Module 2: How AI works

The second module introduces how Artificial Intelligence works, focusing on explaining concepts such as algorithms and machine learning. In addition, the module covers how AI systems are trained and behave, and introduces educators to basic concepts of programming such as if-else statements.

Thanks to the class activities, with instructional videos and practical activities, the trained teachers will be able to introduce students to the programming environment and to transfer them basic computational skills and concepts, being able to orchestrate the use of digital resources in teaching and learning AI technology.

Topic 2.1 - Algorithms and machine learning steps

Related to this topic, some activities will be proposed to students so that they will learn what an algorithm is and how machine learning algorithms work, having an understanding of data training and classification. Getting to grips with the concept of the algorithm is fundamental before delving into machine learning.

An algorithm is a set of instructions that are followed by a computer in order to accomplish a task. Traditionally, algorithms are written in computer language languages by human experts (the programmer) so that when we give input to the computer (for example by clicking a button with the mouse or by pressing a letter in the keyboard) then the algorithms start working and the computer is able to provide an output (for example providing the result of a math calculation o showing a webpage).

In the field of Artificial intelligence, machine learning is the set of techniques that allow computers to perform a task without explicitly being programmed to do so. With machine learning, we give computers access to data and then let them use that data to learn for themselves. Instead of coding software with specific instructions, machine learning trains an algorithm so it can "learn" how to make decisions for itself (or at least guessing what it could be a correct answer).

Traditionally machine learning is not performed by computers on their own but humans play the role of facilitator who controls the process. The first stage of machine learning is about training an algorithm, and in this phase humans provide (a lot of) examples that computers can use to learn. Humans also tell computers how to detect their mistakes and how to improve their performance. The second stage is to test the quality of the algorithm and this happens when the computer sees a new example and makes the best guess on what it could be the result.

A special type of machine learning is called deep learning. Deep learning models introduce an extremely sophisticated approach to machine learning using neural networks to learn from large amounts of data. In deep learning, the algorithm is given raw data and decides for itself what features are relevant - without requiring human supervision. Deep learning is more complex to set up compared to traditional machine learning techniques but requires minimal human intervention. Moreover, deep learning requires powerful hardware and resources and conventional computers might not be enough.

There are some free available resources that can be used to experience how machine learning works. For example, Teachable Machine is a free web app that allows to train an image model, a machine learning algorithm that can classify images based on the traditional training and testing process without requiring coding. This is the tool that will be used in the activities included in the lesson plan. It is important to note that with Teachable Machine it is possible to test different machine learning models and try to understand how classification works (and when it did not work) by changing the type of images used in the training and test phases. Teachable Machine works with images uploaded from the computer or from Google Drive, from images captured from the webcam or sounds recorded with the microphone.

A concept related to image recognition is adversarial images. Adversarial stimuli are images that have been altered with a carefully calculated input of what looks to human eyes like simple noise. Such images look almost the same to a human but totally different to a classifier, and the classifier makes a mistake when it tries to identify them. This is an example of the fact that machine learning algorithms “see” the images in a different way compared to humans (see resources below).

There are many digital tools that can be used for exploring applications of AI algorithms. For instance, Experiments with Google present a number of applications for showing interesting concepts related to how AI works: for example Quick, Draw! is a game where a neural network tries to guess what you are drawing. Autodraw is a suggestion tool that uses machine learning to guess what you are drawing and provide some examples. Teachable snake is the classic snake game that can be controlled by webcam image using pre-trained neural network models. The algorithm recognizes a black arrow on a piece of white paper and directs the snake using information from the webcam. Emoji Scavenger Hunt is another game that uses neural networks and the phone’s camera to identify the real world versions of the emojis.

Useful resources

Real-Life Algorithms

A list of simple practical unplugged activities useful to introduce students to the concept of algorithm
https://www.commonsense.org/education/lesson-plans/awesome-algorithms
https://code.org/curriculum/course2/2/Activity2-RealLifeAlgorithms.pdf

Few tips about explaining the algorithm concept to kids
https://www.idtech.com/blog/algorithms-for-kids

How to explain algorithms to kids
https://blog.codespark.com/posts/how-to-explain-algorithms-to-kids-and-4-activities-to-try

What is an algorithm in programming
https://study.com/academy/lesson/what-is-an-algorithm-in-programming-definition-examples-analysis.html

A visual introduction to machine learning
http://www.r2d3.us/visual-intro-to-machine-learning-part-1/

A video describing **machine learning for five levels of expertise** (child, teen, college student, grad student, expert) https://www.youtube.com/watch?v=5q87K1WaoFI

AI and Machine Learning Module
Description extracted from the web site: "This unit is a hands-on introduction to developing a machine learning model with tabular data. You will explore how computers learn from data to make decisions, then develop machine learning projects around real-world data. The unit culminates in designing a machine learning app to solve a personally relevant problem."
https://studio.code.org/s/aiml-2021

Personal Image classification: this AI unit is broken into three parts. In part 1, students learn how to create and train their own image classification model to identify and classify images. In part 2, students use their model in an app using MIT App Inventor to see how their model performs. In part 3, students create another app using the same model. In this app, the image classification becomes a game, where users must match the emotional expression to score points.
https://appinventor.mit.edu/explore/resources/ai/personal-image-classifier

