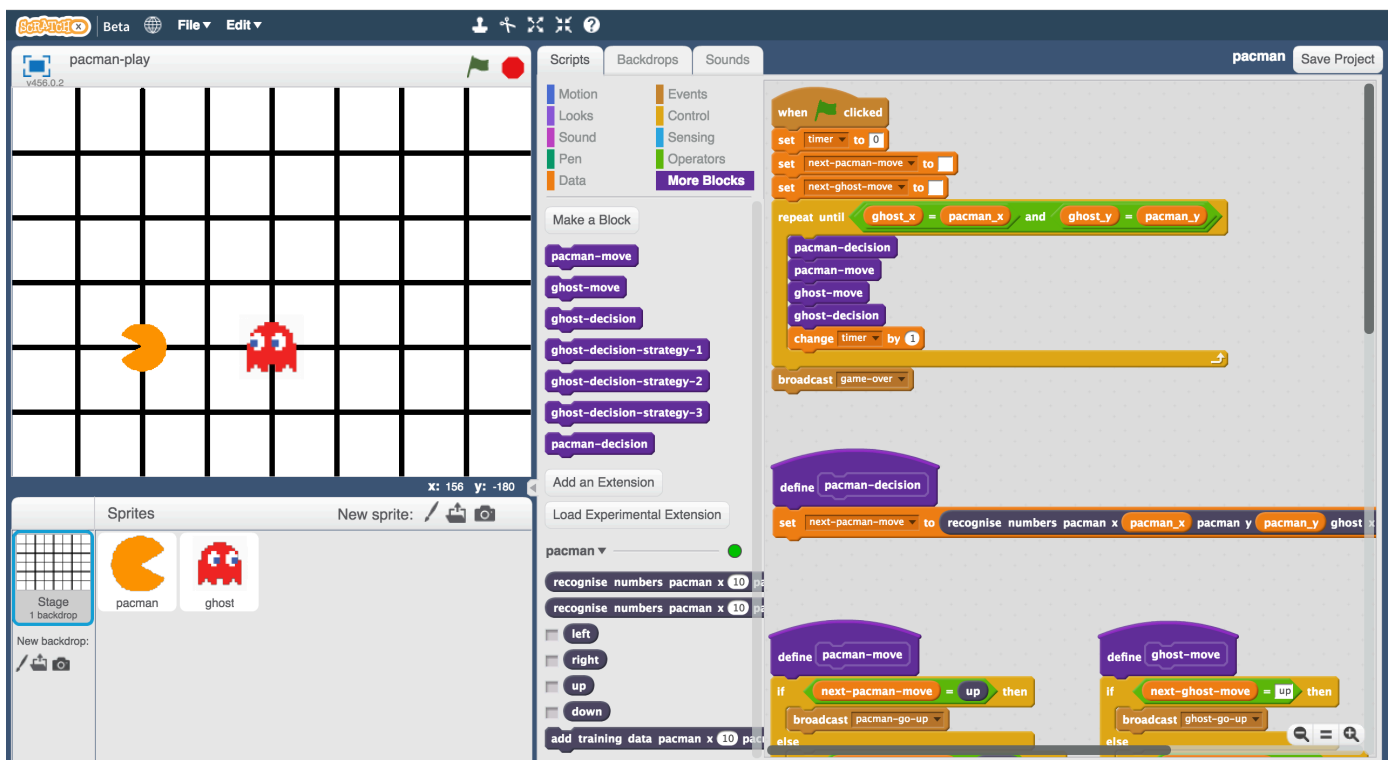


# Pac-Man

In this project you will create a Pac-Man game in Scratch that is able to learn from how you play.

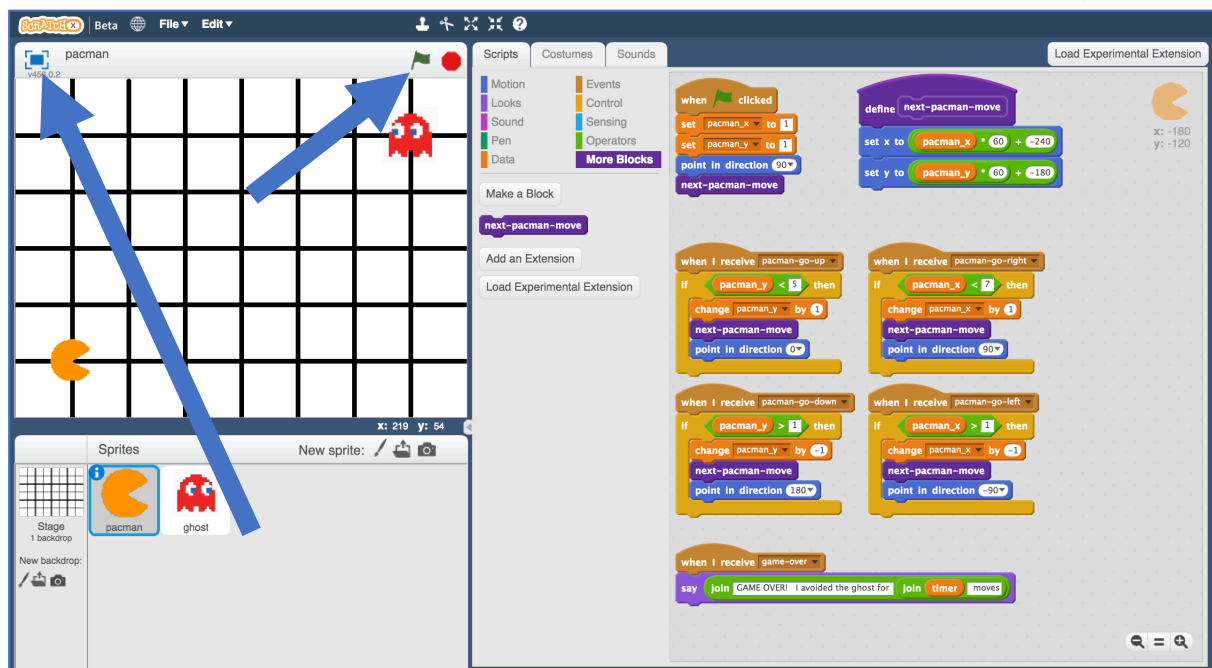
You won't give it instructions for how to play, or tell it what the objective or rules of the game are.

Instead, you'll show it examples of you playing the game.



