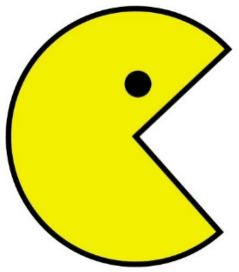

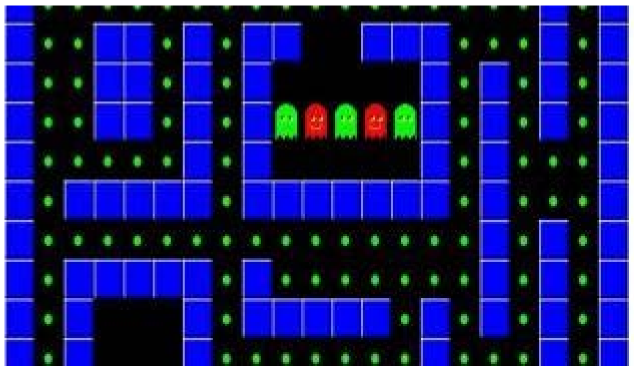

Creating "PacMan"

Create the quintessential arcade game of the 80's!
Wind your way through a maze while eating pellets.
Watch out for the ghosts!

Created by: Susan Miller, University of Colorado, School of Education

This curricula has been designed as part of the Scalable Games Design project.
It was created using portions of prior work completed by Fred Gluck and Cathy Brand.

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Vocabulary/Definitions

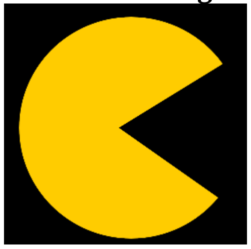
Algorithm............	a set of instructions designed to perform a specific task.
Attribute	a variable held by an agent (such as scent) that is sometimes referred to as a Local Variable
Brackets	method of setting information apart using "[" and "]"
Broadcast	controllers broadcast (or send out) a signal
Ghost	the agent that chases the PacMan
Collision	an event wherein two agents run into each other.
Diffusion..............	the process in which an attribute's values (in this game, scent) change base on the location of the source
Increment............	to increase by one
Hill Climbing.......	a specific form of searching/seeking technique, or algorithm, by which the seeking/searching agent uses information (agent attribute) embedded in the floor.
Method	a set of rules to follow in a specific situation
Parentheses..........	method of setting information apart using "(" and ")"
Polling	the process of contacting and communicating with each agent
Propagate............	the spreading of the scent
Randomly............	to occur in non-systematic ways
Rule Order..........	the order in which rules are placed for each agent
PacMan	the main character who eats the pellets as the user moves him around the worksheet.

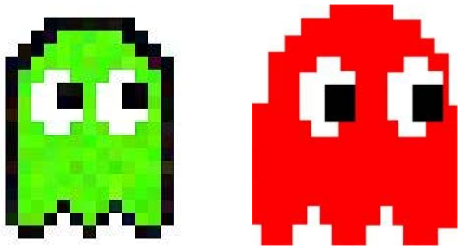
PacMan

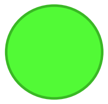
Student Handout 1:
Part I - Basic Game

Initial Story: Create the quintessential arcade game of the 80's! Wind your way through a maze while eating pellets. Watch out for the ghosts!

Create these Agents and the worksheet:

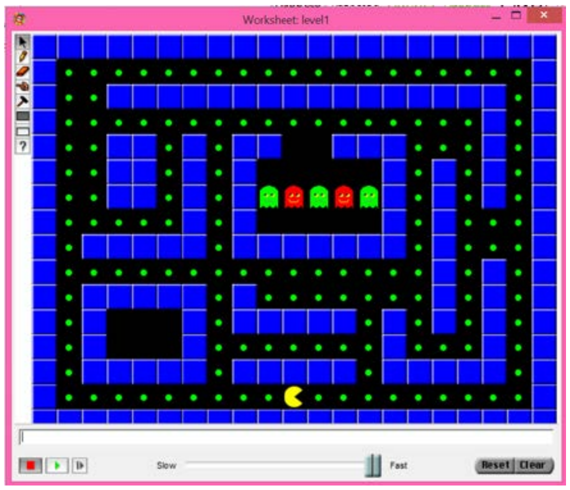

PacMan


Ghost with two depictions


pellets

Background

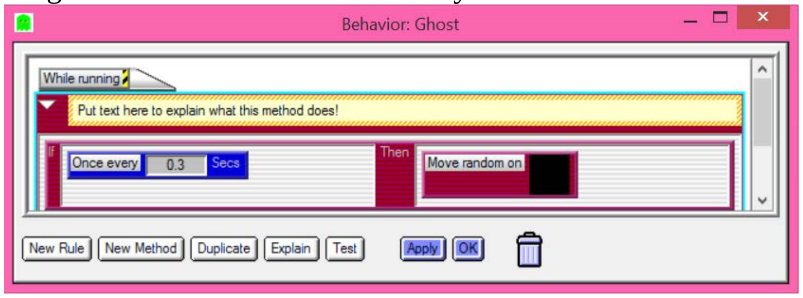
Wall



PacMan (Continued)

Create the following BEHAVIORS for your agents:

Step 1: Ghost:
Program the Ghost to move randomly on the floor.



Step 2: PacMan:

- Set up your agent to move with the arrows (cursor control).

Step 3: Prevent your PacMan from going through walls

Work with the person next to you to figure out how to prevent the PacMan from walking into a wall. Here is the code in words:
IF the <u>Up Arrow</u> is pressed AND I <u>See the FLOOR in the up direction</u>, THEN, I <u>MOVE UP</u>

Step 4: Enable your PacMan to 'eat' the pellets

Work with the person next to you to figure out how to have the PacMan eat the pellets.

