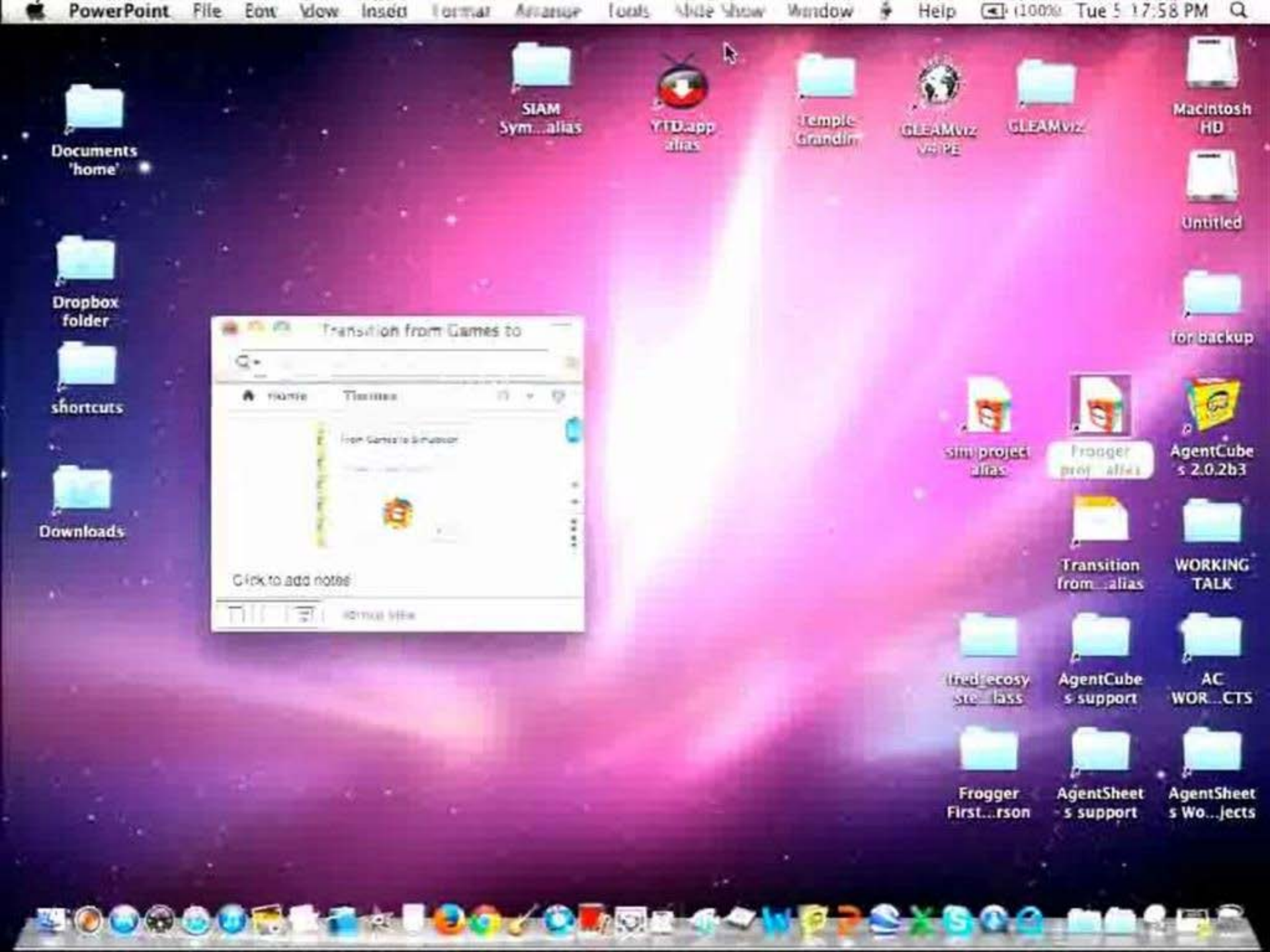
From Games to Simulation

Scalable Game Design Project

Thought Amplifier

AgentSheets®

Funded in part by
National Science Foundation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Transition from Games to
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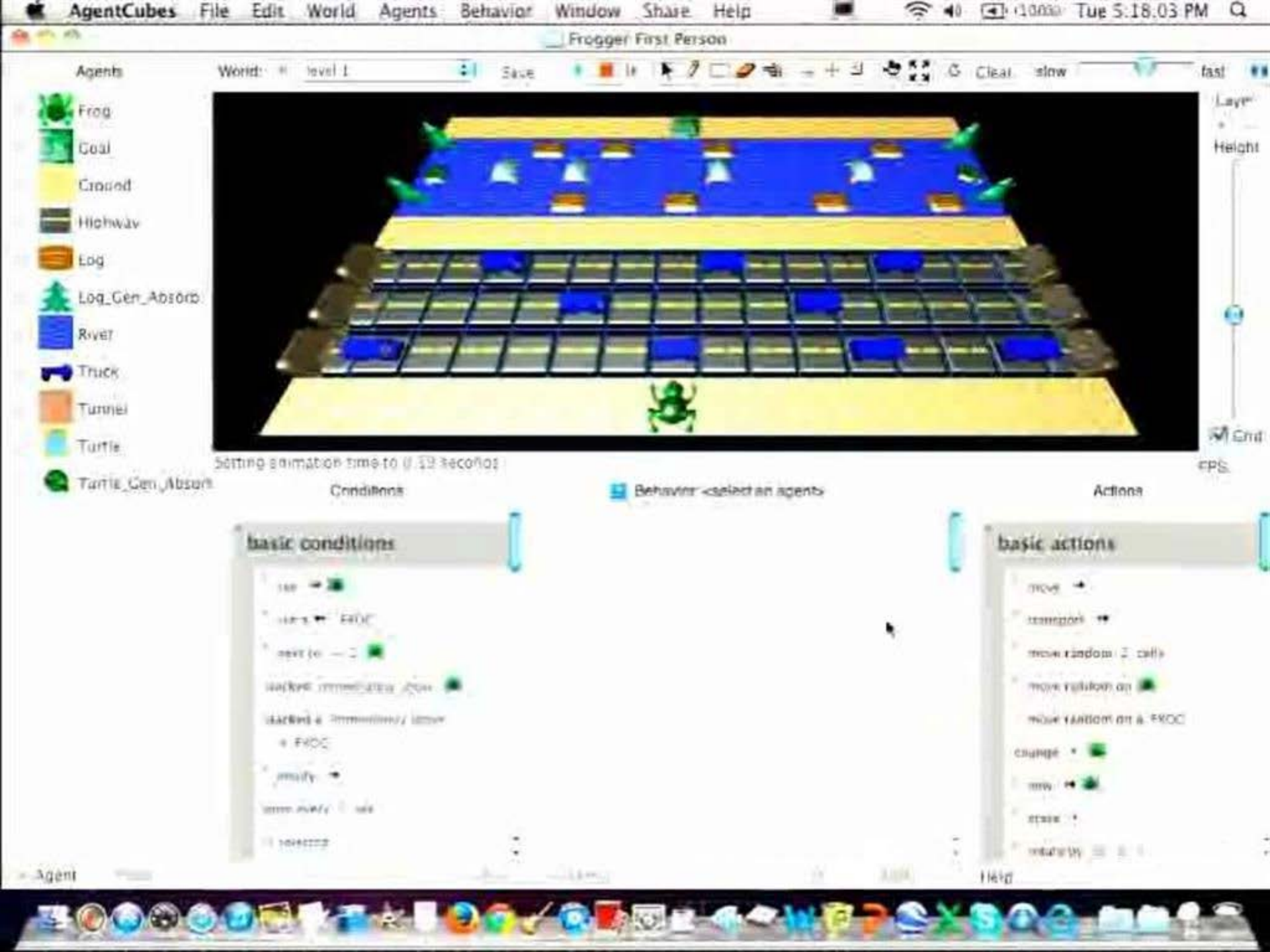
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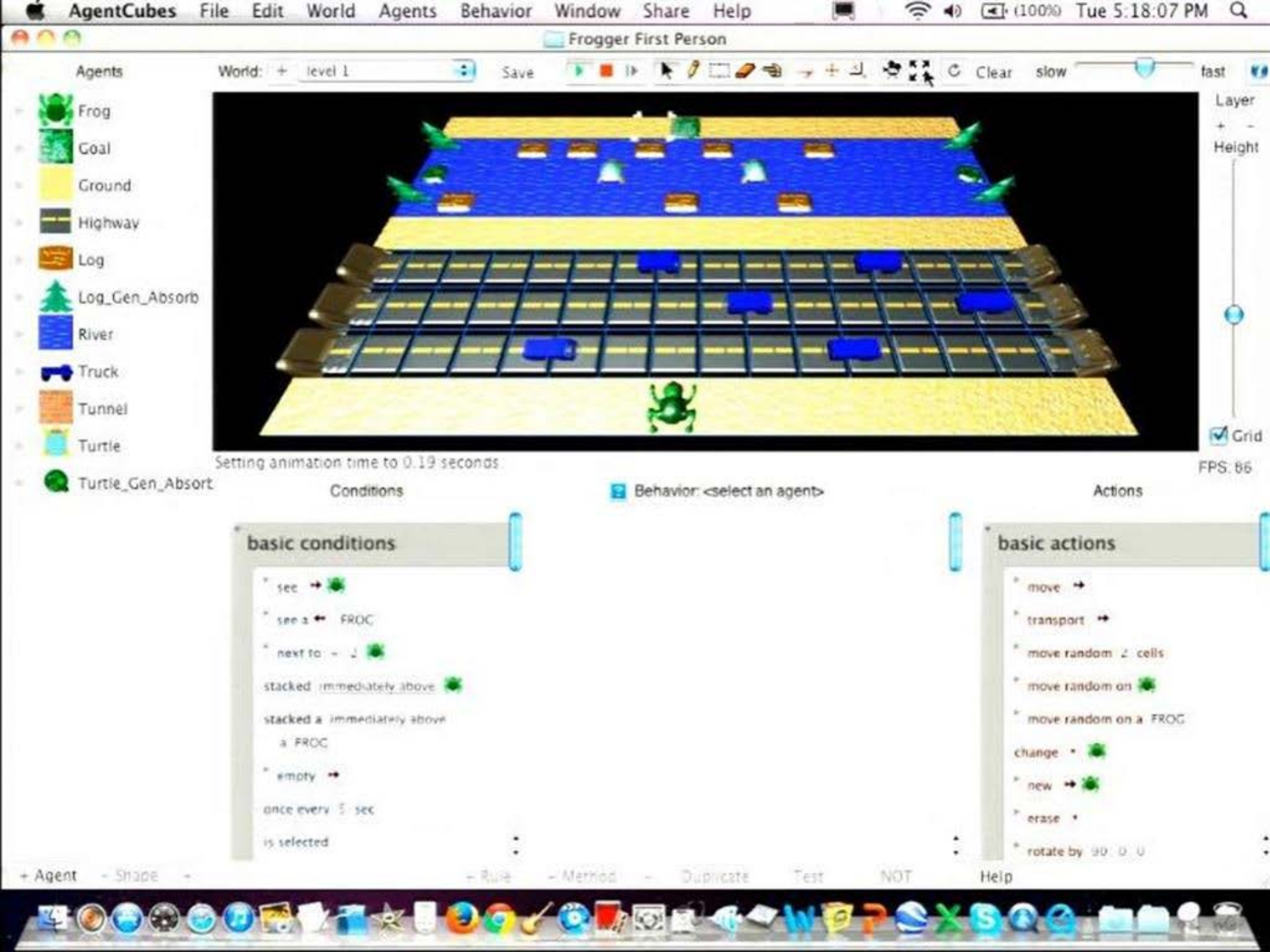
Frogger First Person
Agents
World:
level 1
Save
Clear
slow
fast
Frog
Goal
Ground
Highway
Log
Log_Gen_Absorb
River
Truck
Tunnel
Turtle
Turtle_Gen_Absorb
Height
Grid
FPS
Conditions
Behavior <select an agent>
Actions
basic conditions
basic actions
Agent
Help


