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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Smart Classroom |
| **Activity** | | Create a smart assistant in Scratch that lets you control virtual devices. |
| **Objective** | | **Teach a computer to recognise the meaning of your commands**   * How computers can be trained to recognise the intent behind writing. * Confidence thresholds indicate when the machine cannot recognise the meaning. * How virtual assistants (e.g. Apple Siri, Amazon Alexa, Google Home) work. |
| **Difficulty level** | | Beginner |
| **Time estimate** | | 1 hour (for full version of the project, where students try making it without machine learning first)  or  45 minutes (if students only make a machine learning project) |
| **Summary** | | Students will train a machine learning model to recognise the meaning of instructions. They will use this in Scratch to make a virtual assistant like Alexa that will respond to commands. |
| **Topics** | | digital assistants, confidence thresholds, supervised learning |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students.  There are **two versions of the worksheet** – one that assumes students will try making the assistant without machine learning first and compare, the other assumes students will only use machine learning. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Conversation**  1 workspace per student  One “Lite” API key is free but can only be used to create 5 workspaces  One “Standard” API key can be used to create to create 20 workspaces  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Make Me Happy |
| **Activity** | | Create a character in Scratch that smiles if you say nice things to it and cries if you say mean things to it. |
| **Objective** | | **Teach a computer to recognise compliments and insults**   * How computers can be trained to recognise emotional tone * How supervised learning builds systems that can deal with unexpected input |
| **Difficulty level** | | Beginner |
| **Time estimate** | | 45 minutes |
| **Summary** | | Students will train a machine learning model to recognise compliments and insults by typing examples of kind statements and mean statements. They will use this in Scratch to make a character that reacts to messages based on sentiment. |
| **Topics** | | sentiment analysis, supervised learning |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Conversation**  1 workspace per student  One “Lite” API key is free but can only be used to create 5 workspaces  One “Standard” API key can be used to create to create 20 workspaces  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * Younger students may get carried away when writing insults to train the machine learning model. It may be helpful to set boundaries for what language is appropriate. * Time management is important for this project. Students often lose track of time drawing their face and don’t leave enough time for training or coding. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Snap |
| **Activity** | | Make a card game in Scratch that learns to recognise pictures of your card. |
| **Objective** | | **Teach a computer to recognise what icons look like**   * Learn how computers can be trained to recognise pictures |
| **Difficulty level** | | Beginner |
| **Time estimate** | | 1.5 hours (for full version of the project, where the students make their own cards)  or  45 minutes (if students are provided with pre-made cards) |
| **Summary** | | Students will make cards with different coloured icons. They will train a machine learning model to recognise what the icons look like by taking pictures of them with a computer webcam. They will use this in Scratch to make a Snap game where the computer recognises if it chooses a matching card. |
| **Topics** | | image classification, supervised learning |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students.  There are **two versions of the worksheet** – depending on whether students will make their own cards, or if you will give them pre-made cards. |
|  | **Resources** | Paper, scissors, felt pens (for full project, where the students make their own cards)  or  Pre-made cards (download and print the “Additional project resources”) |
|  | **Technology** | Web-cam |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Visual Recognition**  1 custom model per student  One “Lite” API key is free but can only be used to create 1 custom model  One “Standard” API key can be used to create to create multiple custom models  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * Students will be taking photos and uploading them to a secure site, where they are kept until their photo or project is deleted. As long as only cards are visible in photos they take, then students will not be identifiable from this. If this raises concerns it may be sensible to obtain parental permission. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Mailman Max |
| **Activity** | | Make a postal sorting office in Scratch that can recognise handwritten postcodes on envelopes. |
| **Objective** | | **Teach a computer to recognise handwriting**   * Learn how computers can be trained to recognise handwriting * Learn how “optical character recognition” is used to automate tasks like recognising postcodes on letters |
| **Difficulty level** | | Beginner |
