A Bayesian model of distance perception from ocular convergence
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Introduction
It has been recognized since the time of Descartes that the convergence state of the eyes could provide valuable information about distance in the world. This is because there is a geometric one-to-one mapping between ocular convergence and distance. However, despite correct fixation, observers make progressive underestimates of object distance as it increases (Viguier et al. 2001). Why is distance mis-estimated? Can these mis-estimates in some senses be considered optimal?

Bayesian Model
We assume that the vergence signal is corrupted by zero-mean Gaussian noise. Using the change of variable technique we calculate the probability density functions for distance. For a given fixation distance, an observer’s distance estimate is the peak of this function i.e. the most likely distance to have produced the measured, noisy, vergence signal.

Environmental Priors
Natural scene statistics are typically evoked to explain perceptual bias. However, this assumes that these statistics are accurately sampled and internalized.

We generated 200 scenes composed of randomly placed laser scans of natural objects and generated the priors for distance.

Our optimal observer sampling this scene will internalize a biased model of the statistics of the world.

References
Jacobson, A. gptoolbox: MATLAB Toolbox for Geometry Processing. URL: https://github.com/alecjacobson/gptoolbox

Conclusion
Bias in the perception of distance from ocular convergence can be explained by observers trying to estimate the most likely distance in the world to have caused the measured (noisy) vergence signal.