AgentCubes File Edit World Agents Behavior Window Share Help
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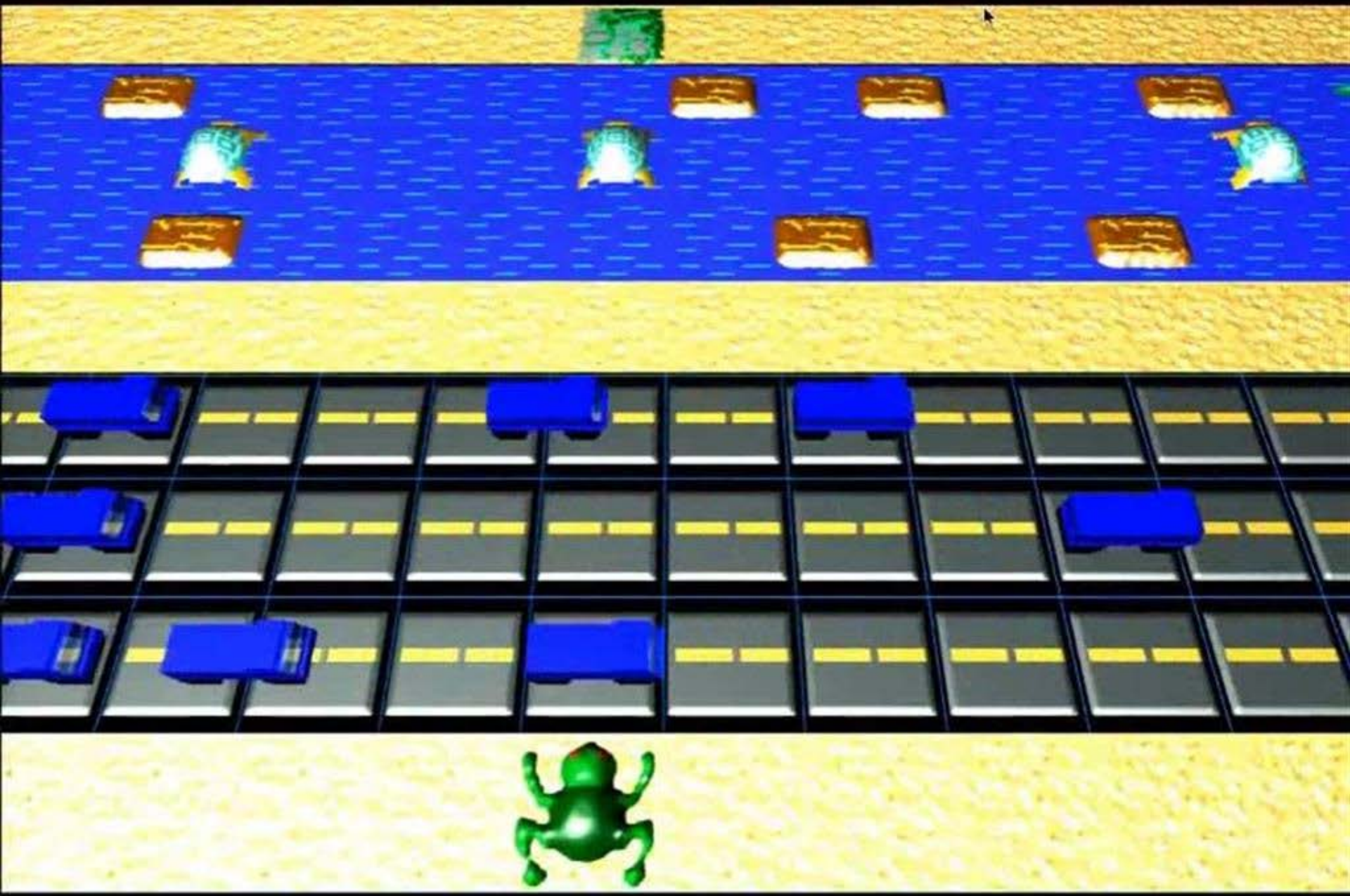
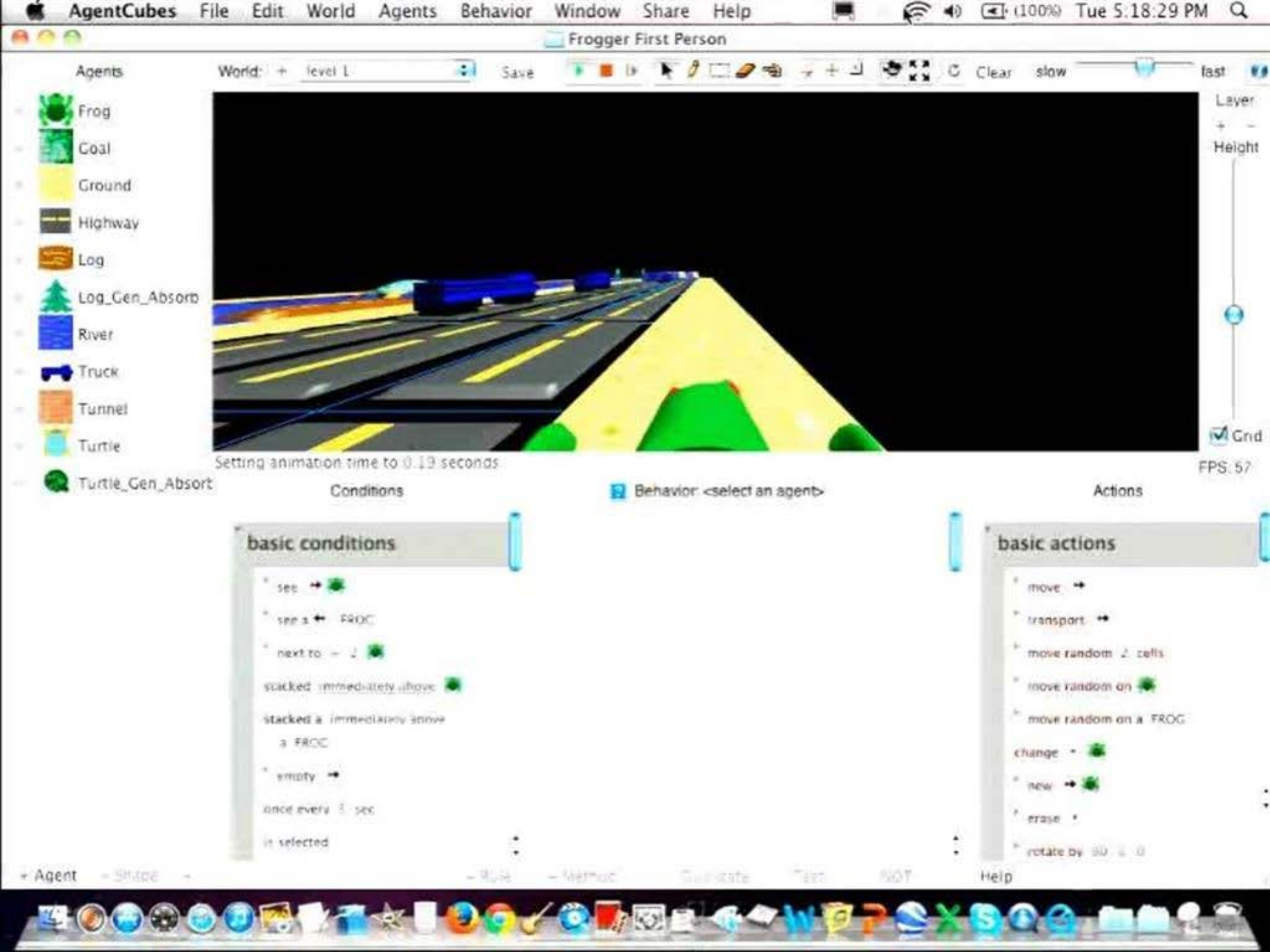
Frogger First Person
Agents
World: level 1
Save
Clear
slow
fast
Frog
Goal
Ground
Highway
Log
Log_Gen_Absorb
River
Truck
Tunnel
Turtle
Turtle_Gen_Absort
Layer
Height
Grid
Setting animation time to 0.19 seconds
FPS: 66
Conditions
Behavior: <select an agent>
Actions
basic conditions
see
see a FROG
next to - 2
stacked immediately above
stacked a immediately above a FROG
empty
once every 5 sec
is selected
basic actions
move
transport
move random 2 cells
move random on
move random on a FROG
change
new
erase
rotate by 90 0 0
+ Agent
- Shape
- Rule
- Method
- Duplicate
Test
NOT
Help