| **Time estimate** | | 1 hour |
| **Summary** | | Students will draw letters on the screen using an on-screen canvas. This will train a machine learning model to recognise some handwriting. They will use this in Scratch to make a project that can automatically sort letters based on the postcodes they write on them. |
| **Topics** | | optical character recognition, handwriting recognition, image classification, supervised learning |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Visual Recognition**  1 custom model per student  One “Lite” API key is free but can only be used to create 1 custom model  One “Standard” API key can be used to create to create multiple custom models  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * Some children may struggle with the coordination needed to write letters on the screen by dragging the mouse pointer on the canvas. Reassure them that it doesn’t need to be perfect, and that training the computer to recognise messy handwriting with examples of messy handwriting is fine! * Transparency isn’t the same as white to the machine learning model. If your student’s model isn’t returning the results they expect from Scratch, make sure they have a white background for their postcode handwriting, and not a deleted transparent background. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Car or Cup |
| **Activity** | | Train the computer to be able to sort photos into groups. |
| **Objective** | | **Teach a computer to recognise pictures of objects**   * How computers can be trained to recognise pictures. * The important of variety in training machine learning systems. |
| **Difficulty level** | | Beginner |
| **Time estimate** | | 45 minutes |
| **Summary** | | Students will train a machine learning model to recognise pictures of cars or cups. They will use this to make a project in Scratch that sorts a pile of photos into groups. |
| **Topics** | | image classification, supervised learning |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students.  There are **two versions of the worksheet** – one that assumes students will work individually, the other assumes students will work together as a whole class. |
|  | **Access** | Access to an image search site (e.g. Google Images, Bing Images, etc.) |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Visual Recognition**  1 custom model per student (if students are training their own models)  or  1 custom model per class (if students work together on a whole class project)  One “Lite” API key is free but can only be used to create 1 custom model  One “Standard” API key can be used to create to create multiple custom models  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * Students will need Internet access to search for pictures of cars and cups to train the computer with. Depending on the age of the students, close supervision may be appropriate to ensure safe searching. * The starter Scratch project includes a test set of images. Accuracy will be affected by how similar these are to the students’ training images. For example, if students collect examples of sports cars to train the computer to recognise cars, this may struggle to recognise non-sports cars. If this happens, encourage them to think about why it’s getting things wrong, and how they could improve this by collecting a more varied set of photos to train the computer with. * Dragging and dropping doesn’t work in Internet Explorer. You can provide your students with a different web browser (Firefox or Chrome work well) or explain to them how to copy/paste image URLs from a page.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Pac-Man |
| **Activity** | | Create a Pac-Man game in Scratch that learns how to avoid the ghost. |
| **Objective** | | **Teach a computer to play a game**   * How machines are taught to play games * Decision tree learning as a way for computers to learn how to play games. |
| **Difficulty level** | | Intermediate  It needs an understanding of 2D coordinates.  The Scratch scripts are slightly complex. |
| **Time estimate** | | 1 hour |
| **Summary** | | Students will train Pac-Man by playing the game in Scratch. The machine learning model will be trained based on the moves that they make while playing. They will use this model to get Pac-Man to play by itself. |
| **Topics** | | AI in games, decision tree learning |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | None |
| **Help** | | |
| **Potential issues** | | * Time management is important for this project. Students often lose track of time while playing Pac-Man and don’t leave enough time for training or coding. It may be helpful to time-box the sections (initial trying out of the game, training the model, testing the model) to keep the class on track. * There is more than one way to avoid the ghost. For example, doing laps of the map. Or flipping back and forth swapping places with the ghost. Let students find their own preferred strategy (there is no “right” way) and see if the Pac-Man they train learns to adopt their strategy. * Encourage students to keep their two Scratch projects separate – one for training Pac-Man, the other to use that training to let the computer play. That means if Pac-Man isn’t very good, they can easily go back and add more training.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Tourist Info |