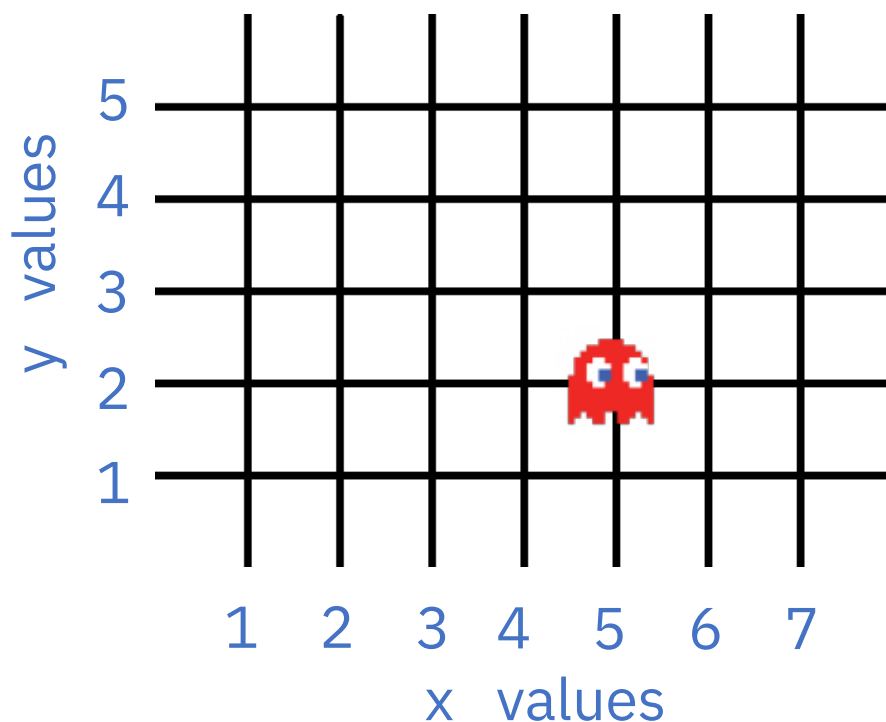
This project worksheet is licensed under a Creative Commons Attribution Non-Commercial Share-Alike License  
<http://creativecommons.org/licenses/by-nc-sa/4.0/>

1. Go to <https://machinelearningforkids.co.uk/scratchx> in a browser.
2. Open the **pacman.sbx** starter file for this project.  
*Click **File** -> **Load Project***  
*If you haven't got this file, ask your teacher or group leader.*
3. Click the **full-screen** button, and then click the Green Flag



4. Play a few games of Pac-Man  
*You control Pac-Man, and have to avoid the ghost as long as you can.*  
*Use the arrow keys to control Pac-Man's next move.*  
*Click the green flag to start a new game.*
5. Try to come up with a plan for how Pac-Man can avoid the ghost

## Representing Pac-Man in Scratch



The game board is a graph, with both Pac-Man and the ghost only able to travel along lines.

The location of each character is stored as:

- \* an x-value (a number from 1 to 7)
- \* a y-value (a number from 1 to 5)

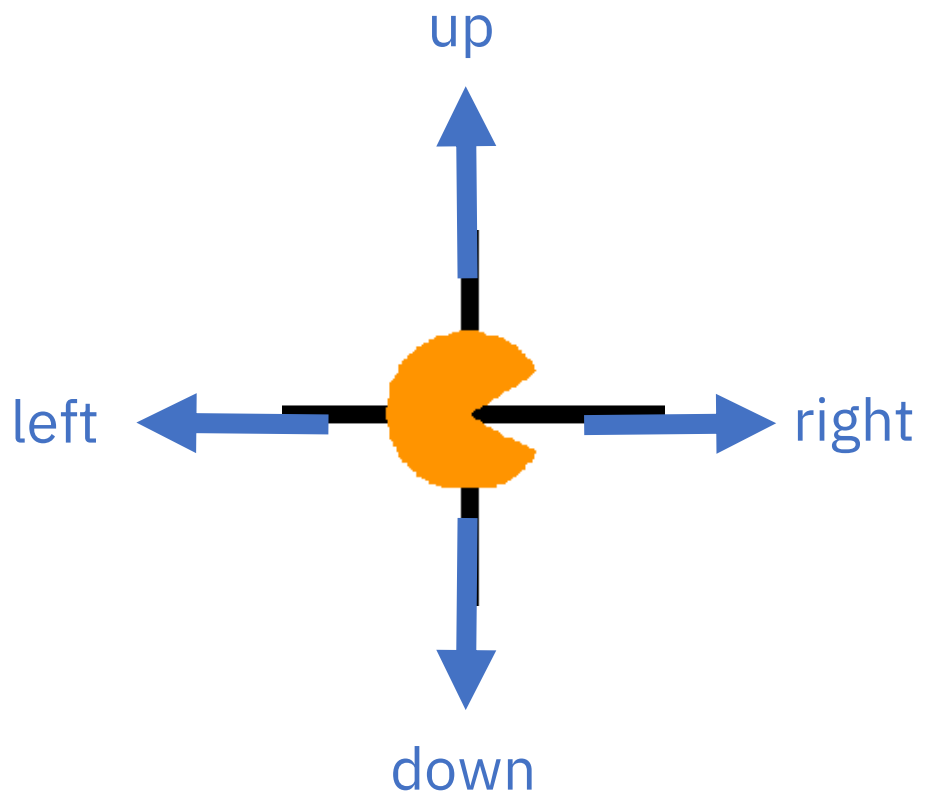
For example, the ghost shown on the left is at:

X = 5

Y = 2

At each turn, each character has to choose between four possible moves: up, down, left, right.

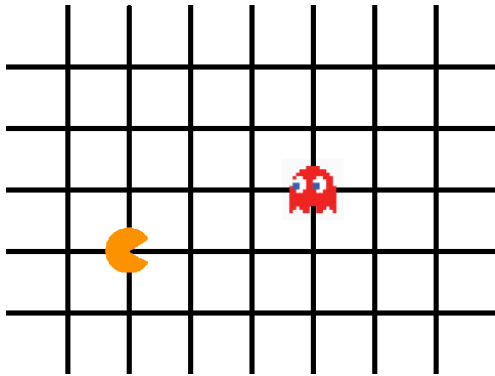
There are no diagonal moves.



## What are you going to do?

You're going to train Pac-Man to avoid the ghost. You'll do this by showing it examples of how you play the game.

Imagine the board looks like this:

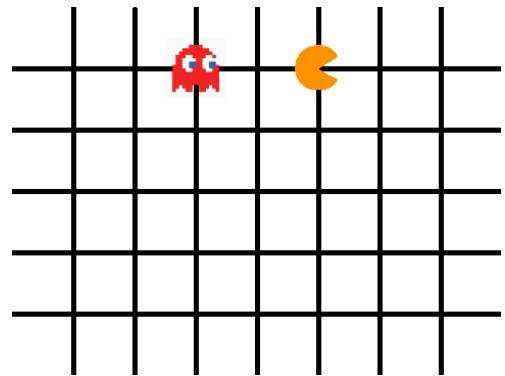


Imagine you decide to go up:

pacman x	2
pacman y	2
ghost x	5
ghost y	3

choice: up

Imagine the board looks like this:



Imagine you decide to go down:

pacman x	5
pacman y	5
ghost x	2
ghost y	5

choice: down

The computer will learn from the decisions that you make when you play the game.

That means if you make moves that avoid the ghost for a long time, the computer should learn how to avoid the ghost!