Collision

The event that occurs when two agents are <u>next to</u> one another

IF the PacMan and the Pellet COLLIDE, THEN the Pellet should ERASE

If the PacMan and the Ghost COLLIDE, THEN the Game is OVER

PacMan (Continued)

Step 5: Game Over when the PacMan is next to a Ghost

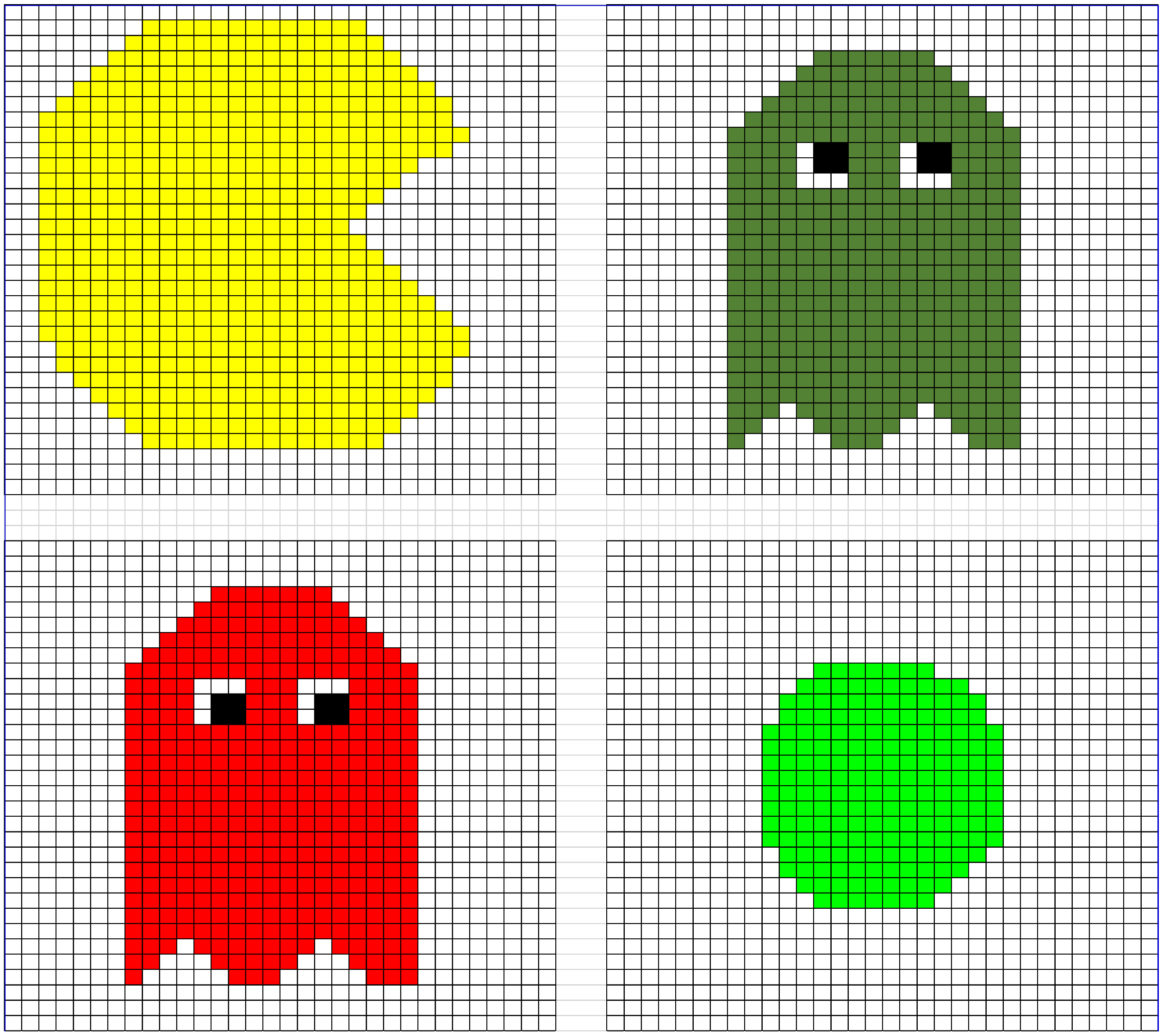
Remember to RESET the Simulation when the Game is over.

Step 5: Test your game

Play your game by pressing the green arrow.

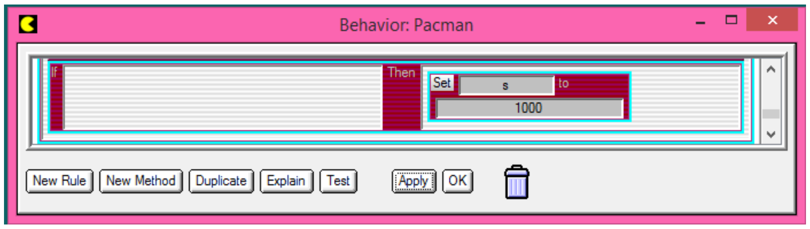
- o Does your PacMan move in all four directions?
- o Does your PacMan stay on the floor (and not go through walls)
- o Do the ghosts move randomly?
- o Does your PacMan eat pellets?
- o Does the game end when the PacMan is next to the Ghost?

