PROJECT GUTS
Growing Up Thinking Scientifically

Agent based modeling in StarLogo Nova

Irene Lee
Nord Anglia Workshop
July 5, 2016

* If you have not already done so, please create an account on slnova.org then go to http://www.slnova.org/GUTS/projects/20704/ to check that a model can load and run.

Introductions

Irene Lee

Hal Scheintaub

And students …

Imara
Max
Jack

Audrey
Michael

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Overview and Logistics

- 3-hour hands-on introduction to StarLogo Nova and Modeling & Simulation as a way to integrate CS in Science

- Your role: computer modeler and computational scientist;
- Report out as student and as a teacher.

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Norms and Expectations:

-Maintain a positive learning environment

-Help one another

-Acknowledge that we are learning something new that is sometimes difficult

-Celebrate and be excited about all progress

-Model the dispositions we'd like to see in our students

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About Project GUTS

NM Adventures in Modeling (MIT & SFI 2003, NSF-ITEST)
Project GUTS afterschool (SFI, 2007, NSF-AYS)
2014+ embedding Project GUTS during the school day!

Goals for the Workshop

- Gain understanding of using models to run experiments
- Gain understanding of how CS relates to modern scientific practice
- Gain understanding of computational thinking in the context of modeling and simulation.
- Learn how to create a simple Agent-based Model
- Design and conduct an experiment using your model as a testbed.

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Workshop agenda

- Mystery Model
- CS in Science Module 1: introduction to modeling and simulation
- Explore another CS in Science module (ecosystems or greenhouse gases)
- Wrap-up and discussion

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Introduction to Computer Modeling and Simulation

-Mystery model

-http://www.slnova.org/GUTS/projects/36743/

- use model observation form
- also, give a quick tour of the interface.
- introduce setup and forever

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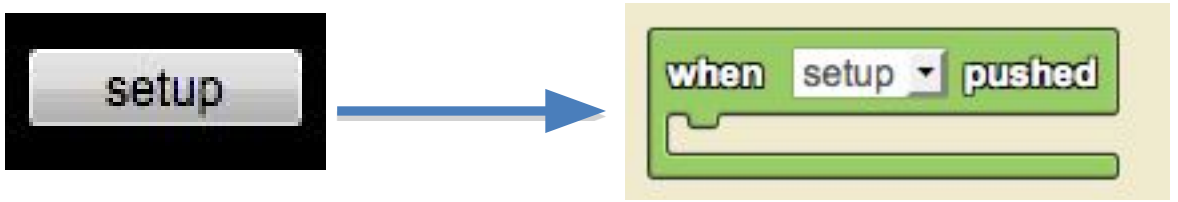
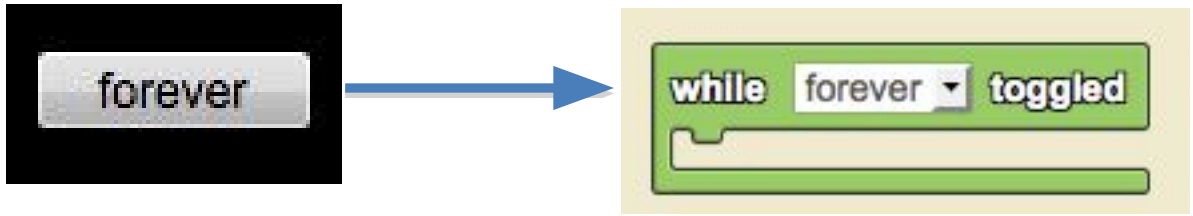
Setup and Forever blocks





Use!

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CS in Science--The Big Picture

-Use-Modify-Create Approach
-Guide on the Side
-Building vs. Using Models
-Study real-world phenomena..
  -cheaply, more safely, more conveniently
  -in ways otherwise impossible

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CS in Science modules

- **Modules for science classroom integration:**
  - Module 2a Water Pump
  - Module 2b Greenhouse Gases
  - Module 3 Ecosystems
  - Module 4 Chemical Reaction

Full modules available at projectguts.org/resouces and code.org/curriculum/science

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Modeling and Simulation

Introduction to StarLogo Nova
Flower Turtles

- We use StarLogo Nova (slnova.org) to explore emergent phenomena & Complex Adaptive Systems.
- Users create simulations by writing simple rules for individual “agents”.
- No sophisticated mathematics or advanced programming skills are required.

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StarLogo Nova Guided Tutorial

- Visit the Project GUTS MOOC at guts-cs4hs.appspot.com

- Scroll down and click on Module 1: Introduction to Computer Modeling and Simulation

Follow along with Lesson 2 Activity 1a - Guided Tour

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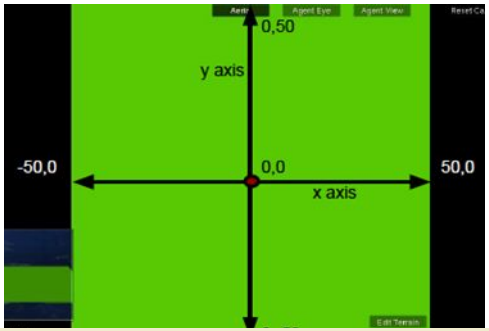
StarLogo Nova
A web-based software program

Create!



Computer Science Concepts

- Instructions
- Computer Program
- Looping
- Iterations
- Conditionals
- Variables
- Remixing

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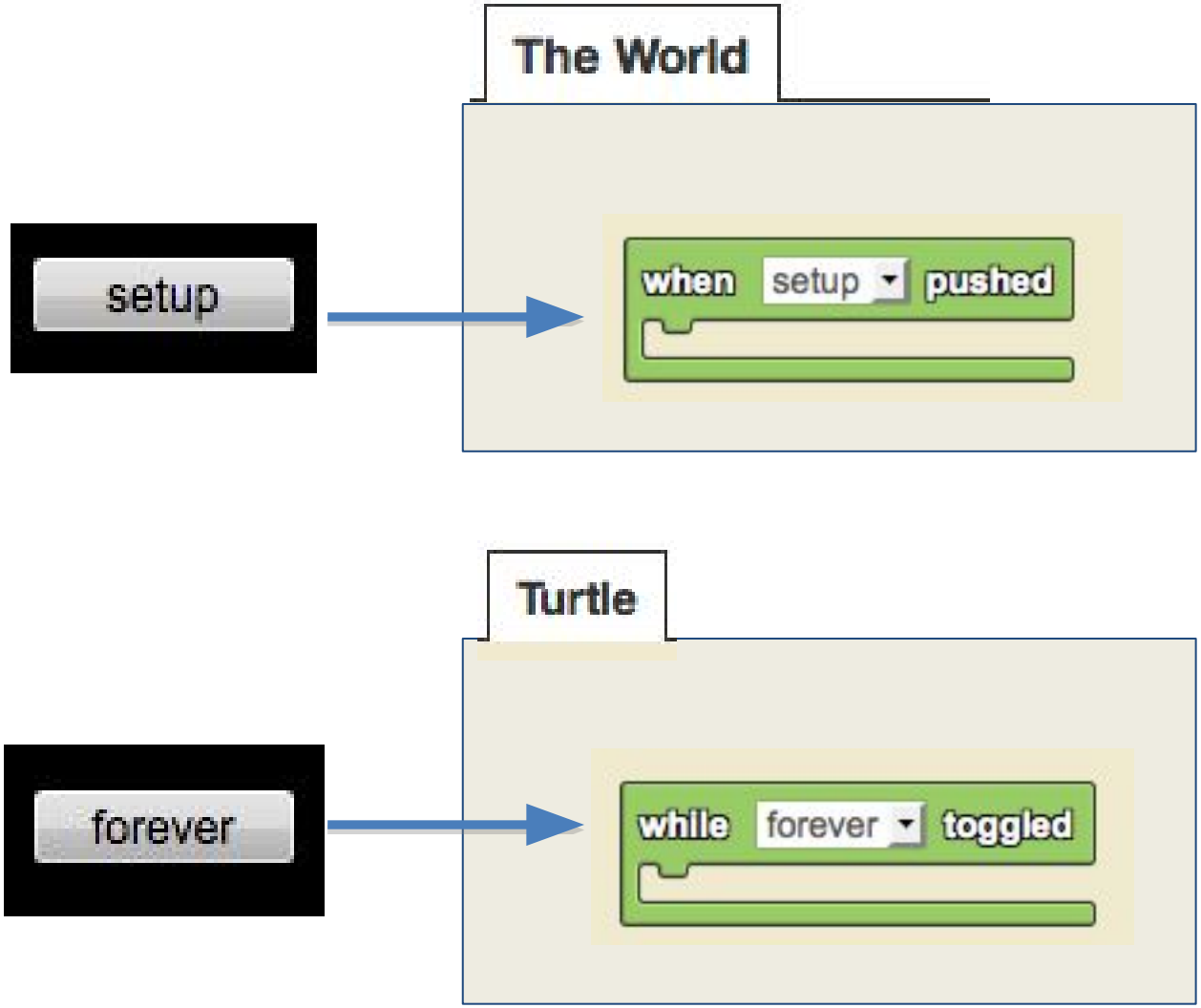
The World & Turtle Pages



