

## **Project 2: Normalization in the visual system**

- 1) Implement the normalization function (Equation 10 in Carandini & Heeger, 2012) and show how this function removes redundancy from image input (i.e., by decorrelating the pixels).
- 2) Show how the normalization function induces winner-take-all competition in a population of neurons tuned to different orientations (see Figure 3e in Carandini & Heeger, 2012).
- 3) Implement the adaptation version of normalization (Equation 12 in Carandini & Heeger, 2012) and show how this produces light adaptation in the retina.
- 4) Discuss a few pieces of empirical evidence for normalization in the visual system.
- 5) When does normalization produce an efficient code? See Bucher & Brandenburger (2022).

### **References:**

Bucher, S. F., & Brandenburger, A. M. (2022). Divisive normalization is an efficient code for multivariate Pareto-distributed environments. *Proceedings of the National Academy of Sciences*, 119(40), e2120581119.

Carandini, M. & Heeger, D.J. (2012). Normalization as a canonical neural operation. *Nature Reviews Neuroscience*, 13, 51-62.