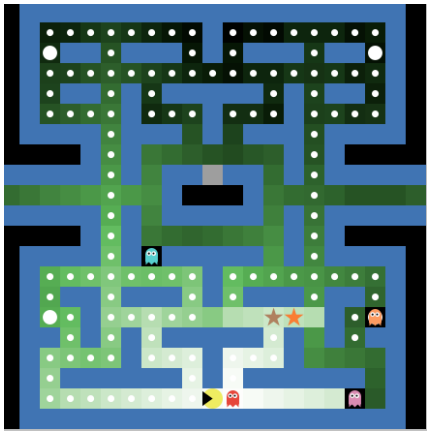
Collaborative Diffusion Instructor Guide



Overview

This package includes three models to teach middle and high school students about collaborative diffusion. Collaborative diffusion is a simple agent-based path-planning algorithm especially useful for navigating agents through complex spaces such as mazes or a Pac-Man board. The first of the three models is a demonstration of collaborative diffusion in mazes and simple corridor setups. It emphasizes the students understanding of collaborative diffusion through simple visualization and code. The second model is an extension of the Pac-Man game in the NetLogo Models Library to make the ghosts seek the Pac-Man via collaborative diffusion. The third model, a HubNet activity, reinforces the students' understanding of collaborative diffusion by having them act as the ghosts, with information about the surrounding patches to guide them to the Pac-Man. See the detailed descriptions of the models below for more information. For more information on how to run the models, see the respective info tabs of the models.

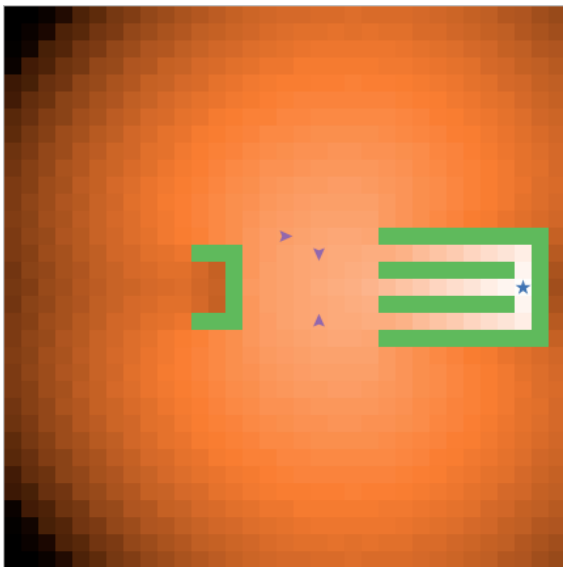
The main goals of this lesson plan are as follows:

- Expose students to agent based modeling and emergent behavior
- Teach students how simple rules can create complex movements and collaboration
- Give them a flavor for game design (Pac-Man), artificial intelligence, path planning, and computer science as a whole
- Get students excited about (and encourage them to enter) STEM fields

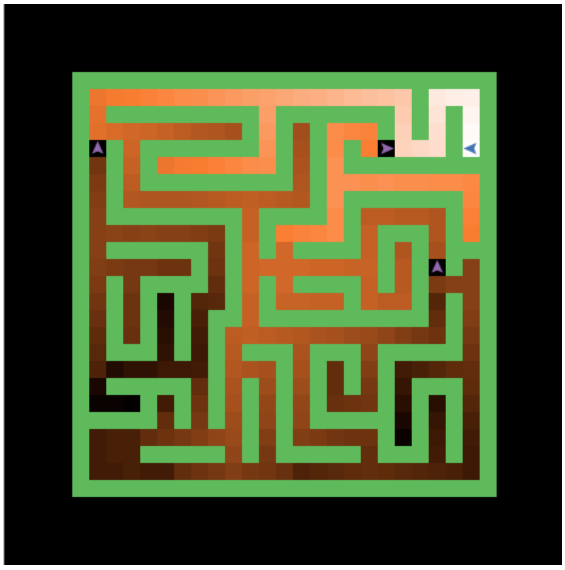
Background on Collaborative Diffusion

Collaborative diffusion is a simple path finding algorithm well suited to mazes and close corridors where multiple agents have to work together to find a goal. It is a simple extension on diffusion that produces surprisingly powerful results.