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Pair Programming- a kid's perspective

- Driver & Navigator protocols
- Switching often
  - (every 7 to 10 minutes)

https://www.youtube.com/watch?v=vgkahOzFH2Q

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Pedagogy for Building Models

-Pair Programming

  -Drivers

  -Navigators

  -Why???

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http://mediad.publicbroadcasting.net/p/shared/npr/styles/placed_wide/nprshared/201310/208254582.jpg

Flower Turtles

(instructing agents to impact their environment)

-Login to StarLogo Nova, go to the GUTS gallery
http://www.slnova.org/GUTS/

-Open and Remix the project called
"Lesson 2a- Flower Turtles- Tutorial Introduction Project"
http://www.slnova.org/GUTS/projects/4703/

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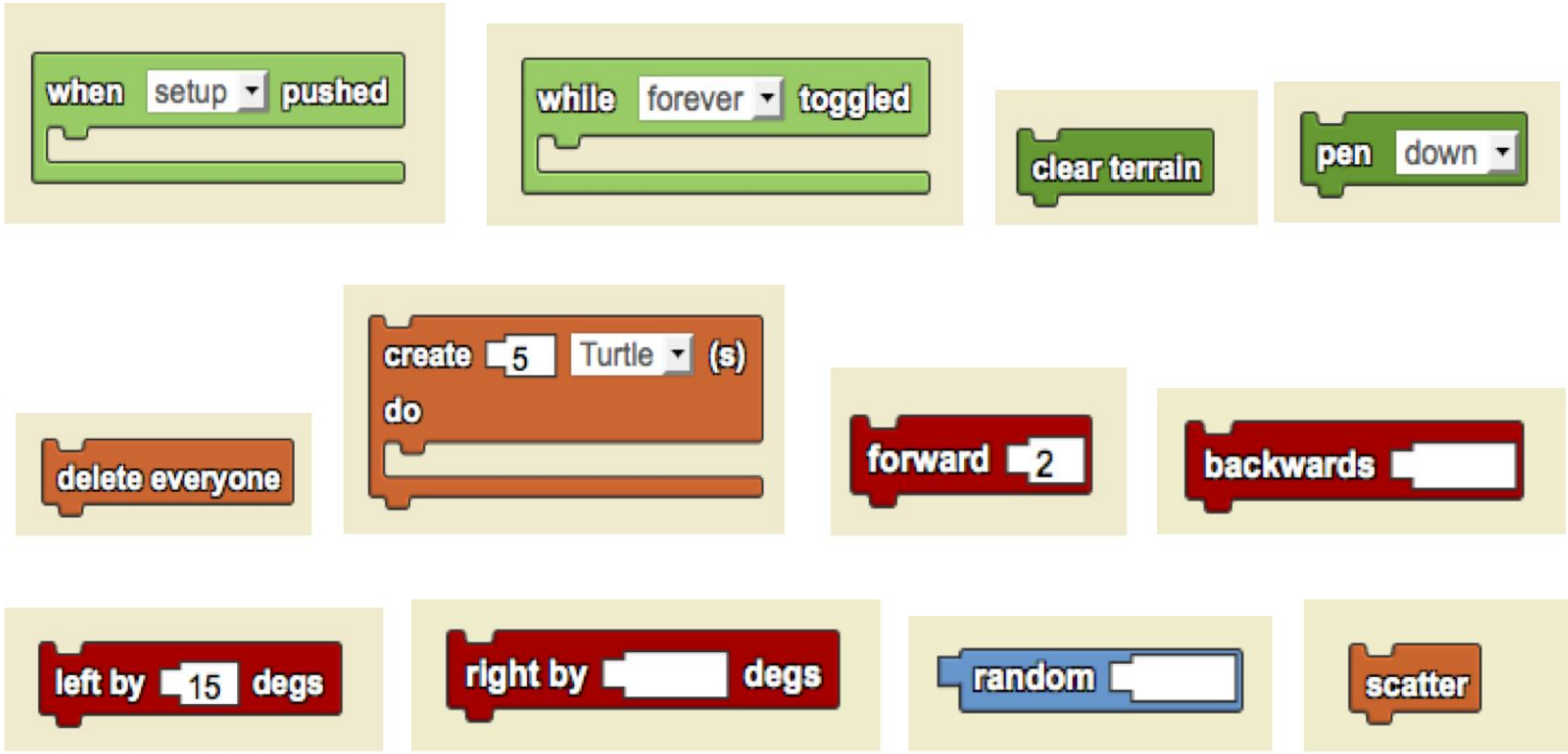
StarLogo Nova Blocks Review



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Terms to Remember

- Agent
- Location
- Heading
- Steps
- Iteration
- Setup
- Runtime
- Random

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Modeling and Simulation

Conditionals and Boolean Logic
Trailblazer and Bumper Turtles

Review from Flower Turtles

- What commands enabled turtles to impact their environment?
- What could an agent leaving trails represent in a real world scenario?

How turtles can react to their environment

Trailblazer

Instructions

- Starting and ending in the same place.
- Using a pencil, draw the path in the CENTER of squares.
- Pick up ALL the gold while avoiding the hazards.
- Color the squares as necessary according to the following rules:
  - **Take a step forward.**
  - **If you are standing on a RED square, then turn right by 90 degrees**
  - **Else If you are standing on a BLUE square, then turn left by 90 degrees**
  - **Else If you are standing on a BLACK square, then turn right by 180 degrees**
- Trade your map with your partner.

