

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 <u>https://machinelearningforkids.co.uk/scratchx</u> in a browser.
- 2. Open the Pac-Man template for this project. *Click Project templates -> Pac-Man*





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



The game board is a graph. Pac-Man and the ghost can only 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 on the left is at:



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 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.

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 <u>https://machinelearningforkids.co.uk/</u> 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"

ml-for-kids	Welcome	About	Projects	Worksheets	News	Help	Log Out	
	Start a new machine learning project							
Project Name *	an							
Recognizing *	ers							*
ADD A VALUE		Start to describe the values that you'll include with each example to train the computer with by clicking the 'Add a value' button.						
								CREATE CANCEL

13. Click "Add a value" and name a value "pacman x" and make it a "number".

Value 1 * pacman x	Type of value * number •	If pacman x can be described as numbers, choose "number". If it can be described as choosing from a few options, choose "multiple- choice".	
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"

Project Name *					
pacman				Give your project a name to describe what sort of thing you'll try to teach the computer to recognise.	
				_	
numbers					•
Value 1 * pacman x	Type of value * number	×	Value 2 * pacman y	Type of value * number	, ×
^{Value 3 *} ghost x	Type of value * number	, ×	Value 4* ghost y	Type of value * number	€ €
ADD ANOTHER VALUE					
				CREATE	CANCEL

15. Click Create.

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



17.	About Projects Worksheets News	Help Log Out		Language
		"pacman"		
	Train Collect examples of what you want the computer to recognise.	Learn & Test	Make Use the machine learning model you've trained to make a game or app, in Scratch or in Python	

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.

ml-for-kids	Welcome	About Proje	ects Worksheets	News Help	Log Out			
			Reco	ognising	numbe	rs as	left	
< Back to project		left –						Add new label
		+ Add exampl	e					

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

21. Click the "Make" button then click the "Scratch" button

22. Click the **Straight into 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.

About Projects Worksheets News Help Log Out	
Using machine lea	rning in Scratch
< Back to project	
You haven't trained a machine learning model yet.	
You can train one now and then come back of sociatch. Or you can go straight into Scratch now.	
Your project will add these blocks to the More Blocks tab in Scripts.	It will look something like this - except with the name of your project.
(recognise numbers pacman x 1) pacman y 2) ghost x 1) ghost y 4 (label) Put numbers in the input for this, and it will return the label that your machine learning model recognises it as.	L + 2: 2: € Sorphi Backhops Sounds Motion Look Devets Sound Serving Pan Operators

23. You should see new blocks in the "**More blocks**" section from your "pacman" project.



24. Open the Pac-Man template project again. *Click Project templates -> Pac-Man*

25. Click on the "**Stage**" and find the "when green flag clicked" script that sets the "left", "right", "up", "down" constants



26. Modify the script to use your new blocks from the pacman project



27. Find the custom block "pacman-decision"



28. Update the "pacman-decision" block to add every move you make to your machine-learning training data

define pacman-decision									
if not next-pacman-	-move = th	en							
add training data pacma	an x pacman_x j	pacman y (pacman_y	ghost x	ghost_x	ghost y 🧧	ihost_y ne	ext-pacman-m	ove

29. Train the computer by playing the game! 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 moves the computer has to learn from.

30. Save your project

Click File -> Save project

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

31. Go back to the training tool

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

	neu	coanisina NU I	mbers as	left. riaht o	r 2 other cl	asses	
				, .			
to project							+ Add new label
	left		right		up		down
parman x 6	nacman x 5	narman x 1	parman x 2	parman x 1	pacman x 1	parman x 6	pacman x 6
pacman y 2	pacman y 2	pacman y 5	pacman y 5	pacmany 1	pacman y 2	pacman y 5	pacman y 4
ghost x 6	ghost x 6	ghost x 3	ghost x 2	ghost x 6	ghost x 5	ghost x 4	ghost x 5
ghost y 4	ghost y 3	ghost y 3	ghost y 3	ghost y 4	ghost y 4	ghost y 5	ghost y 5
pacman x 4	pacman x 3	pacman x 3	pacman x 4	pacman x 1	pacman x 1	pacman x 6	pacman x 4
pacman y 1	pacman y 1	pacman y 5	pacman y 5	pacman y 3	pacman y 4	pacman y 3	pacman y 2
ghost x 5	ghost x 4	ghost x 2	ghost x 3	ghost x 5	ghost x 4	ghost x 5	ghost x 6
ghost y 2	ghost y 2	ghost y 4	ghost y 4	ghost y 3	ghost y 3	ghost y 4	ghost y 2
pacman x 2	pacman x 7	pacman x 5	pacman x 1	pacman x 1	pacman x 1	pacman x 7	pacman x 7
pacman y 1	pacman y 2	pacman y 5	pacman y 5	pacman y 1	pacman y 2	pacman y 5	pacman y 4
ghost x 4	ghost x 7	ghost x 4	ghost x 1	ghost x 3	ghost x 2	ghost x 5	ghost x 6
ghost y 1	ghost y 4	ghost y 4	ghost y 3	ghost y 1	ghost y 1	ghost y 5	ghost y 5
pacman x 6	pacman x 5	pacman x 2	pacman x 3	pacman x 1	pacman x 1	pacman x 7	pacman x 6
pacman y 2	pacman y 2	pacman y 5	pacman y 5	pacman y 3	pacman y 4	pacman y 3	pacman y 5
ghost x 7	ghost x 6	ghost x 1	ghost x 1	ghost x 1	ghost x 1	ghost x 7	ghost x 4
gnost y 3	gnost y 3	ghost y 4	guosi y D	ghost y 1	gnost y 2	ghost y 5	gnost y 5
pacman x 4	pacman x 3	pacman x 4	pacman x 5	pacman x 2	pacman x 2	pacman x 6	pacman x 6
pacman y 2	pacman y 2	pacman y 5	pacman y 5	pacman y 2	pacman y 3	pacman y 4	pacman y 3
ghost x 5	ghost x 5	ghost x 2	ghost x 3	ghost x 4	ghost x 3	ghost x 5	ghost x 6
ghost y 3	ghost y 2	ghost y 5	ghost y 5	ghost y 2	ghost y 2	ghost y 5	ghost y 5
pacman x 6	pacman x 5	pacman x 6	pacman x 3	pacman x 2	pacman x 3	pacman x 6	

