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Generalized Ising model and the dimensionality of the Brain

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There are important evidences that spontaneous fluctuations of the brain are sustained by a structural architecture of axonal fiber bundles. As recently suggested, this well-defined fiber distribution could be highly informative to understand the underlying principles of spontaneous fluctuations as well as to infer the functional connectivity patterns of the brain. Various models have been employed to investigate the structure function relationship of the brain. In this work we implemented the generalized Ising model using the fiber distribution as the input and compared its outcome with the empirical functional connectivity and investigated its properties. A simpler 2-dimensional classical Ising model was used as the baseline model. Thermodynamic properties, such as the magnetic susceptibility and the specific heat, illustrated a phase transition from ordered phase to the disordered phase at the critical temperature. Furthermore, graph properties were extracted from the simulated functional patterns and compared with the empirically created graph. The two graph properties, global degree and global efficiency, clearly depicted a maximum at criticality. Additionally, the generalized Ising model exhibited the emergence of the resting state networks at the critical temperature, thus suggesting its capability to predict the spontaneous fluctuations of the brain at criticality from the anatomical fiber distribution. Despite the contrast between the input structural connectivities, both models exhibited similar behaviour of the global properties such as the global degree and efficiency. This could be explained by the notion of both models being in the same universality class obeying the same scaling relations. This leads to the calculation of the dimensionality of the Brain which could be used to explain the behaviour of the model around criticality. By following this procedure it is possible to investigate properties of other systems in the same universality class to better understand the behaviour of the systems.

Primary authors: Dr SODDU, Andrea (Western University); ABEYASINGHE, Pubuditha (Western University)

Co-authors: Dr OWEN, Adrian (Western University); Mr PAULA, Demetrius (Western University); Mr KHAJEHABDOLLAHI, Sina (Western University); Dr VALLURI, Sree Ram (Western University)

Presenter: ABEYASINGHE, Pubuditha (Western University)

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