Theoretical evidence for an active model of edge sensitivity in human lightness perception

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(1) Introduction

- Our visual system responds best to luminance changes in space (=edges) and time [1]
- Often, early vision models focus only on spatial information like multiscale spatial filtering, assuming stable retinal images during fixation
- However, fixational eye movements (FEMs) are crucial for visual processing [2]
- Can we account better for human edge sensitivity if we incorporate active-sampling via FEMs into multiscale spatial filtering models?

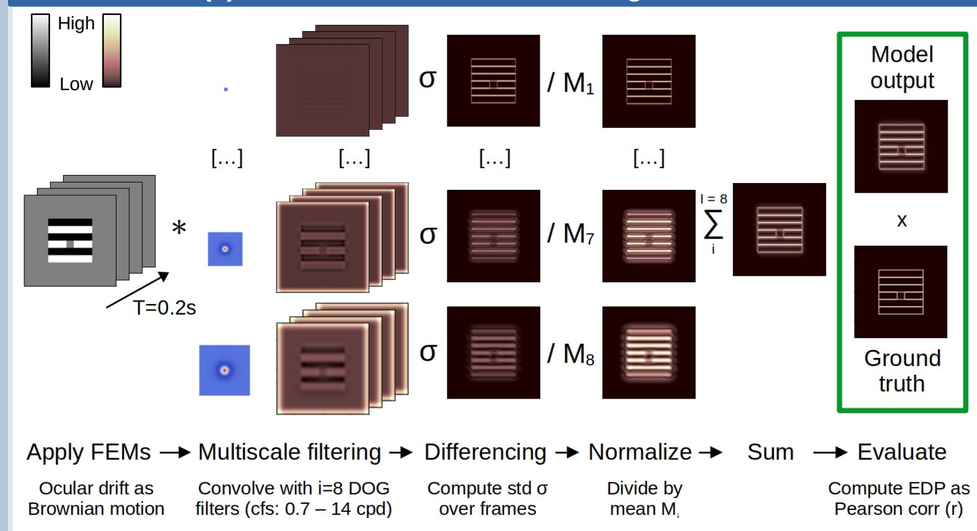
(2) Methods

- Challenging test case for multiscale models
- Can we reproduce the spatial-frequency-specific effect of narrowband noise on lightness perception [3]? (see Demo)
- We test the edge detection performance (EDP) of our model on White's stimuli masked with narrowband noise
- Comparison of performance with control models
- Disclaimer: we assume that the effect is mediated by responses to luminance edges

