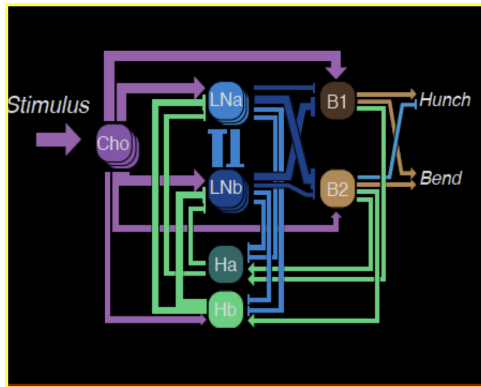


Title of the work program

Small network NeuroAI - From the brain of a larva to ultra-edge AI

Description of the work program



Our project lies in one question: How can we understand this biological neural network found in drosophila larva [1]? This network generates a probabilistic output when receiving a noxious signal (air puff) that will either generate a hunch (larva retraction) or a bend. A simple feedforward network would also work. Hence, why evolution chose such architecture? Our project will consider the physics associated to embodiment in order to find a causal link between larva motion and biological neural network architecture.

The second part of the project is to use the set of circuits we already identified in the drosophila larva connectome to study their mathematics properties and use them to perform ultra-edge machine learning.

[1] Jovanic, Tihana, Casey Martin Schneider-Mizell, Mei Shao, Jean-Baptiste Masson, Gennady Denisov, Richard Doty Fetter, Brett Daren Mensh, James William Truman, Albert Cardona, and Marta Zlatic. 'Competitive Disinhibition Mediates Behavioral Choice and Sequences in *Drosophila*'. *Cell* 167, no. 3 (October 2016): 858-870.e19. <https://doi.org/10.1016/j.cell.2016.09.009>.

Tutor/supervisor

First name, Last name	jean-Baptiste Masson & christian L. Vestergaard
Phone	+33 1 44 38 92 67
E-mail	jbmasson@pasteur.fr ; cvestergaard@pasteur.fr
Profile on http://www.researchgate.net/ (if applicable):	https://bit.ly/32ld9Va https://bit.ly/3vFuLAX https://bit.ly/3vBJJqX

Selected publications or patents of the Research Group offering the work program

1. Laurent, François, Hippolyte Verdier, Maxime Duval, Alexander Serov, Christian L Vestergaard, and Jean-Baptiste Masson. 'TRamWAY: Mapping Physical Properties of Individual Biomolecule Random Motion in Large-Scale Single-Particle Tracking Experiments'. *Bioinformatics* 38, no. 11 (1 June 2022): 3149–50. <https://doi.org/10.1093/bioinformatics/btac291>.

2. Guérinot, Corentin, Valentin Marcon, Charlotte Godard, Thomas Blanc, Hippolyte Verdier, Guillaume Planchon, Francesca Raimondi, et al. 'New Approach to Accelerated Image Annotation by Leveraging Virtual Reality and Cloud Computing'. *Frontiers in Bioinformatics* 1 (2022). <https://www.frontiersin.org/article/10.3389/fbinf.2021.777101>.

3. Blanc, Thomas, Hippolyte Verdier, Louise Regnier, Guillaume Planchon, Corentin Guérinot, Mohamed El Beheiry, Jean-Baptiste Masson, and Bassam Hajj. 'Towards Human in the Loop Analysis of Complex Point Clouds: Advanced Visualizations, Quantifications, and Communication Features in Virtual Reality'. *Frontiers in Bioinformatics* 1 (2022). <https://www.frontiersin.org/article/10.3389/fbinf.2021.775379>.

4. Klein, K.T., Croteau-Chonka, E.C., Narayan, L., Winding, M., Masson, J.-B., Zlatic, M., 2021. Serotonergic Neurons Mediate Operant Conditioning in *Drosophila* Larvae (preprint). *Neuroscience*. <https://doi.org/10.1101/2021.06.14.448341> (3rd review round in E. life)

