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<tr><th>authors</th><td>Johanna Senk
KarolÃna KorvasovÃ¡
Jannis Schuecker
Espen Hagen, Tom Tetzlaff
Markus Diesmann
Moritz Helias</td></tr>
<tr><th>title</th><td>Conditions for wave trains in spiking neural networks</td></tr>
<tr><th>publication_date</th><td>2019-09-23 00:00:00</td></tr>
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<tr><th>volume</th><td></td></tr>
<tr><th>doi</th><td></td></tr>
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<tr><th>id</th><td>id-8141362539885483323</td></tr>
<tr><th>abstract</th><td>Spatiotemporal patterns such as traveling waves are frequently observed in recordings of neural activity. The mechanisms underlying the generation of such patterns are largely unknown. Previous studies have investigated the existence and uniqueness of different types of waves or bumps of activity using neural-field models, phenomenological coarse-grained descriptions of neural-network dynamics. But it remains unclear how these insights can be transferred to more biologically realistic networks of spiking neurons, where individual neurons fire irregularly. Here, we employ mean-field theory to reduce a microscopic model of leaky integrate-and-fire (LIF) neurons with distance-dependent connectivity to an effective neural-field model. In contrast to existing phenomenological descriptions, the dynamics in this neural-field model depends on the mean and the variance in the synaptic input, both determining the amplitude and the temporal structure of the resulting effective coupling kernel. For the neural-field model we employ liner stability analysis to derive conditions for the existence of spatial and temporal oscillations and wave trains, that is, temporally and spatially periodic traveling waves. We first prove that wave trains cannot occur in a single homogeneous population of neurons, irrespective of the form of distance dependence of the connection probability. Compatible with the architecture of cortical neural networks, wave trains emerge in two-population networks of excitatory and inhibitory neurons as a combination of delay-induced temporal oscillations and spatial oscillations due to distance-dependent connectivity profiles. Finally, we demonstrate quantitative agreement between predictions of the analytically tractable neural-field model and numerical simulations of both networks of nonlinear rate-based units and networks of LIF neurons.</td></tr>
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<tr><th>authors</th><td>Diesmann, Markus
Hagen, Espen
Helias, Moritz
KorvasovÃ¡, KarolÃna
Schuecker, Jannis
Senk, Johanna
Tetzlaff, Tom</td></tr>
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<tr><th>abstract</th><td>Spatiotemporal patterns such as traveling waves are frequently observed in recordings of neural activity. The mechanisms underlying the generation of such patterns are largely unknown. Previous studies have investigated the existence and uniqueness of different types of waves or bumps of activity using neural-field models, phenomenological coarse-grained descriptions of neural-network dynamics. But it remains unclear how these insights can be transferred to more biologically realistic networks of spiking neurons, where individual neurons fire irregularly. Here, we employ mean-field theory to reduce a microscopic model of leaky integrate-and-fire (LIF) neurons with distance-dependent connectivity to an effective neural-field model. In contrast to existing phenomenological descriptions, the dynamics in this neural-field model depends on the mean and the variance in the synaptic input, both determining the amplitude and the temporal structure of the resulting effective coupling kernel. For the neural-field model we employ liner stability analysis to derive conditions for the existence of spatial and temporal oscillations and wave trains, that is, temporally and spatially periodic traveling waves. We first prove that wave trains cannot occur in a single homogeneous population of neurons, irrespective of the form of distance dependence of the connection probability. Compatible with the architecture of cortical neural networks, wave trains emerge in two-population networks of excitatory and inhibitory neurons as a combination of delay-induced temporal oscillations and spatial oscillations due to distance-dependent connectivity profiles. Finally, we demonstrate quantitative agreement between predictions of the analytically tractable neural-field model and numerical simulations of both networks of nonlinear rate-based units and networks of LIF neurons.Comment: 36 pages, 8 figures, 4 table</td></tr>
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