



Simulating the Spread of COVID-19

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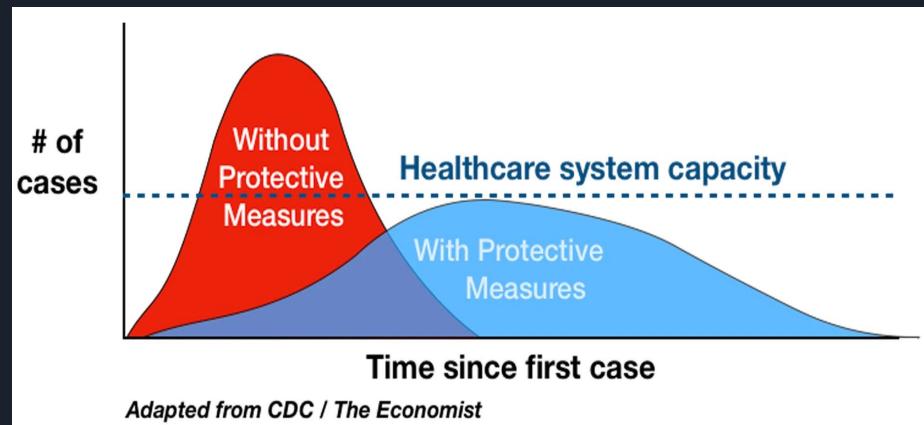
Project Objective

Motivation: Understand the effect of protective measures in combating the spread of an infectious disease such as COVID-19.

Inspiration: Washington Post article by Harry Stevens: **Why outbreaks like coronavirus spread exponentially, and how to “flatten the curve”**

Purpose:

- Simulate the spread of infectious disease within a community
- Analyze the impact of social distancing
- Use population density of a given US county (user input) to tailor the simulation





Description of the Model

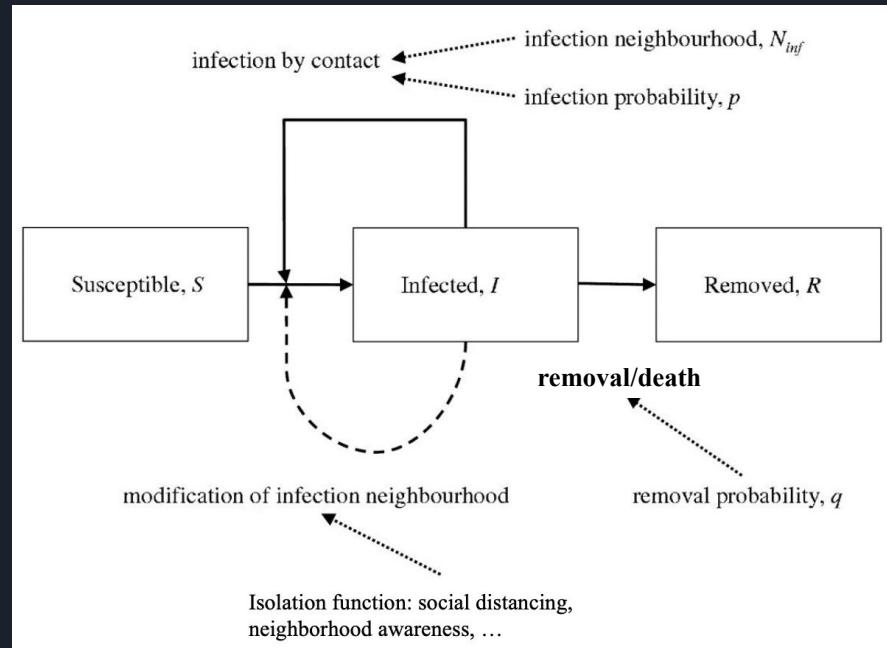
SIR Model+Spatial Network

Susceptible (S) -- has not yet been infected, and has no immunity

Infected (I) -- currently "sick" and contagious to Susceptible neighbors

Removed (R), where the removal from further participation in the process is assumed to be permanent, due to death

Infection neighborhood $\{(i, j) \text{ s.t. } \sqrt{(i - i_0)^2 + (j - j_0)^2} \leq r\}$



Maharaj, S., Kleczkowski, A. Controlling epidemic spread by social distancing: Do it well or not at all. BMC Public Health 12, 679 (2012).



Need for Big Compute

Current Speed: Serial model: 45 minute runtime/population density of 2,000

Time Complexity: $O(n^2)$

The Bottleneck: Calculating the distance between all members of the population

- **Iterative process:** People will be infected within a certain radius of an infected individual
- Need for a **nested for loop**

i: one individual

j: every other individual they may interact with

```
r = np.zeros((len(x), len(x)))
contact = np.zeros((len(x), len(x)))

for i in range(len(x)):
    for j in range(len(x)):
        r[i,j] = np.power(np.power(x[i] - x[j], 2) + np.power(y[i] - y[j], 2), 0.5)
        contact[i,j] = (r[i,j] < r_inf) & (r[i,j] > 0)
```



Tools and Infrastructures

Infrastructures: AWS EC2(CPU, GPU, Cluster)

1. Cost-effectiveness
2. Flexible Services
3. Complete Control
4.



Tools: OpenMP, openACC, MPI, Hybrid

Summary:

- Goal: explore the impact of social distancing by simulating the spread of COVID-19
- Big computing problem: Euclidean distance calculation between individuals at each time
- Infra and tools: AWS, openMP, etc.

Thank you and Questions?