5. Verdier, H., Laurent, F., Cassé, A., Vestergaard, C.L., Specht, C.G., Masson, J.-B., 2022a. A maximum mean discrepancy approach reveals subtle changes in α -synuclein dynamics. <https://doi.org/10.1101/2022.04.11.487825>
6. Verdier, H., Laurent, F., Vestergaard, C., Cassé, A., Masson, J.-B., 2022b. Amortised inference of fractional Brownian motion with linear computational complexity. arXiv:2203.07961 [physics, q-bio]. (accepted Physical Review E)
7. Sailor, K.A., Agoranos, G., López-Manzaneda, S., Tada, S., Gillet-Legrand, B., Guerinot, C., Masson, J.-B., Vestergaard, C.L., Bonner, M., Gagnidze, K., Veres, G., Lledo, P.-M., Cartier, N., 2022. Hematopoietic stem cell transplantation chemotherapy causes microglia senescence and peripheral macrophage engraftment in the brain. *Nat Med* 1–11. <https://doi.org/10.1038/s41591-022-01691-9>
8. Muñoz-Gil, G., Volpe, Giovanni, Garcia-March, M.A., Aghion, E., Argun, A., Hong, C.B., Bland, T., Bo, S., Conejero, J.A., Firbas, N., Garibo i Orts, Ò., Gentili, A., Huang, Z., Jeon, J.-H., Kabbech, H., Kim, Y., Kowalek, P., Krapf, D., Loch-Olszewska, H., Lomholt, M.A., Masson, J.-B., Meyer, P.G., Park, S., Requena, B., Smal, I., Song, T., Szwabiński, J., Thapa, S., Verdier, H., Volpe, Giorgio, Widera, A., Lewenstein, M., Metzler, R., Manzo, C., 2021. Objective comparison of methods to decode anomalous diffusion. *Nat Commun* 12, 6253. <https://doi.org/10.1038/s41467-021-26320-w>
9. Verdier, H., Duval, M., Laurent, F., Cassé, A., Vestergaard, C., Masson, J.-B., 2021. Learning physical properties of anomalous random walks using graph neural networks. *J. Phys. A: Math. Theor.* 54, 234001. <https://doi.org/10.1088/1751-8121/abfa45>
10. Dray, N., Mancini, L., Binshtok, U., Cheysson, F., Supatto, W., Mahou, P., Bedu, S., Ortica, S., Than-Trong, E., Krecsmarik, M., Herbert, S., Masson, J.-B., Tinevez, J.-Y., Lang, G., Beaurepaire, E., Sprinzak, D., Bally-Cuif, L., 2021a. Dynamic spatiotemporal coordination of neural stem cell fate decisions occurs through local feedback in the adult vertebrate brain. *Cell Stem Cell* 28, 1457-1472.e12. <https://doi.org/10.1016/j.stem.2021.03.014>
11. Serov, A.S., Laurent, F., Floderer, C., Perronet, K., Favard, C., Muriaux, D., Westbrook, N., Vestergaard, C.L., Masson, J.-B., 2020. Statistical Tests for Force Inference in Heterogeneous Environments. *Sci Rep* 10, 3783. <https://doi.org/10.1038/s41598-020-60220-1>
12. Blanc, T., El Beheiry, M., Caporal, C., Masson, J.-B., Hajj, B., 2020a. Genuage: visualize and analyze multidimensional single-molecule point cloud data in virtual reality. *Nat Methods* 17, 1100–1102. <https://doi.org/10.1038/s41592-020-0946-1>
13. Masson, J.-B., Laurent, F., Cardona, A., Barré, C., Skatchkovsky, N., Zlatic, M., Jovanic, T., 2020. Identifying neural substrates of competitive interactions and sequence transitions during mechanosensory responses in *Drosophila*. *PLoS Genet* 16, e1008589. <https://doi.org/10.1371/journal.pgen.1008589>
14. El Beheiry, M., Godard, C., Caporal, C., Marcon, V., Ostertag, C., Sliti, O., Doutreligne, S., Fournier, S., Hajj, B., Dahan, M., Masson, J.-B., 2020. DIVA: Natural Navigation Inside 3D Images Using Virtual Reality. *Journal of Molecular Biology* 432, 4745–4749. <https://doi.org/10.1016/j.jmb.2020.05.026>
15. Cocanougher, B.T., Wittenbach, J.D., Long, X.S., Kohn, A.B., Norekian, T.P., Yan, J., Colonell, J., Masson, J.-B., Truman, J.W., Cardona, A., Turaga, S.C., Singer, R.H., Moroz, L.L., Zlatic, M., 2019. Comparative single-cell transcriptomics of complete insect nervous systems (preprint). *Neuroscience*. <https://doi.org/10.1101/785931>
16. Jacob, V., Monsempès, C., Rospars, J.-P., Masson, J.-B., Lucas, P., 2017. Olfactory coding in the turbulent realm. *PLoS Comput Biol* 13, e1005870. <https://doi.org/10.1371/journal.pcbi.1005870>
17. Jovanic, Tihana, Casey Martin Schneider-Mizell, Mei Shao, Jean-Baptiste Masson, Gennady Denisov, Richard Doty Fetter, Brett Daren Mensh, James William Truman, Albert Cardona, and Marta Zlatic. 'Competitive Disinhibition Mediates Behavioral Choice and Sequences in *Drosophila*'. *Cell* 167, no. 3 (October 2016): 858-870.e19. <https://doi.org/10.1016/j.cell.2016.09.009>

Scientific or technical background required for work program

The interested student should either

- be a physicist interested in neuroscience
- an applied mathematician interested in neuroscience