Mathematical Modeling: Intro

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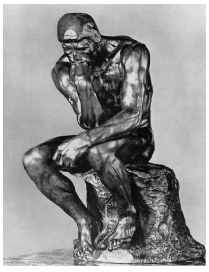
Science, then, and now…

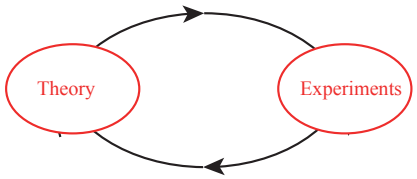
At the beginning, there were thoughts, and observation….

Science, then, and now…

- For a long time, people thought that it would be enough to reason about the existing knowledge to explore everything there is to know.
- One single person could possess all knowledge in her cultural context.
  (encyclopedia of Diderot and D'Alembert)
- Reasoning, and mostly passive observation were the main techniques in scientific research

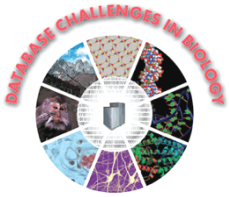


Science, then, and now…

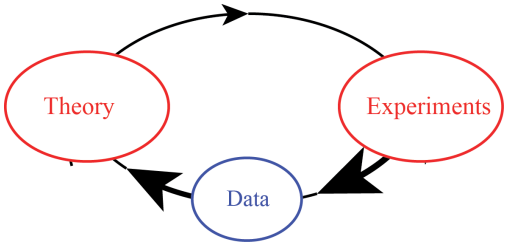


Science, then, and now…

- Today's experiment yields massive amounts of data
- From hypothesis-driven to exploratory data analysis:
  - data are used to formulate new hypotheses
  - computers help formulate hypotheses
- No single person, no group has an overview of what is known



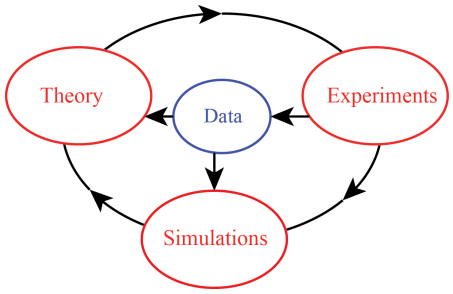
Science, then, and now…



Science, then, and now…

- Computer simulations developed hand-in-hand with the rapid growth of computers.
- A computer simulation is a computer program that attempts to simulate an abstract model of a particular system
- Computer simulations complement theory and experiments, and often integrate them
- They are becoming widesepread in: Computational Physics, Chemistry, Mechanics, Materials, …, Biology

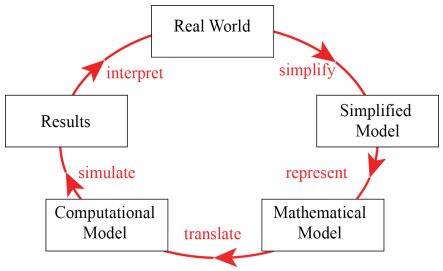
Science, then, and now…



Mathematical Modeling

- Is often used in place of experiments when they are *too large, too expensive, too dangerous, or too time consuming*.
- Can be useful in "what if" studies; e.g. to investigate the use of *pathogens* (viruses, bacteria) to control an insect population.
- Is a modern tool for *scientific investigation.*

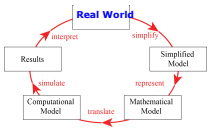
Mathematical Modeling



Mathematical Modeling

Define real world problem:

- Perform background research
- Perform experiments, if appropriate

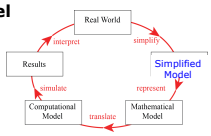


Task: Understand current activity and predict future behavior

Mathematical Modeling

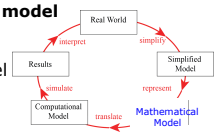
1)Simplification: define model

- Identify and select factors to describe important aspects of the Real World Problem;
- determine those factors that can be neglected.



Mathematical Modeling

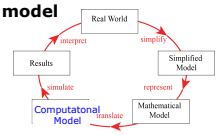
2) Represent: mathematical model



- Express the simplified model in mathematical terms
- the success of a mathematical model depends on how easy it is to use and how accurately it predicts

Mathematical Modeling

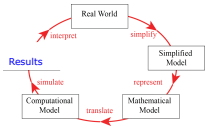
3) Translate: computational model



- Change *Mathematical Model* into a form suitable for computational solution
- Choice of the numerical method
- Choice of the algorithm
- Choice of the software (Matlab)

Mathematical Modeling

4) Simulate: Results

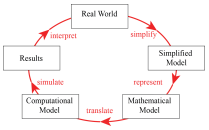


- Run Computational Model to obtain Results; draw Conclusions.
- Graphs, charts, and other visualization tools are useful in summarizing results and drawing conclusions.

Mathematical Modeling

5) Interpret

- Compare conclusions with behavior of the real world problem



- If disagreement, modify Simplified Model and/or Mathematical model

Syllabus

- Introduction to Matlab
- The tools of the trade
- Data analysis
- Data modeling
- Clustering
- Fourier analysis
- Simulations (Monte Carlo)

References

Cleve Moler, Numerical Computing with MATLAB, 2004.

(http://www.mathworks.com/moler)