Student Handout 1B:
Agent Creation short-cuts



Student Handout 2
Part 2 – Making the Ghost Chase the PacMan

Step 1:
First, let's make sure our PacMan gives off a scent. To do this, we need to set an attribute "s" (We have given the arbitrary name of the agent attribute "s" for scent) for the PacMan. There are several ways to do this. For example, we can create this set at the end of the PacMan list of rules:



This rule says to the PacMan, "If I am not doing anything else, I will emit a scent at level 1000 wherever I am." **This rule should be AFTER all the other rules for the PacMan, at the end of the list.**

Looking to challenge yourself a bit more – here are some ideas to ponder…
We may want to use a different means of setting this attribute to 1000. One option is to set the value of "s" only when we place the PacMan on the worksheet. The advantage to this will appear later when we use the PacMan as a controller. To do this, we would use a "when creating" trigger for this rule.
Other potential solutions:
- use the SET action and save the workshop to set the scent to a value
- use a onceEvery (1.0) timer condition.

[1] Note that this method simulates the beginning of the diffusion process – however, in the actual diffusion process, the smell would become evenly distributed eventually, which will not occur in this model.

PacMan (Continued)

Step 2:
Now, since the scent is diffusing, or spreading out, we need to find the average of the scent from the area around that piece of ground. Think of it as the smells are coming in from the North, South, East and West. The smell in the center, then, is the average of these four smells. How will you create that programmatically?

Diffuse the scent with the pellets

The pellet agent will have the behavior below; the single action is to calculate and store the average of the four surrounding agents' agent attributes. Remember, you used the arbitrary name of the agent attribute "s" (for scent).

The "set" action sets each ground agent's attribute "s" to the average of the attributes in the agents above, below, and on each side:

S = 0.25*(s[up]+s[down]+s[right]+s[left])

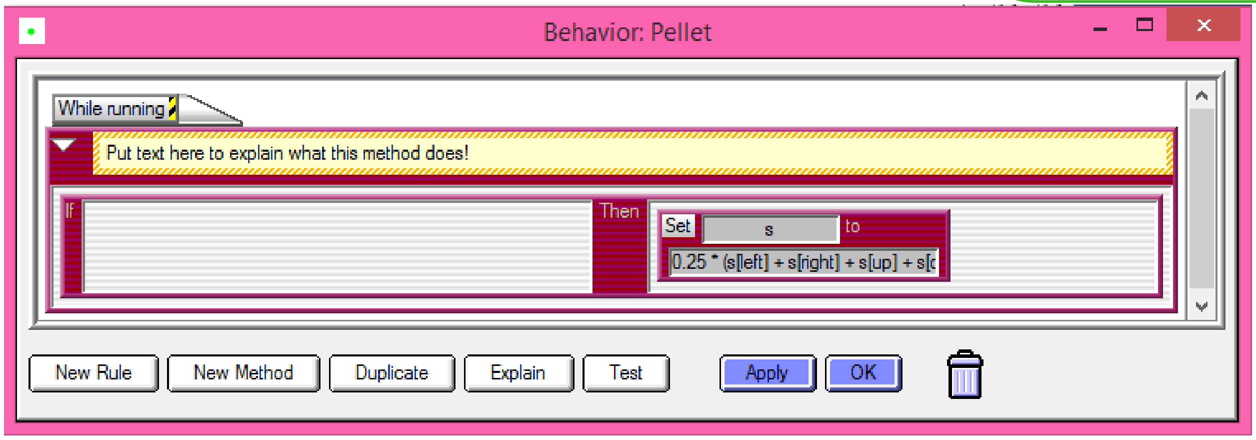
OR

S = (s[up]+s[down]+s[right]+s[left])/4

Why do we multiply by 0.25?

When you find the average of a set of numbers, you add them up and divide by the number of numbers.

In this case, dividing by 4 is the same as multiplying by 0.25



Put text here to explain what this method does!

If Then Set s to 0.25 * (s[left] + s[right] + s[up] + s[c

NOW…diffuse the scent across the ground!

Match both the parentheses "(" and the brackets "[" as shown in the equation.

PacMan (Continued)

What do FIRE ALARMS have to do with coding?

A METHOD is a set of rules with a name…rules to follow in a specific situation. These are done when there is a specific call for them…much like the fire alarm means you follow different rules. You can create a METHOD by clicking "New Method" at the bottom of the behavior box for the Ghost.

Step 3:

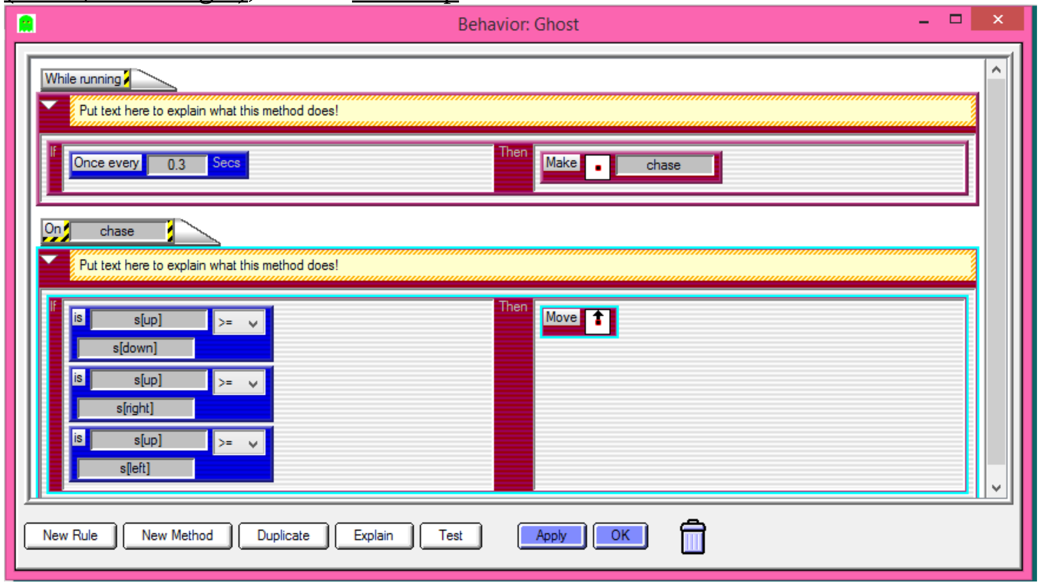
For the Ghost to know which way to walk, he has to determine where the scent is the strongest. We call this HILL CLIMBING. If this were real life, he would smell up, smell down, smell left and smell right. Wherever the smell was strongest, he would walk in that direction. We need to program the Ghost to do this.