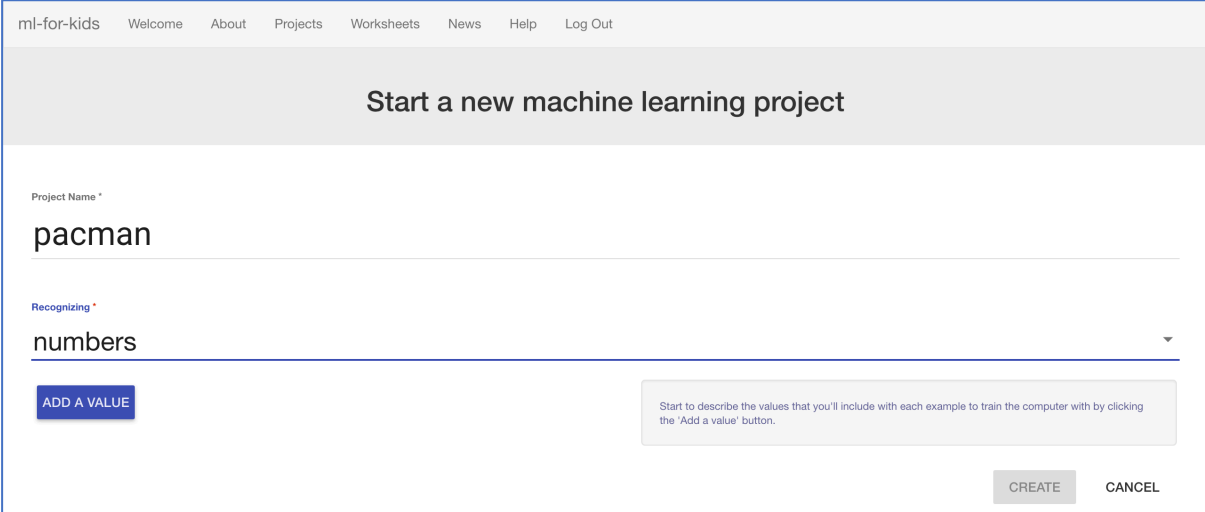
6. Close the Scratch window.
7. Go to <https://machinelearningforkids.co.uk/> in a web browser
8. Click on “Get started”

**9.** Click on **“Log In”** and type in your username and password  
*If you don’t have a username, ask your teacher or group leader to create one for you.*  
*If you can’t remember your username or password, ask your teacher or group leader to reset it for you.*

**10.** Click on **“Projects”** on the top menu bar

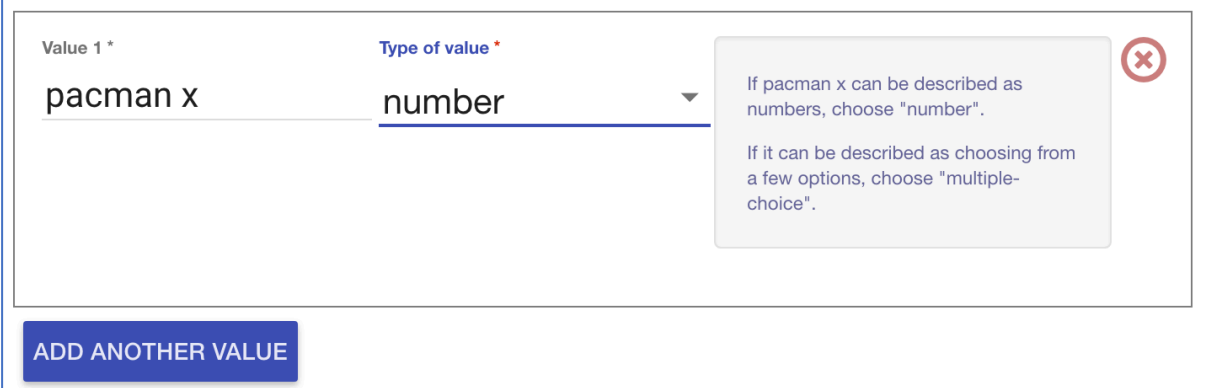
**11.** Click on the **“+ Add a new project”** button.

**12.** Name your project **“pacman”** and set it to learn how to recognise **“numbers”**



The screenshot shows a web interface for creating a new machine learning project. At the top is a navigation bar with links: ml-for-kids, Welcome, About, Projects, Worksheets, News, Help, and Log Out. Below this is a header section titled 'Start a new machine learning project'. The main form has two input fields: 'Project Name \*' with the text 'pacman' and 'Recognizing \*' with a dropdown menu showing 'numbers'. Below the 'Project Name' field is a blue button labeled 'ADD A VALUE'. To the right of this button is a light gray box with the text: 'Start to describe the values that you'll include with each example to train the computer with by clicking the 'Add a value' button.' At the bottom right of the form are two buttons: 'CREATE' and 'CANCEL'.

**13.** Click **“Add a value”** and name a value **“pacman x”** and make it a **“number”**.



The screenshot shows a form for adding a new value. It has two input fields: 'Value 1 \*' with the text 'pacman x' and 'Type of value \*' with a dropdown menu showing 'number'. To the right of the 'Type of value' dropdown is a light gray box with a red 'X' icon and the text: 'If pacman x can be described as numbers, choose "number". If it can be described as choosing from a few options, choose "multiple-choice".' Below the form is a blue button labeled 'ADD ANOTHER VALUE'.

14. Click “Add another value” again and repeat to add values for the other three positions: “pacman y”, “ghost x”, “ghost y”

The screenshot shows the 'Project Name' form. At the top, there is a text input field with 'pacman' entered. To its right is a small icon of a document. Below this is a grey box with the text: 'Give your project a name to describe what sort of thing you'll try to teach the computer to recognise.' Below the input field is a dropdown menu labeled 'Recognizing' with 'numbers' selected. There are four input fields for values, each with a 'Type of value' dropdown set to 'number'. The values are 'pacman x', 'pacman y', 'ghost x', and 'ghost y'. Each input field has a red 'X' icon in the top right corner. At the bottom left is a blue button labeled 'ADD ANOTHER VALUE'. At the bottom right are two buttons: 'CREATE' (blue) and 'CANCEL' (grey).

