Mathematics > Dynamical Systems

Integrate and Fire Neural Networks, Piecewise Contractive Maps and Limit Cycles

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We study the global dynamics of integrate and fire neural networks composed of an arbitrary number of identical neurons interacting by inhibition and excitation. We prove that if the interactions are strong enough, then the support of the stable asymptotic dynamics consists of limit cycles. We also find sufficient conditions for the synchronization of networks containing excitatory neurons. The proofs are based on the analysis of the equivalent dynamics of a piecewise continuous Poincar\'e map associated to the system. We show that for strong interactions the Poincar\'e map is piecewise contractive. Using this contraction property, we prove that there exist limit cycles attracting all the orbits dropping into the stable subset of the phase space. This result applies not only to the Poincar\'e map under study, but also to a wide class of general n-dimensional piecewise contractive maps.

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