The visual systems of animals have long been studied as models of how the neural circuits process information. This is because individual cells throughout the system can be recorded and their responses related to the light input presented. Photoreceptors, the cells responsible for transducing incident light energy into neural signals are the first stage of this system. A schematic drawing of the insect visual system is shown in A, and a detailed sketch of a photoreceptor is shown in B. How insect photoreceptors respond to a wide range of light intensities and patterns has been well characterized over the years, and detailed models describing these responses have been developed. One particularly successful model was developed by Hans van Hateren and colleagues (van Hateren and Snippe 2001) based on responses from fly photoreceptors. This work was partially supported by NSF REU Grant DMS-0755294.

**Introduction**

The van Hateren model was developed using data that was not calibrated with regards to the absolute light intensity. Thus, we needed to find the best linear transform to match the light intensities used during the photoreceptor recordings (exp) to the corresponding range of model input values (Imodel). Since all we had to use were photoreceptor responses, we decided to fit the linear function

$$E_{\text{model}} = A \text{Imodel} + B$$

by minimizing steady state response magnitudes of the van Hateren model and the data for 3 different stimulus intensities. The fitted values of A and B returned to be 16.1738 and 186.6813 respectively.

There were three input values (31.7, 61.2 and 90.4) to observe, and the differences between the model response and locust response were 1.2801, 0.0020, and 1.1096 respectively.

**Finding the Best Model Input**

With the parameter values (tau1 = 1.69; tau2 = 71.8; k1 = 0.689; k2 = 9.07) for fly photoreceptors, the output of the model did not match with the actual data from photoreceptors. The actual response of a locust photoreceptor and that of the van Hateren model with default parameters is shown above.

**Goal**

The goal of this project was to adapt existing models of early visual processing in flies, the van Hateren photoreceptor model and the NLN cascade LMC model, to fit the responses of locust photoreceptors. This will allow the Gabbiani laboratory to run large-scale simulations of higher order visual processing in the locust visual system using the outputs of these models as realistic neural inputs.

**Fitting the Model**

After finding the best fit luminance transform while keeping model parameters constant, we needed to fit the 4 model parameters (tau1, tau2, k1, k2). We first tried to freely vary all 6 parameters values (model parameters plus A, B), but that didn't converge to a solution, and the end parameter values didn't yield good fits to the data (red line). We also tried to hold the parameters k1 and k2 constant, thinking that these govern responses over longer timecourses than the stimulus presented, but the solution arrived at was clearly not a good fit (green line). After limiting the algorithms iterations to 300, but changing start conditions, we found a reasonable solution, shown in blue. It took 7 hours on average to obtain each set of parameters in panel A. These fits are shown for multiple stimulus brightnesses (panel B) and speeds (panel C) to show that they fit the range of experimental data well.

**Conclusions**

We were able to adapt a nonlinear model of fly photoreceptors to locust photoreceptor responses. We began implementing a model to describe the filtering properties of Large Monopolar Cells (LMCs).

**References**


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