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Saturation in SIR model

Consider the following agent-based model of coronavirus spread: people move randomly and infection occurs with some nonzero probability when an infected individual comes within a certain “infection radius” of a susceptible individual. The question is how the infection radius affects the reproduction number. At low infection rates, this model leads to the classical S-I-R ODE model as its continuum limit. However higher infection rates lead to a saturation effect, which we compute explicitly using basic probability theory. Its continuum limit It leads to an S-I-R type model with a specific saturation term that depends on the population density. We also show that this modified model gives a much better fit to the real-world data than the classical SIR model.