BAYESIAN LOCAL DIRECTIONAL ACCURACY OF A DIRECTIONALLY SELECTIVE GANGLION-CELL ENSEMBLE

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On-Off directionally selective ganglion cells (DSGC) of the rabbit retina send information about the direction of motion to the rest of the brain. Each of these cells responds best for motions in a preferred direction. There are four types of DSGC, each type preferring motions along one Cartesian axis (up, down, left or right). Every point in visual space is viewed by one cell of each type. We have measured the distribution of responses of DSGC as a function of contrast and direction of motion. With this information, and knowing the distribution of contrasts and directions of motion in natural images, we can apply Bayesian Analysis to infer the possible local directional accuracy of a DSGC ensemble's output. We applied Bayes Theorem:

$$P[c,\phi|\vec{\mathbf{r}}] = \frac{P[\vec{\mathbf{r}}|c,\phi]P[c,\phi]}{P[\vec{\mathbf{r}}]}$$

where $\mathbf{r}$, c, and ϕ are response, contrast, and direction of motion respectively.

We performed both Maximum-Likelihood and Maximum-a-Posteriori analyses. The former took only the biology into account (*i.e.*, our measurements), while the latter assumed an exponential distribution for contrasts (Balboa & Grzywacz, 2000; Tadmor & Tolhurst, 2000) and a homogeneous distribution of directions of motion (Balboa & Grzywacz, unpublished observations). We found that a local DSGC ensemble could provide highly accurate directional estimates, with RMS errors of less than 3º for stimuli with contrasts of 100%. Moreover, an ensemble could provide directional estimates with less than10º RMS error for stimuli with contrasts of only 15% (the mean contrast in natural images). Interestingly, including the contrast and direction-of-motion priors did not improve performance significantly. This is because the Maximum-Likelihood estimate only fails when the biological system is uncertain. DSGCs have relatively low noise and therefore, low uncertainty. It remains to be seen whether other prior information, such as the distribution of speeds or spatial frequencies, can improve the DSGC system's directional accuracy.