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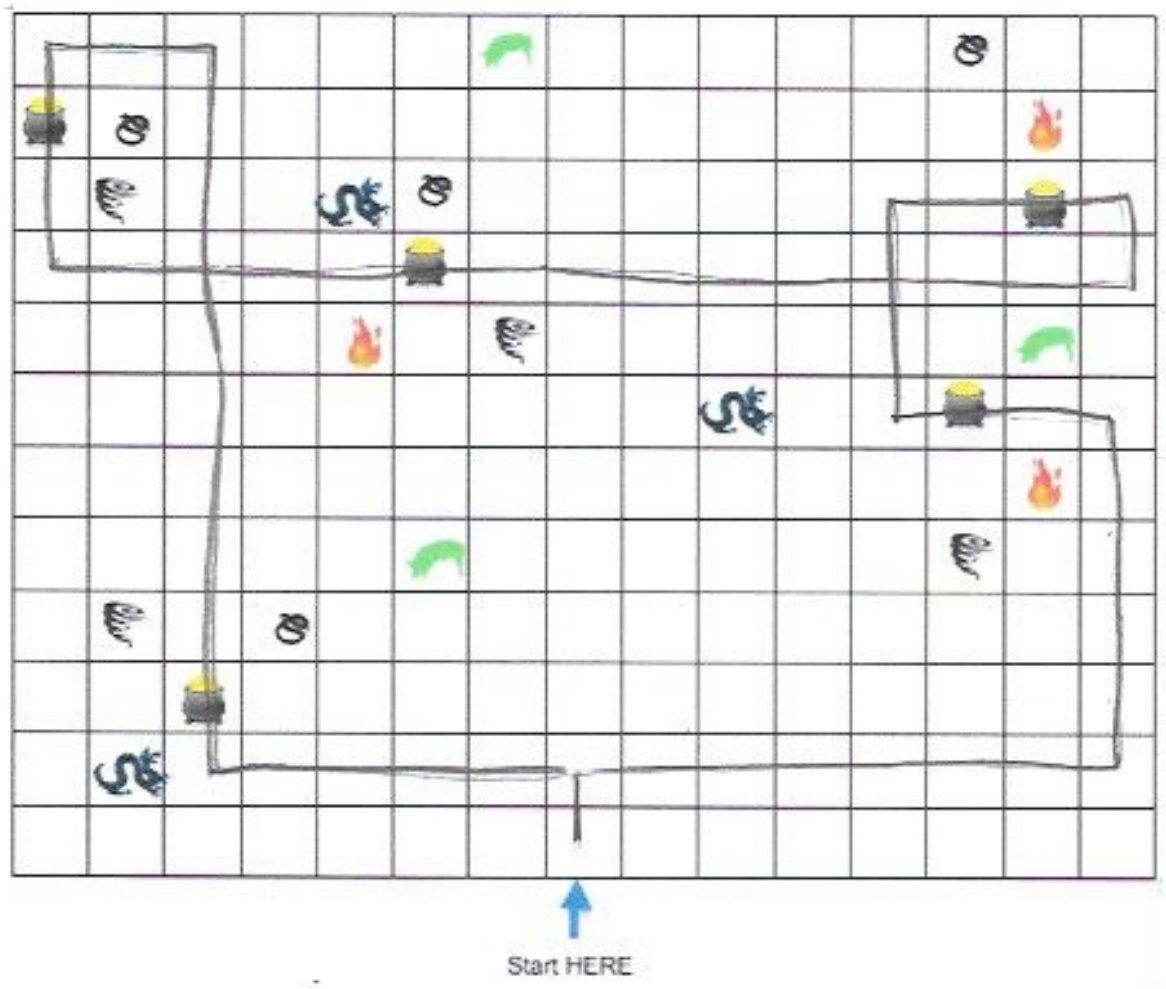
How turtles can react to their environment

Trailblazer



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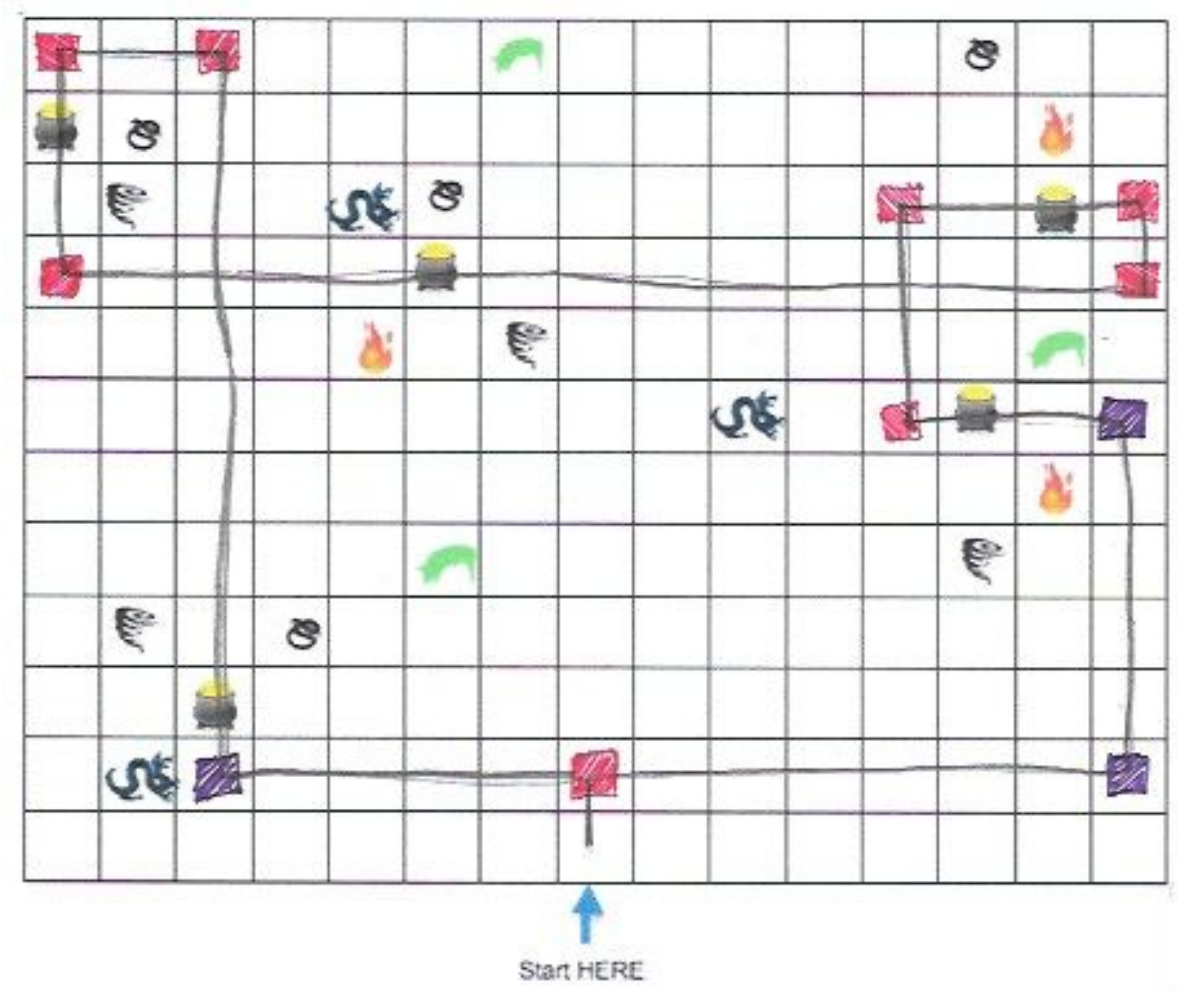
How turtles can react to their environment

Trailblazer



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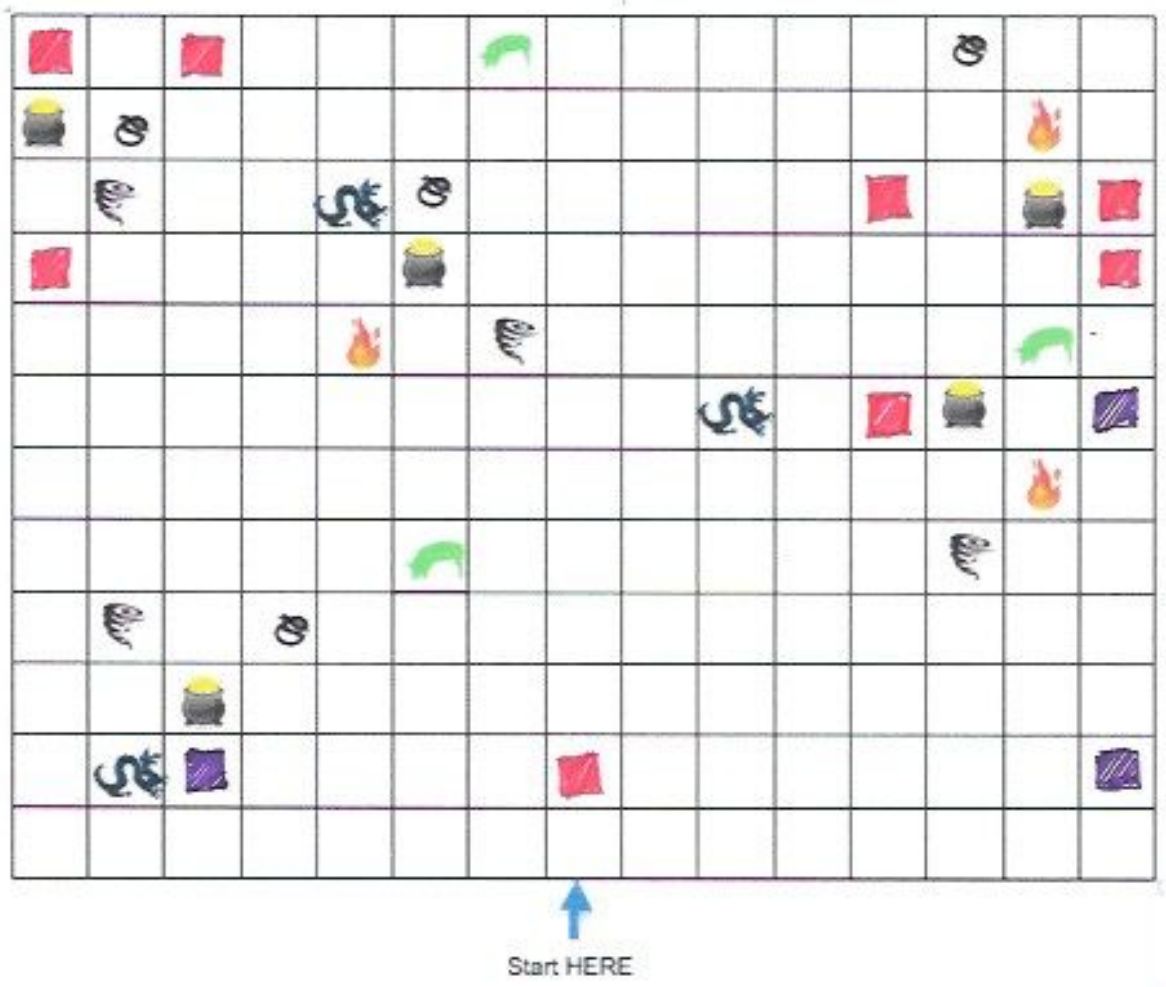
How turtles can react to their environment