AgentCubes File Edit World Agents Behavior Window Share Help
Tue 5:18:29 PM
Frogger First Person
Agents
World:
level 1
Save
Clear
slow
fast
Frog
Goal
Ground
Highway
Log
Log_Gen_Absorb
River
Truck
Tunnel
Turtle
Turtle_Gen_Absorb
Layer
Height
Grid
Setting animation time to 0.13 seconds
FPS: 57
Conditions
Behavior: <select an agent>
Actions
basic conditions
see
see a FROG
next to - 1
stacked immediately above
stacked a immediately above a FROG
empty
once every 1 sec
is selected
basic actions
move
transport
move random 1 cells
move random on
move random on a FROG
change
new
erase
rotate by
Agent
Help

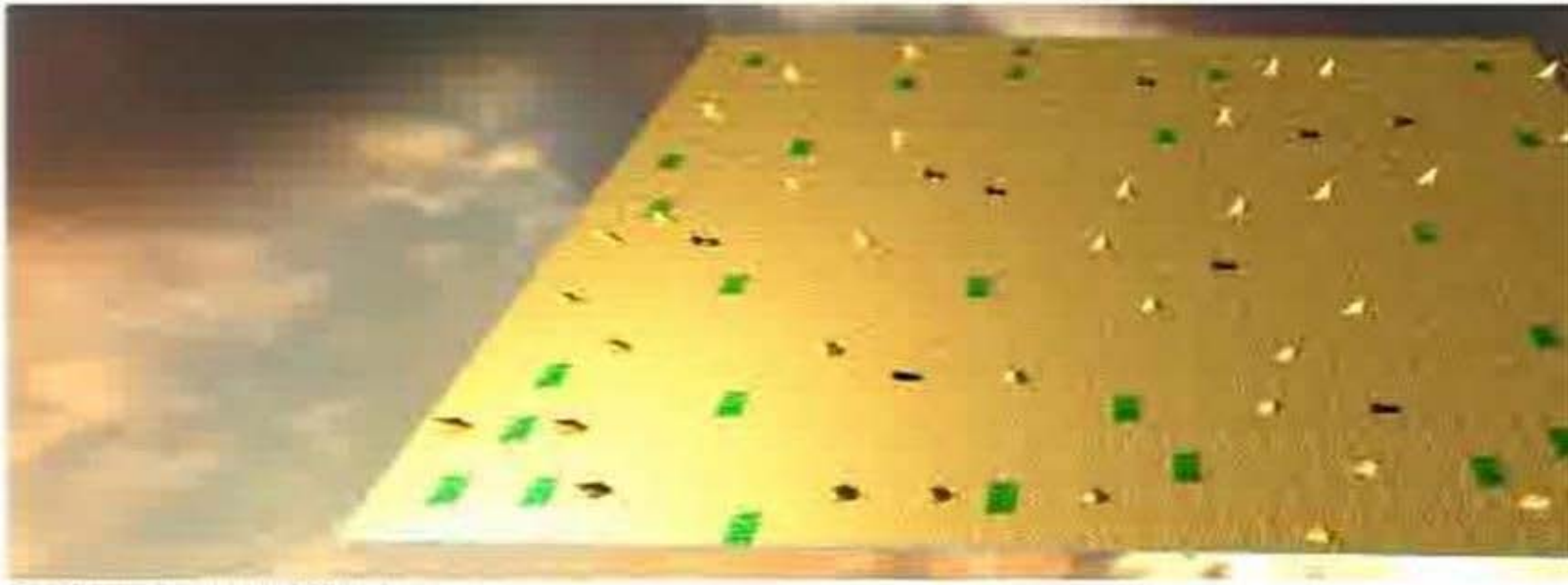
AgentCubes File Edit World Agents Behavior Window Share Help (100%) Tue 5:18:38 PM

