SIR Model - Mass Tests

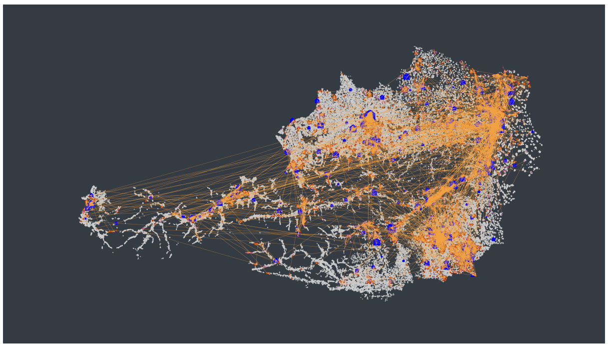

Abbildung 1: Screenshot from a microscopic SIR model.

Motivation

In 2020 the COVID-19 pandemic caused worldwide suffering and deaths and the whole world is waiting for a a vaccine. In winter 2020/2021 countries in Europe came up with the idea of executing nationwide mass tests to reduce the number of unconfirmed cases. This strategy should serve as an alternative to lockdown measures that force person to reduce their contacts.

Model Description

The classical SIR model by Kermack and McKendrick should pose as the basis model for the analysis, which is, in terms of a System Dynamics model represented by three compartments: Susceptible-Infectious-Recovered. Since the target of the project is to make unconfirmed cases visible, it is required to introduce another two compartments: First, an Exposed compartment should be introduced between the Susceptible and the Infectious, to depict those persons, freshly infected by the disease (latency time). These do not contribute to the infections, but behave as a time-delay for becoming infectious. Moreover, the Infectious compartment should be split into two separate compartments: Confirmed and Unconfirmed. While the prior depicts those infected persons known to the general public, the latter stands for all undetected mostly asymptomatic cases. Since exposed persons need to transfer to either of the two, the flow into the two compartments needs to be split with a certain ratio.

Key idea of the model is, that persons in the Detected compartment do not contribute to the infection rate anymore since they are assumed to be under isolation.

The model should contain the following parameters:

- α - infection probability in case of contact
- c - contacts per person per day
- γ - latency rate (1/latency rate)
- p_d, p_u - with $p_d + p_c = 1$ chances of being transferred to the detected or undetected compartment, respectively
- β_d, β_u - recovery rates for detected and undetected persons

Tasks

Task 1

Sketch, first, a causal loop diagram, secondly, a stock and flow diagram that depicts the model described above.

Task 2

Implement the stock and flow diagram in a system dynamics tool of your choice (alternatively extract the differential equations and use an ODE solver to solve them numerically). Look in the internet for feasible parameter values.

Task 3

Implement a mass-text event in which a certain number/ratio of persons in the Exposed and Undetected compartment are transferred to the Detected compartment. How many persons would be required to significantly impact the epidemic wave? Implement also strategies for multiple tests in a row.

Task 4

Implement a "lockdown" event at which the contact rate is reduced for a certain period of time.

Task 5

Compare the two measures qualitatively and quantitatively. How "much lockdown" can be supplemented by how many tests?

Task 6

Document all your findings in a written protocol.