| **Activity** | | Create a mobile app in Scratch that recommends tourist attractions based on people's interests. |
| **Objective** | | **Teach a computer to make recommendations**   * The impact of training bias on machine learning systems * Ethical questions introduced by training bias in machine learning systems. |
| **Difficulty level** | | Intermediate  It can involve a lot of typing.  Although simple to implement, appreciating the objectives requires an understanding of the implications of machine learning so this is more effective as a follow-on to another project. |
| **Time estimate** | | 1 hour (for full version of the project, where the students make more of the Scratch project)  or  45 minutes (if students use the shorter-version of the project with a more pre-made Scratch file) |
| **Summary** | | Students will train a machine learning model to make recommendations to holiday-makers based on their descriptions of likes and interests. They will use this in Scratch to make a mobile app. They will then be guided to make this more biased, and to consider the impact of bias in AI. |
| **Topics** | | training bias, recommendations, supervised learning |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students.  There are **two versions of the worksheet** – depending on the amount of Scratch coding to do. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Conversation**  1 workspace per student  One “Lite” API key is free but can only be used to create 5 workspaces  One “Standard” API key can be used to create to create 20 workspaces  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * Students will type about 25 short sentences. For some younger children, this might not be achievable in a single lesson, so you may wish to allow extra time.  Alternatively, it might be better to do this as a “whole class project” (create the project yourself and tick “whole class project”) so that the class only have to write 25 sentences between all of them. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Sorting Hat |
| **Activity** | | Create a Sorting Hat like in Harry Potter, that puts you in a school House based on what you say. |
| **Objective** | | **Teach a computer to recognise use of language**   * How computers can recognise patterns such as choice of words, phrasing and sentence construction |
| **Difficulty level** | | Intermediate It can involve a lot of typing. |
| **Time estimate** | | 1 – 2 hours (if students are training their own models, depending on how fast they can type)  or  45 minutes (if students work together on a whole class project) |
| **Summary** | | Students will collect quotes from Harry Potter characters, and sort these based on the school House that the character is in. These will be used to train a machine learning model to recognise the use of language from people in each house. |
| **Topics** | | text classification, supervised learning, crowd sourcing |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students.  There are **two versions of the worksheet** – one that assumes students will work individually, the other assumes students will work together as a whole class. |
|  | **Resources** | Access to Harry Potter books  or access to websites with Harry Potter quotes |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Conversation**  1 workspace per student (if students are training their own models)  or  1 workspace per class (if students work together on a whole class project)  One “Lite” API key is free but can only be used to create 5 workspaces  One “Standard” API key can be used to create to create 20 workspaces  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * Approximately 40 sentences are needed for training (10 examples x 4 Houses). If students are each doing this individually, you should allow enough time for this much typing. Copying-and-pasting quotes from websites can be quicker. * If students aren't happy drawing a Sorting Hat, they could find a photo to use * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Rock, Paper, Scissors |
| **Activity** | | Make a Rock, Paper, Scissors game in Scratch that learns to recognise hand shapes. |
| **Objective** | | **Teach a computer to recognise shapes**   * How computers can be trained to recognise pictures. * The important of variety in training machine learning systems. |
| **Difficulty level** | | Intermediate  Taking the training photos of your own hand needs coordination. |
| **Time estimate** | | 45 minutes |
| **Summary** | | Students will train a machine learning model to recognise pictures of hand shapes. They will use this to make a project in Scratch that plays rock, paper, scissors. |