fred_ecosystem_sim_class

Agents

- Brush
- Controller
- Coyote
- Ground
- Hay
- Rabbit

World: world_27x48 Save Clear



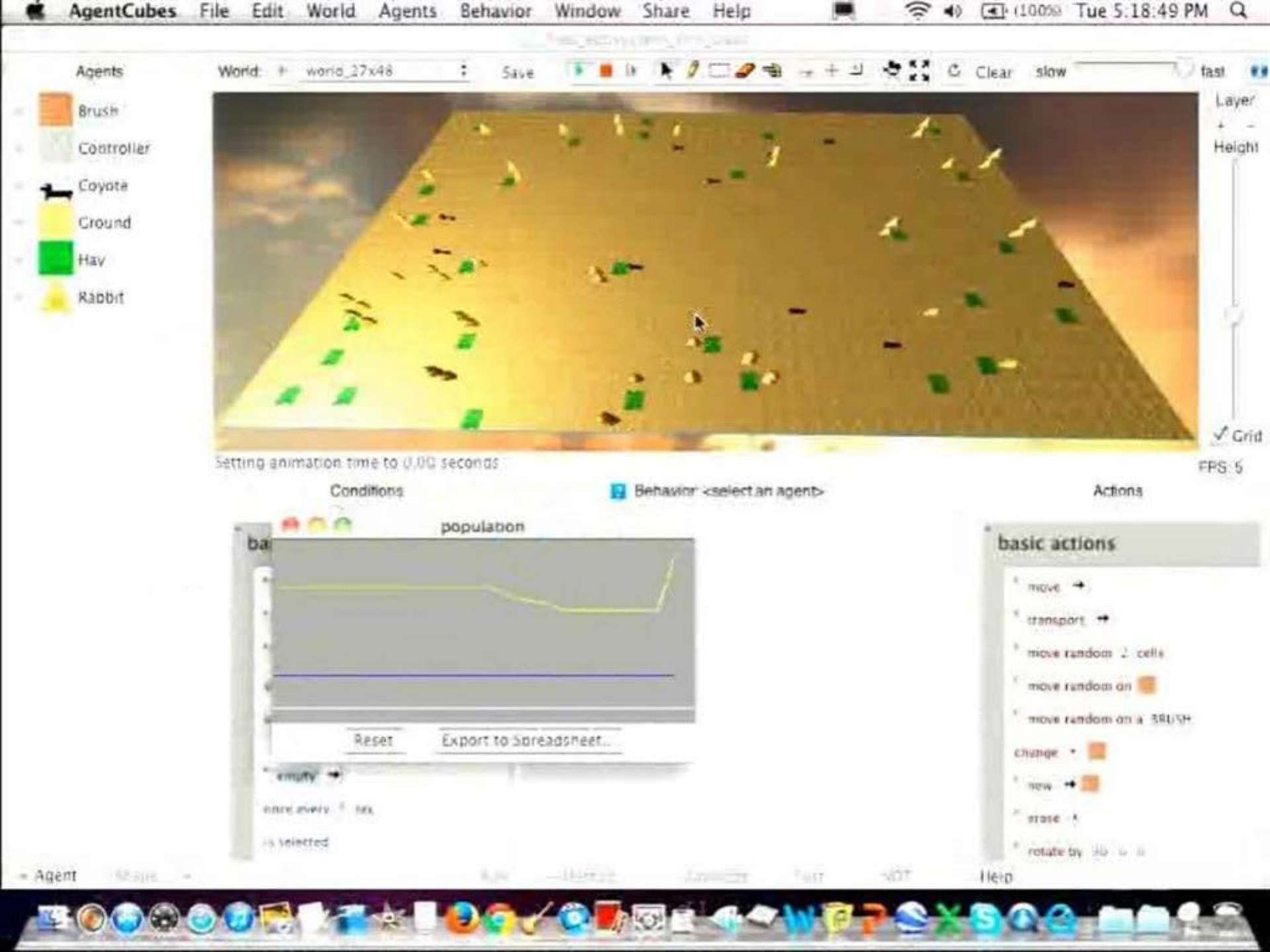
Setting animation time to 0.00 seconds

Conditions

Behavior: <select an agent>

basic conditions

- see
- see a BRUSH
- next to
- stacked immediately above
- stacked immediately above a BRUSH
- empty
- is selected


AgentCubes File Edit World Agents Behavior Window Share Help
Tue 5:18:49 PM
Agents
World: world_27x48
Save
Clear
slow
fast
Brush
Controller
Coyote
Ground
Hay
Rabbit
Layer
Height
Grid
FPS: 5
Setting animation time to 0.00 seconds
Conditions
Behavior <select an agent>
Actions
population
Reset
Export to Spreadsheet...
basic actions
move
transport
move random 2 cells
move random on
move random on a BRUSH
change
new
erase
rotate by
Agent
Help

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Scalable Game Design Project

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Project Overview

- NSF funded project to increase the number of students pursuing computer science.
- Overall strategy:
  - Introduce computer science through game design, starting in early middle school.
  - Encourage transfer of interests and skills toward further computer science education.

Methodology

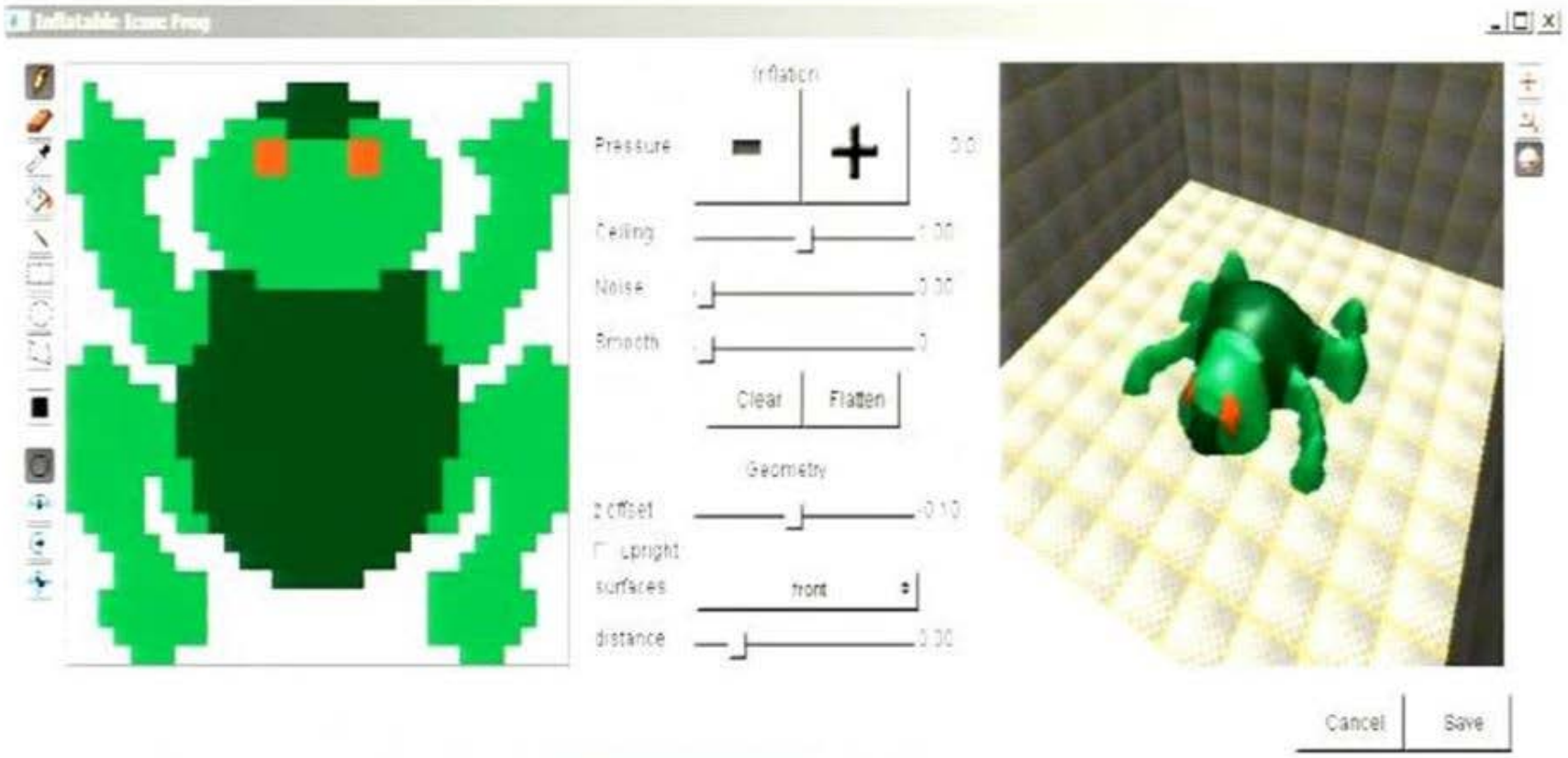
- Computational thinking patterns (CTPs) introduced via familiar games; e.g., Frogger
- Game design skills transfer to simulations
- Grade-level wide application, not small groups, not self-selected.
- Pre- and post-activity surveys used to measure attitude changes

