Exploring machine learning

Content summary:
A whole class data collection activity that uses the **micro:bit machine learning tool** to demonstrate how real-world data samples are used to train machine learning models.

Time: Approx. 1 hour split up into 3 sessions.

Resources required	Prior learning	Before the lesson
• Machine learning video on BBC Teach activity guide. • 1 or 2 micro:bits, 1 battery pack with 2 batteries inserted, 1 micro:bit holder, 1 strap, and 1 USB data lead. • The micro:bit machine learning tool on a computer/screen that the whole class can view. • Playground survey glossary.	**Computing/ICT** • An understanding of how the micro:bit they are wearing works and which sensor is being used (accelerometer). **Maths** • How to read data from graphs/charts.	• Gather all resources required. • Ensure the website works in your setting. If not see here. • Attach 1 micro:bit to a strap in advance to reduce preparation time (see video). **Data discussion** • If pupils have not completed the discussion around data in the Getting started activity, then it may be helpful for teachers to review the examples included there to help discussion in this lesson.

Differentiation

This activity is designed to be a whole-class discussion with individual pupils taking turns to contribute and participate. Allowing discussion between mixed ability pairs and giving pupils time to think before sharing/participating may be helpful.

Session 1: Introduction and planning (10 min)

1. If your class used the Activity tracker in the BBC micro:bit playground survey, recap how the program was trained to recognise movement data and/or watch the Activity tracker video on the BBC Teach activity guide that explains this.
2. Ask: Can you recall any other examples of when personal data samples are collected and used? Why is our data valuable? Have you ever given consent for your data to be used somewhere? (Examples could include: agreeing an app can know your location, allowing your movement data from a smart watch to be transferred to an app on a phone, saying yes to cookies on a computer, agreeing a phone app can identify faces in photos or using voice recognition software).
3. Explain that we are now going to explore how data is used in machine learning (a specific type of Artificial Intelligence (AI) where computers are trained to recognise different types of data).
4. Watch the BBC Exploring machine learning video with the class.
5. Highlight the key questions we want to answer:
   How can computers learn from data?
   How can machine learning models be trained 'better'?

Session 2: Exploring and training (30 min)

1. Have a micro:bit and battery pack ready to use with a flexible micro:bit holder and wearable strap (provided as part of the BBC micro:bit – the next gen class set). This video shows you how to assemble these items.
2. Explain that you're going to use this webpage called the micro:bit machine learning tool to gather data and train a model to recognise when someone wearing the micro:bit on their wrist is clapping or waving.
3. With the class, watch the video on the microbit machine learning tool homepage to discover how to use it.
4. Set up the tool by selecting Start at the bottom of the homepage and following the on-screen instructions to connect 2 micro:bits, which is the recommended option.
   If you only have 1 micro:bit, on the first screen (What you will need to get started) choose the link: ***Alternative method if you only have 1 micro:bit.*** For this method you may need IT support to enable Bluetooth in your browser.
5. With the class, in the Add data tab, name the first action 'Clapping' then add a second action and name this 'Waving'.
6. Explain that the class will take turns to record samples of clapping and waving which will be used to train the model. Once you have these samples, you will train the model, then you will take turns to test the model before exploring how to improve it.
7. Invite pupils to wear micro:bit 1 on their right wrist one at a time. Make sure they wear it with the logo facing upwards as they look at it.
8. As a class, train a model to recognise key movements by following these steps:

Suggested procedure for a class of 30 (if you have a smaller class use smaller groups for testing or pupils can take multiple turns):

9. Check that the live data feed at the bottom of the screen is working by moving micro:bit 1 (wristworn micro:bit) around. You should see the lines on the data feed move as you move the micro:bit.
10. Explain that this graph shows the live data coming from the micro:bit's accelerometer. It shows how the micro:bit is accelerating over time in x, y and z directions.