Diffusion itself is rather simple. The goal emits a scent that gets diffused through the game board. Each patch gives away its scent to its four surrounding Von Neumann neighbors (up, down, left, right). As time goes on, the scent is diffused through the entire board. For an agent to find the goal, it must simply follow the scent as it gets stronger to the goal.



When multiple agents are involved however, simple diffusion is not sufficient. In a situation such as a maze, it is ideal for the agents to take different paths, more of a divide and conquer approach. With simple diffusion, however, they would just all follow the same path, which is not as efficient. The element of collaboration is introduced by the dampening of the scent where agents are. The scent (or diffusion value) is always set to zero at the patch where each agent is located. In close corridors, this essentially blocks the scent from passing through the agent. When the diffusion value/scent is set to zero, this dampens the scent in the area surrounding an agent. The result is that when agents are presented with several possible paths, they will choose different ones. This is because they are essentially following the gradient of the scent. If the gradient is dampened by the presence of another agent, the algorithm forces agents to take a different path.



The two simple rules: agents follow the scent gradient, and agents dampen/block the scent around them results in emergent behavior where the agents take different paths when confronted with multiple possibilities.

Model 1: Collaborative Diffusion Demo

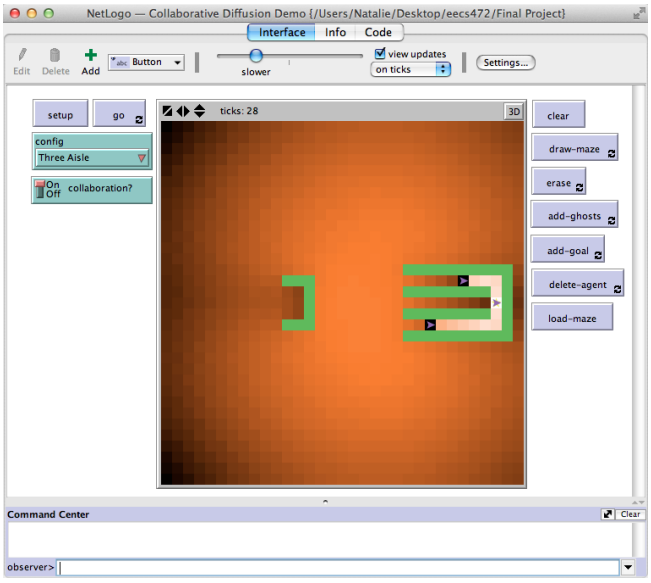
Potential questions for students:
1. Imagine you are in a maze. How do you find your way through? What rules would you use to navigate your way through the maze?
2. Now imagine you are in a group of people trying to find your way through a maze. The goal is for one person (not everyone) to reach the end as fast as possible. How do you and the group navigate the maze then?

To introduce the idea of collaborative diffusion, focus on the scent metaphor. Below is a summary of collaborative diffusion as employed in the Collaborative Diffusion Demo model:

- Be sure to explain the concept of patches. The world is tiled into patches- each ghost (purple triangle) sits on a patch, the goal sits on a patch.
- The goal diffuses a 'scent' through the world. A good way to explain this to the students is to use the comparison of the smell of food spreading through a house- it spreads through the corridors and rooms, but not the wall.
- Introduce the diffusion value by looking at the different colors of the patches. A brightly colored patch (strong scent) corresponds to a high diffusion value, and a darker patch (weak scent) corresponds to a low diffusion value.
- When a ghost decides when to move next, it picks the patch with the strongest scent. It keeps on doing this until one of the ghosts reaches the goal.

To explain the collaboration aspect, run the simulation with and without collaboration and compare the results with the students. Below is a summary of collaboration.

The ghosts block the scent wherever they are- the diffusion value of whatever patch they are on is always set to zero. In this example there are three halls. So if ghost A picks hall 1, the scent cannot pass through that hall- the area behind the ghosts are darker. If the scent is blocked, then the other ghosts will pick different paths with stronger scents.



Some additional ideas:

- Have the students run the Three Aisle configurations, as well as the maze configuration.
- Have them run them with and without collaboration so they can see the difference the dampening of the scent makes.