What have you done so far?

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

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. You'll use those examples to train a machine learning "model".

- **33.** Click the "< Back to project" link
- **34.** Click the "Learn & Test" button
- **35.** Click the "Train new machine learning model" button

	Machine learning models							
< Back to	project							
	What have you done?	What's next?						
	You have collected examples of numbers for a computer to use to recognise when numbers are left, right or 2 other classes. You've collected: • 14 examples of left, • 16 examples of right, • 15 examples of up, • 11 examples of down	Ready to start the computer's training? Click the button below to start training a machine learning model using the examples you have collected so far. (Or go back to the Train page if you want to collect some more examples first.)						
	Info from training computer: Train new machine learning model							

36. Go back to the Scratch window. *If you accidentally closed it, you can get back to it by doing this:*

- * Click the "< Back to project" link
- * Click the "Make" button
- * Click the "Scratch" button
- * Click the "Open in Scratch" button
- * Open the Scratch project you saved before, with "File" -> "Load Project"

7. Click on the St	age	
Beta 🌐 File 🔻 Edit 🔻 Project templates 🔻	1 + X X Ø	
pacman-leam	Scripts Backdrops Sounds	pacman Save Project
	Motion vents Looks Control Sound Operators Data More Blocks Make a Variable Geom (hest 2) (hest 2) (he	cked to D man-move to themore the themore the the the the the the the the
Sarites	Set next-pacman-move to up set next-	pacman-move to right
Stage pagman phost	set right to 0 when down arrow key pressed when left dange right by 0 set rect-pacean-move to down set rect-	arrow key pressed
1 backdrop New backdrop:	show variable right	

38. Delete the key-press scripts because it's the computer's turn! (Delete a script by right-clicking on it and choose "Delete") These are the scripts you don't need any more:

when up arrow very key pressed	when right arrow very pressed
set next-pacman-move v to up	set next-pacman-move v to right
when down arrow very key pressed	when left arrow v key pressed
set next-pacman-move v to down	set next-pacman-move v to left
· · · · · · · · · · · · · · · · · · ·	

39. Modify the custom "**pacman-decision**" block Instead of learning from what you are doing, now you want it 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:*

when r cl	icked															
set timer 🔻	to 0															
set next-pac	man-move	e 🔻 to														
set next-gho	st-move	to														
repeat until	ahos	t x) =	pac	mai	n x	a	nd	1	ahos	st v		pa	cma	ın v	v)	
						/						_			_//	
						-	-								_	_
pacman-d	ecision															
pacman-d pacman-m	ecision	 	· · ·			- - -	•				+			•		
pacman-d pacman-m ghost-mov	ecision love ve	· · ·	· · ·			+ + + +	· ·	+	· · ·		•					
pacman-d pacman-m ghost-mov ghost- <u>dec</u>	ecision hove ve ision				• • •		• • •	+			•	•		•	- - - - -	-
pacman-d pacman-m ghost-mov ghost-dec change tin	ecision hove ve ision	1			· · · · · · · · · · · · · · · · · · ·		+ + + + + +	+ + +		-	+ + +	· • •	· · · · · · · · · · · · · · · · · · ·	•	- - - - - - -	-
pacman-d pacman-m ghost-mov ghost-dec change tin	ecision hove ve ision her v by	1					•	•			•			•		

41. Save your project

Click File -> Save project

Name the file "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.sbx". 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.** 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. Switch back to the Scratch window.
 If you accidentally closed it, you can get back to it by doing this:
 * Click the "< Back to project" link
 * Click the "Make" button
 * Click the "Scratch" button
 * Click the "Open in Scratch" button
- **49.** Open the testing project "pacman-play.sbx" *Click File -> Load Project*
- **50.** Test the computer again *Did the computer do any better after more training?*

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.

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.

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 play well, it can't learn how to play well.

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

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.

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.

Make your own game

This doesn't only work with Pac-Man.

Why not make your own game in Scratch, and then train a machine learning model to be able to play it?