Orientation &
Selected Guest Lecture Models

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MIT 15.879

February 8, 2012
15.879 Focus this Term: Agent-Based Models for Public Health

- Purpose of models
- Model strength & limitations
- Diversity of classes of models available
- How models are built, refined & analyzed
- Model tradeoffs & complementarity with classic stock & flow models
- Software & analytic tools for working with models
- How models mesh with traditional techniques
  - Linkage databases
  - Real-time data collection (EMA)
  - Biostatistics
Goals of Class

• To expose participants to basics of building agent-based models (ABMs) in AnyLogic
• To convey a sense as to the capabilities, strengths and weaknesses of agent-based modeling
• To train AnyLogic users so that they are comfortable running, understanding many elements of, and performing small modifications on ABMs
• To provide aspiring modelers with hands-on familiarity with the capabilities & functions of AnyLogic and sufficient exposure to Java programming to navigate within models
• To help create informed consumers of Agent-based models
Non-Goals of the Class

- To serve as a comprehensive survey of Agent-Based modeling
- To give a thorough conceptual or theoretic framework for understanding and analyzing Agent-Based Models
- To review the tradeoffs between AnyLogic & other ABM platforms
- To create a set of fully proficient Agent-Based modelers
- To render participants into Java programmers
- To sell participants on the superiority of AnyLogic, or the desirability of buying AnyLogic licenses
Anticipated Class Coverage

• Motivations
• System science concepts
• Qualitative sketching of ABM
• Agent dynamics
• Inter-agent interaction
• Hybrid modeling

• Agent environments
  – Irregular topologies (networks)
  – Regular (e.g. CA)
  – Irregular geometries
• Debugging
• Best practices in model building
• Understanding Individual-based & aggregate differences
Class Coverage Cont’d

• Modeling process
  – Scoping
  – Formulation
  – Parameterization
  – Calibration
  – Validation & Confidence building
  – Model analysis tools & techniques
Class will Be...

- Interactive & Informal
- Adapted to student interests
- Project based
- Demanding
- Highly interdisciplinary
  - Aimed for accessibility to diverse audience
  - Some material presented in additional sessions for certain backgrounds
  - Required: Patience in dealing with diverse peers
This Class is Not for Everyone

• The class will be demanding in different ways from different people
  – Health Sciences: A willingness to take on quantitative & computer challenges, and to acquire new skills and approaches
  – Computer Science: Patience with challenges of modeling real-world phenomena, and understanding textured health science concepts, terminology & aspects of public health practice.

• The skills learned in the class have broad applicability, but here have a domain focus

• We encourage students not convinced of their desire to confront challenges to look elsewhere
Class Diversity

• Our class is expected to be diverse in many ways
  – Students/Faculty observers
  – Student backgrounds in Health Science & STEM
  – Participant interests

• The instructor will make efforts to address diverse backgrounds & interests

• Please
  – Be respectful of those from all backgrounds
  – Recognize need to re-hear things you know
Extra Resources for Students

• Office hours

• Focused tutorials (upon student agreement)
  – Extra background & context
  – More advanced material (upon student interest)
What is Expected of Students

- Attendance & Participation
- Modeling exercises
- Project
  - With instructor guidance
  - Interdisciplinary teams required
- End-of-Term Presentation
Administrative Info

• Office Hours: Wed 10-11am (E62-436) & by appointment
  – Especially important b/c of diversity of backgrounds & limited time

• Course website in STELLAR at either
  
  https://stellar.mit.edu/S/course/15/sp12/15.879/
  
or
  
  http://tinyurl.com/MIT15879
Project Information

• Project can be
  – Modeling application (in area for which data is readily available)
  – Methodological study

• Instructor can help facilitate

• Meet early with the instructor (after return) to discuss progress

• Staged deliverables

• Where possible, we suggest interdisciplinary, multi-person projects
# Project Phases

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Informal description of area in which you’d like to work for your model, resources you may use.</td>
<td>Mar 9</td>
</tr>
<tr>
<td>2</td>
<td>Informal estimate of scope of model to be implemented. Further details on any data sources planned for use. Identification of major properties/attributes for agents and major modes of agent interaction</td>
<td>Mar 22</td>
</tr>
<tr>
<td>3</td>
<td>Discussion of agent interaction. Preliminary descriptions of scenarios &amp; sensitivity analyses that you plan to investigate.</td>
<td>Apr 12</td>
</tr>
<tr>
<td>4</td>
<td>Final report</td>
<td>May 17</td>
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<tr>
<td>Area</td>
<td>Description</td>
<td>Contact/Stakeholder</td>
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<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>Chronic Disease</td>
<td>Osteoarthritis through the continuum of care, drawing from existing populated aggregate stock &amp; flow model. Agent based and possible discrete event extensions</td>
<td>Deborah Marshall, University of Calgary <a href="mailto:damarsha@ucalgary.ca">damarsha@ucalgary.ca</a></td>
</tr>
<tr>
<td></td>
<td>Interaction of Gestational &amp; Type 2 Diabetes</td>
<td>See instructor</td>
</tr>
<tr>
<td>Zoonoses</td>
<td>Stray Dogs (Rabies as important illness of concern)</td>
<td>Gustavo Monti Universidad de Chile <a href="mailto:gustavomonti@uach.cl">gustavomonti@uach.cl</a></td>
</tr>
<tr>
<td></td>
<td>Leptospirosis</td>
<td></td>
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<td></td>
<td>Bovine Tuberculosis</td>
<td></td>
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<tr>
<td></td>
<td>Chronic Wasting Disease (Mule Deer focus, extension to exiting model)</td>
<td>Cheryl Waldner University of Sask. <a href="mailto:cheryl.waldner@usask.ca">cheryl.waldner@usask.ca</a></td>
</tr>
<tr>
<td></td>
<td>Animal Human Interface</td>
<td>Iqbal Jamal AMC Consulting <a href="mailto:iqbaljamal@aqlmc.com">iqbaljamal@aqlmc.com</a></td>
</tr>
<tr>
<td></td>
<td>Animal Health/Supply Chain</td>
<td></td>
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<tr>
<td>Transportation</td>
<td>Patterns of Home-To-Work Travel behavior: Reproducing observed US patterns</td>
<td>Asim Zia, Univ. of Vermont <a href="mailto:Asim.Zia@uvm.edu">Asim.Zia@uvm.edu</a></td>
</tr>
</tbody>
</table>
Course Schedule