Problem Simplified and Analyzed

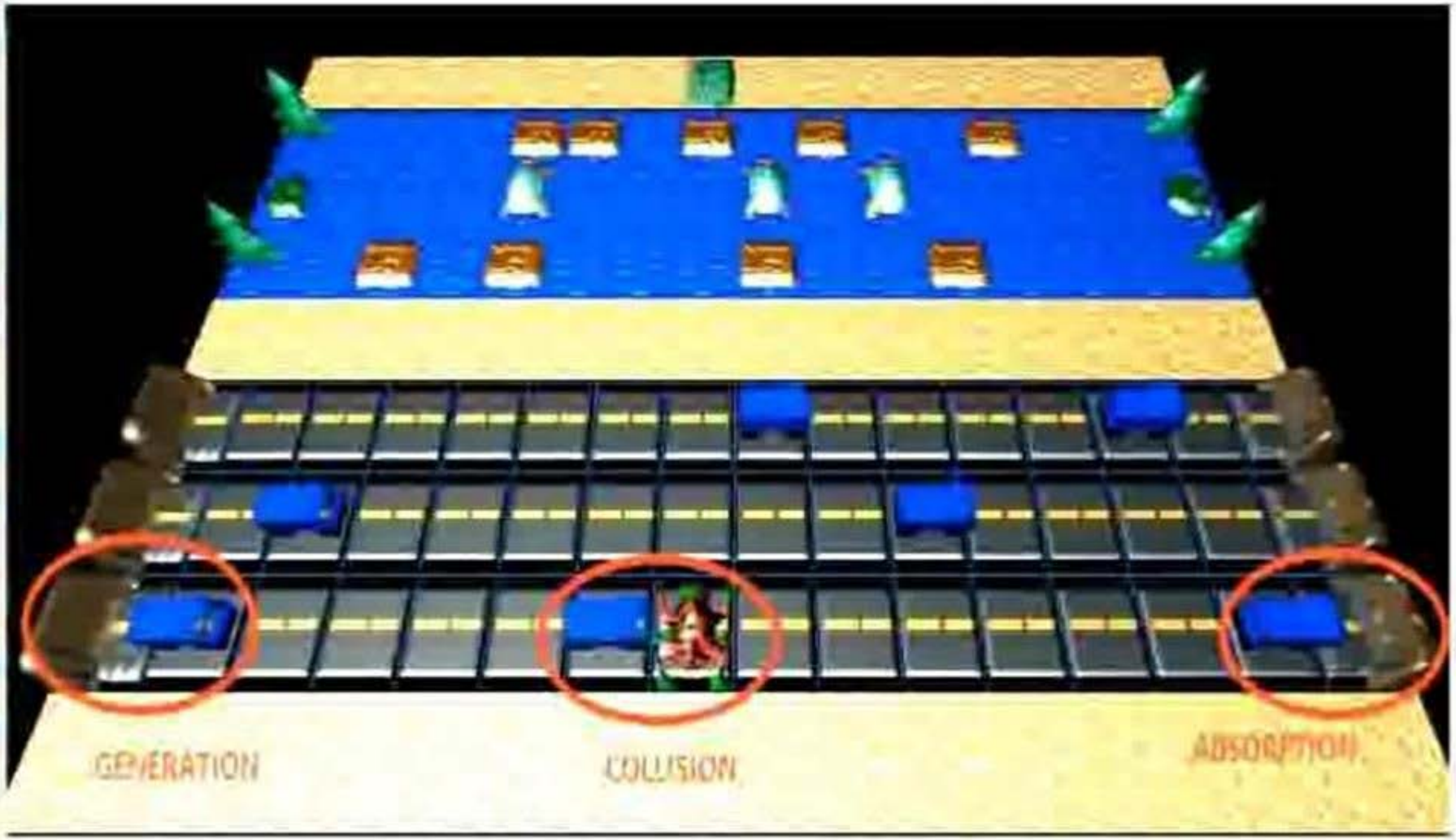
You are a frog. Your task is simple: hop across a busy highway, dodging cars and trucks, to reach the river. You drown by falling into the river, so jump on the backs of turtles and logs to cross the river to reach the grotto.

- Nouns become agents
- Verbs become actions

Making 3D Easy



Computational Thinking Patterns in Frogger



Computational Thinking Patterns
Frogger and Beyond

- Generation – Frogger: tunnel generates trucks
- Absorption – Frogger: tunnel absorbs trucks
- Collision – Frogger: frog and truck collide
- Transport – Frogger: logs & turtles transport frog
- Diffusion – Pacman: spreading a 'scent'
- Hill-Climbing – Pacman: following a 'scent'
- Push-Pull – Sokoban: pushing boxes
- Polling – Sokoban, et al: determining the end of a game or simulation

Diffusion

Discrete Diffusion Equation:

$$u_{0,t+1} = u_{0,t} + D\sum_{i=1}^{n}(u_{i,t} - u_{0,t})$$

Simplified Diffusion Equation (D = 0.25):

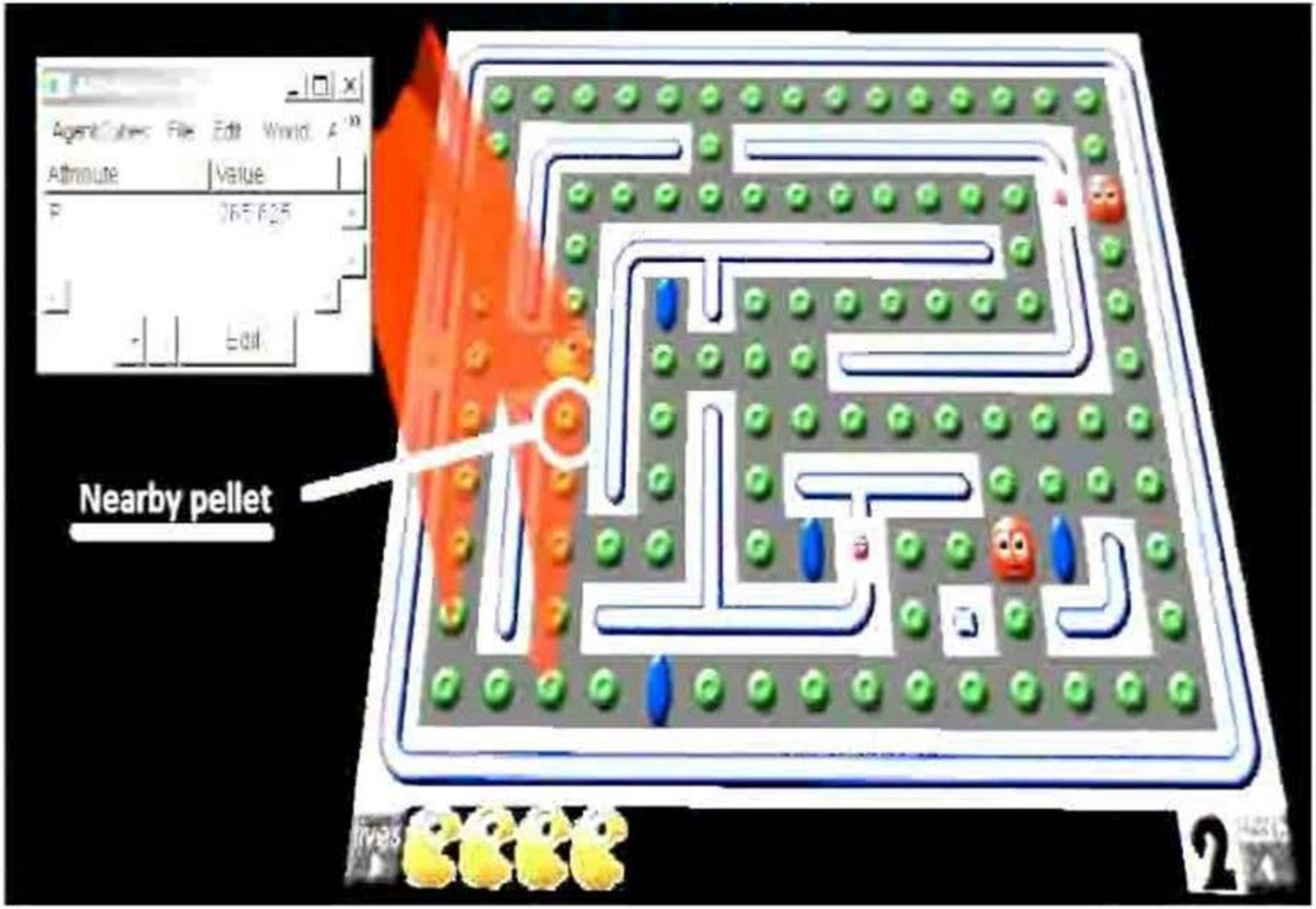
$$u_{0,t+1} = 0.25\sum_{i=1}^{4}(u_{i,t})$$

Or, in AgentCubes:

