A Complex Systems Approach to Spatial Epidemics

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Spatial Epidemics concern the analysis of the spatial distribution of a disease [1]. In human epidemics, the spread of infectious diseases is highly influenced by the structure of the underlying social network [2]
The target of this study is not the network of acquaintances, but the social mobility network: the daily movement of people between locations, in cities, which has already been described as a small world network [3]. This research led to the implementing of a agent based model (ABM), that comprehends both a movement and a infection model.
The movement model establishes the mobility network, which is inherently spacial, and is implemented using Geographical Information Systems (GIS).
Using a bottom up approach, the global structure of the network is emerged from the displacement of each individual (a), according to the expression:

$$a_{(i,j)}^{(t+1)} = a_{(i,j)}^{(t)} + d, \tag{1}$$

The stochastic variable d has a probabilistic distribution, according to:

$$d = (P_1)D_1 + (P_2)D_2 + (P_3)D_3 + (P_4)D_4 = \sum_{4}^{x=1}(P_x)D_x = 1, \tag{2}$$

D1, D2, D3 and D4 are the different ranges of movement.
The infection model describes the contagious process in the network established in the movement model.
The topology of the network is regenerated at each time step, and a evolutionary virus is simulated using random mutations on the infection force.
In this paper, the model will be described, and it will be shown a sensitivity analysis to evaluate the influence of the different parameters and understand a bit of its mechanics. Finally, it will be shown a aplication on a dataset of a mumps epidemic (Portugal, 1993-1996). The results will be discussed and some conclusions will be drawn.

1. Lawson, Andrew. B. (2001). *Statistical Methods in Spatial Epidemiology.* Wiley series in probability and statistics. John Wiley & Sons, England.
2. Zheng, D., Hui, P.M; Trimper, S. and Zheng, B. (2003). Epidemics in Hierarchical Social
3. Chowell, G.; Hyman, J. M.; Eubank, S; Castillo-Chavez, C (2003). Scaling laws for the movement of people between locations in a large city. *Physical Review E (Statistical, Nonlinear, and Soft Matter Physics) 68, 066102, 2003.* The American Physical Society, 1–6.