Project Drosophila

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Contents

1 Drosophila brain regions

1. **OL**: Optical lobe. sits behind the arthropod eye (mostly compound eyes) and is responsible for the processing of the visual information. It is made up of three layers:
   (a) Lamina (ganglionaris): responsible for contrast enhancement through lateral inhibition
   (b) Medulla: processes movement and shows movement direction sensitivity. Possesses local motion detectors
   (c) Lobula: integrates information from large areas of the visual field to abstract visual information and object recognition
2. **MB**: Mushroom body. They are also known to play a role in olfactory learning and memory. In most insects, the mushroom bodies and the lateral horn are the two higher brain regions that receive olfactory information from the antennal lobe via projection neurons
3. **CX**: Central complex, navigation, sleep, learning, memory, nociception
4. **LX**: Lateral complex, I think that has the same function of the central complex but it is lateral.
5. **VLNP**: Ventrolateral neuropils
6. **LH**: Lateral horn. It is one of the two areas of the insect brain where projection neurons of the antennal lobe send their axons. The other area is the mushroom body. Several morphological classes of neurons in the lateral horn receive olfactory information through the projection neurons.n lateral horn, axons of pheromone-sensitive projection neurons are segregated from the axons of plant odor-sensitive projection neurons. In addition, the dendrites of lateral horn neurons are restricted to one of these two zones, suggesting that pheromones and plant odors are processed separately in the lateral horn.
7. **SNP**: Superior neuropils
8. **INP**: Inferior neuropils
9. **AL**: antennal lobe. The antennal lobe is the primary (first order) olfactory brain area in insects. The antennal lobe is a sphere-shaped deutocerebral neuropil in the brain that receives input from the olfactory sensory neurons in the antennae and mouthparts
10. **VMNP**: ventromedial neuropils
11. **PENP**: periesophageal neuropils
12. **GNG**: gnathal ganglia, taste and feeding;

There is no clear definition for the neuropils regions, and so we provide a definition for what the neuropils are. Neuropil (or "neuropile") is any area in the nervous system composed of mostly unmyelinated axons, dendrites and glial cell processes that forms a synaptically dense region containing a relatively low number of cell bodies. We can so think of them as an information bottleneck, the bridges that connects other brain regions. We present in Figure 1 a quick and not exact representation of the network between these high level regions.

2 Coarse graining

It is necessary to define rigorously a way to apply the coarse graining procedure, i.e. our way to combine different neurons in super-neurons. We stress that this procedure is not simple at all, and present different degrees of freedom that can (and will) be chosen with respect to the performances on the data. We start by defining these degrees of freedom:

- the **metric** d_{ij} that we use to define when two different neurons are similar;
- The way in which we aggregate the weights after we combine two nodes. In particular, we are interested in keeping the degree distribution the same. We so define a **threshold** θ.
- add if you think of others

We so present the steps of the algorithms, calling $n_i^(\alpha)$ the i-th neuron at the α-th iteration in the coarse graining algorithm and $w_{ij}^{()\alpha)}$ the links between neurons $n_i^{(\alpha)}$, $n_j^{(\alpha)}$:

1. Pick a neuron $n_i^{(\alpha)}$ at random;
2. Compute the distance $d_i^{(\alpha)} = (d_{i1}^{(\alpha)}, d_{i2}^{(\alpha)}, \dots, d_{iN}^{(\alpha)})$;
3. Combine the two nearest neurons:
$$n_i^{(\alpha+1)} = \left\{ n_i^{(\alpha)}, \min_{d_i} \left[n_k^{(\alpha)} \right] \right\}$$
4. Build the new network connections:
$$w_{ij}^{(\alpha+1)} = \left\{ w_{ij}^{(\alpha)}, \bar{w}_{kj}^{(\alpha)} \right\}$$
where
$$\bar{w}_{kj}^{(\alpha)} = w_{kj}^{(\alpha)} \cdot \Theta \left(\frac{w_{kj}^{(\alpha)}}{\sum_j w_{kj}^{(\alpha)}} - \theta \right)$$
where $\Theta(t)$ is the Heavyside function. Using the normalized weights in $\Theta(t)$ we stress the fact that node sparsely connected has stronger connections than the widely connected.
5. Start again from point 1.