We will create a METHOD for the Ghost to follow a set of rules.

Take a look at the programming below. Here's what it says…

ONCE EVERY 0.5 seconds, follow the Navigate procedure.

IF <u>the smell **above you** is greater than or equal to any of the other smells in different directions (down, left or right)</u>, THEN <u>move up</u>.


Behavior: Ghost

While running
Put text here to explain what this method does!
If Once every 0.3 Secs Then Make chase

On chase
Put text here to explain what this method does!
If is s[up] >= s[down]
is s[up] >= s[right]
is s[up] >= s[left]
Then Move

Now, add the rest of the rules so that the Ghost knows what to do if the smell down (s[down]) is greater…What if the smell to the left is greater? What about the smell to the right?

Run your game to see if the Ghost chases the PacMan! If it isn't working, it's time to do some troubleshooting.

Check the following:

- Location of the rules
- Use of Method
- Use of parentheses and brackets

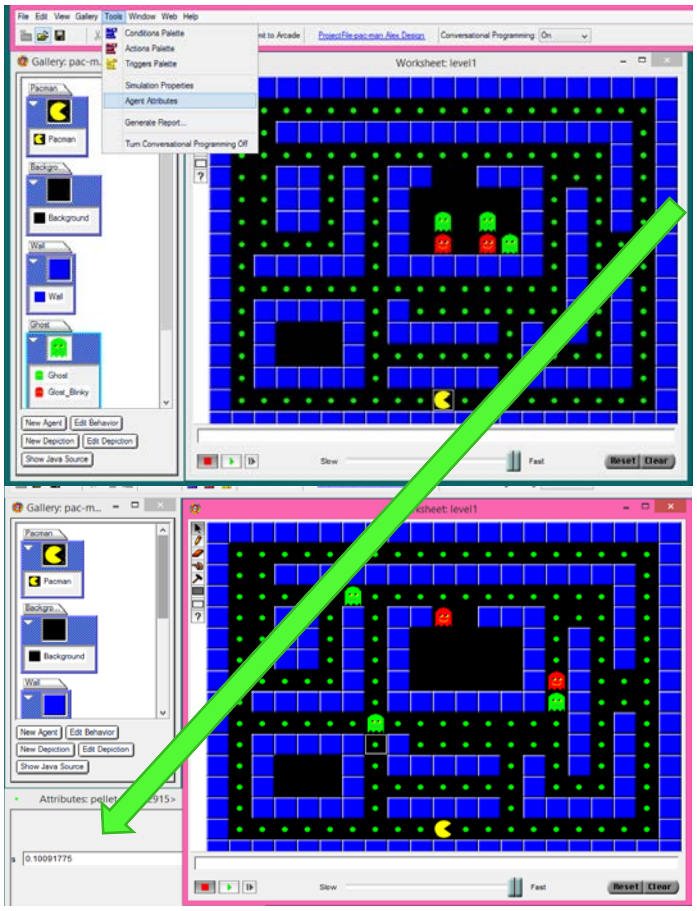
Student Handout:

Troubleshooting Guide for PacMan Part II

Diffusion and Hill Climbing

Step 1:

To determine what is happening in your game, it is sometimes helpful to look at the agent attributes. On your worksheet, click run until the ghosts move out of the box, and then click stop. Do not reset at this point. Your PacMan has now emitted his scent. You can see his scent (the value of s) by clicking anywhere on the ground and then on clicking on Tools>>Agent Attributes.

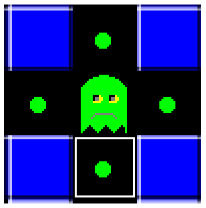


Attributes: pellet ...915>

s 0.10091775

A box will appear that lists the attribute value for that agent. You can see it in the box below.

In this box is the value of the scent to the left of this Ghost. By checking the attributes of the four boxes around the Ghost (up, down, left and right) and then running the game again, you can see if your Ghost is doing what you expected him to do.



If he isn't, go back and check your rules and methods. Some things to consider:

- **Spelling**
- **Parentheses/Brackets**
- **Rule Order**

PacMan

Student Handout 3
Part 3:
Making the game sophisticaed – Polling and Broadcast

In this enhancement to the PacMan project, the PacMan must "eat" all of the pellets in order to win. The game does not end until all of the pellets are gone.

To accomplish this, we introduce the concept of a SIMULATION PROPERTIES, which are bits of information that are shared among all agents in a project.

You can choose to use the PacMan as the "Controller" or make a separate Controller to manage the process of polling the pellets to determine when they are all "eaten"; that is, when there are none left on the worksheet.

Step 1: Counting up the pellets to see if you won

Imagine this conversation…

The teacher has given an assignment to the class and wants to know if everyone is finished. She says to the class, "Put your hand up if you are still working." Hands go up. She counts them – there are five students still working. "Okay, put your hands down and keep working."

