CS526: Advanced Linear Programming
Lecture 21

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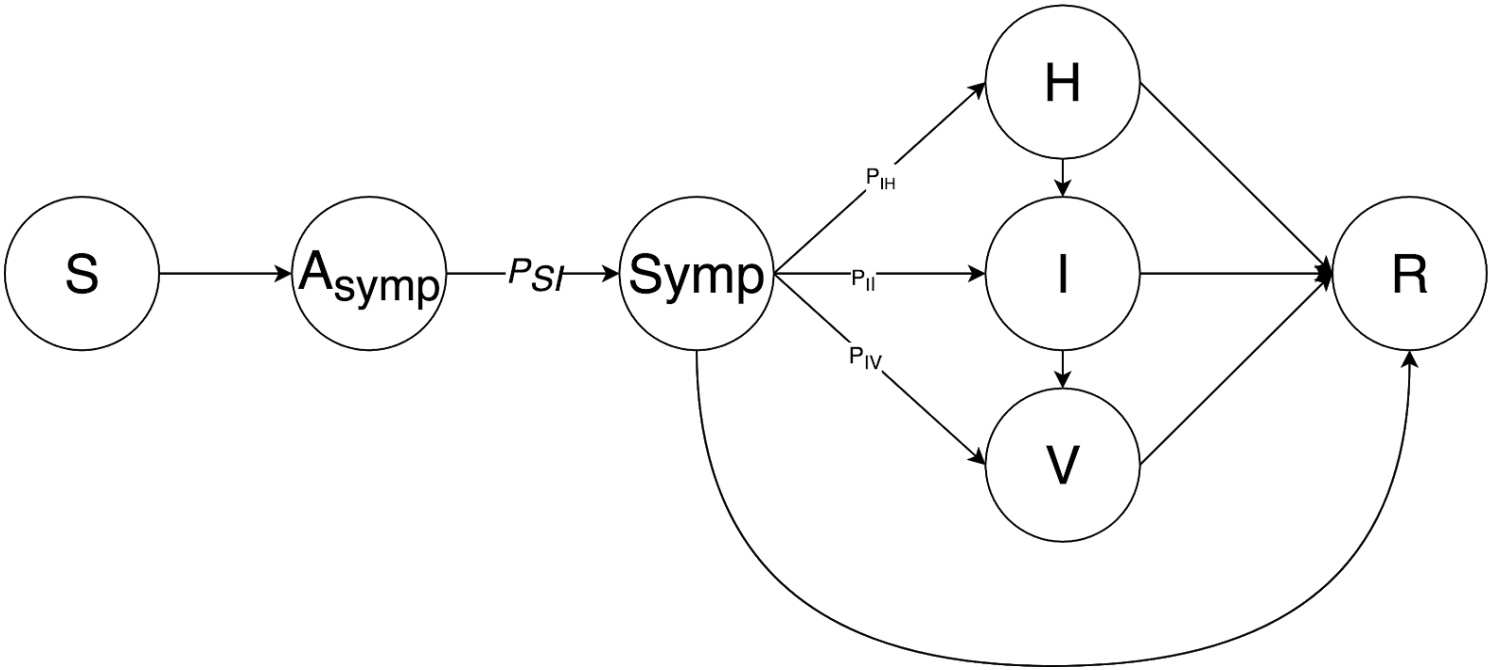
Aside: using operations research to illuminate decisions

- How can mathematical modeling help in understanding physical phenomena and provide information to decision makers to improve decisions?
- Lots of models generate information about (exponential) growth of infections (in coronavirus pandemic)
- Models are based on data at different scales (both spatially, physically and temporally)
  - Spatial scale: worldwide, country, state, county models to convey information about the system at a given level of detail.
  - Temporal: the number of people in some health state at different intervals: yearly, monthly, daily, hourly
  - Physical: ventilators, masks, virus, microbes

Aside: using operations research to illuminate decisions

- Simulation or agent based models provide predictions moving forward based on estimated parameters, often calibrated to existing data collected
  - Starting from assumptions and using data to predict what is going to happen in the future.
  - Using estimated parameters. e.g. the infected rate of nurses within the hospital.
  - Calibration: Use the simulation model by setting back in time and moving forward to corroborate existing data.
- These models are informative - how to improve?
  - The main focus of the lecture
- Sensitivity analysis can help with uncertainties in estimated parameters
  - Varying the estimated parameters over some range, defined by variance and standard deviation of those parameters and do sensitivity and analysis and look at the outcomes to somehow get how good or sensitive those predictions are to the assumption of the data

Adapted SHINE model picture



Additional information in `SIRmodelOutline.pdf`

What can we do with the predictions?

- Simulations provide the numbers of people in each circle (population model not agent - individual model) over time
- Susceptible, Asymptomatic, Symptomatic, Hospitalized, Intensive Care, Ventilator, Recovered
- The simulation generates values for counties (spatial resolution) as days increase (possibly by age cohort) based on the parameters that are encoded in the model (prediction)
- Parameters relate to resources (beds, masks, nurses, ventilators, etc) and how those affect the outcomes or transitions
- Questions/analysis:
  - Which resources at which locations become critical, and at what time?
  - Can we deploy new resources, or move resources from one location to another to improve outcomes?
- This redeployment changes the parameters for the simulation - rerun to see its effects (validation)

Linear programming can help determine the critical resource/location information

- Which resources at which locations become critical, and at what time?
- Show model in GAMS (wimodel.gms)
  - The main focus is to find what to deploy and when.
  - The data is randomized.
  - E.g.: The number of masks at a particular location and at a particular time is counted by today's mask and yesterday's unused mask minus the masks nurses use today
  - Utilize information on population sizes in each category at each time from simulation.
  - Connect to data sources regarding resources, both existing and newly arriving. Use marginal prices to determine value of additional resources at each location and at each time.