A Multiscale approach to modeling the municipal spread of COVID-19

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Joint work with

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- Claire Valva, NYU Courant Center for Atmosphere and Ocean Science.

Note that the phrase,

“All models are wrong, but some are useful"

is in play.

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      i Staggered schedules.
      ii Quarantining/presymptomatic.

Question

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How do schools and universities impact the spread of COVID-19 in the surrounding community?

Ideas

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- Use a (deterministic and homogeneous) compartmental model approach.

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- Describe every agent's schedule, movement, and infection status at every instant in time.
- Let agents interact with one another and keep track of the disease progression.

Examples

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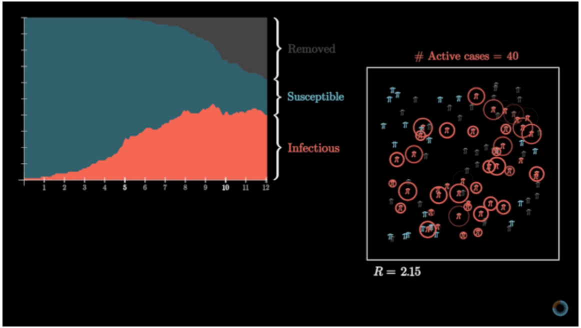
- Particle based simulations. (3Blue1Brown)



Examples

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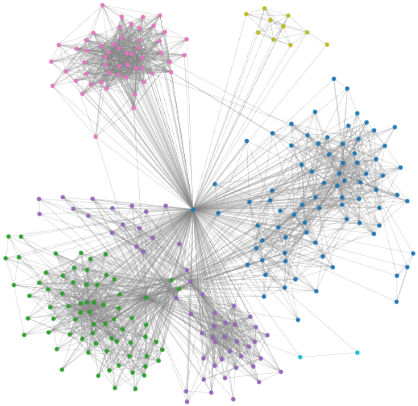
- Network based simulations. (covasim)



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- (Typically) less ad-hoc parameter tuning.

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- Slow to run.
- Stochastic nature requires ensembles to generate statistics.

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- Assume efficient and homogeneous mixing.

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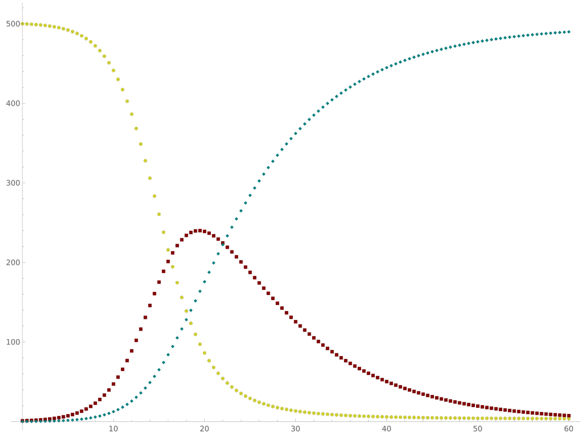
- SIR Model (Kermack and McKendrick, 1927)



SIR equations

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We can write *any* ODE as a first order update of a state $\vec{\boldsymbol{x}}$ by

$$\dot{\vec{\boldsymbol{x}}} = \vec{\boldsymbol{f}}(t, \vec{\boldsymbol{x}}).$$

The SIR equations then read

$$\begin{pmatrix} \dot{S} \\ \dot{I} \\ \dot{R} \end{pmatrix} = \begin{pmatrix} -\beta\, C\, \frac{I}{N} \\ +\beta\, C\, \frac{I}{N} - \gamma I \\ +\gamma I \end{pmatrix},$$

where S, I, and R denotes the ***susceptible***, ***infected***, and ***removed*** populations respectively. Note, $N = S + I + R$ is the total (conserved) population size.

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- β is the likelihood of reaction.

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- $C \in [0, \infty)$ is the contact rate.
- $\gamma \in [0, \infty)$ is the recovery + death rate.

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- Couple together small and large scale models to study complicated systems.
- E.g., quantum mechanics $\to$ molecular dynamics $\to$ kinetic theory $\to$ statistical mechanics $\to$ thermodynamics.

Idea

Can we couple an agent based model alongside a compartmental model to remove the drawbacks and gain benefits?

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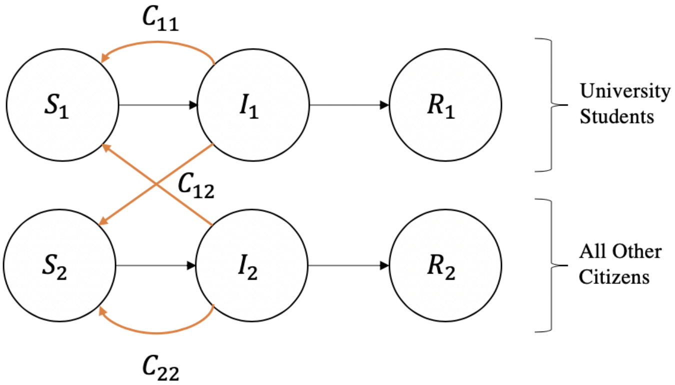

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