| **Topics** | | image classification, supervised learning |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Technology** | Web-cam |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Visual Recognition**  1 custom model per student  One “Lite” API key is free but can only be used to create 1 custom model  One “Standard” API key can be used to create to create multiple custom models  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * Students will be taking photos of their hands and uploading them to a secure site, where they are kept until their photo or project is deleted. As long as only their hands are visible in photos they take, then students are unlikely to be identifiable from this. If using laptops, angling the screen towards the ceiling helps with this. However, if the chance of photos accidentally including students raises concerns it may be sensible to obtain parental permission. * Students often take a large number of very similar training photos. This is less likely to be accurate than photos of hands in a variety of positions and angles. It’s helpful to highlight this and encourage students to think about why it is the case. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Judge a Book |
| **Activity** | | Make a game in Scratch to test whether it really is possible to judge a book by its cover. |
| **Objective** | | **Teach a computer to recognise visual style**   * How effectiveness of a machine learning system can be measured by comparing performance against humans. |
| **Difficulty level** | | Intermediate  The Scratch script is slightly complex.  The term “genres” may require explanation.  The idea of measuring performance by comparing answers against those of another human can require some explaining. |
| **Time estimate** | | 1 hour |
| **Summary** | | Students will use a library or book retailer website to collect photos of book covers, and use these to train a machine learning model to recognise the genre of a book, based on a picture of it’s cover. They will use this to make a project in Scratch. |
| **Topics** | | image classification, supervised learning |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Access to a library or book retailer site (e.g. Amazon, etc.) |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Visual Recognition**  1 custom model per student  One “Lite” API key is free but can only be used to create 1 custom model  One “Standard” API key can be used to create to create multiple custom models  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * Students will need Internet access to search for pictures of book covers to train the computer with. Depending on the age of the students, close supervision may be appropriate to ensure safe searching. * Dragging and dropping doesn’t work in Internet Explorer. You can provide your students with a different web browser (Firefox or Chrome work well) or explain to them how to copy/paste image URLs from a page. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Confused |
| **Activity** | | Learn about how computers can be confused and can make mistakes if they're trained badly. |
| **Objective** | | **Teach a computer to recognise fruit**   * Variation in training data is essential for a reliable machine learning system. * The “Russian Tank” problem. |
| **Difficulty level** | | Intermediate  As a project that explores why machine learning sometimes doesn’t work, it’s perhaps more effective as a follow-on to another project. |
| **Time estimate** | | 45 minutes |
| **Summary** | | Students will use a pre-prepared poor training set of images to train a machine learning model, and then try it for themselves in Scratch to see the impact of overfitting. |
| **Topics** | | image classification, supervised learning, overfitting |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Visual Recognition**  1 custom model per student  One “Lite” API key is free but can only be used to create 1 custom model  One “Standard” API key can be used to create to create multiple custom models  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * The two provided data-sets of pre-prepared training photos each represent a different version of “The Russian Tank problem” story. These versions are summarised in the student worksheet. You may wish to allow time for students to discuss the story and the implications to make sure they understand them. * Dragging and dropping doesn’t work in Internet Explorer. You can provide your students with a different web browser (Firefox or Chrome work well) or explain to them how to copy/paste image URLs from a page. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Noughts and Crosses |
| **Activity** | | Create a noughts and crosses game in Scratch that learns how to beat you. |
| **Objective** | | **Teach a computer to play a game**   * How machines have been taught to play games since the 1960’s. * Decision tree learning as a way for computers to learn how to play games. |
| **Difficulty level** | | Advanced  The Scratch script is long and complex. Most of it is provided in a starter project file, but finding the right places to make changes needs care. |
| **Time estimate** | | 1.5 hours |
| **Summary** | | Students will train the computer to play noughts and crosses by playing the game in Scratch. The machine learning model will be trained based on the moves that they make while playing. |
| **Topics** | | decision tree learning, reinforcement learning, categorical data |
| **Also…** | | *A demo version of this project is available for use at events like Science Fairs, where each child has only a minute or two to try an activity. The notes below are about the classroom version of the project.* |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | None |
| **Help** | | |