Trailblazer



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Trailblazer Learnings

- Different instructions can be followed based on conditions (what color square you are on).
- Algorithms are sequences of instructions that perform a task.
- Each different path we created can be thought of as a different algorithm.

Discussion-

- Are some better algorithms than others?
- Why or why not?

(see http://compass.ups.com/ups-drivers-avoid-left-turns/)

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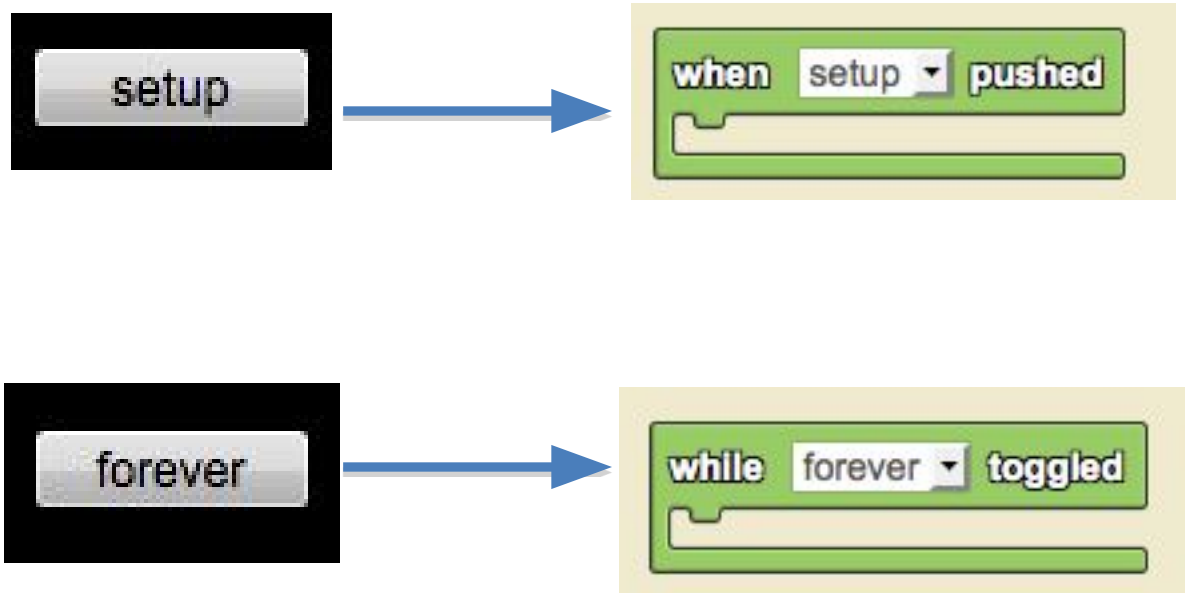
Bumper turtles

- Now we are going to instruct our turtles to follow different instructions based on conditions.

- Use the same rules as trailblazers:
  - **If you are standing on a RED square, then turn right by 90 degrees**
  - **Else If you are standing on a BLUE square, then turn left by 90 degrees**
  - **Else If you are standing on a BLACK square, then turn right by 180**

Setup and Forever blocks



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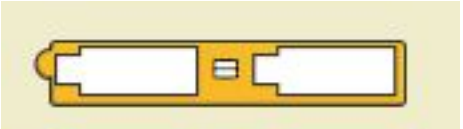
New StarLogo Nova Blocks



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Modify!

Bumper Turtles Challenge

- Start with the program called “Bumper Turtles starter” program

  http://slnova.org/GUTS/projects/9383/

- Click on the “Paint Landmarks” push button and see the program execute the code provided.
- **Remix the project**
- Your challenge is to make the turtles react to the landmarks created by the “Paint Landmarks”

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Bumper Turtles Progress Monitor

Goals!

- ❑ Add logic so turtles react to red squares by turning right by 90°
- ❑ Add logic so turtles react to blue squares by turning left by 90°
- ❑ Add logic so turtles react to black squares by turning around 180°

Bonus!

- ❑ Change the number of landmarks drawn in the “Paint Landmarks” procedure

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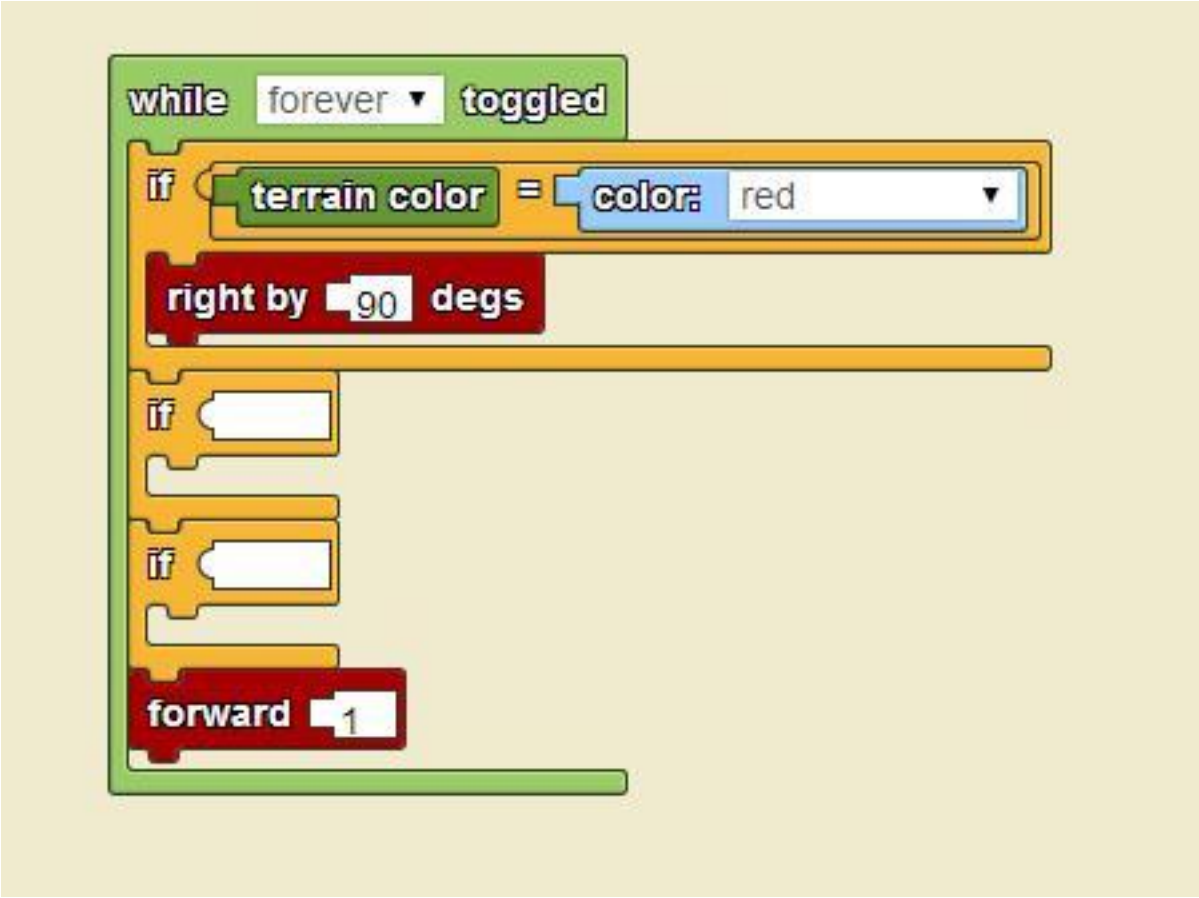
Modify!

