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Modeling Disease Spreading Dynamic via Magnetic Ising Spins Distribution: The Stochastic Monte Carlo and Neural Network Analysis

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In this work, the disease spreading under the framework of SIS (susceptible-infected-susceptible) compartment model was investigated using the magnetic Ising model, the stochastic Monte Carlo simulation, and the knowledge based Neural Network analysis. The defined systems were lattice-like and varied in sizes to observe the finite size effect, where the agents (either susceptible or infected) were represented by the directions of the Ising spins (either +1 or -1). During the Monte Carlo simulation, each agent was randomly allocated on the discrete lattice cell and interacts with its neighboring agents for disease transmission. The +1 and -1 'magnetization' profiles were recorded as well as the basic reproduction number. From the simulation results, the characteristic number of susceptible and infected agents as a function of time were found to prominently depend on the system sizes, the agent concentrations (i.e. number of agents per available cells), and the infectious period. Specifically, the basic reproduction number was found to rise more sharply with increasing population density up to some points and become saturated afterwards. Similarly, the enhancement in infectious period shifts the balance between S-I curve to the infected agent side as expected. These results imply the key factors in this disease spreading dynamic as the infectious period and the 'incubation period'. Note that the 'incubation'in this sense is rather different from the traditional incubation that is defined as the time required to change from being susceptible to infected (infectious), the so called being exposed. Nevertheless, in this work, this exposed state was not directly considered but the 'incubation'was arisen from the population density (which reflects on the time/probability for changing from susceptible to infected agent), and the transmission probability. As is seen, quite a number of degree of freedom is associated to this study framework, the knowledge based Neural Network was then used to establish this complex relationship among parameters. The multi-layer perceptron in the form of input-hidden-output layers was used to formulate the parameter dependencies. The population density, the transmission probability, and the infectious period were used as input parameter, whereas the basic reproduction number was used as the output parameter. Up to 2 hidden layers with up to 40 nodes in each layers were used to extract the optimized network architecture, which is still in ongoing process. The preliminary results on this part show the good agreement between the predicted outputs (from Neural Network prediction) and the targeted outputs (from actual data) was found. The scattering plot between these outputs suggest a linear trend line with satisfied R-square. This therefore confirms the validity of using Neural Network for modeling the dynamic of the SIS disease spreading scope and giving profound database on the topic for future deployment.

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