| **Potential issues** | | * Time management is important for this project. Students often lose track of time while playing the game and don’t leave enough time for training or coding. It may be helpful to time-box the sections (initial trying out of the game, training the model, testing the model) to keep the class on track. * The most common bug in student Scratch scripts is to make the wrong choice in orange drop-down blocks (e.g. choosing “history nought top-right” instead of “history cross top-right”). Encourage students to copy carefully. Working in pairs can help avoid mistakes. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Top Trumps |
| **Activity** | | Train a computer to be able to play the Top Trumps card game in Scratch. |
| **Objective** | | **Teach a computer to play a game**   * Collecting training is easier than manually labelling training data. * Computers can learn to play games where the correct answer cannot be known, by predicting the likelihood of each outcome. |
| **Difficulty level** | | Advanced  The Scratch script is long and complex. Most of it is provided in a starter project file, but finding the right places to make changes needs care. |
| **Time estimate** | | 1 – 2 hours |
| **Summary** | | Students will train the computer to play Top Trumps by playing the game in Scratch. The machine learning model will be trained based on the choices that they make while playing. |
| **Topics** | | decision tree learning, reinforcement learning, categorical data |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | None |
| **Help** | | |
| **Potential issues** | | * The most common bug in student Scratch scripts is to make the wrong choice in orange drop-down blocks (e.g. choosing “you” instead of “computer”). Encourage students to copy carefully. Working in pairs can help avoid mistakes. * The computer is trained using the decisions made by the student when they play. This is inverted when used by the computer to make decisions. (e.g. the computer chooses a move that will result in “lose” because the best move for the computer is one that results in the player “losing”). * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Headlines |
| **Activity** | | Train a computer to recognise headlines from national newspapers. |
| **Objective** | | **Test the computer's ability to recognise use of language**   * How computers can be taught to recognise the source of writing * How machine learning systems are tested. |
| **Difficulty level** | | Advanced  The Scratch script for the advanced version of the project is long and complex. Most of it is provided in a starter project file, but finding the right places to make changes needs care.  The concept of testing and accuracy can require some explanation.  Intermediate  The simple version of the project is easy to make, but typing in a lot of headlines to train the model can be time-consuming. |
| **Time estimate** | | 2 hours (if students are following the advanced project to make a testing framework)  or  1 hour (if students make a simple interactive animated project) |
| **Summary** | | Students will collect examples of headlines from national newspapers. These will be used to train a machine learning model based on language in headlines. They will measure the accuracy of this model in a test framework in Scratch. |
| **Topics** | | text classification, supervised learning, testing |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | None |
| **Help** | | |
| **Potential issues** | | * Some national newspapers use language in their headlines that may not be appropriate for younger children. You may want to tell your class which newspapers to choose if you have concerns. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Locate Larry |
| **Activity** | | Make a Where’s Wally? game in Scratch, and teach the computer to find your character. |
| **Objective** | | **Teach a computer to find something in a picture**   * How computers can be trained to recognise pictures. * How image pre-processing is used to find a small item in a larger picture |
| **Difficulty level** | | Intermediate  The project is reasonably straightforward, but builds on being able to do image classification of individual images. It’s better used as a follow-on project to another images project. |
| **Time estimate** | | 1 hour |
| **Summary** | | Students will make a Scratch project that generates a scene, cuts it into a grid of smaller squares, and trains an image classifier on those grid squares. |
| **Topics** | | image classification, supervised learning, image pre-processing |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Visual Recognition**  1 custom model per student  One “Lite” API key is free but can only be used to create 1 custom model  One “Standard” API key can be used to create to create multiple custom models  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Journey to School |
| **Activity** | | Train the computer to be able to predict how you travel to school in the morning. |
| **Objective** | | **Teach a computer to make predictions**   * Predictive analytics can be used to identify patterns in structured data. |
| **Difficulty level** | | Beginner |
| **Time estimate** | | 45 minutes |
| **Summary** | | Students will train a predictive model based on survey results. |
| **Topics** | | predictive model, testing, accuracy |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