ATTENTION: this algorithm has not been proved yet. In particular the part with the normalization of the weights: it may "break" the network structure due to the presence of Hubs. In particular, given the algorithm structure, merging a Hub to a sparsely connected node may not produce a Hub.

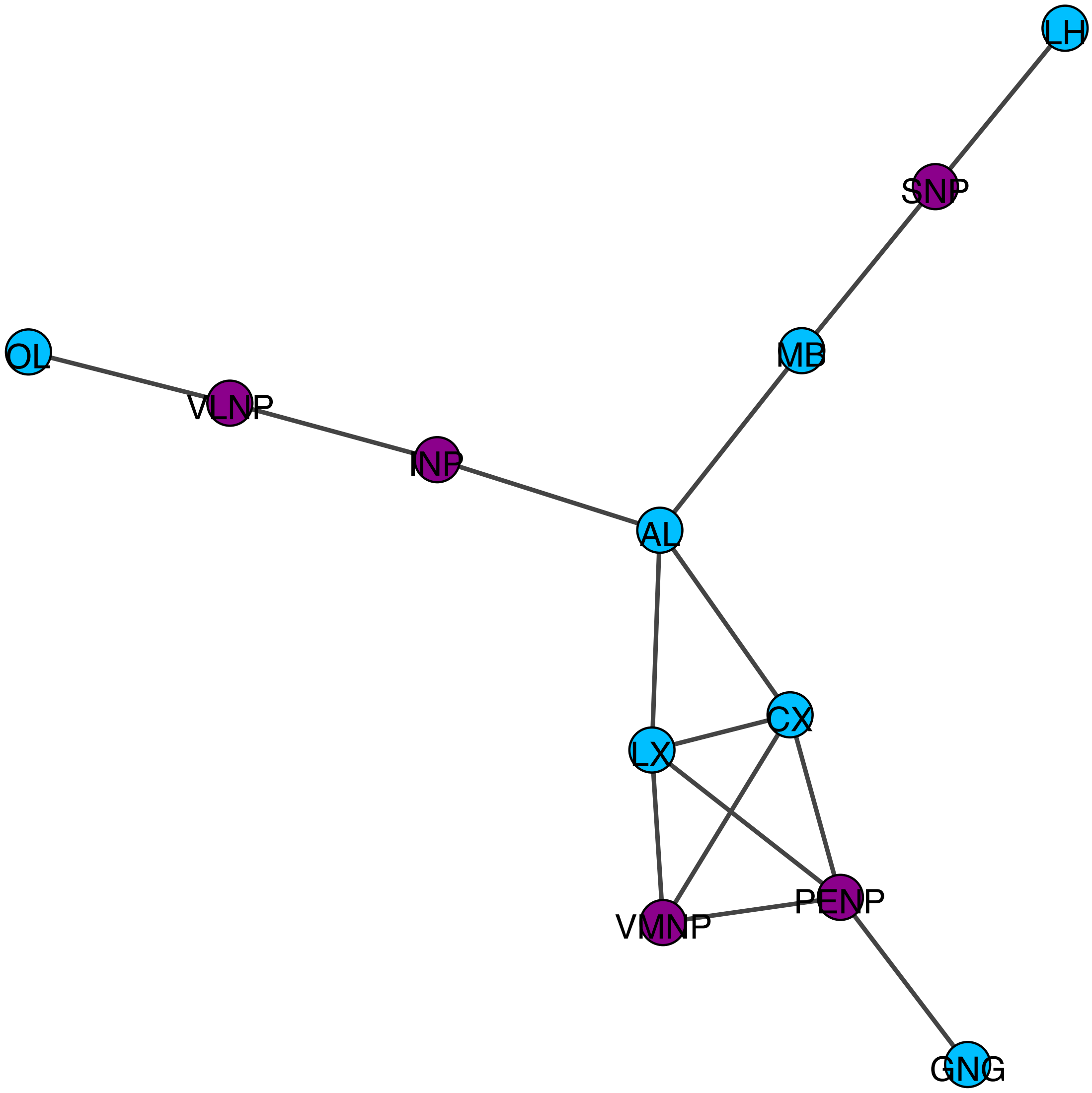

Figure 1: Approximate graph of the high level brain regions. We reported in magenta the neuropils. We can see even in this sketch that they act as bridges between brain regions. Using another layout (tree network) we can see that the central complex is the central one.