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Description automatically generatedModelling Real World Problems - 900393SCIY

Final Project – Modelling Covid-19

In the final project for the Modelling Real World Problems we ask you to design, investigate and report on models that investigate effects of contact network structure on the epidemic dynamics of Covid-19.

The current disease modelling for Covid-19 is largely based on ODE (ordinary differential equation) modelling of SIR models. This modelling platform largely overlooks potential effects of contact network structure on the dynamics of the epidemic. In particular, these models are used to estimate *R0* , the “basic reproduction number”, which is the number of secondary cases cause by one infectious individual. Typically, this number is estimated from the exponential increase rate of the early epidemic. Subsequently, this estimate for *R0* is used to estimate the level of “group immunity”, and the severity of measures necessary to stop the epidemic. However, an initial analysis of a toy model (see accompanying paper) demonstrates that the early growth rate of the epidemic might substantially differ from the “true *R0*” of the disease. Especially if this true *R0*is very large, in a contact network structure you typically observe quick local saturation of available susceptibles, which causes the exponential increase rate of the epidemic to be markedly different from the *R0* value.

In the project, we ask you to further explore potential effects contact network structure on the epidemic dynamics. In particular, you should focus on determining the relation between the true *R0* value of the disease, the early epidemic increase rate, and the necessary measures to stop the epidemic (e.g. vaccination percentage, decrease of contact rate, etc.). You should use a methodical approach, and aim to keep the model simple. You can choose various approaches:

* Study a simple S(E)IR cellular automaton type model, in which you can explore effects of decreasing movement, infection rate, immunity (vaccination), etc.
* Use synthetic networks (RG, W-S, BA, Configuration model) to study how different topological features (degree distribution, clustering coefficient etc.) influence the outbreak of the disease, e.g., by doing some analytical calculations, simulating SIRS on the network, using percolation to compute the epidemic threshold, etc.
* Study a small contact network, e.g., study disease spread in such a network, simulate SIRS on the contact network, use percolation to compute the epidemic threshold of your network, etc.
* Analyse data from observed disease spread contact networks in Covid-19
* A combination of the afore mentioned approaches.

We will provide some starting models and initial questions, to help you to get off to a good start. Subsequently, you will have to make a work plan for the project, which you have to submit by May 15th. We will provide feedback and, if necessary, assist with programming. The work plan should contain the following items;

* What is the specific topic that you want to study?
* Formulate a broad research question (in a later stage you can make it more specific). Make sure that there is an aspect of the effects of contact network structure on epidemic dynamics in your research question
* Make an initial working plan;
  + what are you going to vary?
  + what kind of results are you going to measure?
  + how does this help to answer the research question?
  + what kind of “experiments” can you perform?

During the project phase, we will have general feedback and help sessions during normal class hours. In addition, you can ask for a 10 minute individual feedback session on Wednesdays afternoon, for which you have to sign up. For these sessions, you have to submit your questions beforehand, so that we (and you!) are prepared and we can have an efficient interaction.

For the final product, we ask to write a report in scientific style (deadline May 28th) including the following sections:

**Introduction**

* Introducing the topic
* A research question

**Methods**

* Description of the model: Variables, processes, parameters, assumptions
* Mean-field expectation

**Results**

* Describe the pattern formation, dynamics, and attractor (if this applies to your model)
* Describe the network topology and measure, and how they affect the network dynamics (if this applies to your model)
* Perform small experiments in a logical order
* Include key figures, and adequately describe them

**Conclusions & discussion**

* Draw general conclusions from results (answer research question)
* Discuss effects of contact network structure

**Future research**

* Give specific possibilities for further research

More details about the report, including the grading rubric, will follow.