15. Click **Create**.

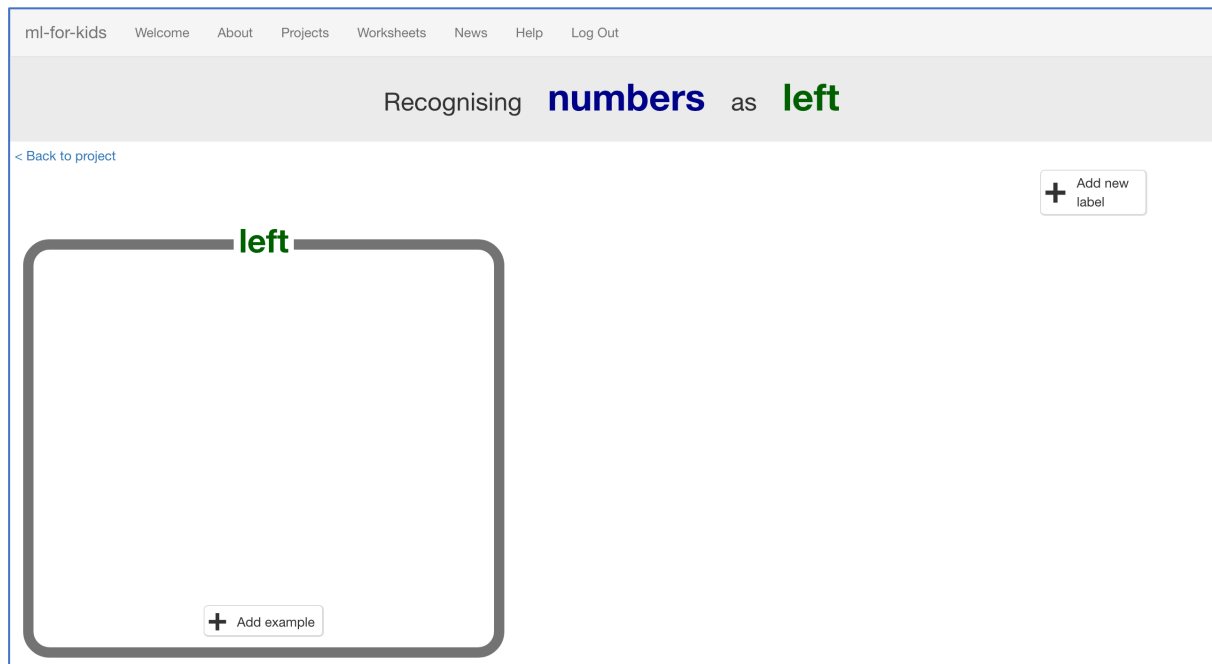
16. You should see “**pacman**” in the list of your projects. Click on it.

The screenshot shows the 'Your machine learning projects' page. At the top is a navigation bar with links: 'ml-for-kids', 'Welcome', 'About', 'Projects', 'Worksheets', 'News', 'Help', and 'Log Out'. Below the navigation bar is a grey header with the text 'Your machine learning projects'. To the right of the header is a button with a plus sign and the text 'Add a new project'. Below the header are two project cards. The first card is titled 'car or cup' and shows 'Recognising images as car or cup'. The second card is titled 'pacman' and shows 'Recognising numbers'. Each card has a trash icon to its right.

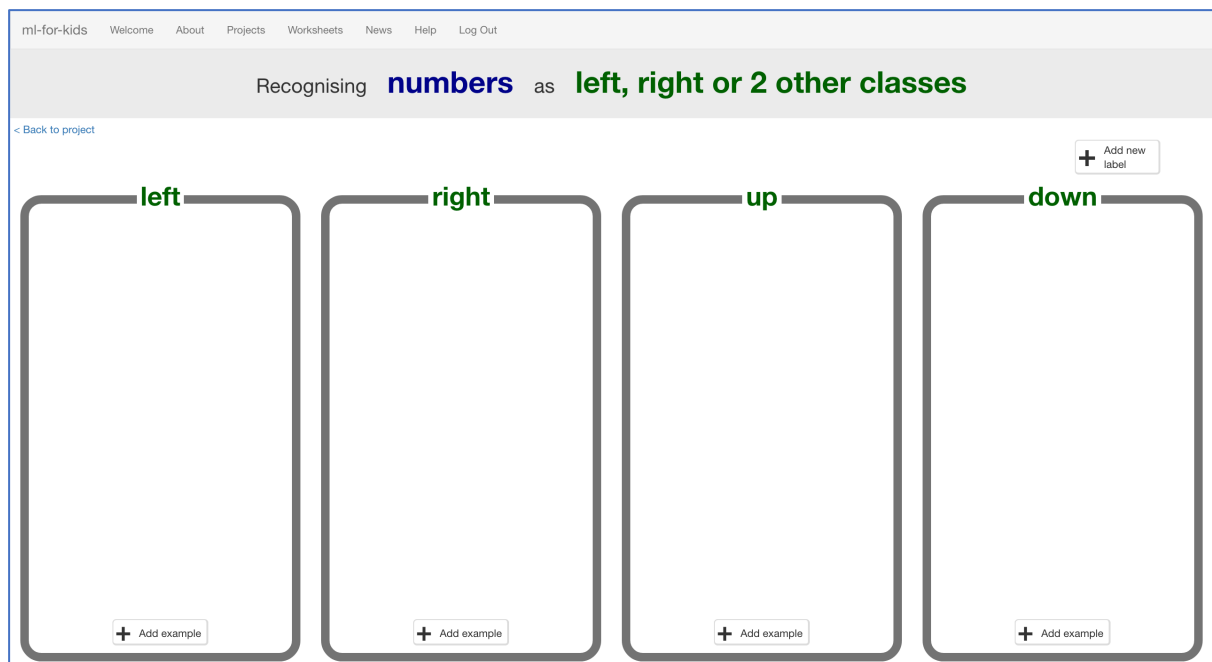
17. Click the “**Train**” button

The screenshot shows the 'pacman' project page. At the top is a navigation bar with links: 'ml-for-kids', 'Welcome', 'About', 'Projects', 'Worksheets', 'News', 'Help', and 'Log Out'. Below the navigation bar is a grey header with the text '"pacman"'. Below the header are three cards: 'Train', 'Learn & Test', and 'Scratch'. Each card has a description and a button. The 'Train' card says 'Collect examples of what you want the computer to recognise.' and has a 'Train' button. The 'Learn & Test' card says 'Use the examples to train the computer to recognise numbers.' and has a 'Learn & Test' button. The 'Scratch' card says 'Use the machine learning model you've trained to make a game in Scratch.' and has a 'Scratch' button.

- 18.** Click “+ Add new label” and create a label called “left”  
*Examples of the locations of the Pac-Man and ghost when you go left will go in this bucket.*



