Editorial: Selected papers from the 14th international neural coding workshop, Seattle, Washington

Editorial

The central question of computational neuroscience is how information is encoded in and transformed by the behaviors of neurons and the networks they form. An answer to this question would be a description of nervous systems as computing devices and will be the result of the efforts of numerous researchers from a wide range of disciplines. Roughly every two years, the International Neural Coding Workshop provides a venue for researchers to present their work in theoretical and experimental neuroscience and cross-fertilize their efforts with results and discussion across disciplinary boundaries. This Special Issue collects a select set of eight papers from those presented at the pandemic delayed Neural Coding Workshop hosted online from Seattle, Washington, USA, 26–29 July, 2021. This was the 14th workshop, with previous ones held in Prague (1995), Versailles (1997), Osaka (1999), Plymouth (2001), Aulla (2003), Marburg (2005), Montevideo (2007), Tainan (2009), Limassol (2010), Prague (2012), Versailles (2014), Cologne (2016), and Torino (2018). More information about NC21, including abstracts and participants, can be found at https://sites.uw.edu/nc2021/.

In a two paper series, Caputi and coworkers provide original experimental and simulated results on a "novelty detection potential", associated with behavioral novelty responses, observed in the electrosensory-electromotor loop of the pulse emitting weakly electric fish *Gymnotus omarorum*.

First, in "Getting the news in milliseconds: the role of early novelty detection in active electrosensory exploration" (Caputi et al., 2022a), the authors bring experimental evidence that a "novelty detection potential" is generated at the level of the first electrosensory relay of the fish electrosensory lobe. Such early novelty detection can dynamically adapt the time resolution of the electrosensory system to the velocity of an object displacement during active exploration by the fish.

Then, the paper "A simple model of the electrosensory electromotor loop in Gymnotus omarorum" (Caputi et al., 2023b) introduces an original model of the sensorimoror loop for novelty detection. The critical point of this model is the time integration of the feed-forward and feed-back signals. In addition to a biological parallel with the known connectivity of the first electrosensory relay within the brain stem of the weakly electric fish Gymnotus omarorum, the authors emphasize that model results might offer new data to interpret the role of other natural and artificial reafferent sensory systems (such as the cerebellum and the auditory pathway).

In "Non-monotone cellular automata: Order prevails over chaos" (Ekström and Turova, 2022), the authors investigate how inhibitory synaptic connections affect activity pattern formation in a 2D square lattice network, where the vertices are considered to be excitatory or inhibitory. The model, with a balance between excitatory and inhibitory neurons, could be used for studying associative memory, as it exhibits a range of limiting states due to the inhibitory connections and depending on the initial activation.

Greenwood and Ward (2022), in "Phase offset determines alpha modulation of gamma phase coherence and hence signal transmission", present a model which enables the understanding specifically of the role of phase offset. In particular, they demonstrate with their proposed model that information transfer for a certain phase difference between alpha oscillations driving each of two modelled cortical regions is optimised, as does the coherence between gamma oscillations within two regions. For this to happen, phase offsets between gamma oscillations and alpha oscillations should match, as the authors demonstrate using a stochastic rate model. This paper contributes to further enhancing the theory of the development of this type of oscillating systems.

The paper "Evaluating the statistical similarity of neural network activity and connectivity via eigenvector angles" (Gutzen et al., 2022) details a method for the comparison of the structure of activity correlations in neural networks and connectivity architectures. The authors construct a statistical test for the comparison of matrices representing pairwise aspects of neural networks, in particular, the correlation between spiking activity and connectivity and they compare it to some classical tests. This work proposes an approach for statistically evaluating the structural similarity of matrices in scenarios of model validation and data integration, and provides a means to quantifying activity and connectivity measures with a common metric.

In "Spike frequency adaptation facilitates the encoding of input gradient in insect olfactory projection neurons", Lee et al. (2022) use the multi-scale adaptive threshold model for projection neurons in *Drosophila* for fitting experimental data and for studying the coding of the rate-of-change information. As they demonstrate by fitting data, spike frequency adaptation is a candidate mechanism for mimicking the phasic response pattern of the *Drosophila* projection neuron. They also show that their model is sensitive to input firing rates of change as opposed to the leaky integrate-and-fire model.

Tomar et al. (2022), in "A simple neuronal model with intrinsic saturation of the firing frequency", present a comprehensive analysis of the firing frequency transfer function of single and two-compartment neuronal models, with and without reversal potentials. These four neuronal models are compared focusing on the "firing rate vs. input" curve and on the saturation of the firing rate in the absence of refractory period. The requirement of both a reversal potential and a two compartment model to achieve intrinsic saturation is one salient result.

The paper "From chaos to clock in recurrent neural net. Case study" (Vidybida and Shchur, 2022) addresses the long-standing debate over the genesis of chaotic activity in nervous systems through numerical simulation of a simple, deterministic dynamical network with fixed connectivity. In particular, they show that there exist specific, short-lived external stimulus patterns that can trigger transient but very long-duration chaotic responses from the network. This is despite the fact that this network's stationary behavior is periodic.

In closing, we would like to thank all of the contributors and participants in NC21, including the organizing and scientific committees (listed on the workshop website). We would also like to thank our colleagues who contributed their time to review the contributions to this special issue, without whom it would not have been possible.

References

Caputi AA, Rodríguez-Cattáneo A, Waddell J, Pereira AC, Aguilera PA, 2022a. Getting the news in milliseconds: the role of early novelty detection in active electrosensory exploration. BioSystems https://doi.org/10.1016/j.biosystems.2022.104803.

Caputi AA, Waddell J, Aguilera PA, 2023b. A simple model of the electrosensory electromotor loop in Gymnotus omarorum. BioSystems 223, 104800.

Ekström, H., Turova, T., 2022. Non-monotone cellular automata: Order prevails over chaos. BioSystems 220, 104756.

Greenwood, P., Ward, M. L., 2022. Phase offset determines alpha modulation of gamma phase coherence and hence signal transmission. BioSystems 219, 104729.

Gutzen, R., Grün, S., Denker, M., 2022. Evaluating the statistical similarity of neural network activity and connectivity via eigenvector angles. BioSystems BIOSYS-D-22-00185

Lee, H., Kostal, L., Kanzaki, R., Kobayashi, R., 2022. Spike frequency adaptation facilitates the encoding of input gradient in insect olfactory projection neurons. BioSystems https://doi.org/10.1016/j.biosystems.2022.104802.

Tomar, R., Smith, C. E., Lansky, P. (2022). A simple neuronal model with intrinsic saturation of the firing frequency. Biosystems, 222, 104780.

Chris Christodoulou
Department of Computer Science, University of Cyprus, P.O. Box 20537, Nicosia, 1678, Cyprus
cchrist@ucy.ac.cy

Giuseppe D'Onofrio
Department of Mathematical Sciences, Politecnico di Torino, 10129 Turin, Italy
giuseppe_donofrio@polito.it

Michael Stiber[1]
Computing & Software Systems Division, School of STEM, University of Washington Bothell, Bothell, WA 98011 USA
stiber@uw.edu

Alessandro Villa
Neuroheuristic Research Group, Complexity Science Research Center, Université de Lausanne, CH 1015 Lausanne, Switzerland
Alessandro.Villa@unil.ch

[1]Corresponding author.