Partial Solution



Discussion

- What could these trails and bumpers represent in Bumper Turtles model?

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Modeling and Simulation

Probability with Dice and Data, Wiggle Walk, and Colliding Turtles

Use!

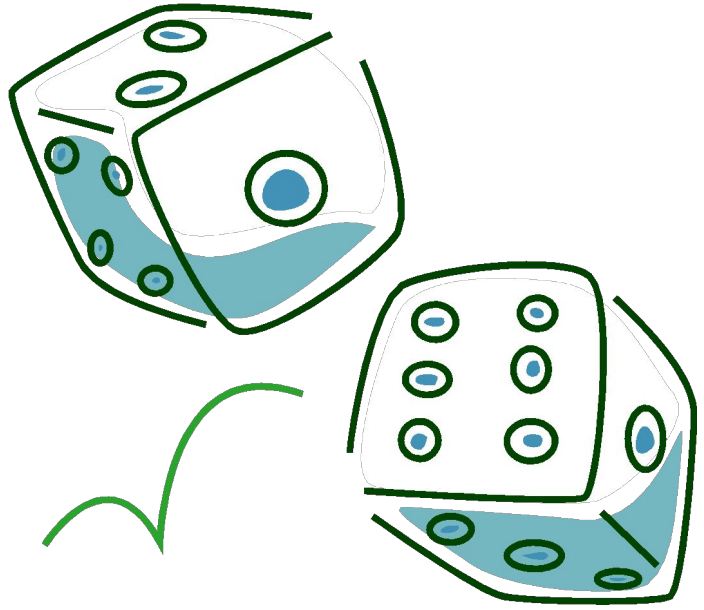
Using Probability

- Next, we are going to learn about probability (or the likelihood of something happening).
- Then we are going to use probability to make turtles do a “wiggle” walk.

Dice and Data

-Gain understanding through hands-on exercise

-Materials used



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Roll one die

- Record the result using a hatch mark.

1		Sum:
2		Sum:
3		Sum:
4		Sum:
5		Sum:
6		Sum:

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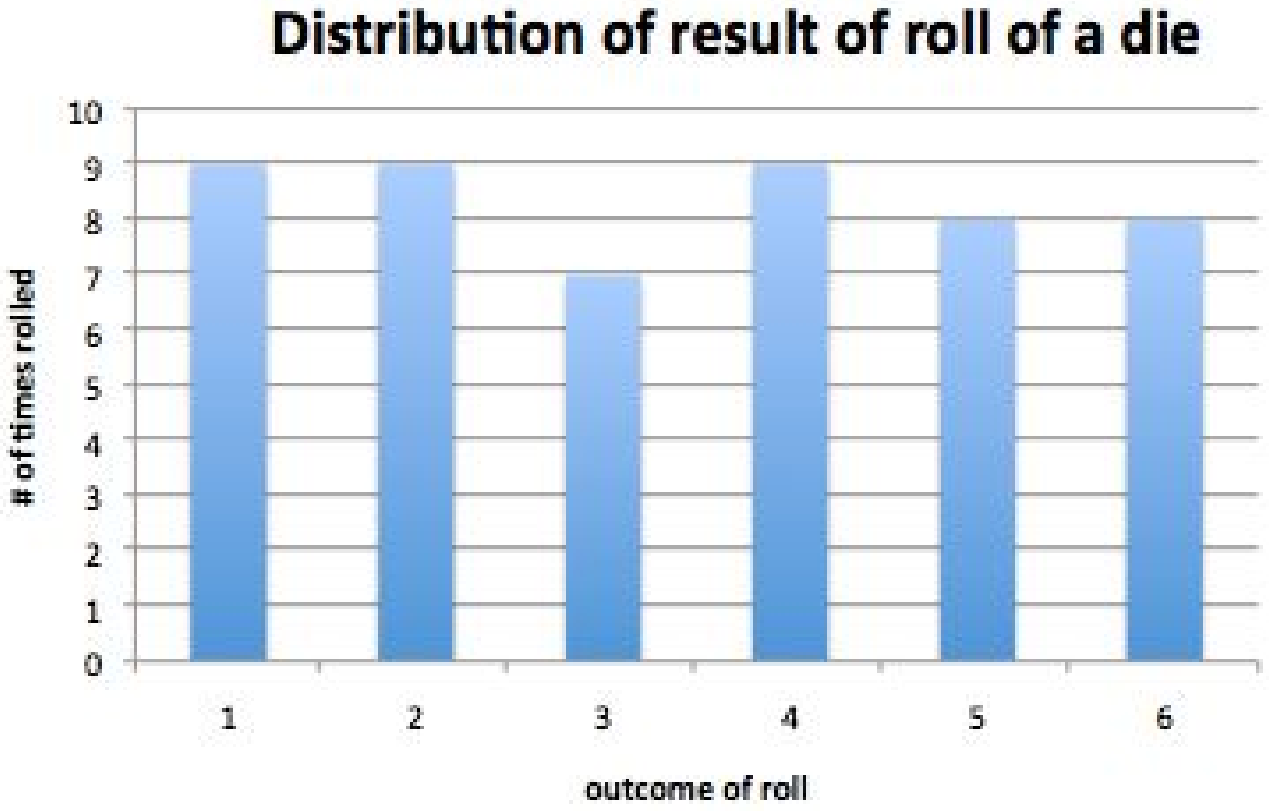
Roll one die

- Possible result of 50 rolls.



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Roll two dice

- Record the result with a hatch mark

2 dice (subtraction)	# of occurrences	Sum of tally
5		
4		
3		
2		
1		
0		
-1		
-2		
-3		
-4		
-5		

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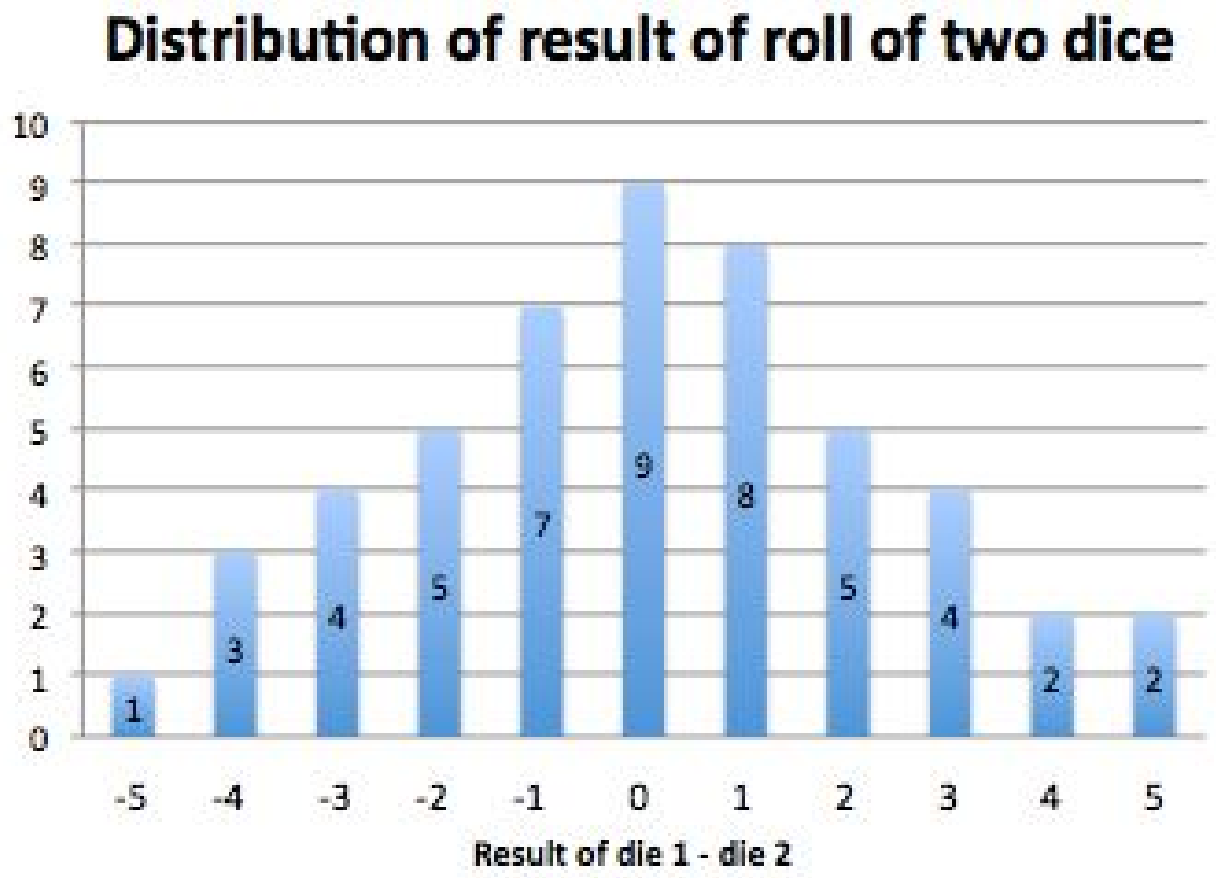
Roll two dice