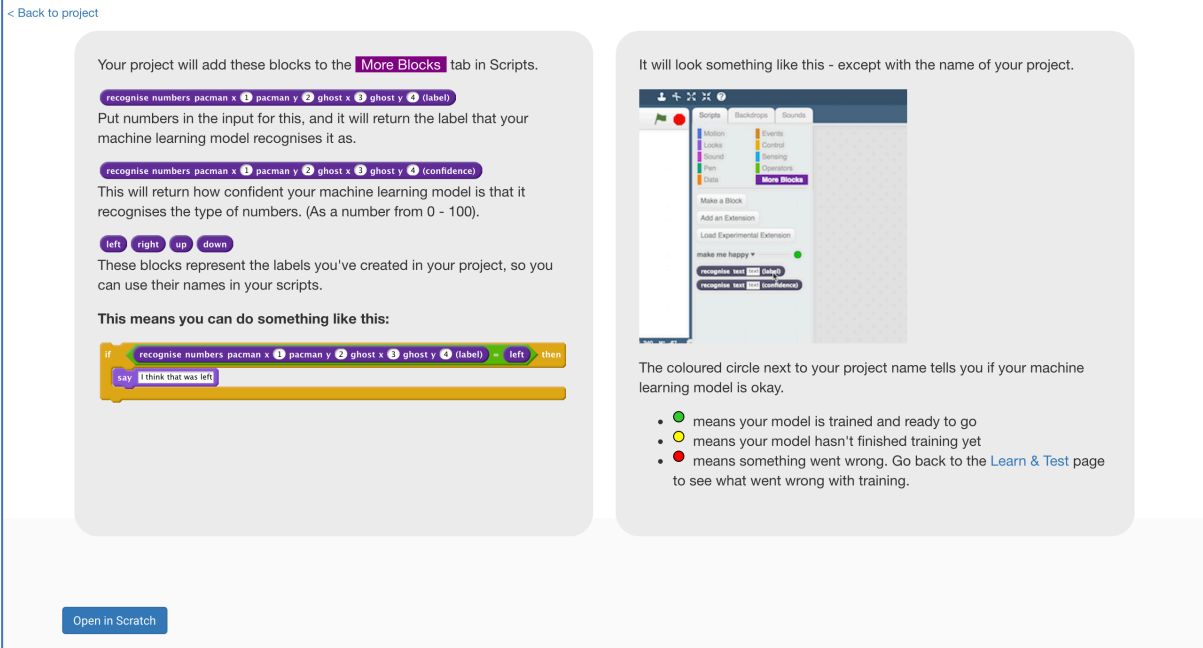
- 19.** Click “+ Add new label” again and create labels for the other three moves in the game.  
*“right”, “up”, “down”*



**20.** Click the “< Back to project” link then click **Scratch**

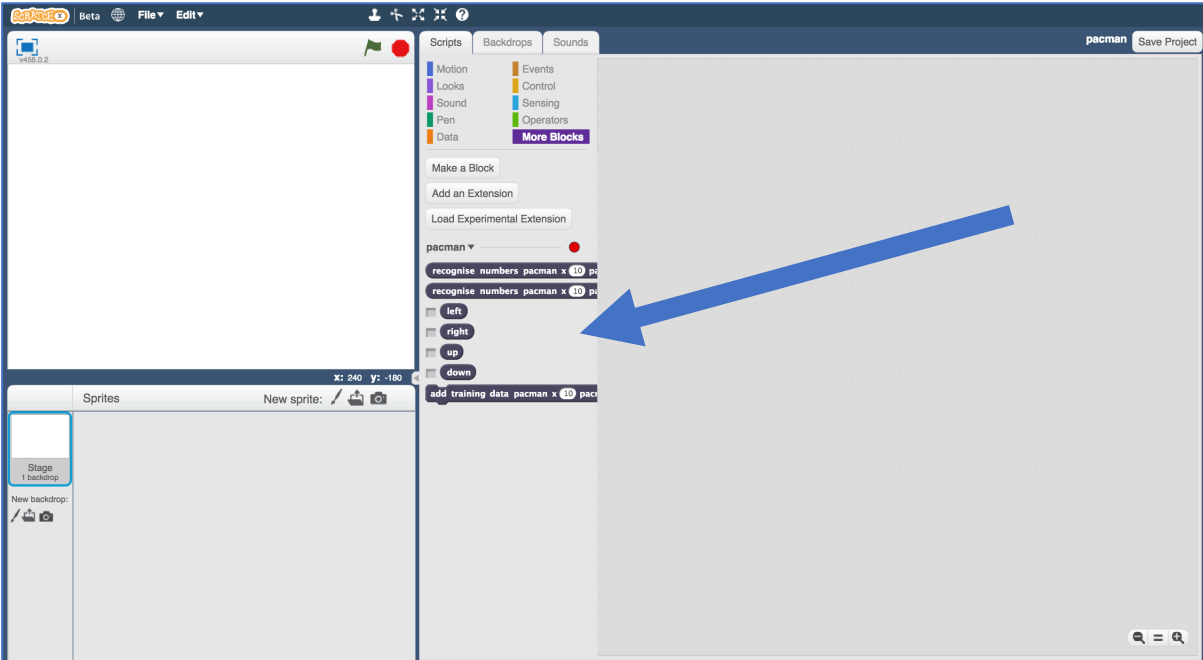
**21.** Click the **Open in Scratch** button

*It will warn you that you haven't trained the computer yet – but that's okay, as you'll use Scratch to collect the training examples. Click the “go straight into Scratch now” link.*



The screenshot shows a Scratch project setup page. On the left, there's a section titled "Your project will add these blocks to the **More Blocks** tab in Scripts." It lists several blocks: "recognise numbers pacman x 1 pacman y 2 ghost x 3 ghost y 4 (label)", "recognise numbers pacman x 1 pacman y 2 ghost x 3 ghost y 4 (confidence)", and "left right up down". It explains that these blocks represent labels and confidence values. Below this, it shows a script example: an "if" block with "recognise numbers pacman x 1 pacman y 2 ghost x 3 ghost y 4 (label)" and "left" as conditions, followed by a "say" block with the text "I think that was left". On the right, there's a section titled "It will look something like this - except with the name of your project." It shows a preview of the Scratch interface with the "More Blocks" tab selected. Below this, it explains the colored circle next to the project name: a green circle means the model is trained and ready to go, a yellow circle means the model hasn't finished training yet, and a red circle means something went wrong. At the bottom left, there is a blue button labeled "Open in Scratch".

