Modeling of Complex Social Systems

MATH 800
Fall 2011
Complex Social Systems

• A system is a set of elements and relationships
• A complex system is a system whose behavior cannot be easily or intuitively predicted
Complex Social Systems

• A **system** is a set of elements and relationships
• A **complex system** is a system whose behavior cannot be easily or intuitively predicted

\[ 300 = (5-3) t + 200 \]
Complex Social Systems

• A social system is a collection of individuals and interactions.

• A complex social system is a complex system whose behavior is primarily the result of the behavior of individuals
Complex Social Systems

• A **social system** is a collection of individuals and interactions.

• A **complex social system** is a complex system whose behavior is primarily the result of the behavior of individuals.
What is Modeling?

• is abstraction of reality!
• is a representation of a particular phenomena, idea, or condition.
• is never perfectly accurate.
What is Mathematical Modeling?

• Framing questions in/about the real world in mathematical terms.
• Simplified representations of some real-world entity in equations
• It is characterized:
  – Variables (the things which change)
  – Parameters (the things which do not change)
  – Functional forms (the relationships)
What is Mathematical Modeling?

\[ 300 = (5-3) t + 200 \]

\[ X(t) = (5-3\% X(t-1)) + 200 \]
Purpose of Modeling

• In General, Modeling helps
  – Answering specific questions
  – Understanding problems better
  – Communicating with others
First Steps in Modeling

• Define systems and boundaries.
• Simplify assumptions.
• Draw an overall block diagram
Good Models

• Simple
  – Have clearly defined questions
  – Have clearly stated assumptions

• Adaptable

• Reproducible
  – Have clearly defined variables

• Validated
  – Use the best data available
  – Interpret results with caution
The Modeling Process

Conceptual Modeling

Mathematical Modeling

Computational Modeling

Validation
The Modeling Process

- Conceptual Modeling
- Mathematical Modeling
- Computational Modeling

Validation
The SIR Epidemic Model

### Variables
- **S** (Susceptible): Individuals susceptible to the disease
- **I** (Infectious): Infected Individuals able to transmit the parasite to others
- **R** (Recovered): Individuals that have recovered, are immune or have died from the disease and do not contribute to the transmission of the disease

### Parameters
- $\alpha$, $\beta$

### Diagram
- **S** → **I** (Transmission $\alpha$)
- **I** → **R** (Recover $\beta$)
The SIR Epidemic Model

Susceptibles (S): Individuals susceptible to the disease
Infectious (I): Infected Individuals able to transmit the parasite to others
Recovered (R): Individuals that have recovered
Death (D): Individuals that have died from the disease

Parameters: $\alpha$, $\beta$, $\gamma$, $\delta$
Variables: S, I, R, D
Computational Modeling

• **Simulation**: Simulation is any technique for analyzing, designing, and operating complex systems.

• **Visualization**: Visualization is any technique for creating images, diagrams, or animations to communicate and describe the behavior of complex systems.
Types of Mathematical Models

• Linear vs. Non-linear Models
  – In linear models all the variables and the parameters are connected by linear equations. Otherwise the model is non-linear.

The SIR Epidemic Model

- S: Susceptible
- I: Infected
- R: Recovered
- D: Death

Transmission ($\alpha$) → Recover ($\beta$) → Death ($\delta$) → Transmission ($\gamma$)
Types of Mathematical Models

- Aggregate vs. Individual Models
Types of Mathematical Models

• Deterministic vs. Stochastic Models
  – Deterministic models have no uncertain components (no parameters are characterized by probability), as opposed to stochastic models.
Types of Mathematical Models

• Static vs. Dynamic Models
  – A dynamic model refers to a system that changes over time, whereas static model refers to a system that is at steady state
  – Dynamic model is a representation of the behavior of the static components of the system.
Types of Mathematical Models

- Continuous vs. Discrete Models
  - In discrete Models variables change only at a countable number of points in time, whereas in continuous models variables change in a continuous way.
Types of Mathematical Models

• Qualitative vs. Quantitative Models
  - Quantitative models lead to a detailed, numerical predication about responses, whereas qualitative models lead to general descriptions about the responses.