A few minutes later, she does it again. She says to the class, "Put your hand up if you are still working." Hands go up. She counts them – there are two students still working. "Okay, put your hands down and keep working."

A few minutes later, she does it again. She says to the class, "Put your hand up if you are still working." This time, no hands go up. "Everyone is done, put your books away"

That's what this programming will look like. The Controller will say, "Pellet count starts at zero" (like the classroom, no hands are up when the teacher asks who is still working). When the pellets 'hear' the Controller ask (broadcast) the question, the pellets respond back (raise their hands). The controller counts the pellets. If the answer is more than zero, nothing happens and the game continues. If the answer is zero (meaning that there are no remaining pellets on the board), the game ends.

PacMan (Continued)

There are three parts to the Controller behavior.

Part 1: Set the number of pellets to zero. (this is like the teacher saying "hands down")
Set @pellets to zero

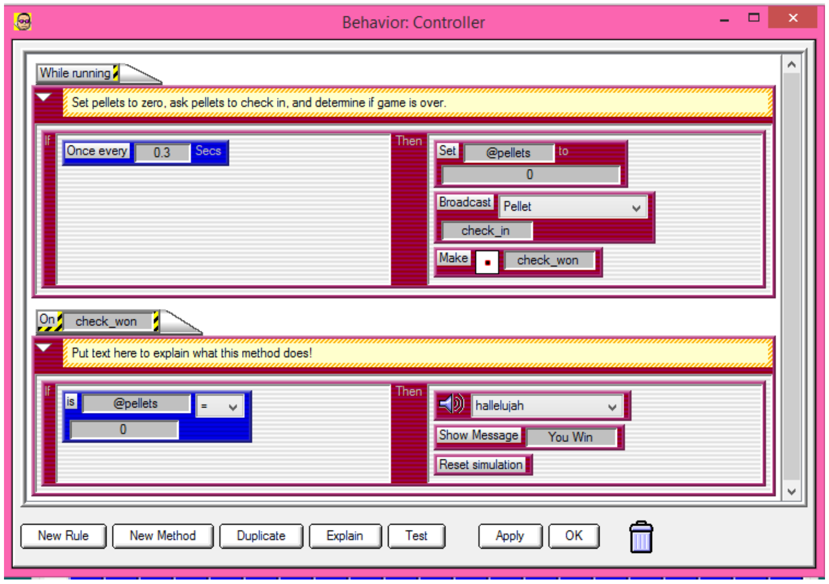
Part 2: Ask the pellets (broadcast/polling) if they are still on the board
Broadcast Pellets check_in

Part 3: Use the count of the pellets to see if the game is done.
Make myself check-won

How do Simulation Properties Work?

In the "While Running" method, the control first sets the simulation property "@pellets" to zero. Then it broadcasts a signal to all pellets. This broadcast is called polling. Finally, the controller calls upon the "check_won" method to determine whether the game is won. This is true only if there are no pellets remaining, which is determined by the @pellets simulation property being zero. If any pellets are left, we will see that this simulation property will be greater than zero

Your behavior for the PacMan or Controller should look like this:



```
While running
Set pellets to zero, ask pellets to check in, and determine if game is over.
If  Once every 0.3 Secs
Then  Set @pellets to 0
      Broadcast Pellet check_in
      Make ● check_won

On check_won
Put text here to explain what this method does!
If  is @pellets = 0
Then  hallelujah
      Show Message You Win
      Reset simulation
```

PacMan (Continued)

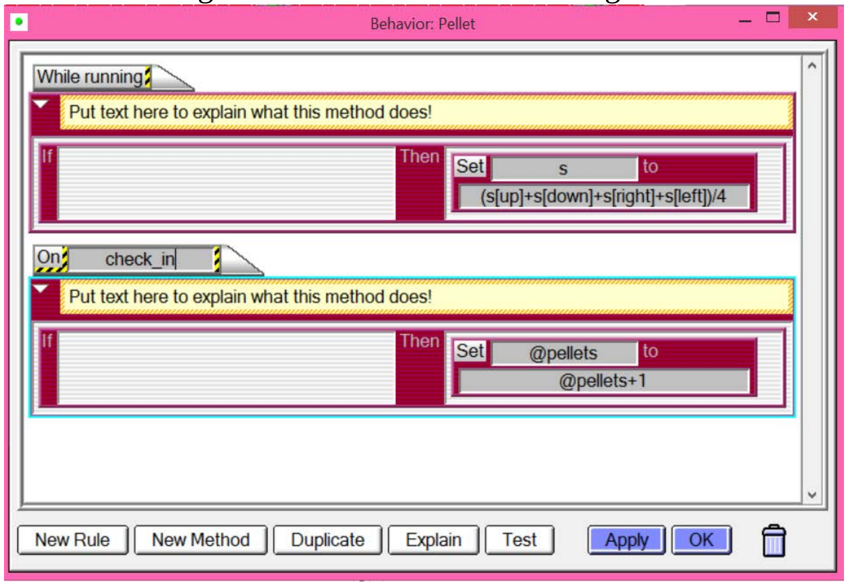
Pellet behavior changes: The controller has told the pellets to "check_in" but they don't know how to do that. We have to program them to check in when asked.

- The rule will tell the pellet agent to respond to the "poll" (broadcast) called *check_in* from the Controller, to update the @pellets simulation property.

Helpful Tips

This change is in the form of a separate method; it is not part of the continually running "While Running" method, since it only runs when called by the controller agent.

During *check_in*, each remaining pellet agent will increase (or **increment**) the @pellets simulation property. If no pellet agents remain, then the @pellets property will be zero, which the controller agent will detect and declare the game won.