**22.** You should see new blocks in the “**More blocks**” section from your “pacman” project.

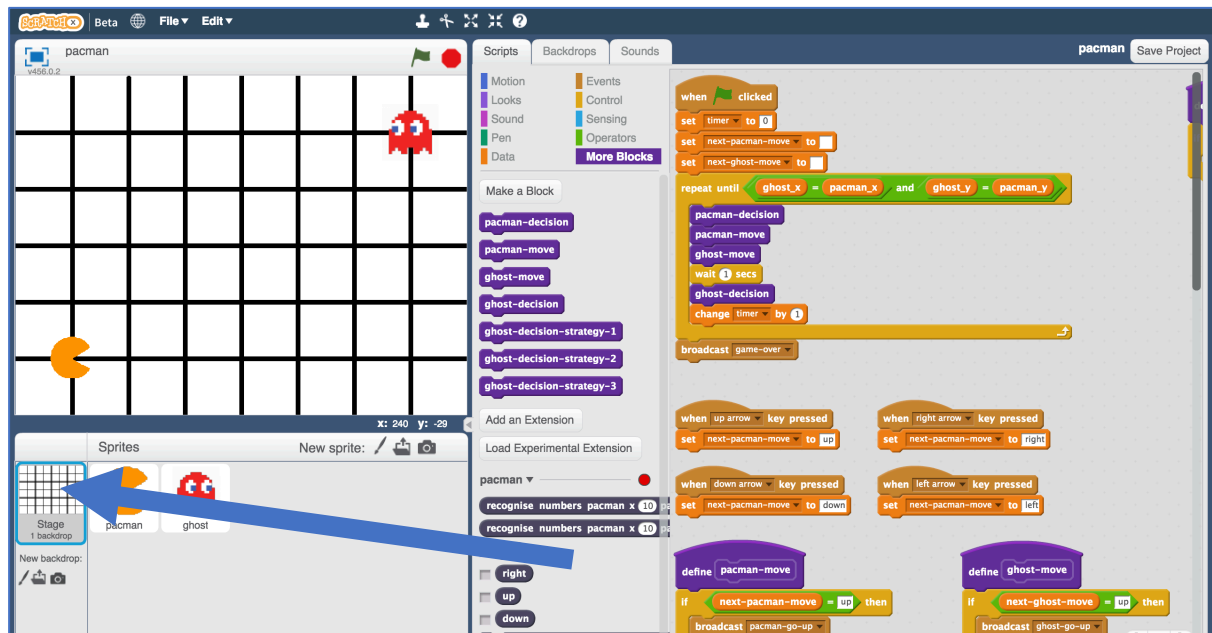


The screenshot shows the Scratch interface. The "More Blocks" section is expanded, showing several new blocks: "recognise numbers pacman x 10 pacman y 10 ghost x 10 ghost y 10 (label)", "recognise numbers pacman x 10 pacman y 10 ghost x 10 ghost y 10 (confidence)", "left", "right", "up", "down", and "add training data pacman x 10 pacman y 10 ghost x 10 ghost y 10 (label)". A blue arrow points to the "recognise numbers pacman x 10 pacman y 10 ghost x 10 ghost y 10 (label)" block. The interface also shows the "Scripts" tab, the "Backdrops" section, and the "Sprites" section.

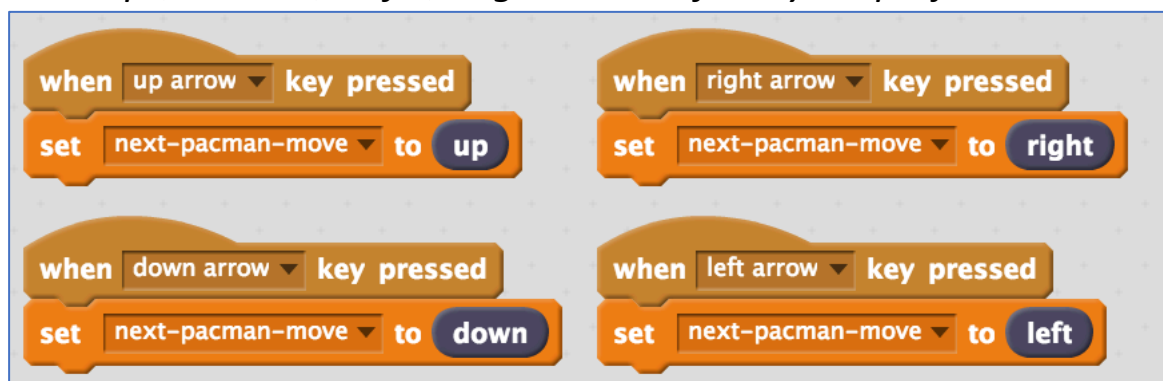


**23.** Open the “pacman.sbx” starter project file again.  
Click **File** -> **Load Project**

**24.** Click on the “Stage”

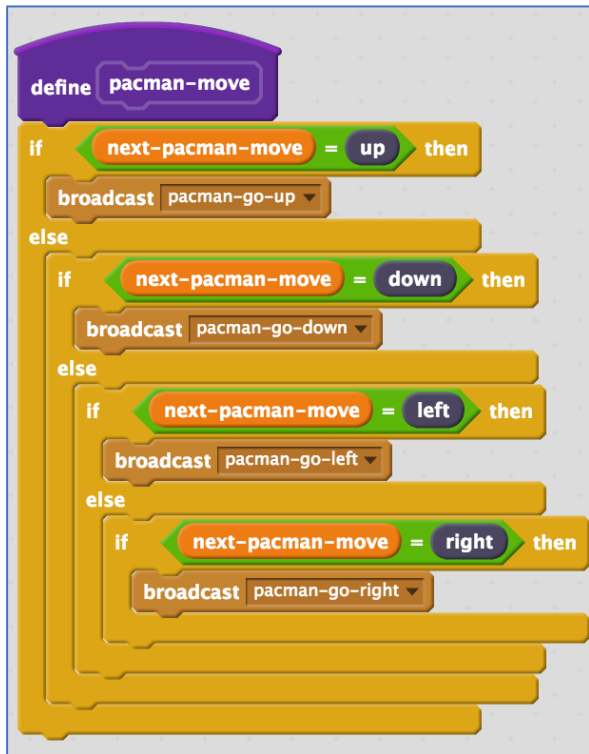


**25.** Modify the key press scripts to use the move choices you created  
*Drag the “up”, “down”, “left” and “right” blocks from your “pacman” project into the boxes in the scripts like in the picture below.*  
*You don’t need to add these scripts – you just need to drag in the dark blue “up”, “down”, “left”, “right” blocks from your project.*



**26.** Modify the custom block “**pacman-move**” to use the move choices you created

*Drag the “up”, “down”, “left” and “right” blocks from your “pacman” project into the boxes in the script like in the picture below.*



**27.** Update the custom block “**pacman-decision**” to add every move you make to your machine-learning training

*The purple “pacman-decision” block is ready for you in the starter project, at the top right of the Stage canvas.*



**28.** Train the computer!

*Click on full-screen again, and then the Green Flag.*

*Play a few games of Pac-Man, doing your best to avoid the ghost. The better you play, the better the computer has to learn from.*

## 29. Save your project

Click **File** -> **Save project**

Name the file something like “pacman-learn.sbx” to remind yourself that this version of the project is the one to train Pac-Man.

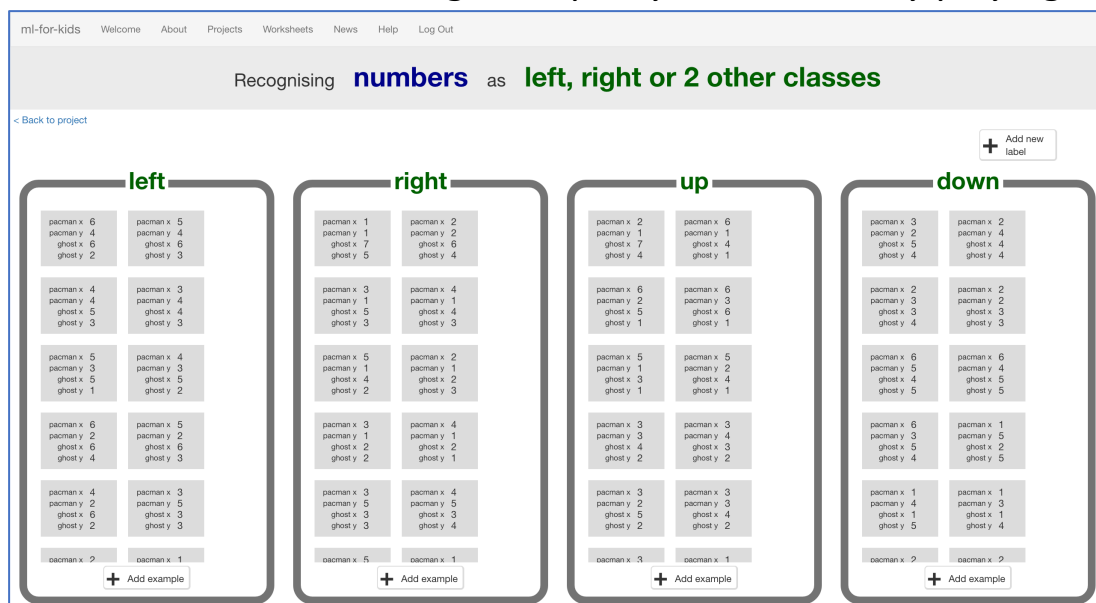
## What have you done so far?

