Designing an Agent-Based Model (ABM) - Summary

Introduction

Agent-based modeling (ABM) is a powerful simulation technique used to model complex systems composed of interacting agents.

Topics of Discussion

Various aspects essential to designing and implementing ABMs:

- Model Design
- Model Implementation
- Calibration and Validation
- Running Experiments

Model Design

Conceptual Modeling

1. **Pattern-Oriented Modeling (POM)**
    - **Hierarchical Structure**: POM models systems across multiple scales and levels.
    - **Multi-Criteria Design**: Used for design, selection, calibration, and validation of models.
    - **Pattern Identification**: Identify patterns from empirical observations, literature, or other models.
    - **Model Structure**: Define a model structure using only necessary components to achieve the model's purpose.
2. **Hypothesis Testing in POM**
    - Identify and implement alternative submodels.
    - Compare and contrast these alternatives.
    - Iteratively refine the model to match observed patterns.

Participatory Modeling

1. **Cognitive Mapping**
    - Visual representation of mental models showing relationships between concepts.
    - Relationships are often binary (positive or negative associations).
2. **Fuzzy Cognitive Mapping (FCM)**
    - Extends cognitive mapping with fuzzy logic to represent varying degrees of association.
    - Relationships are assigned fuzzy values between 0 and 1.

3. **Rule-Based FCM**
    - Integrates rule-based reasoning to enhance modeling capabilities.
    - Uses if-then statements to define system behavior based on fuzzy relationships.

Model Implementation

1. **Start Simple, Add Complexity**
    - Begin with the simplest version of the model and gradually increase complexity to reach the desired level of detail (Medawar Zone).
2. **Components of a Complex System**
    - Hierarchical and modular design with submodels (e.g., mobility model, synthetic population, fire/smoke diffusion model, evacuation model).
3. **Practical Implementation Examples**
    - Use of procedures and primitives in NetLogo for defining agent behaviors.
    - Different types of variables (global and local) and agents (breeds).

Calibration and Validation

- **Calibration**: Adjust model parameters to ensure the model behaves as expected based on real-world data.
- **Validation**: Ensure the model accurately represents the real-world system it is intended to simulate.

Running Experiments

- Iteratively test and refine the model.
- Use the model to conduct experiments and explore different scenarios.

Example: Mushroom Search in Forest

- **Concept**: Model of human behavior in searching for mushrooms.
- **Behavior**: Agents scan the neighborhood and switch to detailed search upon identifying mushrooms.

Example: Wolf-Sheep Predation Model

- **Components**: Agents (wolves, sheep), environment (grass patches).
- **Interactions**: Predation (wolves eat sheep), grazing (sheep eat grass).
- **Emergent Behavior**: Patterns and structures arising from agent interactions.

Practical Exercises

- Engage in team-based learning activities using NetLogo models.
- Explore model dynamics, feedback loops, non-linear behavior, and emergent properties.

Conclusion

Designing an ABM involves a structured approach from conceptual modeling to practical implementation, calibration, and experimentation. Pattern-oriented and participatory modeling techniques, along with tools like NetLogo, provide a robust framework for developing and analyzing complex systems.