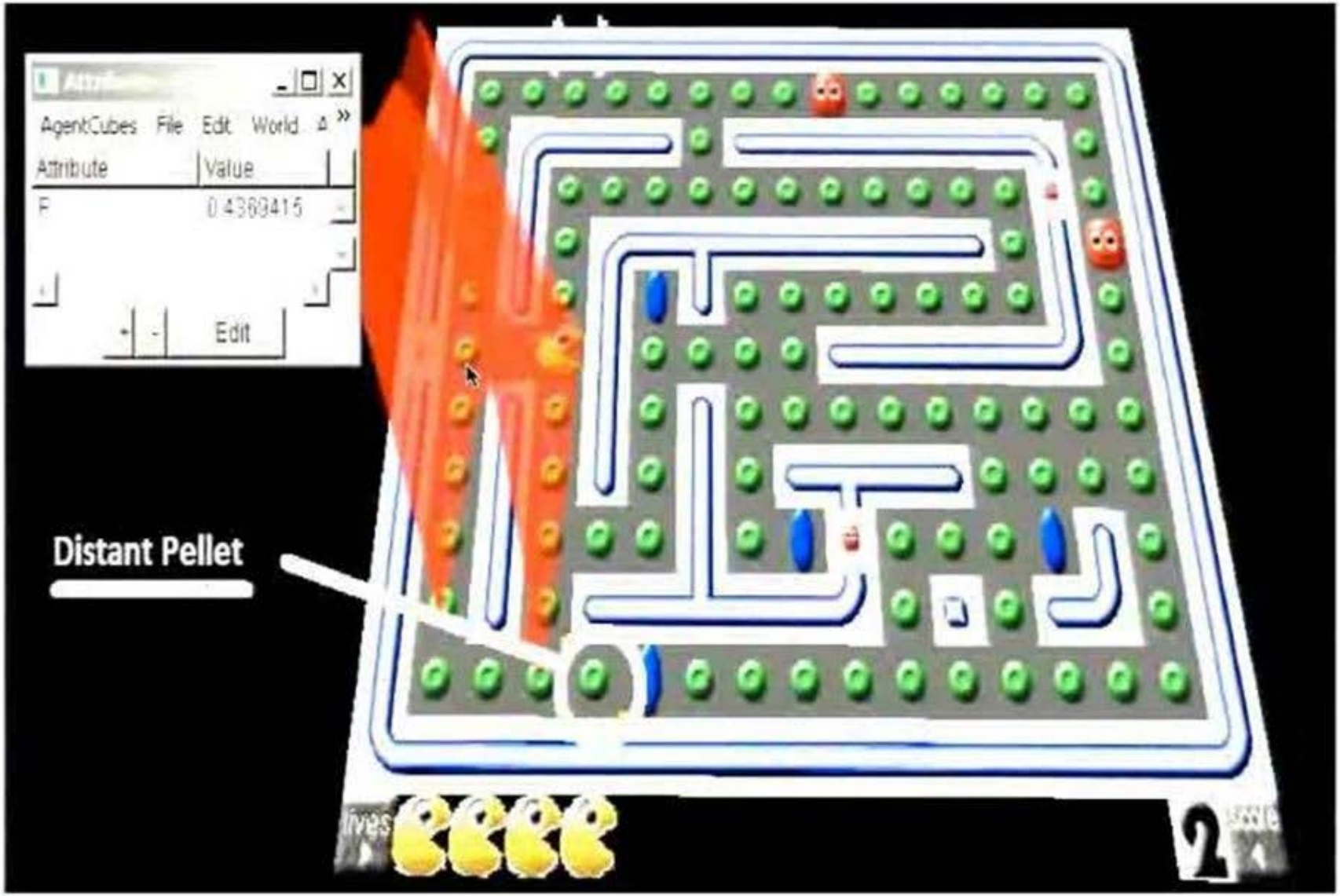
	U(up)	
U(left	U(0)	U(right)
	U(down)	

u{current cell} = 0.25 * (u[up]+u[down]+u[left]+u[right])

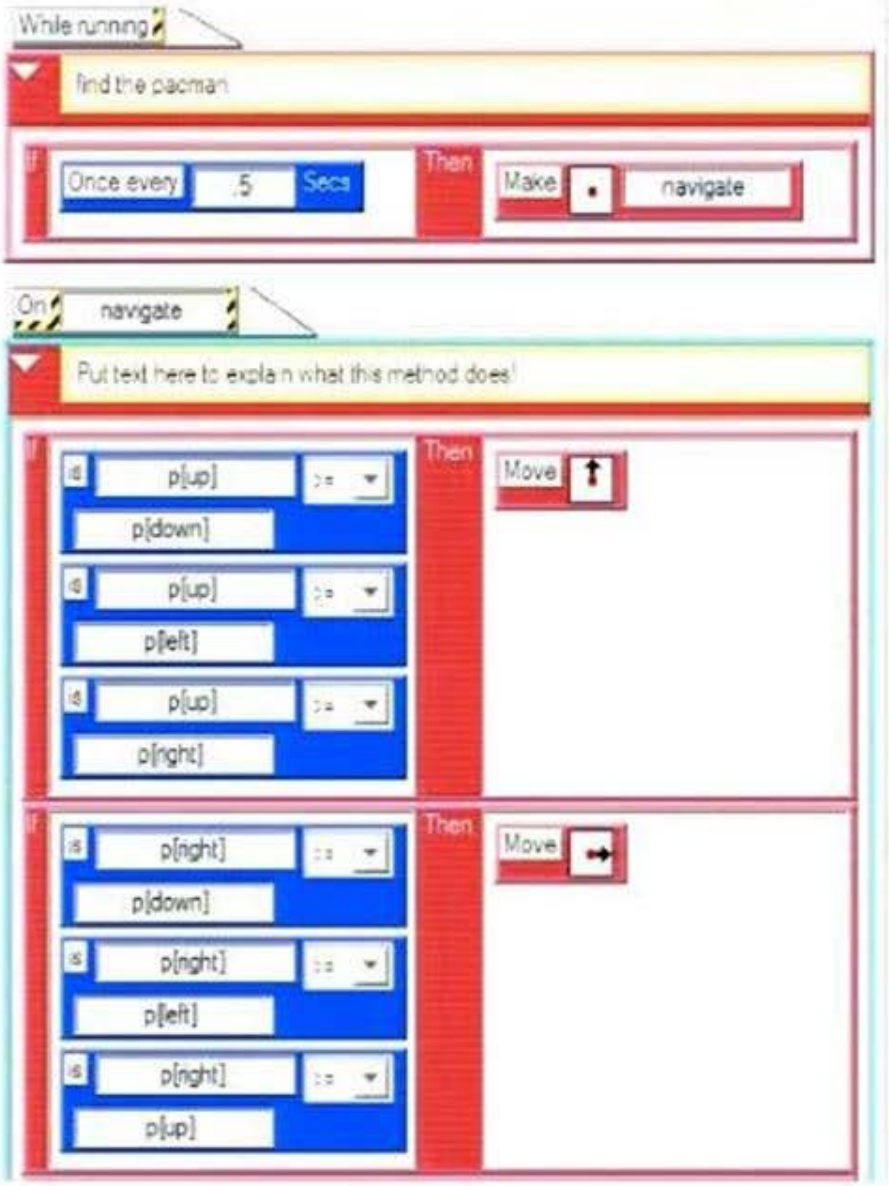
Diffusion Visualized – 3D



Diffusion Visualized – 3D



Hill Climbing



Hill Climbing (single instruction)

Transition to STEM Simulation

Simulation vs. Game

1) A game is a simulation
2) A simulation can become a game (challenge)
3) Key differentiations for a simulation vs. game:
   1. Answers a question (primary focus)
   2. Collects data for assessment/analysis
   3. Usually involves less or no real-time hand-eye coordination than a game
4) Example games: Frogger, Pacman, Centipede
5) Example STEM simulations: predator-prey model, contagion model, wildfire model

Transition to Simulation
The Process

- Start with a simple model: e.g., predator-prey
- Problem: How to maintain stable populations?
- Apply CTPs learned from game design
- Add plotting & data collection

Simple Model "Spec"

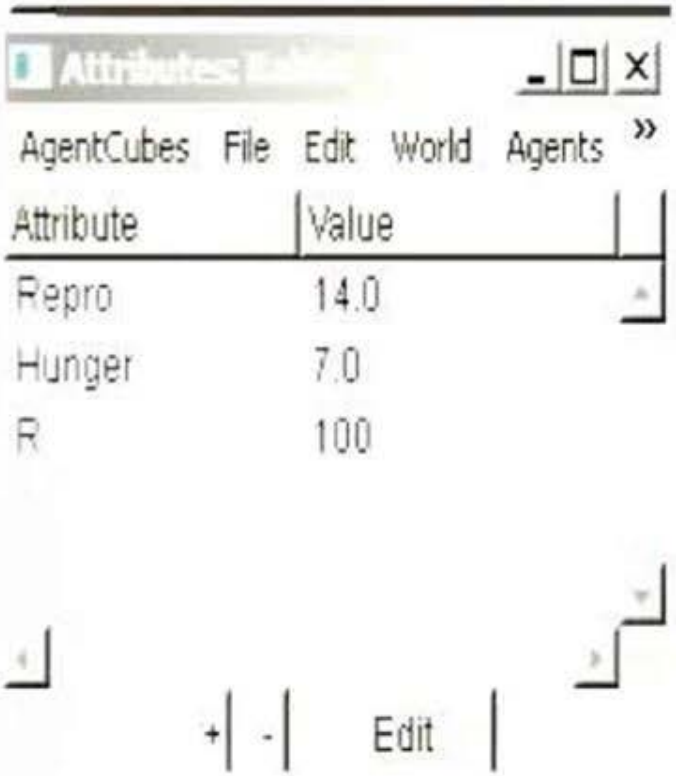
- **Problem Statement:**
  - Food chain: coyotes -> rabbits -> hay
  - Animals move randomly unless seeking food
  - Seeking food is intelligent (diffusion and hill-climbing CTPs)
  - Lowest level (hay) is not consumed
  - No starvation or longevity-driven mortality
  - Only the middle level (rabbit) reproduces
  - Goal: stable and healthy populations