You’re teaching a computer to play Pac-Man.

So far, you updated a Scratch Pac-Man game so that it can collect examples of how you play and add them to a set of examples. And you’ll use those examples to train a machine learning “model”.

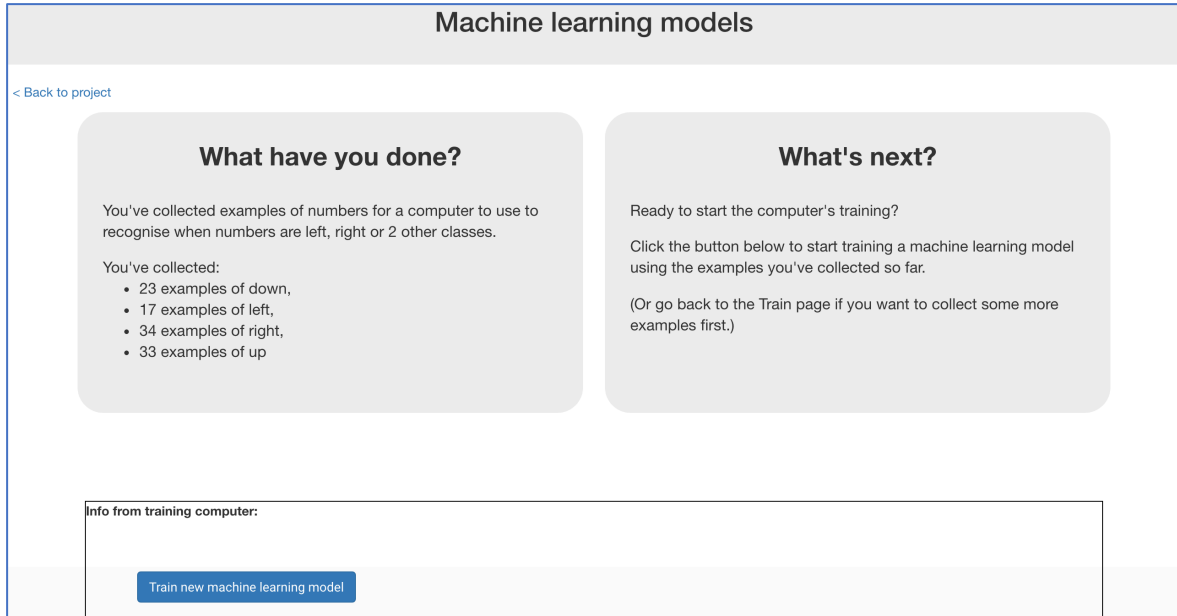
## 30. Close the Scratch window and go back to the training tool

## 31. Click the “< Back to project” link, then click the “Train” button You should see the training examples you collected by playing Pac-Man.



## 32. Click the “< Back to project” link, then click “Learn & Test”

### 33. Click the “Train new machine learning model” button

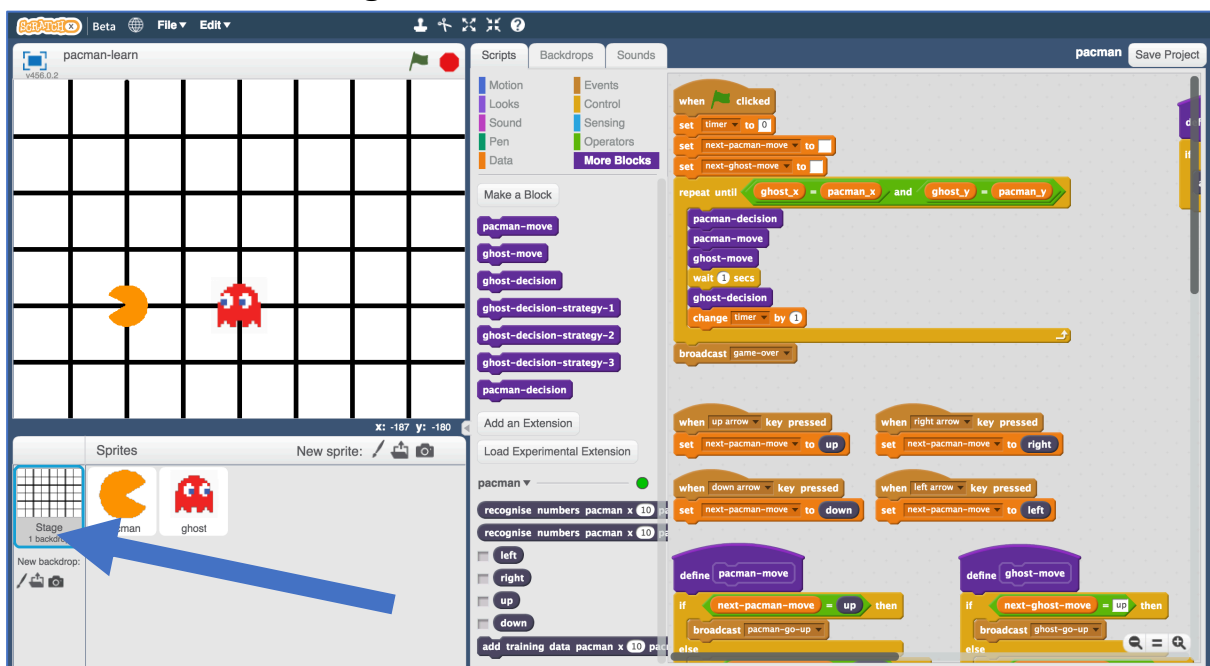


### 34. Click the “< Back to project” link, then click “Scratch”

### 35. Click the “Open in Scratch” button

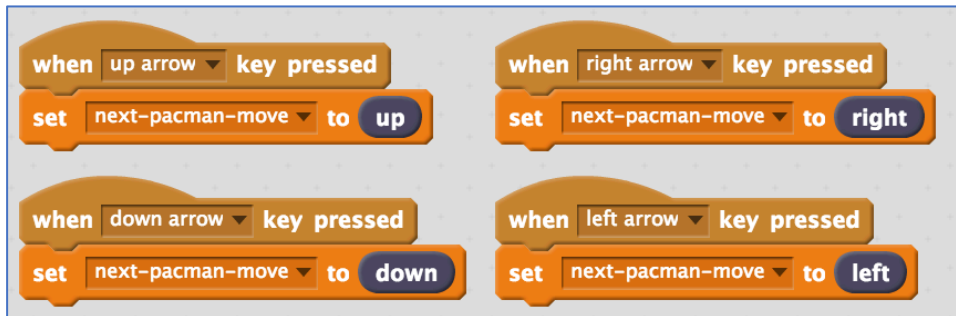
### 36. Open the pacman-learn project you saved before Click **File** -> **Load Project**

