ESD.84 Doctoral Seminar – Session 14 Notes

Session Overview:

- Welcome and Overview and Introductions (5-7 min.)
- Initial Identification of Questions from Readings from Axtell and Epstein (7-10 min.)
- Discussion of Agent Modeling (20 minutes)
- The Potential for applying Agent Modeling Methodologies to Complex Engineering Systems – Student Presentation by Ben Koo (10-15 min.)
- Break (10 min.)
- Engineering Systems Simulations (30-45 min.)
- Discussion (10-15 min.)
- Discussion of Molecular to Modular Biology Paper (10 minutes)
- Can Complex Engineering Systems Have Underlying "Genetic Codes?" – Is the biological analogy useful in understanding Engineering Systems? – Student Presentation by Jeroen Struben (10-15 min.)
- Next Steps (10-15 min.)

Questions:

- Do these materials help us to set up new mental models that are useful in the field – or is this just a highly sophisticated tool?
- How well received is agent-based modeling in the social science community? Also, how is it likely to be received in engineering?
- The agent modeling is appealing in the way it replicates the limited view that human agents have – why is it not more widely used?
- In the "sugarscape" they pointed to additional specialization in the future – but how can you get specialization where there is a "best" agent? How does this relate to "tit for tat" algorithms where there is no one best strategy?
- The resulting behavior is interesting and seems to fit with intuition – but how to develop methods and tools to have a more thorough understanding of what is going on "under the hood"? What are the methods and means to understand this better? Comment by Epstein that this is a new field – but that doesn't make this any less important to pursue.
- For artificial societies – what is the difference between game theory and agent-based modeling?
- Is this more of a top-down approach or is this more of an emergent approach?
- Is agent-based modeling presenting us with unique results that would not be visible with a more aggregate approach such as system dynamics?

Discussion

- The review process in social sciences is inherently conservative
- Axlerod has led a branch of game theory that is linked to comp
- From the book "Liar's Poker" you make money primarily in inefficient markets – the model of direct competition or collusion at the expense of others, each followed by a "bubble" and a crash

Discussion of Agent Modeling Presentation by Chris Magee

Spherical chickens

- **Model**-***Definition***: small scale; a preliminary construction or plan; standard
- **Simulate**-***Definition***: To make in imitation or as substitute of; to create a representation or model of
- FIDELITY, ACCURACY, PRECISION, GENERALIZABILITY, FLEXIBILITY, UNDERSTANDABILITY, ETC.
- "ALL MODELS ARE *WRONG* BUT SOME ARE MORE *USEFUL* THAN OTHERS"

The uses of Models or Simulations of Complex Systems

- To Aid in Making (design/strategy/policy) **Decisions**
- To **Predict** (unemployment rate In 12 months, MTBF)
- To aid in **Verification** of design
- To **Test** hypotheses
- To **Learn/Discover** General Principles
- To **Train** Operators (Experienced or New)
- To **Educate** people about complex systems
- To **Learn from the Process** of constructing a model – including the interactive, iterative process as the model evolves

The Potential for applying Agent Modeling Methodologies to Complex Engineering Systems – Student Presentation by Ben Koo

- So much of what we are doing at MIT is centered on human/machine interactions
- Agents as a widely accepted metaphor

Discussion:

- Basic question about how to model a human being as an agent
- The key is the interactions with others – not what is build into fixed algorithms
- A distinction between agents who are acting autonomously based on certain codes or protocols versus agents who are representing and acting on behalf of human beings based on iterative instructions from them
- There are limitations on how much you can learn from multiple agents with multiple interactions – computational complexity limits
- The model UN is an example in which there are forms of agency that do simulate real world systems by setting loose people acting in roles as agents
- How to jump from micro modeling to macro insights? Agent modeling is inherently hierarchical – with some smaller, fine-grained models that then aggregate into larger macro systems
- Bottom-up agent based models can represent systems on a macro scale – but how to then model different strategies in the full model? Are there ways to embed a simple agent-based model in a rich context that allows for scenario testing?

Engineering Systems Simulations – Low Orbit Satellite Case Example

- Issues around the sensitivity of models to one or a few variables
- Issues of model development – conceive of a spectrum of types of models with support to aid alternative applications
- Question around how much technology insertion happens during the intervening years
- Concept of running models backwards to validate models – but issues of how to shift the right and left halves of the models to do that
- Issue of how to represent the state of knowledge at the time that Globalstar and Iridium were conceived
- An interesting challenge in how to represent design assumptions at different points in time

Question on Biological Systems:

- The code has evolved in biology – so how good is the analogy in engineering systems?

Can Complex Engineering Systems Have Underlying "Genetic Codes?" – Is the biological analogy useful in understanding Engineering Systems? – Student Presentation by Jeroen Struben

- Robustness – key dimensions:
  - Systems control
  - Redundancy
  - Structural Stability
  - Modularity

Discussion:

- Code for the gene is based on four basic types – can you use systems dynamics types of modules for biological systems, such as building from the four basic types?
- Systems dynamics models can represent agents and hierarchies, but that is for the purpose of aggregating – not to make predictions at the individual element level
- The issue centers on whether this is a match to the types of dynamics around which system dynamics tools are oriented
- Biologists don't know how to make the transition from the code level to the form/function level
- A core limitation in many domains – building from components to aggregate systems
- Key property in which successive developments are shaped by that which was pre-existing