Adding data samples

11. Invite the first pupil to wear the micro:bit on their RIGHT wrist, checking the logo is facing up. Then select 'Record' next to the 'Clapping' action. The pupil should start clapping before the countdown finishes and keep going until the sample has been collected.
12. Repeat this procedure for pupils 2-5, passing the micro:bit to the next person after they have created their sample. Check each time that the micro:bit is on their RIGHT wrist with the logo facing up before clicking 'record'. (Note: pressing button B on the pupil's micro:bit will also start recording).
13. Pupils 6-10 follow the same procedure to create 5 samples for 'waving' while wearing the micro:bit on their right hand (waving with the RIGHT hand that has the micro:bit attached to the wrist).

Training the model

14. The teacher then highlights the Train model button and clicks it, then shares the 'training a model' explanation on screen and selects 'Train model' to run the training.

Testing the model

15. Pupils 11-15 try out the newly trained model in the Test model tab by wearing the micro:bit and completing each action in slightly different ways. They are testing if the model recognises the action, or not, by viewing the feedback on screen. If the action is recognised, then the estimated action will match the real-life action.
16. Next, ask a pupil to stay still and see what the model estimates they are doing. Discuss what is going on here – the model only has data for clapping and waving so it does not know what 'still' looks like.

Adding more data samples

17. Look at how to reduce false positivity rate by including 'still' data examples. Go back to the 'Add data' tab and click on the 'add action' button. Label the new action 'still'.
18. Pupils 16-20 wear the micro:bit on their right wrist and add still data samples making sure they keep their wrist 'still' in different orientations.

Training with new data sets

19. The teacher then re-trains the model by clicking on Train model.

Testing the new model

20. Go to Test model. Ask pupils 21-25 to test the model out once it has been trained a second time with the additional data samples. Ask them to evaluate if the model is confusing one activity for another? What do they think the certainty graph shows? Do they think they need to add any other data?
21. Can pupils think of any other data that would help increase accuracy for more people here? Ask someone wearing the micro:bit on their right wrist to wave with their left hand to highlight the lack of lefthanded data. Will it be exactly the same movement? Discuss.

Exploring further

22. Pupils 26-30 add more data samples using LEFT hands and see if this improves the accuracy.

Troubleshooting

- Ensure micro:bit 1 is the micro:bit being worn by the pupils and micro:bit 2 is connected to the computer via USB.
- Ensure battery pack wires are clicked in fully before beginning.
- Have spare batteries to hand in case they are needed.
- Have a spare micro:bit to hand in case an error code appears.

Session 3: Discussion (20 min)

Making connections

The purpose of this discussion is to highlight how understanding how machine learning works means pupils can be:

- more informed when making decisions about their personal data.
- aware of how models are only as good as the data they are given and how this impacts inclusivity e.g. if only left-handed data samples were used for waving, would it accurately detect a right-handed wave?
- aware that not all information will be complete when pupils use digital technologies to search, access and retrieve information – there may be gaps or missing data.

Link back to the model they used on the Activity Tracker and how it could be improved:

1. What gaps were there in the data collected when you wore the Activity tracker? 'For example, The model did not know when I was playing chess / reading a book / in gardening club.' (If your class have not completed the Activity Tracker sessions, then it may be helpful to view the sample movement slide in BBC Teach activity guide slides.)
2. What else could be included in the data set that trained the model to make it more accurate? For example, data samples of more unusual activities like those listed above, and more data samples of more activities in general.

Connect to discussion on inclusivity in technology:

3. Highlight that so far, the class have been thinking about how to make sure the model works for our class group. Will the same model work for everyone?
4. Think about another possible gap. What else should the data set include if we want the model to be as inclusive as possible?
5. Support the class to think about implications for inclusivity regarding movement, voice or facial recognition technology.
6. Ask the class to think about how someone with a physical disability may find it harder to use the model you have just created in class, for example, would a wave that only used fingers and didn't move the wrist be recognized by this model?
7. Highlight the need for data sets used in machine learning to include samples from many, many different groups of people to ensure that it is not biased towards one group only.
8. Use the example of voice recognition: if only female voices were used to train a model then would the model easily recognised instructions from a male voice? Discuss.

Link back to what we wanted to find out:

9. *How do computers learn from data?*
10. *How can models be trained 'better'?*