9-10 – 9-24 – Approaches to building virtual worlds

* The art, science, and craft of virtual worlds
  + We’ll use forest fires as a guiding example. Our goal is to understand how best to control and eliminate a forest fire.
  + Messy and complex real world
    - Different tree species
    - Different moisture levels
    - Schedule of firemen
    - Different levels of experience in firemen
  + We have to simplify for a virtual world
  + A good simplification is accurate, policy-relevant, and computationally feasible
  + Building a virtual world can involve a tricky balance of many priorities
    - Some parts are scientific. “Accuracy” can be defined by deviating by at most x% from an expected result.
    - We rarely have infinite time and computers to test all of our ideas
  + Scientific criteria
    - Accuracy
    - Policy-relevance
    - Computational feasibility
  + Art and craft
    - Choosing between seemingly interchangeable alternatives
    - Estimating the impact of choices
    - Determining which option is preferred by the end user
* Overview of approaches
  + Continuous mathematical models
  + Discrete Computational models
    - Cellular automata
    - Agent-based models
* Continuous mathematical models: principles
  + Groups, not individuals
  + Susceptible – initial 1000
  + Infectious – initial 1
  + Recovered – initial 0
    - Recovery rate y = 1 / 8
    - Infection rate B = .13 \* S \* I
  + For each box, write one line of equation:
    - d Stock name/dt = -(outflow) + (inflow)
    - dS/dt = -B\*S\*I
    - dl/dt = B\*S\*I - y\*l
    - dR/dt = y\*1
  + Write the equations when:
    - The phenomenon to model is simple enough
    - The model doesn’t need to be described to any non-math major
  + Otherwise, we draw the diagram, and a software takes care of turning it into equations for us
  + Some problems can, but are really hard to write as equations. And even harder to solve. That happens when there is a lot of heterogeneity.
    - Spatial heterogeneity
    - Individual heterogeneity
      * Contact patterns, susceptibility, disease progression
* Cellular Automata
  + Has two components
    - A set of cells, having some content
      * Cells have the same, and it can be hexagonal, circular, square…
    - Rules that change the cells’ content
  + All cells change content at the same time, using the same rules, and based on the state of surrounding cells
  + Cells change based on the previous state of neighboring cells
  + At any point in time, a cell is in only one state
  + Works well with spatially heterogeneous processes – phenomena whose result is heavily influenced by the spatial configuration of cells and their neighborhood
* Agent Based Modeling
  + These define an ABM
    - Interact with environment
    - Interact with other agents
    - Complex states
  + What is needed to describe an ABM
    - The types of agents
    - Agent characteristics
    - States for the environment
    - What each type of agent does at each step (the rules)
    - Provide the initial configuration
  + Steps to abstract a problem as agents
    - Isolate the agents
      * Eliminate what belongs to the environment
      * Identify agent types by grouping entities that have similar properties
    - Find all the numbers/quantities that matter
      * Categorize them, if they change they are variables, if they do not change they are parameters
      * Attribute them, do they belong to an agent type, or each agent
    - Summarize the change
      * Describe how the variables change over time