Behavior: Pellet

While running
Put text here to explain what this method does!
If | Then Set s to (s[up]+s[down]+s[right]+s[left])/4

On check_in
Put text here to explain what this method does!
If | Then Set @pellets to @pellets+1

SCALABLE GAME DESIGN

PacMan

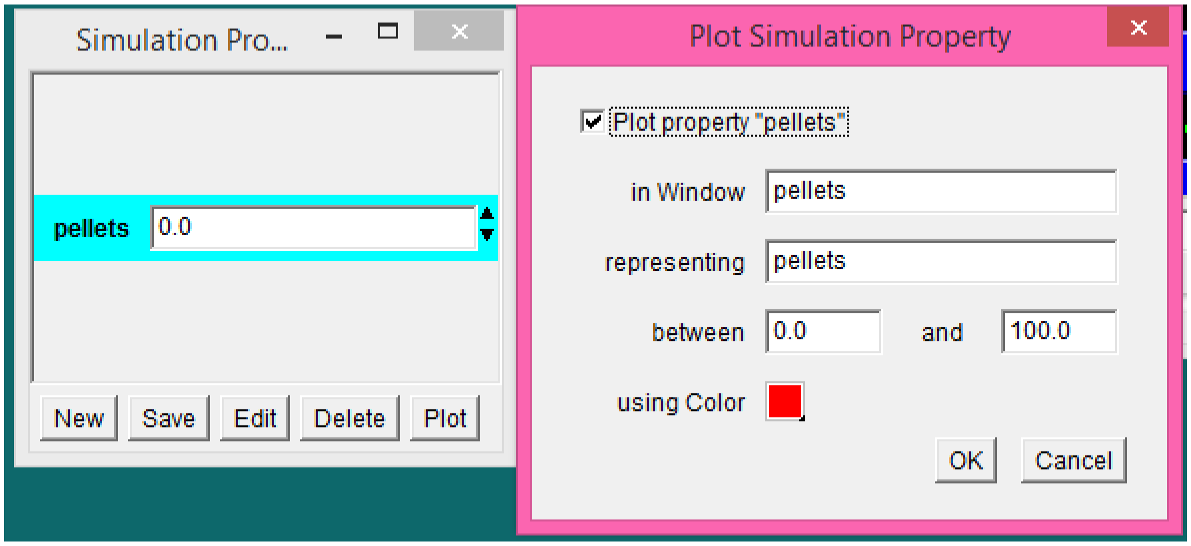
Student Handout:

Troubleshooting Guide for PacMan Part III

Polling and Broadcast

More detailed troubleshooting:

To determine what is happening in your game, it is sometimes helpful to look at what the simulation property is doing. To do this, have your worksheet open as well as the simulation property box (Tools>>Simulation Property). Click on the property, and then click on Plot. It will look like this:



pellets 0.0

☑ Plot property "pellets"

in Window: pellets

representing: pellets

between 0.0 and 100.0

using Color 🟥

Click Plot Property ‘pellets’. Change the plot to graph between 0 and the total number of pellets on your worksheet

This will provide a graph that shows you what’s happening ‘behind the scenes’ while you play the game. This information will help you determine where a mistake may be. For example, if the pellets never goes above 0, there is a problem with the method ‘check_in’ or the broadcast. If the pellets goes to zero but the game doesn’t end, there is a problem with the game ending commands with the controller.

End of Unit Review Sheet - PacMan

A) The main computational thinking patterns we reviewed were:

1) **User Control**: intentionally moving an agent.
    a. Using keyboard keys to move an agent.
    b. Example is moving the PacMan.

2) **Absorb**: deleting agents on the screen.
    a. Use the "Erase" action in AgentSheets.
    b. Examples are erasing the pellets.

3) **Collision**: when 2 agents collide (run into each other).
    a. Use the "See" condition
    b. Use the "Stacked" condition, OR
    c. Use the "Next to" condition.
    d. Examples are the eating pellets and losing the game when the ghosts touch the PacMan.

B) The main NEW computational thinking patterns we learned were:

1) **Diffusion**: spreading the scent (smell) of an agent across a medium (like the background). We use an agent attribute (like s = 1000) on the agent with the smell, and we diffuse the smell by setting the attribute on the background using the average of the 4 smells around it; like the smell on the city background,

    s = (s[left]+s[right]+s[up]+s[down])/4.

2) **Hill Climbing**: following the highest scent. It only works if there is diffusion done with it, so they go hand in hand. Example is the method we created on the Ghost to follow the highest value of the scent "s" around him.

3) **Broadcasting**: is when we "shout out" to all agents of a certain type requesting them to execute a specific method.

    a. Use the "broadcast" action in AgentSheets.

    b. Example is the broadcast to the Controller - the method check_in" to check in with the pellets to see if they are still there.

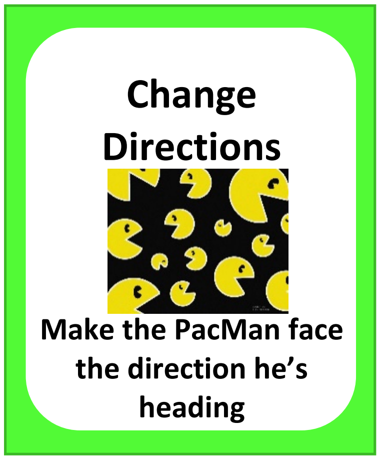
C) Other concepts we covered in AgentSheets are:

1) Troubleshooting the simulation, and considering rule order.
2) Using sounds and messages in the game.
3) Timing our actions using the "Once every" condition.