|  | **Other** | Students will need to conduct a travel survey first, using the results to train the computer. Sample results are included in the project worksheet. |
| Class account will need: | | |
|  | **API keys** | None |
| **Help** | | |
| **Potential issues** | | * The most time-consuming part of this project is designing a survey and carrying it out. After that, there is not very much to do. * Design your own survey! Consider using this as inspiration, but do your own survey on your own topic. Can this be combined with any other projects that the students are already doing? * There are sample survey results in the worksheet in case that is helpful, but if the students aren’t involved in designing and carrying out the survey, then the activity becomes largely a data entry exercise which may not be interesting for them. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | School Library |
| **Activity** | | Create a school librarian in Scratch that suggests who a reading book might be suitable for. |
| **Objective** | | **Teach a computer to make recommendations**   * Predictive models can be used to make recommendations. |
| **Difficulty level** | | Intermediate |
| **Time estimate** | | 1 hour |
| **Summary** | | Students will train a predictive model based on attributes of books. |
| **Topics** | | predictive model, recommendations |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
|  | **Resources** | Students will need access to several books, sorted by reading level. The project was written for a school group that have their computer suite in the school library. |
| Class account will need: | | |
|  | **API keys** | None |
| **Help** | | |
| **Potential issues** | | * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Chatbots |
| **Activity** | | Create a chatbot that can answer questions about a topic of your choice. |
| **Objective** | | **Teach a computer to recognise questions**   * How computers can be trained to recognise the intent behind writing. * How chatbots are used to automate answering people’s questions |
| **Difficulty level** | | Beginner |
| **Time estimate** | | 1 hour |
| **Summary** | | Students will train a machine learning model to recognise questions by typing examples of how those questions could be asked. They will use this in Scratch to make a character that answers those questions. |
| **Topics** | | sentiment analysis, supervised learning |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Conversation**  1 workspace per student  One “Lite” API key is free but can only be used to create 5 workspaces  One “Standard” API key can be used to create to create 20 workspaces  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * The worksheet tells students to make a chatbot that can answer five questions. If you think that might be too much typing for your students, you could tell them to train it to answer three or four questions instead. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |

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| **Machine Learning For Kids :: Teachers’ notes** | | |
| **Worksheet** | | Face Lock |
| **Activity** | | Make a phone in Scratch that can only be unlocked if it recognises your face. |
| **Objective** | | **Teach a computer to recognise what faces look like**   * Learn how computers can be trained to do facial recognition * Learn how facial recognition can be used for authentication |
| **Difficulty level** | | Beginner |
| **Time estimate** | | 1 hour |
| **Summary** | | Students will train a machine learning model to recognise their face, by taking pictures with a computer webcam. They will use this in Scratch to make a phone that unlocks if it recognises the owner’s face. |
| **Topics** | | facial recognition, biometrics, image classification, supervised learning |
| **Setup** | | |
| Each student will need: | | |
|  | **Print-outs** | Project worksheet (download from <https://machinelearningforkids.co.uk/worksheets> )  Blocks in Scratch scripts are colour-coded, so printing in colour will make it easier for students. |
|  | **Resources** | Toys with faces (if you don’t want the students to take photos of their own face) |
|  | **Technology** | Web-cam |
|  | **Access** | Username and password for machinelearningforkids.co.uk |
| Class account will need: | | |
|  | **API keys** | **Watson Visual Recognition**  1 custom model per student  One “Lite” API key is free but can only be used to create 1 custom model  One “Standard” API key can be used to create to create multiple custom models  more detail at: <https://github.com/dalelane/ml-for-kids/raw/master/doc/machinelearningforkids-apikeys.pdf> |
| **Help** | | |
| **Potential issues** | | * Students will be taking photos of their face and uploading them to a secure site, where they are kept until their photo or project is deleted. You may need to obtain parental permission before running this activity.  Alternatively, you could tell them to take photos of toys with faces (e.g. Lego figures, cuddly toys, action figures, etc.) instead. The screenshots in the student worksheet uses Lego figures as an example of this. * “https://machinelearningforkids.co.uk” is a long URL to type for some children. You may find it easier to set up a bookmark that they can click on instead.   General troubleshooting and help at <https://machinelearningforkids.co.uk/help> |