- Possible result of 50 rolls.



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What does this have to do with a modeling and simulation?

- One die represents right turn amount, the other represents left turn amount.
- Most common outcome is ?

Left turn \ Right turn	1	2	3	4	5	6
1	0	1	2	3	4	5
2	-1	0	1	2	3	4
3	-2	- 1	0	1	2	3
4	-3	-2	-1	0	1	2
5	-4	-3	-2	-1	0	1
6	-5	-4	-3	-2	-1	0

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Use!

Random function

- We can mimic a roll of a die in StarLogo Nova using the random command.
- Random 6 will return a number between 0 and 5.

In StarLogo Nova

- We use a single random function like a single die.

In StarLogo Nova

- We use two randoms to represent rolling two dice.

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Modify!

Wiggle Walk

- What kind of motion does this produce when run repeatedly?

What's really going on?

1. Agent has an initial heading.

2. Agent turns left by some random number of degrees between 1 and 6. In this case, it is 2 degrees. (Image not to scale)

3. Agent turns right by some random number of degrees between 0 and 5. In this case, it is 5 degrees, so the final heading is 3 degrees to the right of the original heading. (Image not to scale)

4. Agent takes one step forward at new heading. (Image not to scale)

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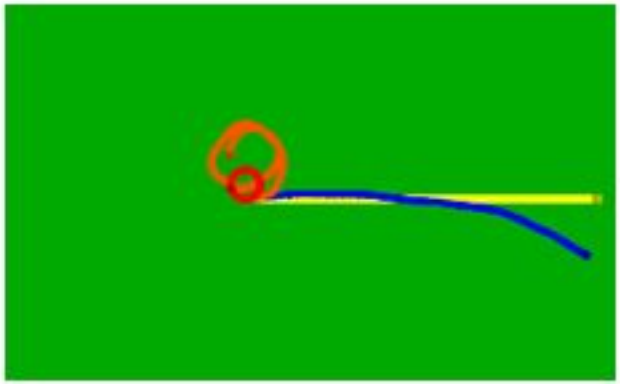
Self-test of understanding



Match the command blocks a, b, c, and d with the path created by an agent following those blocks.

a.

color: _____

c.

color: _____

b.

color: _____

d.

color: _____

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Modeling and Simulation

Colliding Turtles

Modify!

Collisions

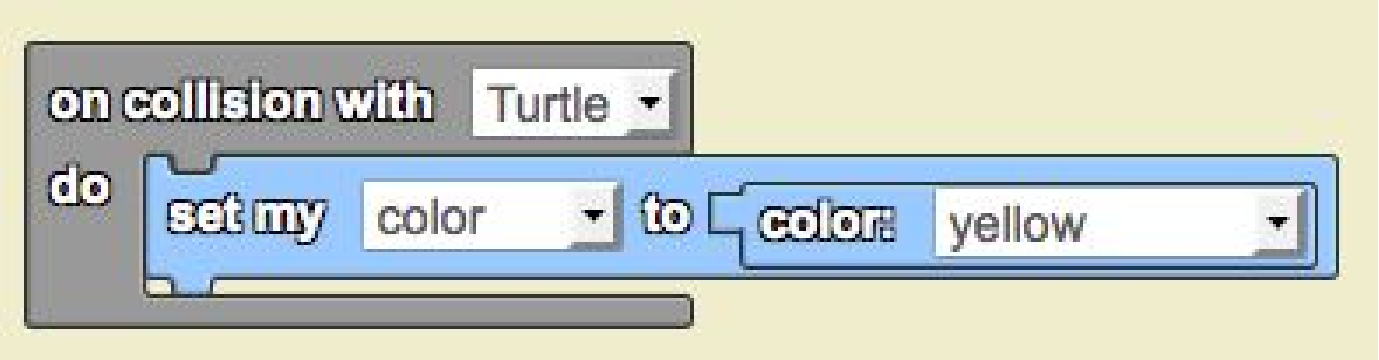
New Command: Collision

- Collisions occur when two agents bump into one another. (They do not need to be centered on the same patch.)

Colliding Turtles

Modify!

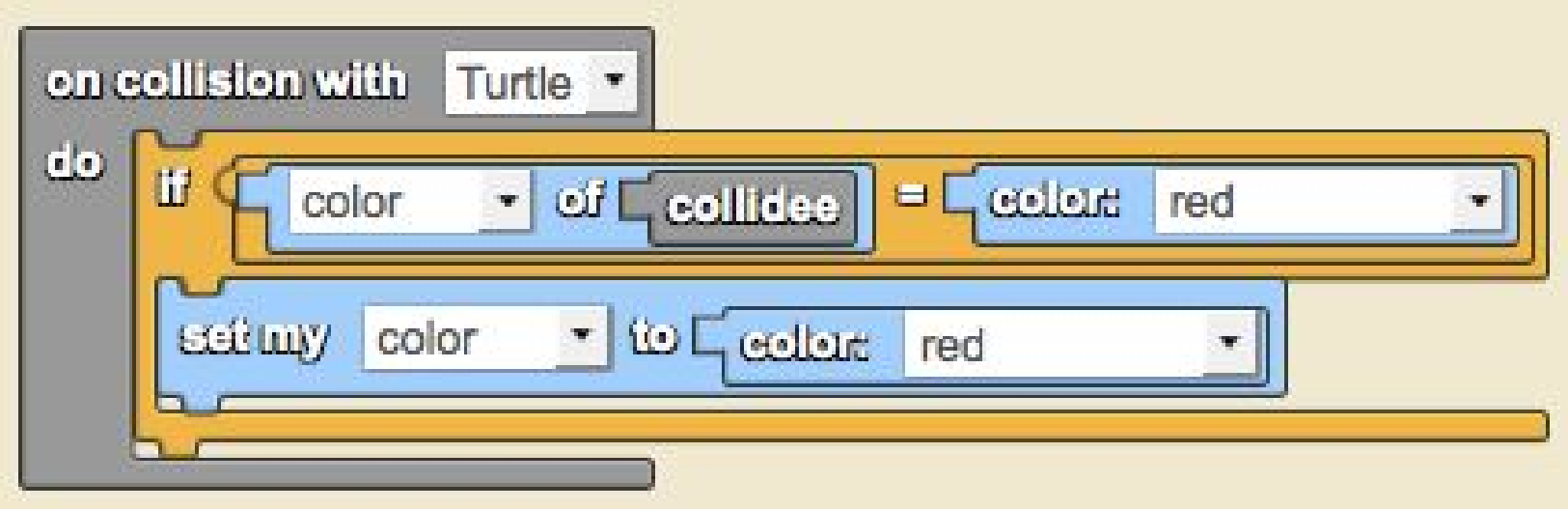
New Command: Collision



Colliding Turtles

Modify!