SCALABLE GAME DESIGN

Student Handout 4a:

PacMan Changes Direction Challenge



Before your start this challenge:

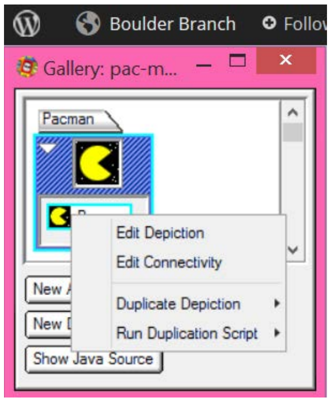
You must have a complete basic PacMan game with a PacMan who wins if s/he eats all the pellets and Ghosts who either move randomly or chase the PacMan. The PacMan loses if a Ghost gets too close. The worksheet should have walls that the Ghost and PacMan cannot cross.

Description of the Challenge:

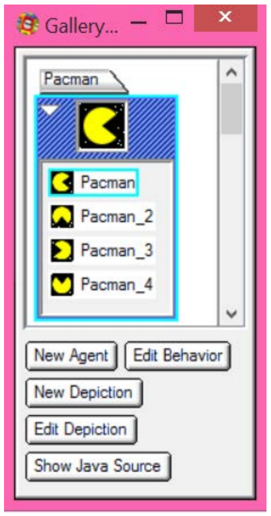
- PacMan will turn in the direction he's heading.

What to consider:
Do you need a new agent?
Do you need a new rule?

You might be thinking you need new agents…BUT WAIT! Since each PacMan will follow the same rules, you don't need a new agent, but rather a new DEPICTION…



Right click on the depiction of the original agent. Check out the options under "duplicate depiction" and "run duplication script" to figure out how to create three other directions of the PacMan. You may want to rename them to help you stay organized. When you have done it correctly, it will look like this →.



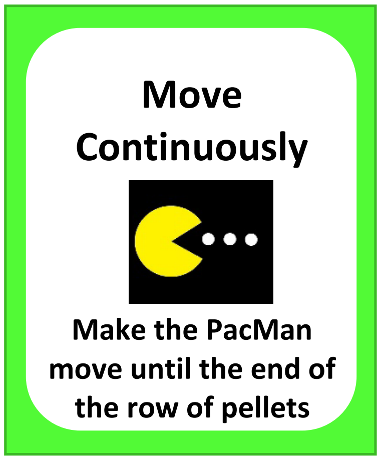
Once you have the different depictions, you will want to change your code so that WHEN THE PACMAN MOVES, it CHANGES into the new DEPICTION.

TEST your program to confirm that the depiction changes when the PacMan changes directions.

Student Handout 4b:

PacMan Moves Continuously

Challenge



Before your start this challenge:

You must have a complete basic PacMan game with a PacMan who wins if s/he eats all the pellets and Ghosts who either move randomly or chase the PacMan. The PacMan loses if a Ghost gets too close. The worksheet should have walls that the Ghost and PacMan cannot cross.

You must have different depictions of the PacMan so that he faces the direction he heads.

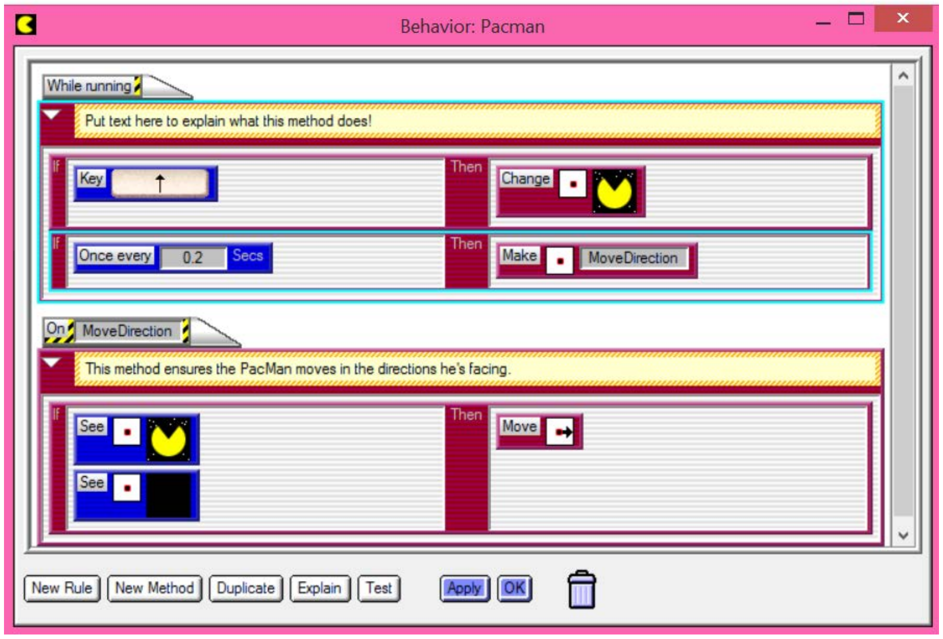
Description of the Challenge:

- PacMan will continuously move in the direction he's heading.

This challenge gets you started, but won't give you all the code. Review the code below: It says, when the up arrow is pressed, change to the up depiction. Once every 0.2 second, make me (the PacMan) MoveDirection.

When the MoveDirection method is called, the PacMan does the following:

If I see myself heading up AND I see the floor in the up direction, I will move up.



