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Social Distancing as a Population Game in Networked Social Environments

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Abstract : While social living is considered to be an indispensable part of human life in today's ever-connected world, social distancing has recently received much public attention on its importance since the outbreak of the coronavirus pandemic. In fact, social distancing has long been practiced in nature among solitary species and has been taken by humans as an effective way of stopping or slowing down the spread of infectious diseases. A social distancing problem is considered for how a population, when in the world with a network of social sites, decides to visit or stay at some sites while avoiding or closing down some others so that the social contacts across the network can be minimized. The problem is modeled as a population game, where every individual tries to find some network sites to visit or stay so that he/she can minimize all his/her social contacts. In the end, an optimal strategy can be found for everyone when the game reaches an equilibrium. The paper shows that a large class of equilibrium strategies can be obtained by selecting a set of social sites that forms a so-called maximal r-regular subnetwork. The latter includes many well-studied network types, which are easy to identify or construct and can be completely disconnected (with $r = 0$) for the most-strict isolation or allow certain degrees of connectivity (with $r > 0$) for more flexible distancing. The equilibrium conditions of these strategies are derived. Their rigidity and flexibility are analyzed on different types of r-regular subnetworks. It is proved that the strategies supported by maximal 0-regular subnetworks are strictly rigid, while those by general maximal r-regular subnetworks with $r > 0$ are flexible, though some can be weakly rigid. The proposed model can also be extended to weighted networks when different contact values are assigned to different network sites.

Keywords : social distancing, mitigation of spread of epidemics, populations games, networked social environments
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