New Command: Collision with a condition



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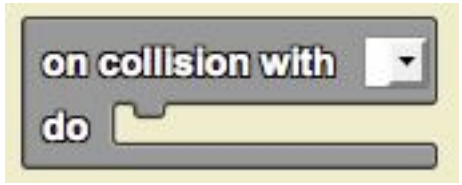
New StarLogo Nova Blocks

Modify!



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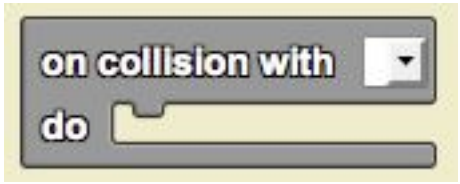
Agent-Agent Interactions

Modify!

Your Challenge: Colliding Turtles

Goals!

- ❑ http://www.slnova.org/GUTS/projects/73800/ and REMIX it.
- ❑ Have the turtles move forward with a little wiggle in their walk.
- ❑ Add detection block (collision) so turtles react to each other
- ❑ Change a turtle's trait after a collision [size, color, shape, ?]



Bonus!

- ❑ Upon colliding with a red turtle, have blue turtles react by changing their color to red.

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Review from Colliding Turtles

- What could collisions represent in the real world?
- Why do we use probability in models?

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Modify!

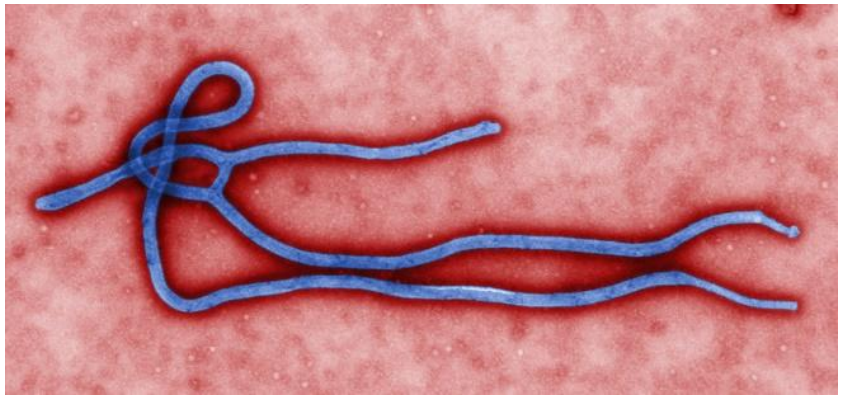
Modeling and Simulation

Modeling the Spread of Disease

Designing and Running Experiments

An Example:

- Ebola virus disease (EVD)
- Transmitted to humans from wild animals and then via human-human contact
- Colorized transmission electron micrograph (TEM) of ebola virus virion



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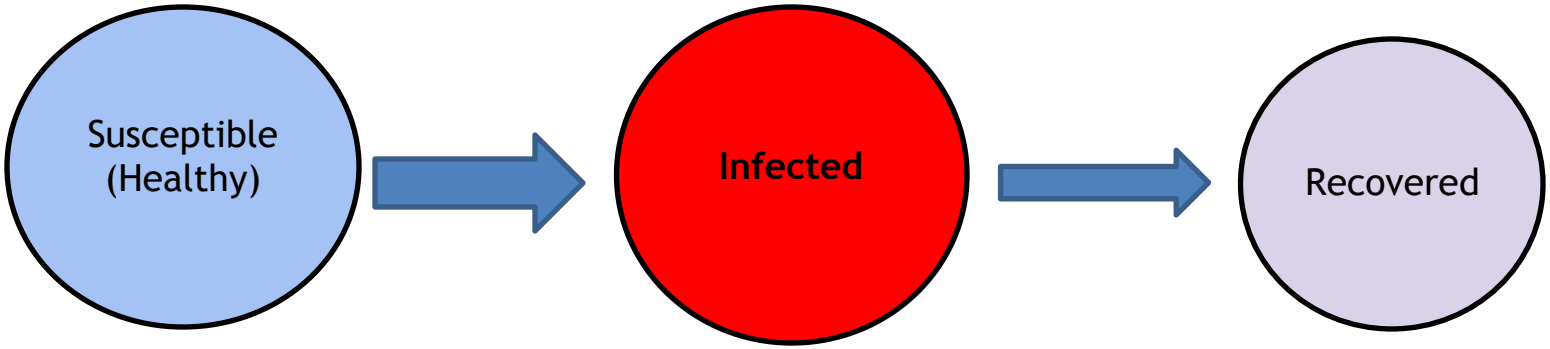
Transmission Cycle

- Ebola



CT for the Epidemic Model

- We are going to turn our colliding turtles model to make it into an epidemic model.
- What do we need? (agents and behavior)
- How do we formulate the task/problem so it can be studied/solved using a computer?

Epidemic Model

Modify!

- Agents:
- Environment:
- Behaviors:

- CS concepts: Variables and Traits

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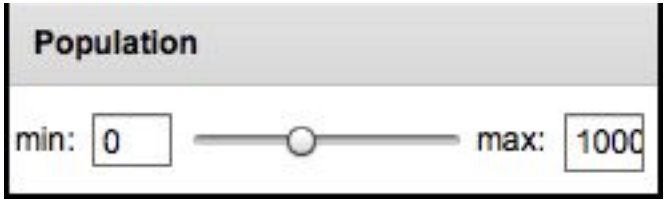
CS Concept
Traits & Variables

Modify!

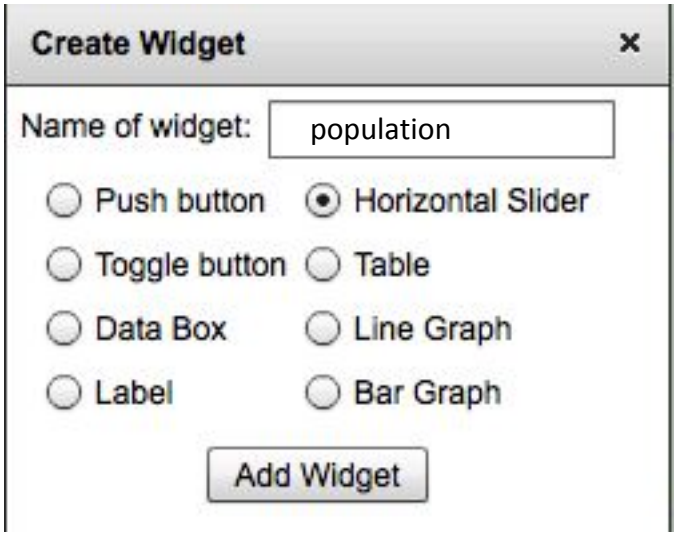
- Traits & variables are containers for holding values.
- Think of a variable as a box with a label.
- In StarLogo Nova, sliders can be used to hold values and set values as inputs to the model.



Modify!

Create a New StarLogo Nova widget

- Name the widget
- Select “Horizontal Slider”



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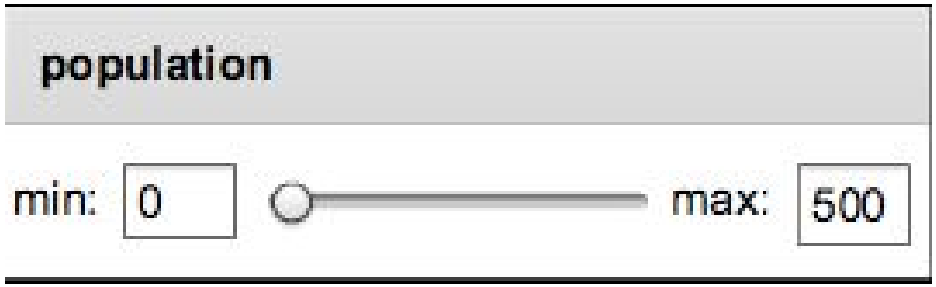
Modify!

New StarLogo Nova widget



- Make a new slider to control the initial number of turtles.
- Change the max value to 500 by typing in 500 next to max and **hitting the return key**.
- Click on “Edit Widgets” again to get out into editing mode and back into play mode.

