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Poster presentation

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Synchronizing a 2D continuum of two populations of neural masses

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Background

Neural field models of firing rate activity have played a major role in developing an understanding of the dynamics of neural tissues [1]. In this paper we study the possibility of synchronizing a two-dimensional neural field of excitatory and inhibitory layers of neural masses. This is the first step toward an investigation of the properties of visual areas in man and monkey. Each population is described by its post-synaptic potential (PSP), hence the state space is a two-dimensional function defined on the 2D continuum. The field is modeled by an integro-differential equation. At a given point in the continuum this equation models the synaptic integration of the neural mass through a linear term and the contributions of its neighbors to the variation of its PSP through a spatial integration of their firing rates weighted by a connectivity function. The firing rates are classically related to the PSPs through sigmoidal functions.

Methods

We use techniques from functional analysis to establish a sufficient condition for the neural masses in the continuum to globally synchronize. The Frechet derivative of the right-hand side of the integro-differential equation is shown to define a compact operator on the set of square integrable functions. The sufficient condition described below is obtained by imposing that the spectrum of the symmetric part of this operator be negative.

Results

We provide sufficient conditions on the connectivity matrix of the neural field for the existence of an homogeneous solution. We perform a classical linear stability analysis of this solution in this multidimensional framework [2]. We then use an extension of the contraction analysis for nonlinear systems [3] and of the analysis of concurrent synchronization in dynamic system networks [4] to obtain sufficient conditions for the neural masses in the continuum to globally synchronize when they receive the same input. In the case where the connectivity matrix of the network is translation invariant the condition can be elegantly expressed in terms of its Fourier transform. We also show that this condition implies the linear stability of the homogeneous solution.

Conclusion

The sufficient condition described above raises interesting biological questions that may be partially answered through such measurement techniques as Optical Imaging (OI). Conversely, OI measurements can provide clues for the spatial shape of the connectivity matrix. Finally these results open the door to a principled investigation of the properties of the visual areas in man and monkey where spatial synchronization would be the support of spatial similarity in terms of such visual features as color, texture, edges, optical flow.

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