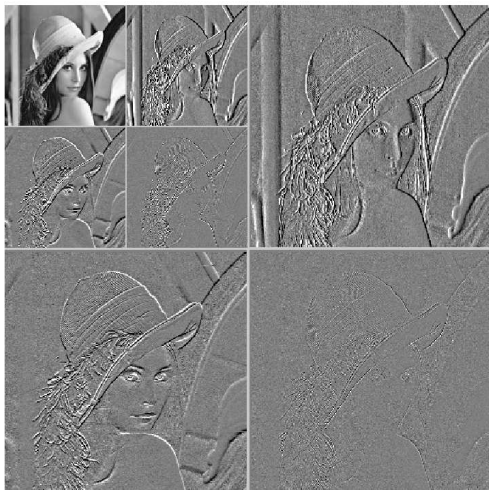
Image decomposition methods



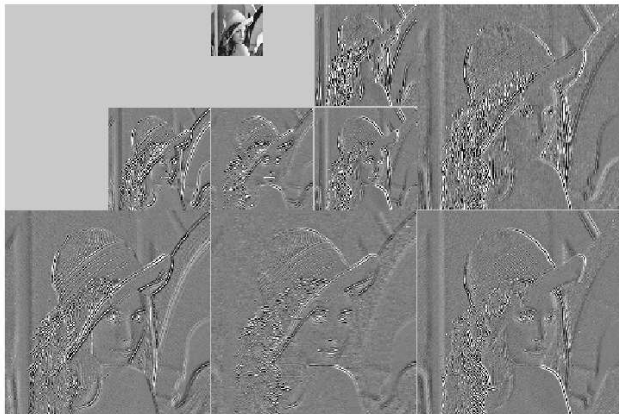
Original image “Lena”



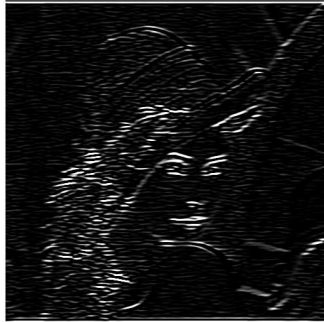
Wavelet pyramid decomposition



Steerable pyramid decomposition



Gabor decomposition



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Definition

- What is center-surround interactions?
- CRF
- changes in CRF sizes with stimulus contrast, ...
- Normalization model

why we use this model

- Hypothesis of neural processing.
- explains the non-linear effects in cortical areas
- fits psychophysical data

Mathematical Relation for the model

$$R = C^2 / \left[\sum_k \omega_k P_k^2 + \sigma^2 \right]$$

$$\{\omega_k, \sigma\} = \min_{\omega_k, \sigma} \mathbb{E} \left[C^2 - \sum_k \omega_k P_k^2 - \sigma^2 \right]^2$$

$$R = P_k^2(x, y) / \left[\sum_{k(i,j)} \omega_{\bar{k}k} P_k^2(x + i, y + j) + \sigma^2 \right]$$

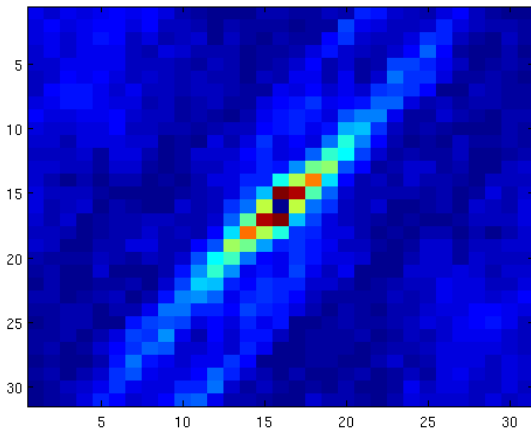
Optimization

- 3 set of images.
- window size
- convergence issue

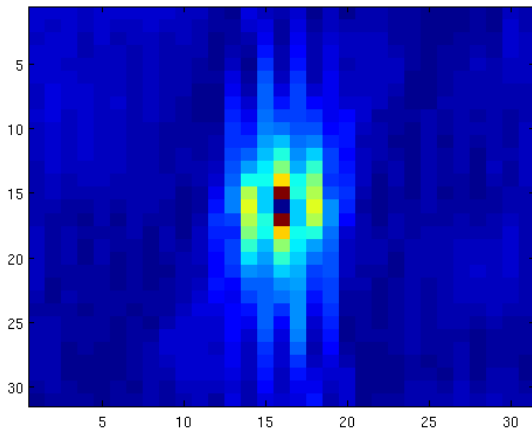
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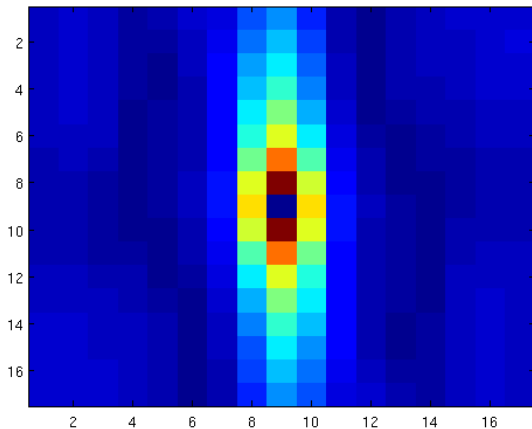
Wavelet pyramid subband 6.



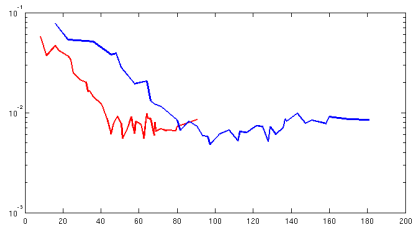
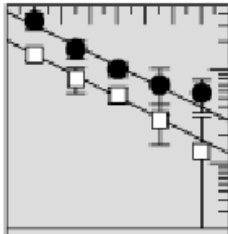
Steerable pyramid subband 6.



Log-Gabor subband 6.



Comparison with Petrov & Mckee result



Discussion

- suppression is strongest for surround cells in the proximity of the center
- drop off in suppression happens over certain distance
- drop off in suppression is faster for low resolution than for high resolution

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conclusion

- response of the center to a stimulus presented outside the receptive field is influenced by surround contrast, orientation and spatial frequency.
- We obtained the set of weights that minimizes the squared prediction error
- separation varies largely with the scale and spatial frequency

Main References

- E P Simoncelli & O Schwartz. Modeling surround suppression in V1 neurons with a statistically-derived normalization model. In *Adv. Neural Information Processing System*, volume 11, pages 153-159, Cambridge, MA, 1999. MIT Press. Presented at NIP-98, Denver Co, 1-3 Dec 1998.
- Schwartz, O., & Simoncelli, E. P. (2001). Natural signal statistics and sensory gain control. *Nature Neuroscience*, 4, 819Y825. [PubMed] [Article]
- Yury Petrov & Suzanne P Mckee. The effects of spatial configuration on surround suppression of contrast sensitivity. *Journal of Vision* (2006) 6, 224-238
<http://www.journalofvision.org/6/3/4/>

End of presentation

Thank you for you attention