Modify!

Use the New Widget

- We now have a way to set the number of turtles through the user interface with a slider.
- We can get the value of population in code.
- Replace the # in create do block with population slider value.

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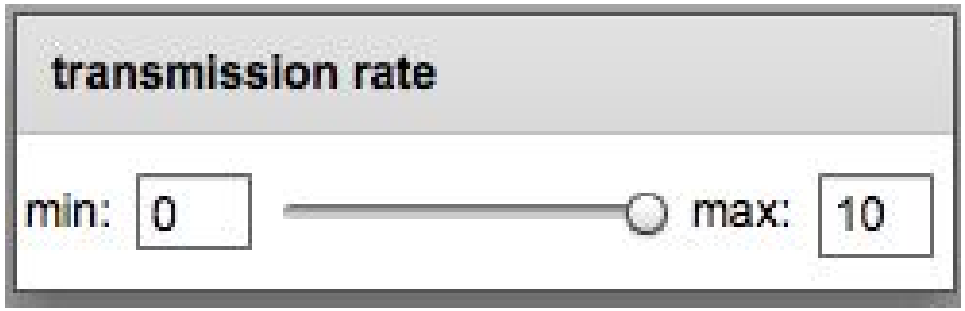
Epidemic Model

Modify!

- Now let's add a new slider to hold a value called the transmission rate.
- This rate is the percentage of time a disease gets passed from one person to another upon collision.

Modify!

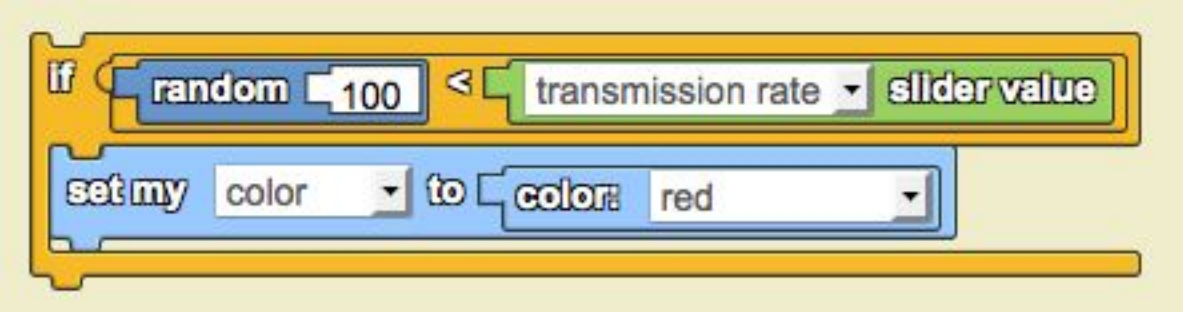
2nd slider- Transmission Rate



- Add a second slider for transmission

Modify!

Use the Transmission Rate Widget



- We are rolling a 100-sided die. If the result is less than the transmission rate, pass the disease on.
- How often should we roll less than the transmission rate?
- What kind of distribution does the roll of a single die give us?

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Epidemic Model Progress Monitor

Goals!

- ❑ Create several hundred blue turtles and a few red turtles [hint: Setup]
- ❑ Make them wiggle! [hint: Forever]
- ❑ Create a collision block in which blue turtles turn red when they encounter red turtles [hint: Lesson 4 Student Activity #2 Guide]
- ❑ Create a slider and an if-then for the probability of transmission rate [hint: Lesson 4 Student Activity #2 Guide]

Bonus!

- ❑ Add a line graph with a line for infected turtles and one for healthy turtles [hint: Lesson 6 Student Activity #1]
- ❑ Add a slider (or more) for one (or more) of the following:
  - ✧ Number of original healthy population
  - ✧ Number of original sick population

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Modify!

Save and Test your Model

- Try changing the transmission rate
- Where in your code will the transmission slider value go?

Next Steps-

- Use your model as an experimental test bed
- Is anything missing if you wanted to collect data?

Review

- What can this model tell you?
- What is the impact of changing the transmission rate?
- What other things move through a population like a disease?

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Modeling and Simulation

Exploring Content Area Modules

CS in Science Modules

Module structure:

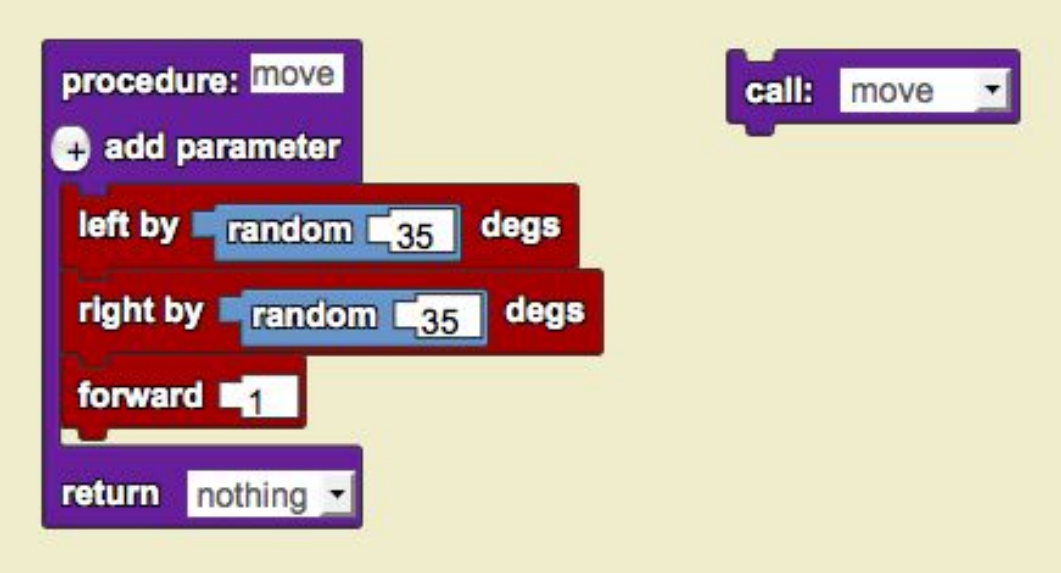
- Lesson 1: Engage and use a base model
- Lesson 2: Explore and decode
- Lesson 3: Experiment and explain
- Lesson 4: Extend and experiment
- Lesson 5: Evaluate

*assumes you have completed Module 1.

CS Concept
Procedures

Modify!

- Procedures are stacks of commands that perform a particular function and can be given a name.



Decoding Models

Greenhouse Gases

GUTS project #6069

The world page

Sun page

Solar Energy page

CO2 page

Car page

Heat page

Reflected energy page

Ecosystems

GUTS project #21061

Rabbit hop procedure

Rabbit reproduce proc.

Rabbit die procedure

Rabbit collide procedure

Grass sprout procedure

The world page

Modifying Models

Greenhouse Gases

REMIX GUTS project #6069

Change albedo

Make a factory

Limit car driving

Change rate of decay / sequestration

Ecosystems

REMIX GUTS project #21061

Change repro. rate

Change initial populations

Change sprouting rate

Add a predator

Add hunting

Running experiments

- Design and run experiments.
  Use the experimental design form.
- What is the impact of the change you made?
- How would you assess whether this model is valid?

Greenhouse Gases Ecosystems

Scientific practices covered

- Take a look at the Scientific Practices form
- Give examples of how we covered each one through computer modeling and simulation.

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In closing:

-Reflect!

-In small groups (2 pairs) discuss:

-What was the best part of the day?

-What was the most exciting thing you learned?

Be ready to share!

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Project GUTS resources

- Our website: projectguts.org
  - -top menu, click on **Resources**
  - -top menu, click on **Curriculum**
- Our MOOC: guts-cs4hs.appspot.com
- http://code.org/curriculum/science
- All modules & resources are free

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Did we meet the Goals for the Day?

- Gain understanding of using models to run experiments
- Gain understanding of how CS relates to modern scientific practice
- Learn how to create a simple Agent-based Model
- Design and conduct an experiment that uses a computer model as an experimental testbed.

- Explore existing modules and models

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THANK YOU!

Websites:

projectguts.org (curriculum & resources tabs)

code.org/curriculum/science

Contact information:

ireneannelee@gmail.com

ialee@mit.edu

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