Can Cone Signals in the Wild Be Predicted From the Past?

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In the natural world, the past is usually a good guide to the future. If light from the sun and sky is blue earlier in the day and yellow now, then it is likely to be more yellow later, as the sun's elevation decreases. But is the light reflected from a scene into the eye as predictable as the light incident upon the scene, especially when lighting changes are not just spectral but include changes in local shadows and mutual reflections? The aim of this work was to test the predictability of cone photoreceptor signals in the wild over the course of the day. Cone signals were estimated from sequences of 7–9 time-lapse hyperspectral radiance images each of size 1024 × 1344 × 33 acquired from four outdoor scenes in the medium-to-far distance [1]. The scenes contained mixtures of herbaceous vegetation, woodland, barren land, and rural and urban buildings. Figure 1 shows consecutive samples of three images from each of the four sequences. For each sequence, Shannon's mutual information was estimated between signals X_n at one instant n and signals $X_{n-1}, X_{n-2}, \ldots, X_1$ at earlier instants $n-1, n-2, \ldots, 1$. An asymptotically unbiased information estimator due to Kozachenko and Leonenko was used with an offset calculation to improve convergence. For all scenes, mutual information $I(X_n; X_{n-1})$ between signals at instants n and $n-1$ remained roughly constant or decreased with the inclusion of signals from earlier instants $n-2, n-3, \ldots, 1$; that is, $I(X_n; X_{n-1}) \geq I(X_n; X_{n-1}, X_{n-2}, \ldots, X_1)$. By contrast, when sequences were simulated to differ solely in spectral content without mutual reflections or other sources of noise, mutual information between signals at successive instants increased markedly with the addition of signals from earlier instants. In the wild, changes in local shadows and mutual reflections and other uncertainties limit the information that the past can provide about the future.

Figure 1. Color renditions of triplets of consecutive images from sequences of time-lapse hyperspectral radiance images of outdoor scenes. Acquisition times indicated. Data from [1].

References

[1] Foster, D.H., Amano, K., and Nascimento, S.M.C.: *Vision Res.*, 2016, 120, pp. 45-60.