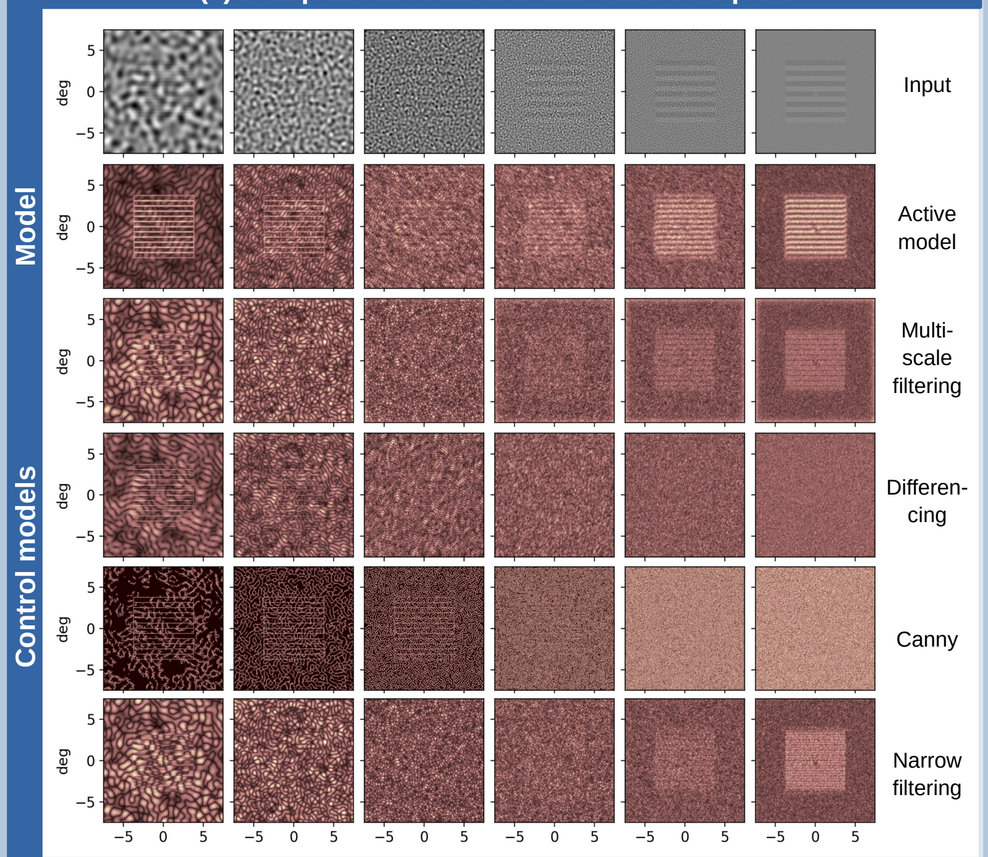
(5) Control models

1. **Multiscale filtering:** Model component; omits differencing operation
2. **Differencing:** Model component; omits multiscale filtering operation
3. **Canny**: Alternative model; standard computer vision approach
4. **Narrow filtering**: Alternative model; narrow SF tuning (cfs: 1.4 – 5 cpd), no active-sampling

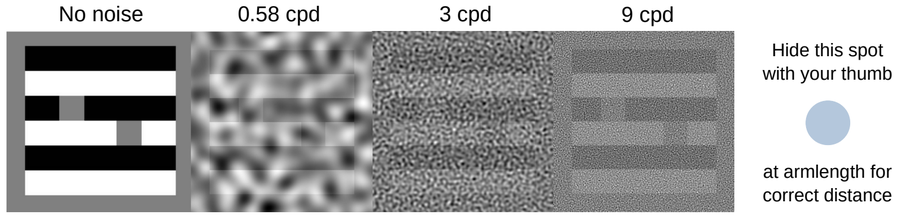
(4) Model architecture: Active edge detection



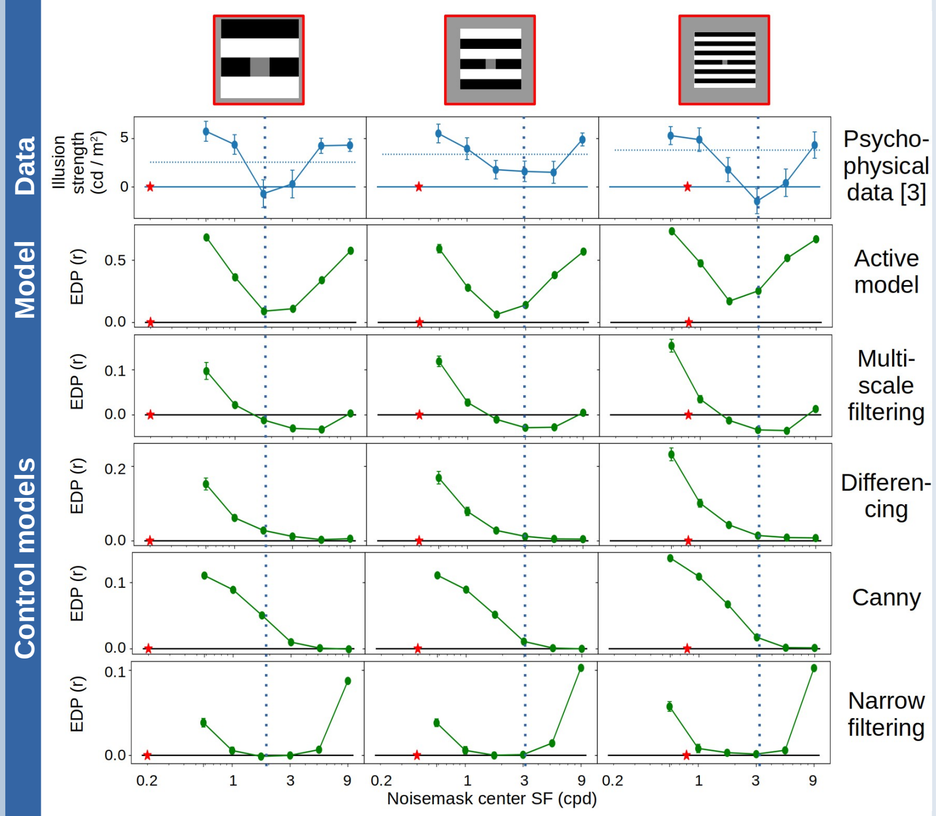
(6) Comparison of model and control outputs



(3) Demo: MF narrowband noise diminishes White's illusion



(7) Comparison of edge detection performances (EDP)



(8) Conclusion

- Edges naturally emerge in multiscale filter responses if we incorporate FEMs
- Responses are specific to luminance edges (unlike spatial multiscale models)
- Reproduction of spatial-frequency-specific interference on early visual processes
- Outlook: test human edge sensitivity in noisemasking experiments with narrowband noise & extend model to lightness perception model

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References: [1] Robson (1966), JOSA, doi: 10.1364/JOSA.56.001141 [2] Rucci & Victor (2015), Trends in Neurosciences, doi: 10.1016/j.tins.2015.01.005; Betz, Shapley, Wichmann, & Maertens (2015), Journal of Vision, doi: 10.1167/15.14.1