Managing the Simulation

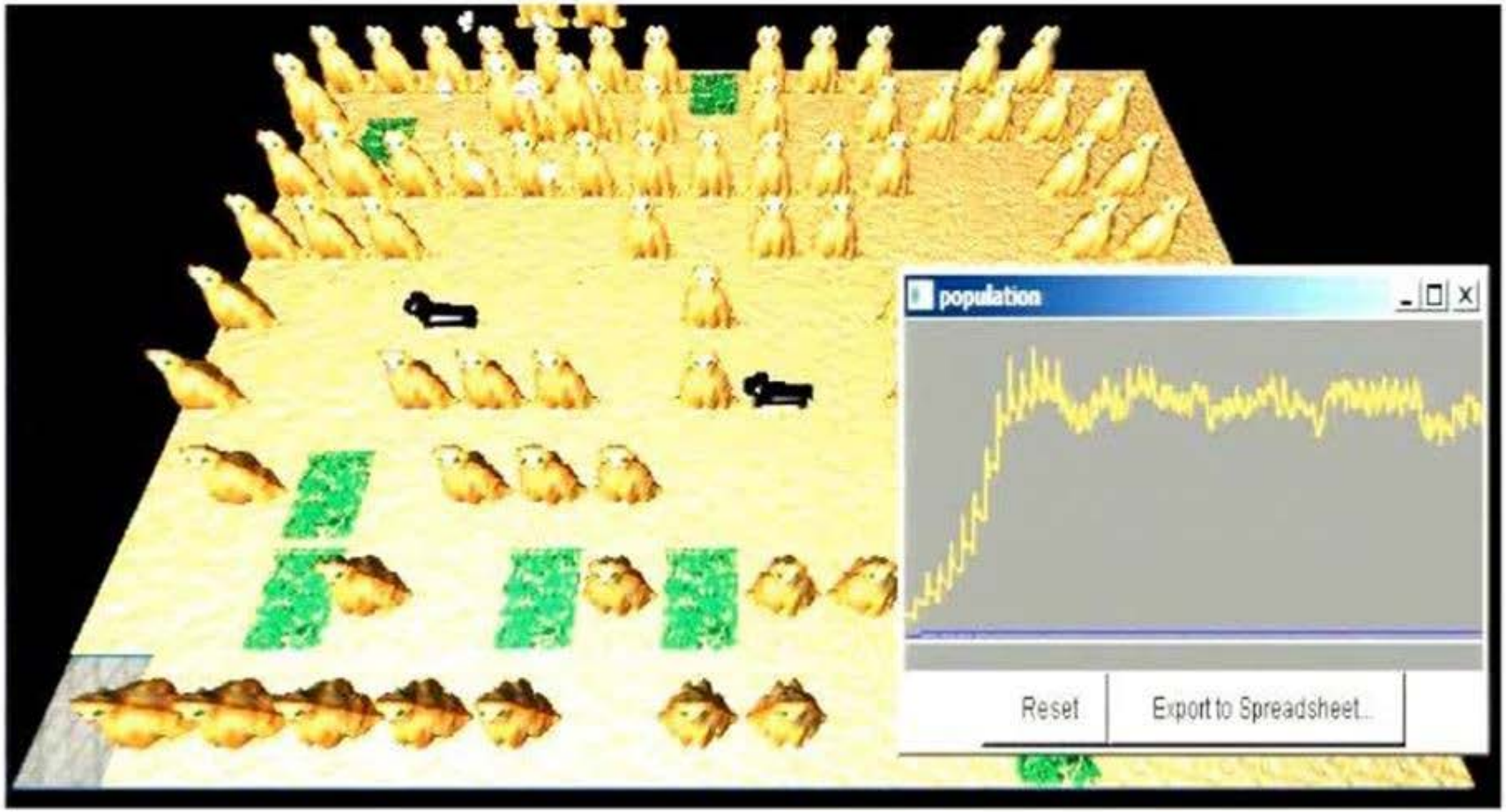
- Additions to the basic model "spec":
  - A monitor watches the simulation and keeps track of the populations via simulation properties
  - The monitor determines if the simulation ends: when a population size falls to zero (polling CTP)

