HoP 101

Bonus Content

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July 29, 2023

This document includes some of our discussions on Teams which are relevant to the course and may provide some additional insight.

On why we are simulating

For some extra reading on disease-spread models, you can check out this website.

- As I mentioned, the description on the website is purely analytical. What we will be doing is different (and this is also a hint for you) - we will treat time discretely, simulate the disease-spread process and make inferences from observing the simulation (this is a "numerical" solution).
- You will also notice that the model on that website is pretty simple and only remotely realistic. Can you think of things to add?
- As mentioned before, this is not what I had initially claimed (I had talked about implementing a Viscek model). The main reason behind this is the complexity in visualizing the result from a Viscek model (which involves motion or other emergent behaviour which makes sense only visually/spatially). We would either have to use some external ready-made Python package to do the visualization, but in my opinion that would take away a lot of fun from the process. Alternatively, we would have to implement something ourselves which would be hugely out of scope. Nevertheless, Viscek is also an agent-based model and our model too will have some properties reminiscent of Viscek (for example, a notion of neighbors when talking about probability of infection!). All in all, I hope that once you implement this disease spread model, you will be well equipped to try out a Viscek model yourself.

On the Tower of Brahma

Last time, Jay raised that our optimal solution to Tower of Brahma may not be unique. It indeed is, and we can show this by induction. The idea is that when you have to move n discs from pole A to pole C, at some point you will have to move the n-th disk as well. But the n-th disc can be moved only when there is no other disc above it, and when there is no other disc on the destination pole. That is, the remaining $(n-1)$ disks must be on the third pole. From the inductive step, we have the most optimal way to move $(n-1)$ disks. The base step for $n = 1$ can be shown trivially.

On Probability of Recovery

n practice, probability of recovery is not a measurable quantity. What we generally know about a disease is the number of days it takes on average to recover from that disease (what we called d). Tracking every infected person's history is a hassle (in computational terms, a memory overhead). But that in itself is not the problem. The problem is that we want a distribution of number of days for recovery, i.e., we don't want every patient to recover in d days. Like in the real-world, we want this to be a probability with d as the most likely number of days.

Now let us think of this from a higher-level view, from the point of view of the system and not the individuals. Let's say a disease has been going on since a long period of time. So at a given instance, you will have people who have had the disease since 1 day, since 2 days, since 3 days, and so on till people having the disease since 10 days. Assuming that the rate of disease spread has stabilized, we can expect a homogenous distribution where the number of people in each stage of the disease is roughly equal. So, 10% of the people have the disease since 10 days and so 10% of the infected people will recover on any given day. This is motivation behind taking $r = 1/d$.

Now, these two ideas don't fit together perfectly and at best give us a fair approximation in a system with large number of agents.

On going forward

We will now proceed to the most important part of HoP101 – experimenting! I request you all to consider one of both of the following to directions to get either a better model, or some interesting observations which our simulation can offer.

- **Modifications in the model:** A lot of ideas have come up to address the gaps and shortcomings of our existing model. Some of these include
  - What if probability of recovery was a function of the number of days since an agent is infected?
  - What if the probability of infection was a function of some "distance" from the infected individuals?
  - Can we put people into groups within which they interact? Can we make these groups overlapping?
  - Can we introduce reinfection and death in the system? Can we then have probability of infection change with number of times an agent is infected?
- **Questions that can be answered through the existing or a modified model:** Can we use these models to answer questions like (these are just examples!)
  - When should we place a lockdown? How long should the lockdown be?
  - How does a new cure/preventive measure affect the system? (like medicine, vaccine, etc.)
  - How does herd community work?