



UNIT 10B

Visualizing Data: Simulations

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Simulation

- The imitative representation of the functioning of one system or process by means of the functioning of another, for example a computer program. (Merriam Webster)
- Simulation involves developing a model of a system and experimental manipulation of the model to observe the results
 - accelerated results, easy to control via parameters, usually cheaper
- vs. Real experiments
 - very time consuming, difficult to control, potentially dangerous, potentially unethical, expensive

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Uses of Simulation

- Testing –safety engineering, usability testing
- Predicting – understanding how natural and human systems work to predict future behavior
- Training – providing lifelike but controlled experiences for learners in educational, occupational and military situations



Models

- A *model* is an abstraction of the real system. It represents the system and the rules that govern the behavior of the system.
 - The model represents the system itself, whereas the simulation represents the operation of the system over time.
- Concerns:
 - Achieve a certain level of accuracy while keeping the complexity manageable
 - Parts of the system may be stochastic (may exhibit random behavior).

Physical Models

- Physical models: small-replicas
 - May not exist, may be unsafe to work with, expensive to build and modify.
 - Some change too slowly over time.
 - Mississippi River Basin model:
<https://youtu.be/WeTcYcd5dUM>
 - Scale model of the solar system in the desert:
<https://youtu.be/zR3lgc3Rhfg>



Computational Sciences

- Computational sciences use computational models as the basis of obtaining scientific knowledge.
 - Computational Biology
 - Computational Physics
 - Computational Chemistry
 - Computational Neuroscience

Large Scale Simulations

- Computing power of today enables large scale simulations.
 - Department of Defense: Battle simulations
 - Blue Brain Project at EPFL to reverse engineer the human brain
 - National Center for Atmospheric Research : 1,000 years of climactic changes
<https://youtu.be/d8sHvhLvBo>



IBM Blue Gene supercomputer

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Simulation Tradeoffs

- Agent-based vs. Equation-based
 - how different individuals/units interact with each other or how a system's global behavior is derived from mathematical models
- Abstract vs. Accurate
 - minimal relevant factors or complex components?
- Static vs. Dynamic
 - snapshot of single point of time or changes over time?
- Deterministic vs. Stochastic
 - no randomness or random elements?
- Continuous vs. Discrete
 - does time advance smoothly or in steps?

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NetLogo (netlogoweb.org)

- Modeling environment run in the browser that lets you create simulations, varying numerous parameters
 - Art
 - Biology
 - Chemistry & Physics
 - Computer Science
 - Earth Science
 - Math
 - Social Science