• Due to instructor time travel constraints, the course schedule will have some gaps
  – Despite gaps, 3-hour Wednesday & Friday class times will provide a full-length course
  – Biggest gaps in schedule
    • February 9-28 (starting tomorrow!)
    • April 16-20
• Not all weeks will contain both Wednesday & Friday sessions
• Please check your schedule before coming to class
Tasks for the Next 2-3 Weeks

• AnyLogic
  – Download
  – Install
  – Request permanent key
  – Active using permanent key

• Investigate projects of interest (awaiting my return for finalization, if required)

• Complete Problem Set 1
  – A First Encounter With Anylogic: Modifying A Simple Sample Model
  – Building a Minimalist Network-Based Model Framework
Exercises: Available Now

A First Encounter With Anylogic: Modifying A Simple Sample Model

Building a Minimalist Network-Based Model Framework

A Simple Network Based Infection Spread Model

Incorporating Attribute Heterogeneity Among Agents

Building A Minimalist Two-Population Model Framework

A Simple Debugging Exercise

Legend

Strength of Prerequisite Relationships

- Recommended
- Required

Target Skill Level

- Introductory
- Basic
- Intermediate
Some Featured “Real-World” Models

- TB
- CWD
- ESRD
- Treatment Prioritization
- ABMs for Evaluating Reliability of Statistical Inference
- HPV & Smoking
- Immuno-Epidemiology of H1N1 influenza
- Influenza-like illness & smartphone-based microcontact location-data
Tuberculosis Spread, Prevention & Control
(Earlier Version)
Chronic Wasting Disease
Health & Cost Implications of Diabetic ESRD
HPV & Smoking
Exogenous Infection
Pressure

Susceptible

Latent

Asymptomatic

Infectious

Symptomatic

Infectious

Symptomatic

Uninfectious

Recovered

Stable Agent States

Disease Progression

Probability Distribution

Disease Model

Endogenous Infection Probability

Disease State Durations

Person and Place Contact History

SHED 1 dataset

Probability Distribution

Disease Model

Endogenous Infection Probability

Disease State Durations

Person and Place Contact History

SHED 1 dataset

Disease Progression

Stable Agent States

Exogenous Infection Pressure
Synthetic Population Studies

- Establish a “synthetic population” for a “virtual study”
- Perform simulation, simulating study design of interest
  - Actual underlying situation is blinded from researcher
  - Collect data from the synthetic population similar to what would collect in the external world
  - Optionally, may actually simulate roll out and dynamic decision protocols
- Analysis procedures being evaluated are applied to the data from the synthetic population
- We compare the findings from those analysis procedures to the underlying “ground truth” in the simulation model
Use of Simulation in Evaluation of Statistical Models & Study Design
Performing the Filtering

**Agent-Based Model Using Sensor Data**

**Aggregate System Dynamics SIR Model**

Simulation

Measured Data (Estimates of count of Susceptibles, Infectives Recovereds)

Kalman Filtering

Updated System Dynamics Model
Network Embedded Individuals

- Uninfected Cells
- Infected Cells
- Virus Load
- New Cell Infections
- Uninfected Cells:
  - Replenishment Rate
- Infected Cells:
  - Death
- Virion Production:
  - From Infected Cells
  - Clearance
- Virion Production Rate:
- Per Contact Virions Rate
- Non Quantized Infection
- Per Infected Cell Virion Production Rate
- Mean Viral Load of Neighbors
- Mean of Viral Load of Neighbors
- Mean Infected Cells
- Mean Uninfected Cells
- Likelihood Density of Infection by Single Virion
- Virion Production Rate of Non Quantized Infection
- Virion Production Rate
- Per Infected Cell Virion Production Rate
- CTLs:
  - Immune response to infected cells
  - CTL turnover
  - Mean CTL Lifespan
  - CTL responsiveness
- CTL turnover which infected cells are killed by CTLs
- Rate which infected cells are killed by CTLs
- Mean Viral Load
- Mean Virion Lifetime
- Mean Infected Cell Lifetime
- Mean Uninfected Cell Lifetime
- Mean Uninfected Cell Replenishment Rate
- 1 Person Mean Viral Load
- Mean Virion Lifetime
- Uninfected Cell Death