ABMs and IBMs
Designing a Worthwhile Model

Class 7:

Testing and Debugging
(and More flashing fireflies)

More on the "Design Concepts" of the ODD –
Stochasticity (and NetLogo)

Testing and Debugging

- …should be a continuous process! Do not wait until the end to test/debug the entire program. Test and debug each small part as you progress.

- "When our model produces an interesting and unexpected result, we should immediately ask: Is this [1] a novel and important result, or [2] the consequence of a questionable model design decision, or [3] just the result of a programming mistake."
- ***Be conscious of your design decisions… and record them!***

Finding Errors

Don't assume that because a program runs it is free of logic errors.

1. Program Tracing

   print/show statements (within procedures and reporters)

   ```
   globals [ trace ]
   set trace 3            ;  in the setup
   if trace > 1 [ print (word "Entering procedure; x = " x)]
   if trace > 2 [ ask turtles [ show age ] ]
   ```

2. Visual observation
3. Monitors (of patches and turtles)
4. Test individual procedures and reporters for values where you know the correct answer or can observe the correct behavior.

Firefly Debugging

```
to go
  ; 1. end flashing of flashing turtles
  ask turtles with [flashing?] [stopflash]
  ; 2. initiate flash if timer at 0, and reset t to R
  ask turtles [ if t = 0 [flash set t R]]
  ; 3. decrement counter
  ask turtles [ set t t -1 ]
  ; note: for flashing turtles, we now have t=R-1
  ; 4. random movement
  ask turtles [ wander ]
  ; 5. synchronize  "If there is a yellow firefly within one patch, set timer to R"
  ask turtles [
    if any? nearby-flashing-turtles [set t R – 1]
  ]  ; why not R?  This is a bug in pseudocode.
end
;  Can you combine the ask commands?
; Yes to the first four!
```

Stochasticity (Later Today!) Means Experiments

- Go over the NetLogo behavior space!
- Do example with Firefly Model

- Lab Part 1: With yesterday’s lab partner

Lab

Part 1 (30 minutes)

- Get Firefly model working.
- Add (if you don't have them already) sliders for:
  - number of fireflies
  - R
  - speed (how far each firefly moves in a step)
  - distance/radius a firefly sees
- With your partner, try to predict (by intuition) the impact on the time required to synchronize of the various parameters in the sliders!
- Run experiments to determine the relationships.

ODD: *Overview, Design Concepts, and Detail*

Overview:

Purpose; Agents, Variables, and Spatial-Temporal Scale; Process overview and scheduling

Design Concepts

Principles, emergence, objectives, learning, prediction, sensing, interaction, stochasticity

Details

Initialization, input, structure and submodels

ODD Part 1: Overview

1. **Purpose**

   What is the model for?

2. **Entities, Variables and Scale**

   Identify the variables for… agents, patches and the observer.

   Be explicitly about spatial and temporal scope.

3. **Process overview and scheduling**

   What happens at each step? What is the sequence of steps for each agent?

ODD Part 2: Design Concepts

Design Concepts

- Basic Principles
- Emergence
- Adaptation
- Objectives
- Learning
- Prediction
- Sensing
- Interaction
- Stochasticity
- Collectives
- Observation

ODD Part 2: Design Concepts

Design Concepts

- **Basic Principles**
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What theories, concepts, etc. underlie the design? How is the model related to previous thinking about the problem?

ODD Part 2: Design Concepts

Design Concepts

- **Basic Principles**
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What are the results and outputs?
Which might be emergent (agent-level) vs. imposed (system-level)?

ODD Part 2: Design Concepts

Design Concepts

- **Basic Principles**
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- How do agents respond to changes in the environment? What decisions do they make?
- How are these behaviors modeled? Do we assume agents choose among alternatives by considering which is most likely to increase some objective?

ODD Part 2: Design Concepts

Design Concepts

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- If agents have objectives, what measures are used to rate decisions alternatives (in the agents internal model)?
- How were variables that impact the objectives chosen? Are agent variables (state) considered?

ODD Part 2: Design Concepts

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- Do agents change behaviors based on experience? (i.e. do they “learn”?)
- Do agents predict future conditions in their adaptive traits? What assumptions are made as the basis for this predictive behavior?

ODD Part 2: Design Concepts

Design Concepts

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- What variables of the environment can agents sense – and incorporate in their behavior? (What does this represent?)
- What sensing is explicit and what is implicit/assumed?
- What is the range and accuracy of sensing?

ODD Part 2: Design Concepts

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> - How do agents interact (directly or indirectly)?
> - With which agents do they interact?
> - What is being modeled? What is temporal and spatial scale?

ODD Part 2: Design Concepts

Design Concepts

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- **Stochasticity**
- Collectives
- Observation

- How is randomness (or psuedo-randomess) used and what is it modeling?
- What simplifications are being made? How many different factors are being combined?
- How, if at all, is empirical data used in distributions?

ODD Part 2: Design Concepts

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- Are groups of agents (collectives) explicitly represented? How? What is being modeled?
- How are the groups formed?
- How are groups represented?

ODD Part 2: Design Concepts

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> - What outputs are needed to observe the system dynamics? The internal behaviors?
> - What outputs are needed to test the model and solve the design problem?

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Stochasticity
and various distributions

Standard deviation and ***variance***.

- Standard deviation of a set of values measures the amount of variation from the average
- The ***variance*** of a set of values is the average of the squared difference of the values from the average.
- The ***standard deviation*** is the square root of the variance.
- In a normal distribution, about 68% of the population is within a standard deviation of the median, and 95% are within 2 standard deviations.

Stochasticity
and various distributions

Side note: `random-seed n` initializes the random number generator seed so that it is not random. This allows for repeated identical runs of a model (still using psuedo-random numbers)

Uniform distribution.

- All values are equally likely.
- NetLogo: `random` and `random-float`
- Also: `random-xcor`, `random-ycor`, `random-pxcor`, and `random-pycor`

Stochasticity
and various distributions

Normal (Gaussian) distribution.

$$f(x,\mu,\sigma) = \frac{1}{\sigma\sqrt{2\Pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

The parameter μ in this definition is the mean (expectation) of the distribution (and also median). The parameter σ is its standard deviation. (Thus the variance is σ^2.)

We will see some examples soon!

Many real world (natural) examples.

NetLogo: `random-normal mean standard-deviation`

Stochasticity
and various distributions

From [RG]:

- Stochasticity allows us to "represent some kind of variability, but without representing all the detail needed to explain *why* that variability occurs."
- "Simplification is the most essential characteristic of modeling, and one way to simply variables or processes that change over time or space is to assume that they are random. Then instead of having to model what causes those variables or processes to change, we simply draw random numbers to make them change."

Common uses:

- ***Variable initialization***
- ***Variable outcomes***

NetLogo also provides ***Poisson*** (discrete), ***exponential***, and ***gamma*** distributions. Know which distribution to use (based on what you are modeling)!