Ecosystem – Basic Model

Basic Model Parameters



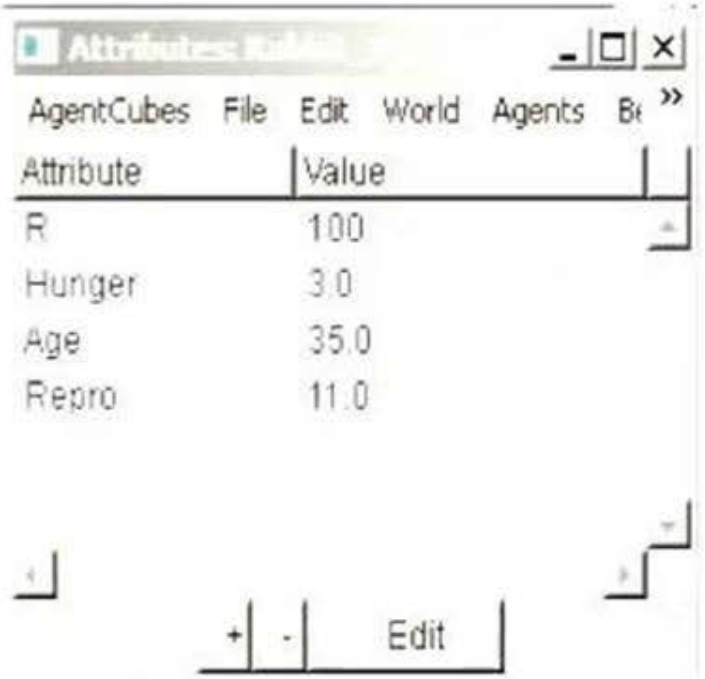
Ecosystem – Model Run

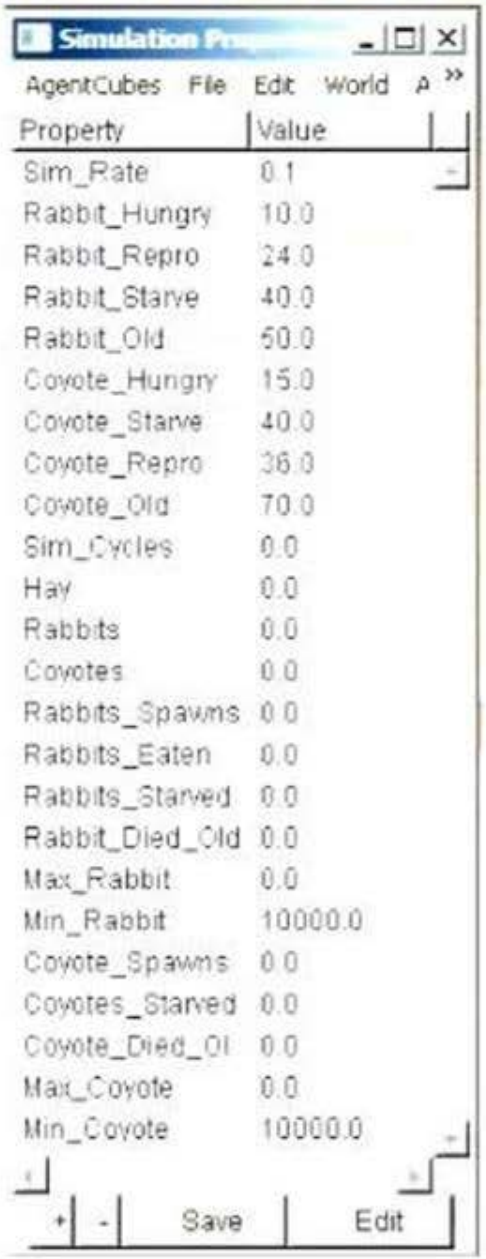


Enhancing the Model

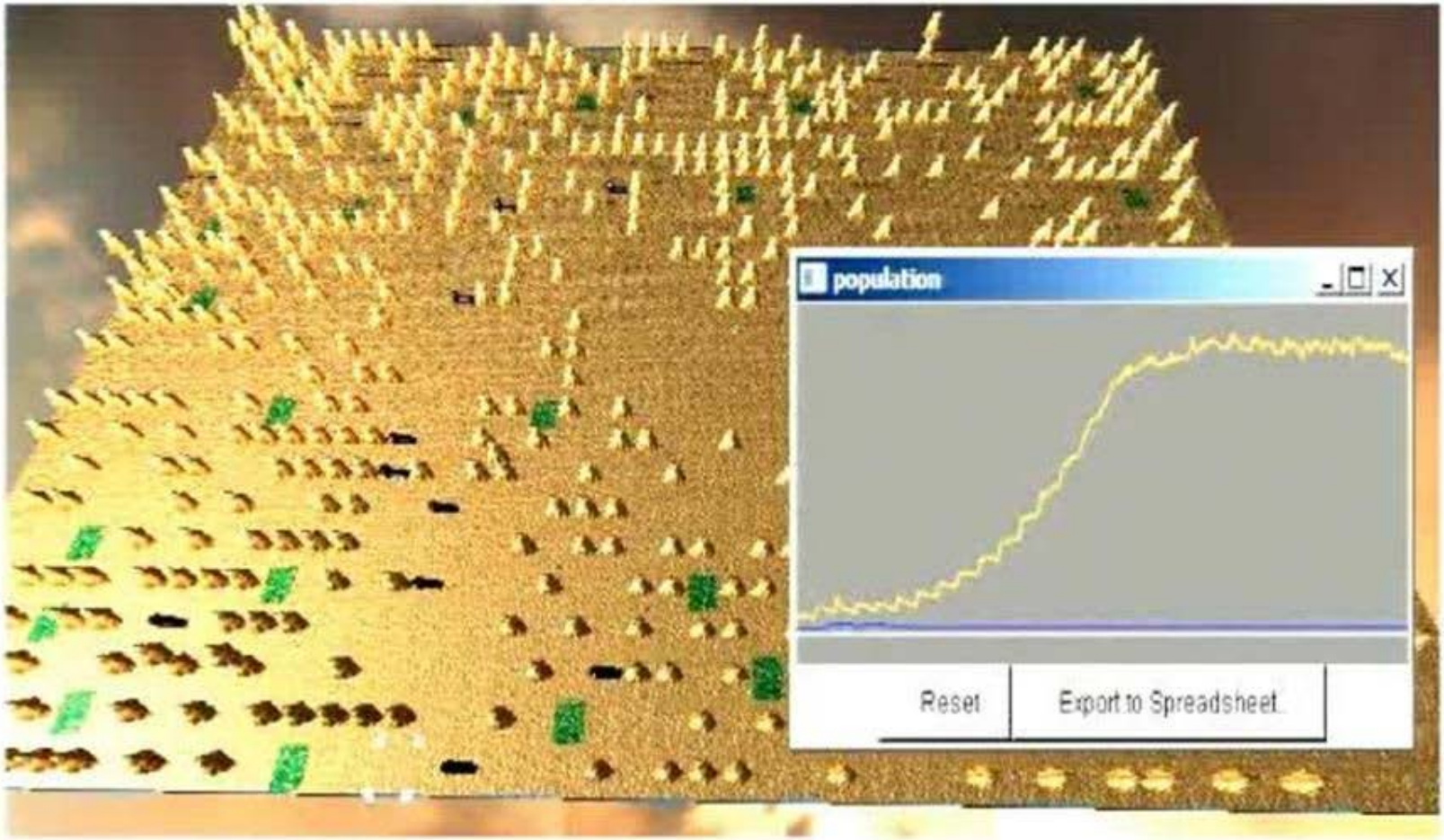
- Add starvation thresholds for predators
- Add longevity thresholds for predators
- Add reproduction and mortality for other food chain members
- Add habitat boundaries and obstacles
- Add additional elements in the food chain
- Etc.

Large Model Parameters





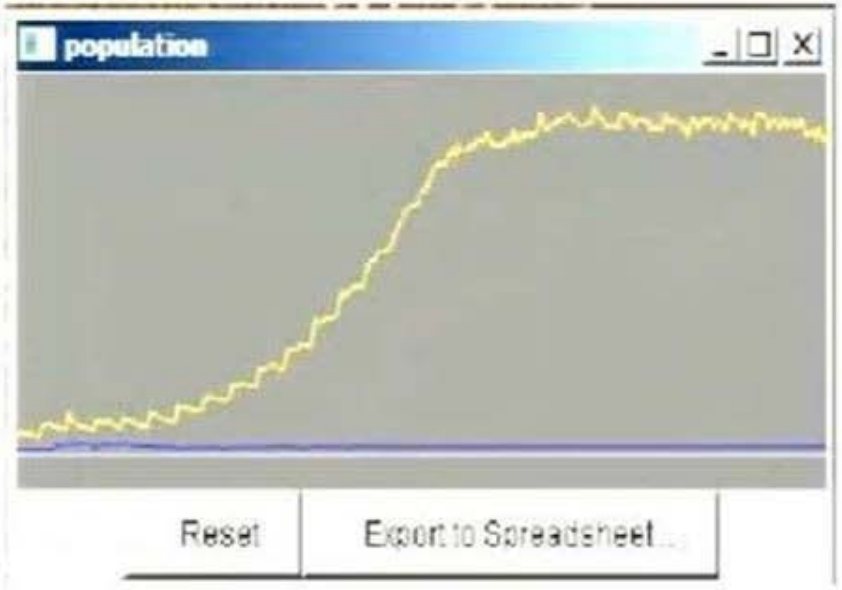
Enhanced Model



Results - Recap

Small Model

Large Model

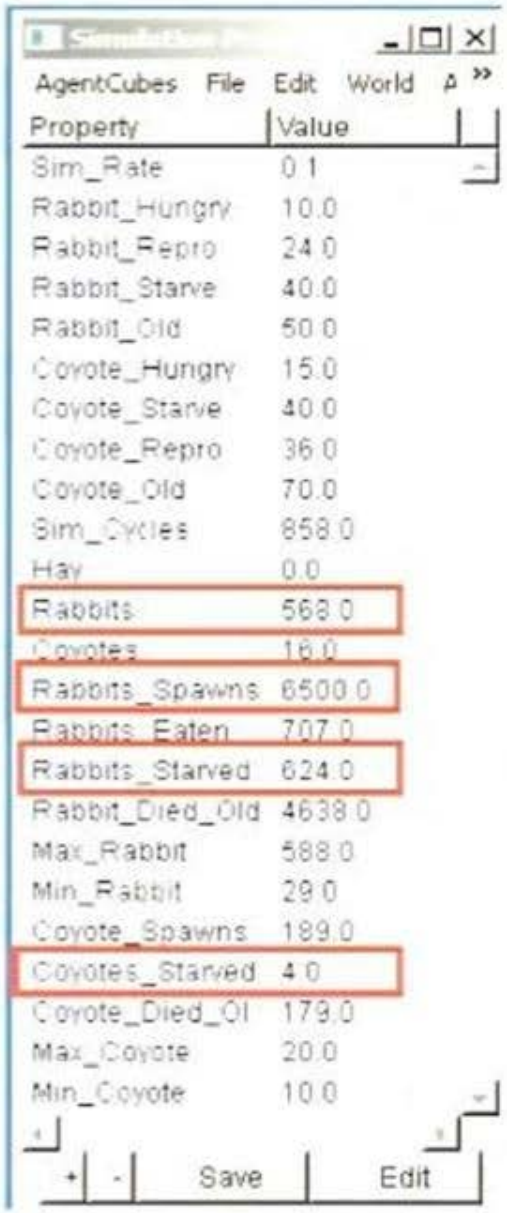


Results Compared

1	Rabbits	Coyotes
2	11	2
3	11	2
655	95	4
656	97	4
657	100	4
658	97	4
659	95	4
660	90	4
661	94	4
662	97	4
663	97	4
664	96	4
665	97	4
666	100	4
667	100	4
668	99	4
669	98	4

1	Rabbits	Coyotes
2	37	10
3	37	10
655	572	13
656	568	13
657	567	14
658	562	14
659	564	13
660	566	14
661	567	14
662	566	14
663	570	13
664	587	14
665	575	14
666	576	14
667	569	14
668	563	14
669	565	14

Results - Insight



WHY?

Rabbit Population: 568

Rabbits Spawned: 6,500

Rabbits Starved: 624

Coyotes Starved: 4

Project Participation

- Initial project three-year goals:
  - ~ 50 teachers
  - ~ 1300 students
- Goals exceeded in first year
- After 5 years (U.S. only):
  - > 300 teachers
  - > 18,000 students
- Student motivation post-survey responses
  - 2/3 positive experience and desire to go further
  - gender and ethnicity independent
- Expanded to Europe, Brazil, et al

source: http://sgd.cs.colorado.edu/wiki/Research_Snapshot#Scalable_Game_Design_Research_Snapshot