PacMan (Continued)

There is still much to code:

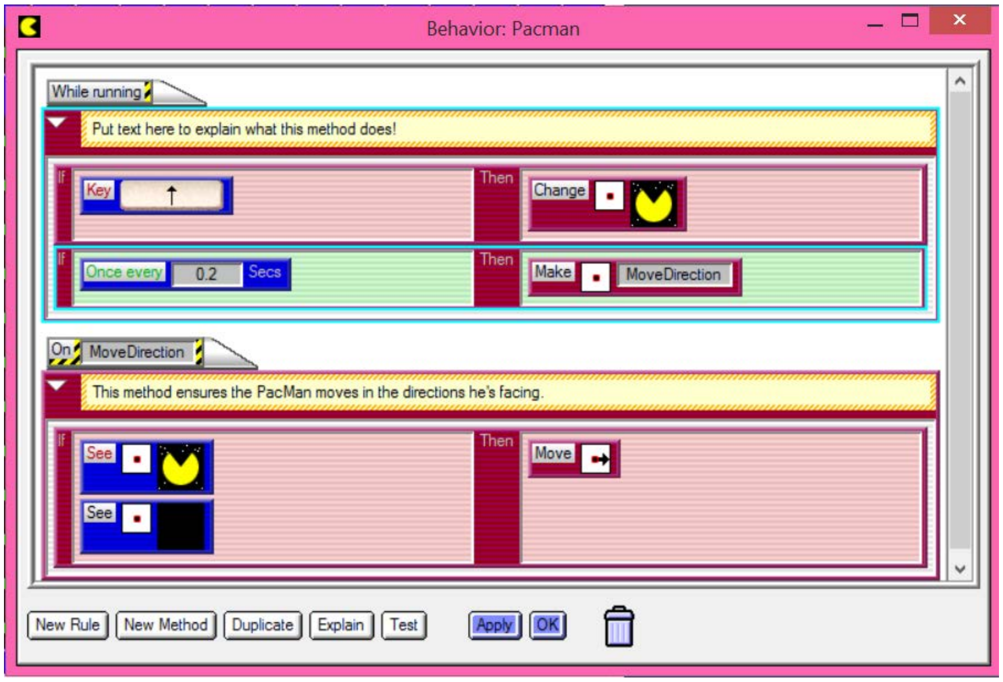
Step 1:
Add code to tell the PacMan what to do when he sees an up depiction **<u>and</u>** a pellet in the up direction.

Step 2:
Create code for all the other directions.

Step 3:
Test your program. (Hint: be sure your PacMan still leaves his scent everywhere.) Click on the PacMan and run the program. Use the colors to decide which rules are true or false. In this case, the first rule is red, which means the Up arrow was not pressed.

The next rule is green, which means every 0.2 seconds, the PacMan is being told to MoveDirection.

The method MoveDirection is red, which means that either/both are true. The PacMan does not see the Up Depiction AND/OR does not see the floor, making the rule FALSE.



PacMan

Student Handout 4c: Power Pellet Challenge

Power Pellets

Make a Power Pellet that allows the PacMan to eat the ghosts.

Before your start this challenge:

You must have a complete basic PacMan game with a PacMan who wins if s/he eats all the pellets and Ghosts who either move randomly or chase the PacMan. The PacMan loses if a Ghost gets too close. The worksheet should have walls that the Ghost and PacMan cannot cross.

You must have different depictions of the PacMan so that he faces the direction he heads, and he must move continuously.

Description of the Challenge:

- Power Pellets are added to the worksheet
- Power Pellets provide Pac-Man with the temporary ability to eat the enemies. The enemies turn deep blue, and reverse direction

This challenge gets you started, but won't give you all the code.

To help you think this through…

- You will need a new agent (Power Pellet)
- Do you need a new agent for the blue ghost?
- When the ghost chases the PacMan, he has a scent of 1000. What happens if he has a scent of -1000? How can you set that new scent? How can you time-limit that value?
- Hint: Use the **hill climbing** action rather than all the code for sniffing.

SCALABLE GAME DESIGN

PacMan

Student Handout 4d:

Next Level

Challenge

Next Level

Next Level!

Make a second level for your PacMan!

Before your start this challenge:

You must have a complete basic PacMan game with a PacMan who wins if s/he eats all the pellets and Ghosts who either move randomly or chase the PacMan. The PacMan loses if a Ghost gets too close. The worksheet should have walls that the Ghost and PacMan cannot cross.

You must have different depictions of the PacMan so that he faces the direction he heads, and he must move continuously.

Description of the Challenge:

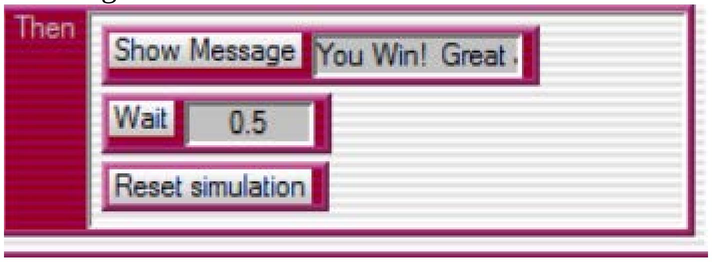
- When the game ends, a new level appears, even harder than before!

This challenge gets you started, but won't give you all the code.

To help you think this through…

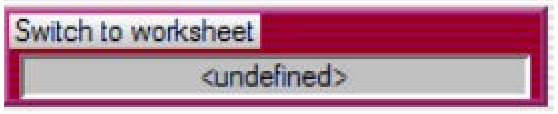
- Do you need a new agent? A new worksheet?
- When would a new level appear?
- What code needs to change to make the new level appear?

You might have code like this:



```
Then
    Show Message  You Win!  Great
    Wait  0.5
    Reset simulation
```

How could you incorporate this action instead?



```
Switch to worksheet
    <undefined>
```

HINT: You will need to BROWSE to name the new level properly. Click in the box, do not just type in the name.