CNeuro2024

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Reading Material: *Basic and Advanced*

Lecture 1 (Basic):

In lecture 1, we will first cover the basic concepts related to the formation of spatiotemporal wave patterns. We will then introduce a methodological framework for effectively detecting and analysing wave patterns in large-scale neural data. Finally, we will demonstrate how propagating wave patterns and their interactions provide a mechanism for flexibly coordinating large-scale brain activity during cognitive processes.

Below are the papers most closely related to this lecture:

- *Townsend, R.G. and Gong, P. (2018). Detection and analysis of spatiotemporal patterns in brain activity. PLoS Computational Biology, 14: e1006643.*
- *Xu, Y., Long, X., Feng, J., and Gong, P. (2023). Interacting spiral wave patterns underlie complex brain dynamics and are related to cognitive processing. Nature Human Behaviour, 7: 196–1215.*
- *Townsend, R.G., Solomon, S., Pietersen, A., Martin, P.R., Solomon, S.G., Gong, P. (2015). Emergence of complex wave patterns in primate cerebral cortex. Journal of Neuroscience, 35: 4657-4662.*

These are a few papers that provide some general context:

- *Cross, M.C., and Hohenberg, P.C. (1993). Pattern formation outside of equilibrium. Reviews of Modern Physics, 65: 851.*
- *Muller, L., Chavane, F., Reynolds, J., and Sejnowski, T.J. (2018). Cortical travelling waves: mechanisms and computational principles. Nature Reviews Neuroscience, 19: 255–268.*

Lecture 2 (Advanced):

In lecture 2, we will delve into a theory termed Fractional Neural Sampling (FNS), which explains how wave patterns with rich spatiotemporal dynamics implement sampling-based probabilistic computation. We will show that FNS offers a unified account of various brain functions, from visual perception inference to attention and interareal communication. Additionally, we will illustrate how FNS can be applied to understanding deep learning, representing a shared fundamental principle between biological and artificial intelligence.

Below are the papers related to this lecture:

- *Qi, Y., Gong, P. (2022). Fractional neural sampling as a theory of spatiotemporal probabilistic computations in neural circuits. Nature Communications 3: 4572.*
- *Chen, G., Gong, P. (2022). A spatiotemporal mechanism of visual attention: Superdiffusive motion and theta oscillations of neural population activity patterns. Science Advances 8: eabl4995.*
- *Ni, S., Harris, B., and Gong, P. (2024). Distributed and dynamical communication: a mechanism for flexible cortico-cortical interactions and its functional roles in visual attention. Communications Biology, 7: 550.*
- *Wardak, A., Gong, P. (2022). Extended Anderson criticality in heavy-tailed neural networks. Physical Review Letters 129: 048103.*
- *Chen, G., Qu, C.K., Gong, P (2022). Anomalous diffusion dynamics of learning in deep neural networks. Neural Networks, 149: 18-28.*