Adversarial images: Articles describing stimuli that can trick machine learning systems like adversarial images
https://www.theverge.com/2017/4/12/15271874/ai-adversarial-images-fooling-attacks-artificial-intelligence

https://spectrum.ieee.org/hacking-the-brain-with-adversarial-images#toggle-gdpr

Scientific article on the effect of similar images for deep learning algorithms.
Togootogtokh, E., & Amartuvshin, A. (2018). Deep learning approach for very similar objects recognition application on chihuahua and muffin problem. arXiv preprint arXiv:1801.09573. https://arxiv.org/pdf/1801.09573.pdf

Scientific article on physical objects that can be used as adversarial stimuli .
Sharif, M., Bhagavatula, S., Bauer, L., & Reiter, M. K. (2016, October). Accessorize to a crime: Real and stealthy attacks on state-of-the-art face recognition. In Proceedings of the 2016 acm sigsac conference on computer and communications security (pp. 1528-1540). https://www.cs.cmu.edu/~sbhagava/papers/face-rec-ccs16.pdf

Experiments with Google
Teachable Machine - https://teachablemachine.withgoogle.com/
Quick Draw - https://quickdraw.withgoogle.com/
Autodraw - https://www.autodraw.com/
Teachable Snake - https://teachable-snake.netlify.app/
Emoji Scavenger Hunt - https://emojiscavengerhunt.withgoogle.com/

Topic 2.2 - Facial recognition and basic programming concepts

This topic covers some practical exercises on the use of Scratch programming language for using some basic AI algorithms for facial recognition.

Scratch is a programming language used by a large online community that enables children to program and create interactive media such as stories, games, and animation. Scratch is available free of charge and runs in the web browser so there is no software to install. With Scratch, students can learn the basics of programming using code blocks. In the resources you can find useful material for introducing the Scratch's basic functionalities.

In this module we will make use of a particular set of code blocks designed for Scratch, named Face Sensing. The Face Sensing blocks are based on machine-learning technology to enable the computer to detect different parts of a face. Face Sensing blocks use data from the webcam and run entirely and securely in the browser. For any given webcam image, the extension can tell whether or not a face is present, and where eyes, ears, a nose, and a mouth are located on that face. Face Sensing can be used to introduce students to the use of Scratch or to expand their knowledge of Scratch programming including new blocks with machine learning capabilities. Face Sensing can be used for example to create simple games that use the head movement as a controller or add images (like glasses or hats) that can be virtually worn.

Similarly to other face recognition algorithms, Face Sensing uses machine learning models that are pre-trained on large amounts of data to recognize faces in front of the webcam. In this case, developers provided a learning model with many images of faces. The model then looks for patterns and predicts answers based on what it has already seen. This type of technology is susceptible to "algorithmic bias," meaning that it might detect faces of some people more accurately than others. The algorithm can also recognize faces not only from people but also from puppets or drawings. Since Scratch is a tool mainly targeted to young users, the team behind Scratch has built the platform and the Face Sensing tool around values like security, fairness, responsibility, transparency and accountability. The face recognition module used by Face Sensing is Google's BlazeFace model. This model is freely available and open source, its fairness was tested by recording and comparing the model's accuracy on different images and its authors published quantified results of their fairness evaluation (see in the resources for more information about this). The topics related to ethical implications of face recognition and potential discrimination of such technology will be further discuss in Module 3.

Useful resources

Resources for Scratch

- **Scratch website**
  https://scratch.mit.edu/

- **Some tutorials to start using Scratch**
  https://scratch.mit.edu/projects/editor/?tutorial=all

  https://cdn.scratch.mit.edu/scratchr2/static/__709da8e5f3d72129538a4ccdbcbf5f2a__/pdfs/help/Getting-Started-Guide-Scratch2.pdf

- **Educator guidelines**: they show the educator how to prepare and run Scratch classes and workshops.
  https://resources.scratch.mit.edu/www/guides/en/EducatorGuidesAll.pdf

Example - Facial recognition in Scratch

- **Face sensing**: a creative and safe introduction to machine learning using Scratch
  https://lab.scratch.mit.edu/face/
- And a blog post explaining the motivations behind Face Sensing
  https://medium.com/scratchteam-blog/exploring-a-creative-safe-introduction-to-machine-learning-c42f1d0133e7
- **Google's BlazeFace model fairness:**
  https://drive.google.com/file/d/1f39lSzU5Oq-j_OXgS67KfN5wNsoeAZ4V/view

Creative computing curriculum: this is a collection of ideas, strategies, and activities for using Scratch to introduce creative computing experiences.
http://scratched.gse.harvard.edu/guide/

Erase your face: A group of teens and young adults have come up with a creative way to fool facial recognition and get around surveillance.
https://interactive.yr.media/erase-your-face/

FaceMesh: a demo for real-time face mesh from webcam
https://storage.googleapis.com/tfjs-models/demos/facemesh/index.html

Machine Learning for Kids: Scratch projects with downloadable step-by-step guides, with explanations and colour screenshots for students that will guide students in creating games or interactive projects that demonstrate a real-world use of artificial intelligence and machine learning.
https://machinelearningforkids.co.uk/#!/worksheets

Resource for combining Scratch with Teachable Machine using a script in PictoBox. The example in the link present a project for creating a Scratch program that can recognise if the person in front of the webcam is wearing a face mask or not
https://thestempedia.com/tutorials/making-a-mask-identifier-machine-learning-in-pictoblox/