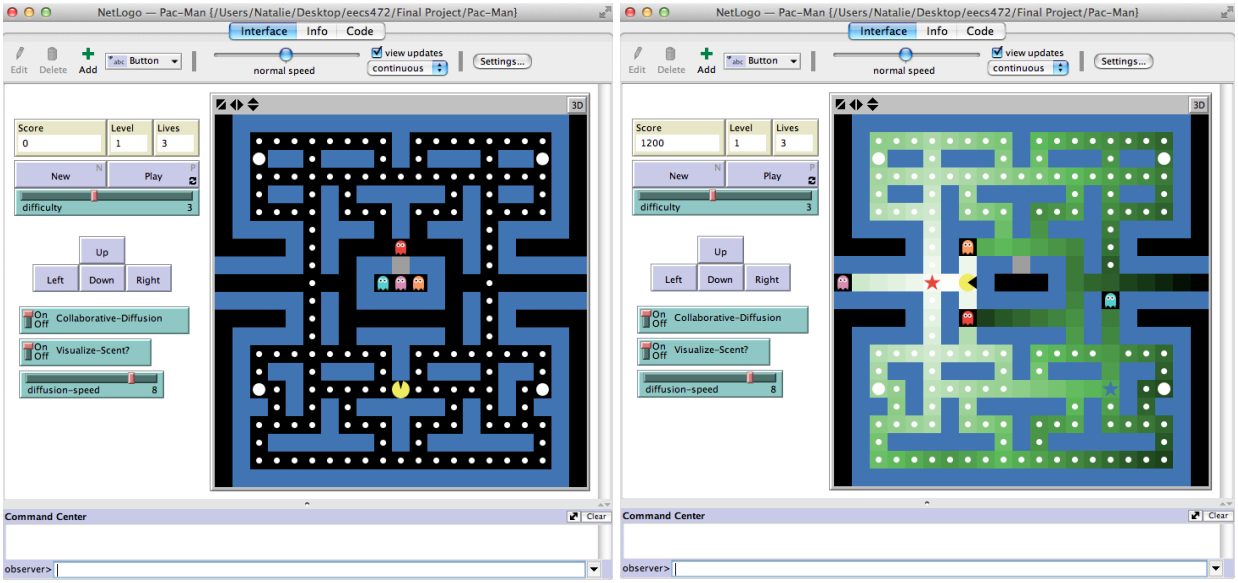
- Stop the simulation at different places so the students can see the effect of dampening the scent at the location of ghosts.

The last configuration, 'Draw' allows the students to draw their own mazes. See the info tab for information on the interface. Things to ask the students:
-What kind of maze works best for collaborative diffusion?
-What kind of situations don't work so well?

To discuss the code, simply look at the two procedures 'set-diffusion-values' and 'move-ghosts.' Those are the two functions that drive the program. Set-diffusion-values updates diffusion values by diffusing the scent and setting the diffusion values of walls and ghost patches to 0. Move-ghosts instructs the ghosts to orient themselves toward their neighboring patch with the strongest scent and move forward 1 in that direction.

Model 2: Pac-Man

This model is an adaptation of the Pac-Man model in the games library. The extension to it is that the ghosts search for the Pac-Man via collaborative diffusion rather than the algorithm in the original version. There is an optional visualization for the scent, and you can turn collaborative diffusion on and off.



The slider for diffusion-speed controls how many times the scent diffuses per call to set-diffusion-values. A higher diffusion speed means the scent diffuses faster.

Encourage the students to play around with the diffusion-speed slider and see how the ghosts search for the Pac-Man. Make sure they notice how the ghosts always follow the scent and take different paths to find the Pac-Man.

