PROJECT #1

ECBM E6070, Professor Aurel A. Lazar

Deadline: 11:59PM, Saturday, March 9th, 2024

In this assignment you will explore a small object detection model, based on circuits observed in the fruit fly's early visual system. In particular, we will replicate results from [1], and references to Figures, Equations and Tables pertain to the contents of the aforementioned paper.

1. (10 points) Connectomics: (i) Trace out the circuit (to the extent possible) depicted in Figure 1 using NeuroNLP for the FlyWire dataset. Provide screenshots of the morphology of each celltype and the full circuit, and of the celltype connectivity graph. (ii) Retrieve neuron-neuron connectivity matrices from the FlyWire dataset using FlyBrainLab. Using synapse counts as a proxy for synapse strength, comment on how the connections observed in the connectome support/question the DSTMD model.

2. (60 points) Model implementation: You are asked to implement the DSTMD detector. In particular, implement equations (1)-(17) and (25)-(27). The paper provides required model parameters in Table 1. The handout provides code to generate video frames of a small object (rectangular dot) moving across a random background. (i) Provide the video frames as input to your implemented model and visualize the output from each layer as video frames, and plot at least three frames (at say 0ms, 10ms and 100ms) per celltype implemented. (ii) Let $S(t) = \sum_{x,y} D_I(x, y, t)$. Plot $S(100ms)$ as a function of (a) dot velocity and (b) dot width and compare with the red trace in Fig. 9(b) and 9(c) respectively.

3. (30 points) Model analysis: (i) Relate Figure 14 to Equations 24 to discuss the functional logic of the ESTMD detector. Clearly state the assumption of the model, what motion correlate was derived based on the assumptions, and also discuss two or more scenarios where the assumptions don't hold and thus the motion detector may fail. Also comment on how these assumptions prescribe the contrast and velocity sensitivity of the detector. (ii) Repeat the analysis for the DSTMD detector using Equation 25.

1 Submission Instructions

Please submit the provided `.ipynb` file with your code and results. If you have additional files (figures, *.gifs*, etc) please submit a single *.zip* containing all files. You must restart, run all your code cells, and subsequently save the notebook before submitting it. The notebook should also have your names at the top in a Markdown cell. Submit your work under the **Assignments** on Courseworks.

Please post any questions regarding this assignment on the **ED discussion forum**. Your questions and the answers may also benefit the other students in class. If you have any other questions, please do not hesitate to contact the CA using their email address that is available on the course website.

References

[1] Hongxin Wang, Jigen Peng, and Shigang Yue. A Directionally Selective Small Target Motion Detecting Visual Neural Network in Cluttered Backgrounds. IEEE Transactions on Cybernetics, 50(4):1541–1555, April 2020.