### 37. Click on the Stage

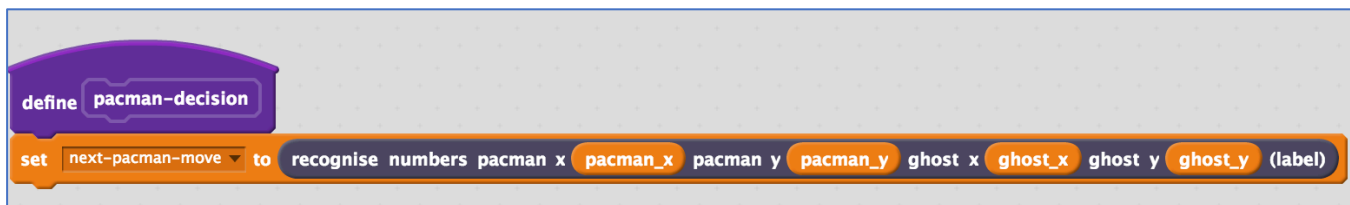


- 38.** Delete the key press scripts because it's the computer's turn!  
(Delete a script by dragging it back onto the palette, or right-click and choose "Delete")

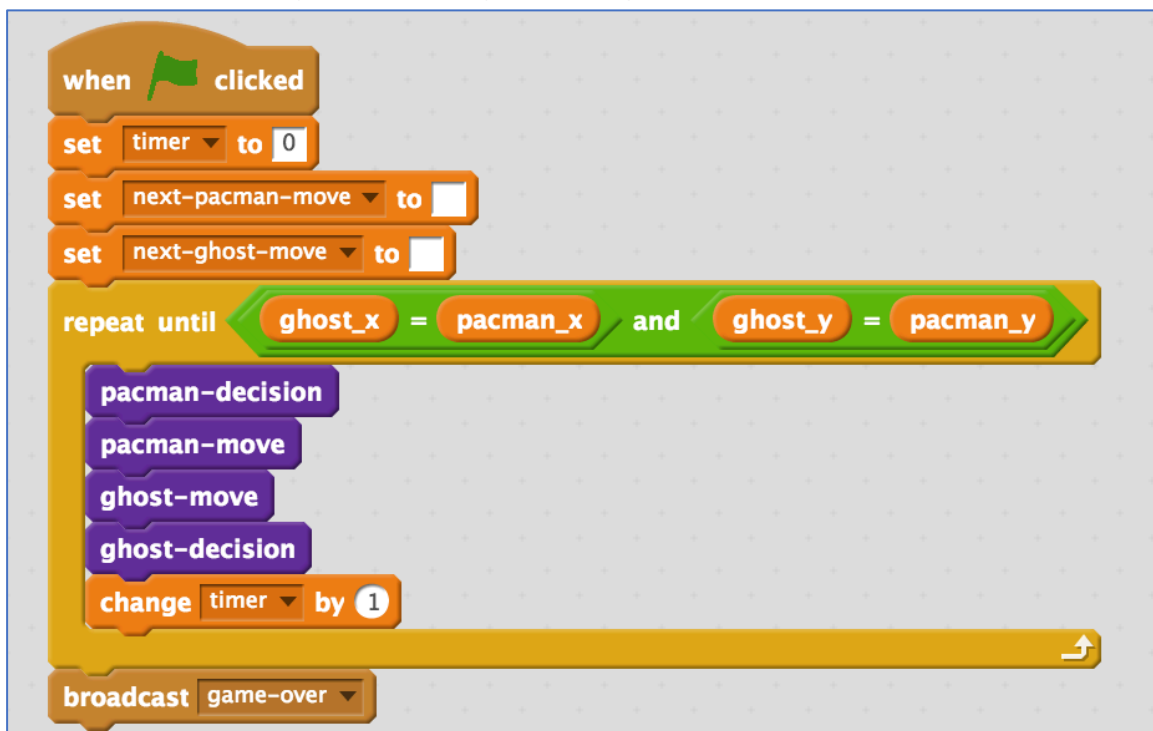
*These are the scripts you don't need any more:*



- 39.** Modify the custom "pacman-decision" block  
*Instead of learning from what you are doing, now you want to use your machine learning model*



- 40.** Modify the "Click Green Flag" script to remove "wait 1 second".  
*You want the script to end up looking like this:*



- 41.** Save your project  
*Click **File** -> **Save project***  
*Name the file something like “pacman-play.sbx” to remind yourself that this version of the project is where the computer controls Pac-Man.*
- 42.** Test the computer!  
*Click on full-screen again, and then the Green Flag.*  
*Watch the Pac-Man you’ve trained try to avoid the ghost.*
- 43.** Open the training project pacman-learn.  
*Make sure you save your pacman-play project first!*  
*Click **File** -> **Load Project***
- 44.** Train the computer some more by playing a few more games.
- 45.** Close the Scratch window and go back to the training tool
- 46.** Go back to the “Learn & Test” page  
*Click the “< **Back to project**” link, and then click “**Learn & Test**”*
- 47.** Click the “**Train new machine learning model**” button again
- 48.** Go back to the “Scratch” page  
*Click the “< **Back to project**” link, and then click “**Scratch**”*
- 49.** Click the “**Open in Scratch**” button
- 50.** Open the testing project pacman-play  
*Click **File** -> **Load Project***
- 51.** Test the computer again  
*Did the computer do any better after more training?*

## Tips

### Getting stuck in a loop

Sometimes the computer can get lucky, and find a circular route around the board that gets into a never-ending loop.

When this happens, Pac-Man will never lose!

You can press the red stop button if you need to stop though.

### Keep training

The more examples the computer has to learn from, the better it will get. If you have time, play a lot of games and train a new model again.

### Don't be kind!

You might be tempted to go easy on the ghost when you're playing against it.

Don't. It is learning from the way that you play. If you don't complete a three-in-a-row when you can, you will be teaching it that it should do that.

If you want it to get better quickly, **play as well as you can.**

## What have you done?

You've trained a computer to play Pac-Man.

You didn't have to describe the rules to the computer.

You didn't tell it that it should try to avoid the ghost.

You didn't describe the boundaries of the board.

(The rules are in the Scratch game, but that doesn't count – that wasn't used in the machine learning model).

Instead, you showed it how you play, by collecting examples of decisions that you made when you play.



## Ideas and Extensions

Now that you've finished, why not give one of these ideas a try?

Or come up with one of your own?

### **Add another ghost**

The game is beatable with only one ghost – Pac-Man can just carry on avoiding the ghost forever.

But with a second ghost chasing after Pac-Man, it will get really hard.

### **Change the game board**

Try making the game board bigger.

Or add obstacles that Pac-Man and the ghost will need to go around.