Model 3: Pac-Man HubNet Activity

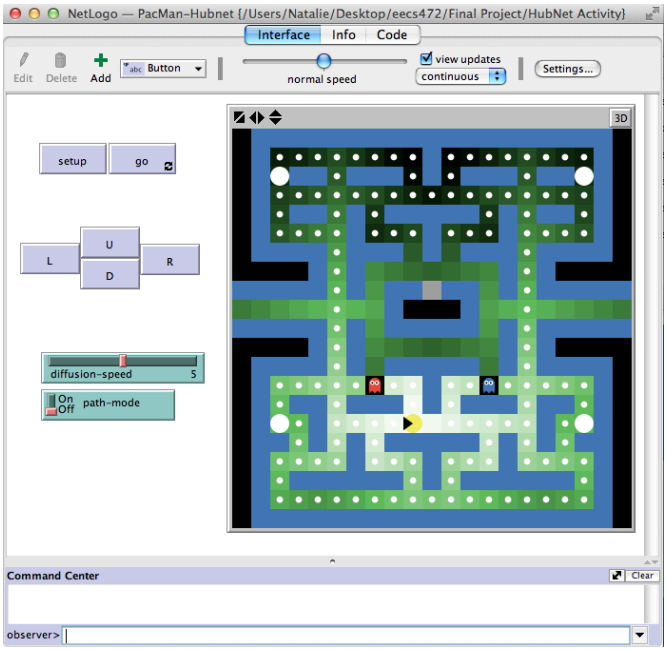
The HubNet game is a participatory simulation. It can accommodate up to five students- four ghosts and one Pac-Man. The ghosts (students, client side) only can see the walls, other ghosts, and the diffusion scent of the surrounding patches. The Pac-Man is controlled from the servant side.

Make sure HubNet is open on each of the students' computers. Open up the Pac-Man HubNet simulation in NetLogo and make sure the 2d view is mirrored for the clients. Have the students sign into the simulation (if you broadcast the server location it should just show up).

Rules to make sure the students are aware of:

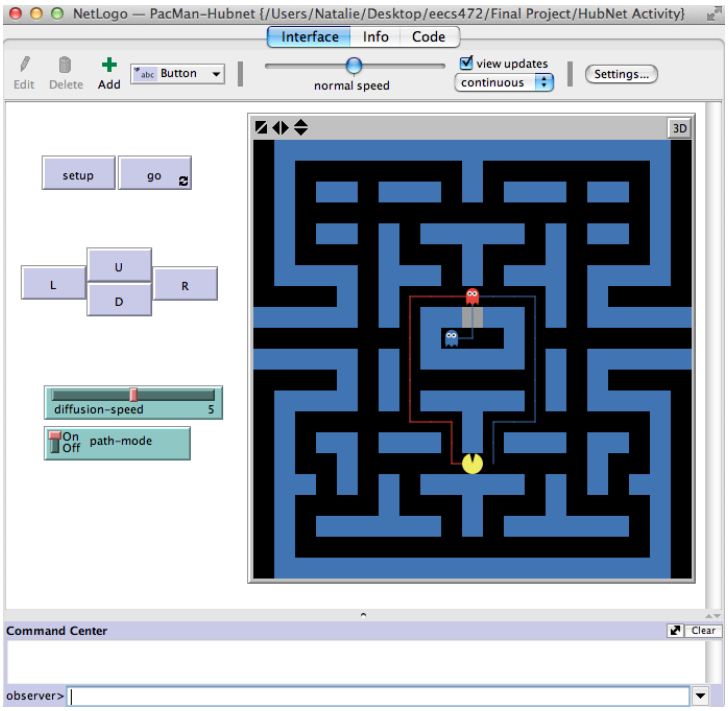
- They will only be able to see the patches surrounding them. The will not be able to see the Pac-Man, pellets, or bonuses. The can only see the walls, other ghosts, and the diffusion scent. Their goal is to use the diffusion scent to find the Pac-Man.
- Each student will simply navigate the maze by going in the direction of the brightest shade of green.
- If they are eaten, they will be able to see the entire screen so that they can return to the home base.

To control the simulation: click setup, then click go. The scent will start diffusing and whoever controls the Pac-Man can navigate using the controls on the screen.



The only new control on the screen is the switch for path-mode. Path-mode runs the simulation with all of the pellets cleared- so it is just the Pac-Man, ghosts, and scent visualization. The ghosts' paths are traced with 'pens' the color of each ghost respectively. The purpose of this aspect of the simulation is to show how the students all take different paths.

When first running the simulation it is probably best to set the path-mode switch to on and set diffusion speed to at least 4 so that the diffusion spreads faster. Leave the Pac-Man at its starting position and let the students find the Pac-Man. After they capture the Pac-Man, let the students see the main screen where the paths are shown. They will see that even with limited information, they were able to work together and take separate paths.



After that, let students rotate between playing the Pac-Man and the ghosts so they get a good idea of how collaborative diffusion works from the view of the ghost, as well as how it looks seeing their peers moving the ghosts. This activity should reinforce how simple rules result in a nice and powerful emergent behavior.

Student's view: