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AI in Everyday Life

Introducing the 5 Big Ideas in Artificial Intelligence using Internet of Things in STEM education

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AI4STEM Educational Framework Topic: AI in Everyday Life

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Summary

Recently we have been witnessing a growth of the use of artificial intelligence (AI) in our daily life and we may not even have been aware of these changes.

AI's growing has allowed people and business to achieve levels of efficiency and organization that were unthinkable a few years back.

"Our intelligence is what makes us human, and AI is an extension of that quality" – Yann LeCun

Artificial intelligence is so integrated into our daily lives that we often don't realize how dependent we have become on its use, nor the impact of its use.

If we want teachers to be able to use AI in their classrooms, they first need to understand a little more about what is AI, how is it integrated in our everyday life and why.

This document intends to give teachers a better understanding of this topic, also giving some classroom activities suggestions so they can ensure that their students are being able to follow and understand the topic.

To help teachers with a simpler way to teach AI literacy to their students, we chose to use the Five Big Ideas in Artificial Intelligence framework, that was creates by the Association for the Advancement of Artificial Intelligence and the Computer Science Teachers Association.

In this document, teacher will see what are the 5 Big Ideas and how do they relate to the use of AI in our everyday life.

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Chapter 1: Introduction

In this module we will explore what is Artificial Intelligence (AI) and how is AI used nowadays in our everyday life. The goal of this module is to help teachers understand and explore this theme in the classroom using AI examples but also exploring the interaction between AI and the Internet of Things (IoT).

Throughout this module, teachers can find simple information about AI, what it is and how is it applied in the everyday life and with the IoT. Theachers will also find examples and some questions/activities suggestions along with the learning objectives of each, to facilitate the explanation of these aspects in the elementary and secondary school classrooms.

It will also be possible to find some scenarios on how AI and the IoT can be approached and introduced through the lens of the 5 Big ideas (as proposed by the AI4K12 initiative), and with a particular focus on the 5th Big Idea, namely Societal Impact.

Chapter 2: Glossary – Key notions and concepts

Artificial Intelligence (AI): At its simplest form, artificial intelligence is a field, which combines computer science and robust datasets, to enable problem-solving. AI is the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

Robot: Any automatically operated machine that replaces human effort, though it may not resemble human beings in appearance or perform functions in a humanlike manner.

Capacity-based (type of artificial intelligence): Based on how they learn and how far they can apply their knowledge, all AI can be broken down into three capability types: Artificial narrow intelligence, artificial general intelligence, and artificial superintelligence.

Functionality-Based (type of artificial intelligence): Concerns how an AI applies its learning capabilities to process data, respond to stimuli and interact with its environment. As such, AI can be sorted by four functionality types.

The AI4K12 project: It Is a project focused on teaching AI in K-12 in the US. The AI4K12 team have aligned their vision for AI education to the CSTA standards for computer science education. These Standards, published in 2017, describe what should be taught in US schools across the discipline of computer science, but they say very little about AI.

Internet of Things (IoT): IoT is about using computer tools to automate real-world processes, and like all automation tasks, it's expected to reduce the need for direct human participation. IoT is defined as the ability of computing devices to transfer information over a network without requiring human-to-human or human-to-computer interaction.

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Chapter 3: Introduction to Artificial Intelligence (AI)

Artificial Intelligence (AI) is the ability of some machines to simulate human intelligence processes using computer programs. AI has been used in switch programs for a long time, but it is now applied to different products and services to make our lives easier.

Compared to humans from a multidisciplinary point of view, AI focuses on the development of algorithms and systems that can perform tasks that require human intelligence such as reasoning, self-learning, problem-solving, pattern recognition, decision-making and the understanding of a form of language.

When we think of artificial intelligence, it is common to think of robots, but the truth is that not all artificial intelligence is a robot. These are a more complex form of AI, with which we can interact more closely.

One of the peculiarities of Artificial Intelligence is that it can learn, just as it does with your human. This learning can happen in three different ways:

- **Supervised**, in which there is a person who passes on to the Artificial Intelligence the information that he must give when faced with certain situations. Thus, the programmer can show the AI that when it sees the picture of a cat it responds, "It's a cat" and when it shows the image of a dog, the AI identifies "It's a dog". By repeating the process with multiple images, eventually, the AI will be able to identify the animal present in an image that was not used in the training.
- **Semi-supervised**, in this case, the programmer makes known to the AI a series of images of animals and identifies them as cats and other images that it identifies as dogs. However, it shows a set of images that it does not classify and that the AI, from the initial classification process, classifies itself.
- **Unsupervised**, in this case, the AI has access to multiple images of mixed cats and dogs and the AI itself identifies patterns and differentiates the images autonomously.

3.1 Types of Artificial Intelligence

They exist in various types of AI and even simultaneously. Each has its own set of applications and challenges and serves to solve complex problems. Its use provides advantages and limitations that combined allow the resolution of complex problems. AI is constantly evolving, and investment is increasingly comprehensive in different areas and sectors.

The classification of the types of artificial intelligence depends on the criteria used. Usually, we use two major criteria in the classification – Capacity-based and Intelligence and Functionality-Based.

In the Capacity-based type of AI, we can find three types of capabilities:

Artificial Narrow Intelligence (ANI) describes AI tools designed to execute very specific actions or commands. This AI cannot learn skills that are beyond what they have been designed to do. This type of capability is common when we use image recognition software, in self-driving cars and AI assistants, like Siri or Alexa.

Artificial General Intelligence (AGI) describes AI that can learn, think and perform tasks almost as a human. The goal of creating artificial general intelligence is to create machines that can multitask and act in everyday life like assistants for humans.

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This kind of machine is still under development, this kind of machine can be built using supercomputers and generative AI models, like ChatGPT.

Artificial Superintelligence (ASI) is the kind of machine that we see in science fiction movies. Once AI machines reach the general intelligence level, scientists believe they will keep learning and will be able to become stronger than any human.

We can find this concept being used in movies like *Ex Machina* or *I, Robot*.

Regarding their functionality, AI can be sorted into four different types:

Reactive Machines, which is the most fundamental type of AI. This kind of machine reacts immediately to a request but can't store any memory or learn from past experiences. They respond to external stimuli in real time but don't improve their functionality by experience. This sort of AI is used to filter spam from email boxes and to recommend movies based on our Netflix searches.

The most famous reactive machine from IBM was Deep Blue, the computer that was able to beat Gary Kasparov, the Russian chess grandmaster, back in 1997.

Limited Memory refers to the AI that can store past data and make predictions using it. This allows the AI to improve its performance using the knowledge that it builds constantly, by being able to store and learn from past experiences.

Most of the AI applications we use nowadays are under this category, like chatbots or self-driving cars.

Theory of Mind refers to a model of AI that can pick up on emotions and subtle environmental changes and act on them. Researchers and computational scientists are still very far from being able to create an AI that responds to human emotions and predicts actions based on this reading.

Self-awareness marks a type of AI that reaches its singularity. This means that the AI machines would be out of our control because they would be able to have a sense of self and be able to think independently.

Sophia, a robot that was developed by *Hanson Robotics* is an example of a more developed AI, even though it is not technically self-aware.

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Reactive AI	Limited memory	Theory of mind	Self-aware
★ Effective for straightforward classification and pattern recognition tasks ★ Excels in scenarios where all parameters are known and can outperform humans due to its ability to perform calculations at a much faster rate ★ Incapable of handling situations that involve imperfect information or require historical understanding	★ Capable of handling intricate classification tasks ★ Able to leverage historical data to make accurate predictions ★ Can handle complex tasks such as self-driving cars, but remains susceptible to adversarial examples ★ This is the present state of AI	★ Able to understand human motives and reasoning. ★ Can deliver personal experience to everyone based on their motives and needs. ★ Able to learn with fewer examples because it understands motive and intent ★ Considered the next milestone for AI's evolution	★ An intelligence that is as advanced as that of humans, and can even outsmart our own intelligence.
			

Types of AI: https://www.rapidops.com/blog/executives-guide-to-artificial-intelligence/

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3.2 Task for the classroom – AI in the classroom

Even though AI is all around us, and students use it in their everyday lives, it is not easy to explain to them how it works and why are there different types of AI.

So, to introduce the theme, the teacher can show different images where AI is used and ask the students if they know what they are and how to use those machines or apps. Teachers can choose images of robots, virtual assistants (like Alexa or Siri), facial recognition apps, self-driven cars, chatbot websites (like chat GPT) and the recommendations part of Netflix, for instance. After assessing if the students can understand what they are and how they would use them, the class can enrol in a conversation about the types of AI they can find.

Questions that could be asked:

- Do all these types of AI work in the same way?
- What are the bigger differences you can name? Why do you think they work/act differently?

After this, the teacher can ask the students to create groups and separate the AIs by group so that the teacher can introduce the different types of AIs and why they are different.

Learning Objectives:

Through this task, students should be able to:

- Discuss and understand what is an AI
- Understand that there are different types of AI
- Discuss the similarities and differences between the different types of AI

3.3 Application of AI in everyday life

Nowadays AI is present in our routine, and we often do not realize this presence. From the ability to unlock the phone with facial recognition to recommendations for Netflix movies or series or products to buy from Amazon, AI has been occupying a space in our day-to-day lives, often making the most routine tasks easier.

But AI is not only in our routine, we can also find AI in various sectors such as healthcare, finance, manufacturing, transportation, entertainment, and education.

Search engines such as Google, use AI algorithms (Voice and Image search, Translate, Maps), social networks and other platforms of the kind, use AI to do pattern analysis so that we are revealed personalized content. In addition to these examples, we can also mention virtual assistants such as Apple's Siri or Amazon's Alexa that allow you to interact, answer questions and even perform tasks through natural language processing (NLP, Speech Recognition, Smart Device Integration). AI is present in the automotive industry with autonomous transportation (TESLA, Efficiency Optimization, Intelligent Navigation).

In medicine, the use of AI helps us in medical diagnoses where algorithms can find patterns and assist doctors' decisions by detecting anomalies.

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Even in teaching, it is already possible to find AI in educational platforms that adapt the contents, and learning to the needs in the progress of the student (Khan Academy, Duolingo, Squirrel AI).

In addition to these applications, one of the most common and most recurrent uses is the use of AI in the home, the famous smart homes. The use of thermostats or light and safety systems that use AI to learn user preferences and better adjust to what is expected of them is one of the closest proofs that AI is present in our day-to-day lives, taking on a progressively more important role.

3.4 Task for the classroom – AI in everyday life

The teacher can discuss with the students how much their everyday life relies on AI.

Questions like:

- Do you think AI has made our lives better or easier? Why?
- Do you have any smart equipment at home? What does it do? How does it help you/your family?
- Do you remember any AI that we use here at school? Do you think it is useful?
- Can you name areas that might be improved with the use of AI?

Learning Objectives:

Through this task, students should be able to:

- Identify how is AI a part of their daily routine.
- Discuss about the use of AI in their everyday life.
- Understand that AI is more than just a robot working and get familiarized with all the different ways we can have AI present in our everyday lives.

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Chapter 4: AI and the 5 Big Ideas

What are the 5 Big Ideas

The "Five Big Ideas" of Artificial Intelligence (AI) were proposed by John Haugeland, philosopher, and AI researcher, as a way to summarize the key concepts that make up the area of AI.

These ideas offer an overview of the fundamental principles behind the development of AI. The Five Big Ideas provide a foundation for understanding the fundamental principles and concepts of Artificial Intelligence and have been influential in the development of the field and in the ongoing quest to create systems that can perform intelligent tasks in a manner like humans.

The Five Big Ideas of AI4K12 that have made the industry soar with AI are:

- **Perception** - Computers can perceive the world with sensors. AI has enabled computers to 'see' and 'hear' for practical use. Perception has enabled the process of extracting meaning from sensory signals.
- **Representation & Reasoning** - In processing data, agents maintain representations of the world and use them for reasoning. In both natural and artificial intelligence, representation is one of the fundamental problems of intelligence. AI helps generate a semblance of representation and reasoning that can help to work with big data.
- **Learning** - Computers hold the capability to learn from the various inputs it receives. Machine learning provides a statistical interference that helps in finding patterns in data. The learning algorithm of AI, as mentioned earlier, has generated significant progress in creating new representations. The learning that is triggered by the input of data can come either from human input or from the machine itself.
- **Natural Interaction** - AI agents require many kinds of knowledge to interact with humans naturally. The humanistic quality of AI, like conversing in human languages, facial expressions, and emotions, and drawing upon social conventions are a must for better interaction.
- **Societal Impact** - AI has both a positive and negative impact on society. Technology has impacted a lot in our daily lives. But there must be a balance between using technology and limiting it for enhanced human interactions.

4.1 Perception in AI

One of the main goals in artificial intelligence is to have machines that perceive the world as humans do. To achieve this, researchers have been working on ways to teach machines how to use input data from their sensor (cameras, microphones, wireless signals, among others) to learn about the world and its different features.

This area of AI deals with object detection and recognition as well as navigation issues. To do so, machine perception is strongly linked with computer vision, pattern recognition, robotics, and image processing.

Since the goal of AI is to mimic human senses, is easy to understand that some senses are easier to mimic then others. Actually, machine vision is probably the most powerful sense since the cameras used are sophisticated and their optical lenses allow them to gather more light. This means that machines with these cameras are able to perceive light changes better that humans.

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We can see the same happening regarding sound, with machines having microphones that are more sensitive than human ears and therefor being able to detect frequencies well outside the human range.
As for touch, machines can sense it but only in special circumstances, like touchscreens and touchpads that can be very precise. Researchers have worked in this precision so that machines can sense different lengths of touch and respond to it in different ways.
Smell and taste are the senses that researchers work less on, maybe because there is complex chemistry involved in these senses.
We find perception is our everyday life when we use the face recognition system in our mobile phones, for instance.

4.2 Representation & Reasoning on AI

Knowledge representations is related to the "thinking" part of the AI systems. It's the process that allows computers to use the knowledge in a format they can use to solve problems. To do this, computers use a formal language to represent knowledge and then use reasoning algorithms to solve different problems.
When it comes to how to use the representation and reasoning, there are many ways to do it. Some machines use simple rules or decision trees while other use more complex methods like Bayesian networks or Markov decision processes.
To solve problems in different areas, like planning, scheduling or robot control, machines use reasoning. This feature can also be used to answer questions, make recommendations, or provide explanations.
In our everyday life we use representation & reasoning in complex tasks as diagnosing a medical condition or having a dialog in a natural language.
Deep Blue, the computer created by IBM and that was able to play chess, used a lot of representation and reasoning to be able to beat, the world chess champion at the time, Gary Kasparov.
Impact of AI can be positive or negative, as there is always a chance of having biases in the data while training the AI and this can lead to having different outcomes on the AI performance.

4.3 Learning on AI

Machine learning is usually confused with AI but, if fact, machine learning represents the process by which AI can learn.
Machine learning has a big influence in our everyday life, since it can be found in different areas, such as the entertainment industry. All the suggestions and recommendations we are offered from Netflix, Spotify, Google Play, between others, are the result of an algorithm that uses our stream data to be able to predict viewing habits or topic themes that we search.
We can find other examples of Machine Learning in our everyday life, like the face recognition that some phones are capable of or the feed suggestion on our Instagram or Facebook pages.

4.4 Natural Interaction on AI

This Big Idea focus on the goal of having machines and AI that can interact with humans, understanding their language and being able to react to the interaction in a natural and meaningful way.

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Natural interaction implies that AI systems can understand and create language, process the context and engage in a conversation.
With all the developments in the NLP (natural language processing), machine learning and deep learning, AI is becoming more and more close to reach these goals.
In our everyday life we can see the impact of the natural interaction in AI when we use voice assistants such as Siri, Alexa, or Google Assistant. By being able to respond to voice commands, these systems are enabling natural interaction.
Because they use automatic speech recognition and natural language understanding, these assistants make interactions seem and feel more like the ones that occur between humans.
Despite all the evolutions made so far, this area faces some difficulties regarding some of the specifications of language, like its ambiguity, the easy context switching that happens when humans are engaging a conversation, or the emotional intelligence needed to read a person's response and its emotional indicators.

4.5 Societal Impact on AI

Artificial Intelligence (AI) has a significant impact on society in various areas and levels. Its influence extends from the economy to people's daily lives, transforming aspects of society, and bringing with it benefits and challenges.

Examples are the use in automating repetitive and predictable tasks in various industries, in Health and Medicine improving the accuracy of treatments and reducing costs, in transport driving the development the autonomous and intelligent systems, improving safety on the roads, optimizing traffic, and offering more accessibility to people with reduced mobility. In Education transforming the way people learn, enabling the personalization of education based on the individual needs of students, in E-Commerce and Personalized Recommendations creating personalized product recommendations based on purchase history and user behaviour, which improves the online shopping experience and consumption, in Accessibility originating technologies that make life more accessible for people with disabilities, such as voice recognition systems for people with motor difficulties, in Cyber Security to detect patterns of cyber threats and attacks, improving the security of networks and systems, in Ethics and Privacy when it raises ethical and privacy issues, especially about the collection, analysis and use of personal data and also Government and Global decision-making to improve the efficiency of public administration, predict risks and make informed decisions in areas such as public safety and health.

The Societal Impact of AI can be positive or negative, as there is always a chance of having biases in the data while training the AI and this can lead to having different outcomes on the AI performance.

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Chapter 5: The Internet of Things and Artificial Intelligence

5.1 The Internet of Things and Artificial Intelligence

IoT is strongly connected to AI. IoT helps the AI to process and create an appropriate response to a real-world event that was signalled by the IoT. This means that AI is essential to IoT.

Nowadays, the question that IoT users and developers are asking is not if they should use AI but how far can AI be taken. The answer to this question relies on the complexity of the real-world system the IoT supports.

If we use a simple, rule-based AI, it could say "If the trigger switch is pressed, turn on light A". On the other hand, if we use a more sophisticated AI, it might say "If the trigger switch is pressed, and it's dark, turn on light A". This means that the AI would have to recognize not only the event (the button being pressed) but also the state (the darkness). This means that AI can help the IoT to reduce the need for direct human participation. As the IoT is aimed at reducing the need for direct human work, it still needs human judgment and decisions. In this point, AI can help, providing that the capabilities of the AI tools are an advance over the simple IoT programming and controllers. As we have AI improving and becoming closer to mimicking human capabilities, the contribution it can make to IoT applications will be greatly expanded. As this is a field that is quickly developing and evolving, IoT users should monitor AI developments closely and watch for new opportunities and symbiosis.

Some examples of the interaction and contribution of AI to the IoT:

1. **Robots in Manufacturing**

Manufacturing is one of the industries that is embracing many of the new technologies like facial recognition, IoT, AI, robots and many more.

In this kind of industry, robots are employed and facilitate data transmission as they are turning smarter with the implementation of different sensors. As these robots are equipped with AI algorithms, they can learn from the new data the sensors (IoT) provide to them. This approach not only saves time and cost but also makes the manufacturing process better over time.

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2. Self-driving Cars

A good example of IoT and AI working together is the Tesla self-driving cars. These cars predict the behaviour of pedestrians and other cars in different circumstances. They can take into consideration road conditions, weather, and optimal speed, and, since we have AI connected with the IoT, they get better each trip.

3. Smart Thermostat Solution

Some thermostat solutions have AI-powered IoT, being able to check and manage the temperature from anywhere based on the work schedule and temperature preferences of its users.

5.2 Task for the classroom – Iot and AI

After going through the theory about IoT and AI, the teacher can ask the students to think of some examples where they think the two are used and describe what is the role of the IoT and the role of the AI.

For instance:

- Smart parking system in an office or school, where the AI studies the movement of cars inside the park for some time (a month, for instance) and then, with the help of sensors and cameras, the algorithm created can analyze the data connected to do that it can send each car to the most convenient place in the park.
- A healthy diet monitoring system that collects data on the choices each student makes daily while choosing their lunch and, with the help of sensors, gives the student the most healthy choices they can have.

This kind of activity will help teachers to understand if students fully understand the concept of IoT and AI working together and how they can make their lives easier.

Learning Objectives:

Through this task, students should be able to:

- Understand and communicate the main differences between IoT and AI;
- Identify examples of applications or industries that apply IoT and AI combined.
- Understand the role of both IoT and AI in the execution of some interactions.

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Chapter 6: Ethics in Artificial Intelligence

As the use of AI has become more and more common in our everyday lives, facilitating some of the tasks we do and lowering the risk of failure, like in healthcare diagnoses or creating labour efficiencies through automated tasks, it also raises some ethical concerns. Some examples of AI ethic issues include fairness, data responsibility and privacy, climate degradation, threats to human rights, accountability, and technology misuse, among others.

When we focus on AI in education and child-rearing, we necessarily think about the potential invasion of privacy that using AI can lead to. All the devices that are AI-powered – like smart speakers or virtual assistants- can collect a lot of data about children's behaviour, preferences and learning patterns. Despite this data that can help teachers and learners by producing more tailored content to each child's needs, the fact that we are unaware of who has access to this information is a matter to worry about and that we should always take under consideration.

Apart from this point, we cannot forget the fact that being able to rely on AI can prevent students from developing certain social and personal skills like communication, perseverance, or critical thinking. The fact that AI can provide questions and suggestions easily might reduce the opportunities for students to search for information, try and fail to solve a situation or seek help from others.

6.1 Task for the classroom – Ethics and AI

The teachers can start by showing the students some school equipment that is used in the classroom and ask students to describe the equipment shown that might demonstrate artificial intelligence. Then, teachers can take the conversation further by asking what some of the benefits and drawbacks of these technologies might be.

Afterwards, the teacher can divide the class into smaller groups and ask each group to focus on one piece of equipment and define the positive and negative aspects of using it, asking for the students to deliver some safe rules while using the equipment. Once finished, each small group can share their conclusions with the rest of the class.

In the end, the teacher can create an "Ethics in the Classroom" anchor chart with the suggestions done by the students.

Learning Objectives:

Through this task, students should be able to:

- Describe at least one example of an ethical issue about AI, along with its impact on society;
- Create at least one guiding principle that addresses an AI ethics issue;
- Gain conscience about the risk involved while using AI;
- Reflecting on the positive and negative aspects of AI.

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Assessment Questions

1. How many capabilities do we consider if we are considering a Capacity-based type of AI?
   a) Two
   b) Three
   c) Four

2. If we regard functionality, how many different types of functions and we consider?
   a) Four
   b) Five
   c) Seven

3. Which of the following is **not** based on AI?
   a) Self driving car
   b) Phone face ID unlocking
   c) Bluetooth connection
   d) Voice assistant

4. When playing music, which of the following uses artificial intelligence?
   a) Using Bluetooth to connect to a wireless speaker
   b) A playlist recommendation
   c) A wireless internet connection to stream the music
   d) Shuffle play from a chosen playlist

5. Thinking about devices in the home, which of the following uses artificial intelligence?
   a) Programming a home thermostat to change temperatures in certain times
   b) A security camera that sends an alert when there is an unrecognized person at the door
   c) Programming a timer to control when lights in a home turn on or off
   d) An indicator light that turns red when a water filter needs to be replaced

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https://www.tableau.com/learn/articles/machine-learning-examples
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Representation & Reasoning in Artificial Intelligence:

https://ai4k12.org/resources/big-ideas-poster/
https://www.autoblocks.ai/glossary/knowledge-representation-and-reasoning

Learning in Artificial Intelligence:

https://ai4k12.org/resources/big-ideas-poster/
https://elitedatascience.com/machine-learning-impact
https://www.coursera.org/articles/machine-learning-vs-ai
https://www.forbes.com/sites/bernardmarr/2019/12/16/the-10-best-examples-of-how-ai-is-already-used-in-our-everyday-life/?sh=6bcd0c1171fc

Natural Interaction in Artificial Intelligence:

https://ai4k12.org/resources/big-ideas-poster/
https://www.igebra.ai/blog/how-is-natural-interaction-possible-through-ai/

Societal Impact on Artificial Intelligence:

https://wisteed.com/5-big-ideas-of-ai/
https://ai4k12.org/resources/big-ideas-poster/

The Internet of Things and Artificial Intelligence:

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AI Applications

Introducing the 5 Big Ideas in Artificial Intelligence using Internet of Things in STEM education

22.09.2023 | ASSERTED KNOWLEDGE
PROJECT NUMBER: 2022-1-FR01-KA220-SCH-000085611

AI4STEM Educational Framework Topic: AI Applications

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Summary

AI applications in STEM education have the potential to revolutionise learning by incorporating the five big ideas of AI: perception, representation & reasoning, learning, natural interaction, and social impact.

AI-powered tools like learning platforms with AI features toys and games provide immersive learning experiences through computer vision, adaptive learning, and personalized interactions. AI-based assessment systems improve measuring learning progress but may have limitations in recognizing unique solutions. Personalized learning environments benefit students with difficulties and allow for individualized study plans. Ethical concerns such as privacy and algorithm bias must be addressed through responsible data handling and transparent algorithms.

The applications discussed in this module are divided into 5 categories depending on the functions they serve and the features they offer to facilitate STEM learning:

- **Virtual assistants and chatbots**
- **Advanced AI models developed by OpenAI**
- **Learning Apps and platforms with AI features: for teaching STEM subjects (Robotics, Coding & Machine Learning and Mathematics)**
- **AI-powered natural language processing (NLP) platforms (Grammarly, Quillbot, Quizlet) & computational knowledge engines (Wolfram Alpha)**
- **AI-powered Toys and Games-Puzzles, Virtual Reality (VR) & Computer games**

Overall, AI in STEM education can transform learning and prepare students for the future. AI in STEM education has the potential to revolutionize the way students learn and engage with science subjects. By providing personalized learning, virtual laboratories and simulations, data-driven insights, virtual tutors and study assistants, AI applications in education offer both teachers and students the opportunity to engage with more interactive educational content and can lead to improved learning outcomes and a deeper understanding of STEM subjects among students.

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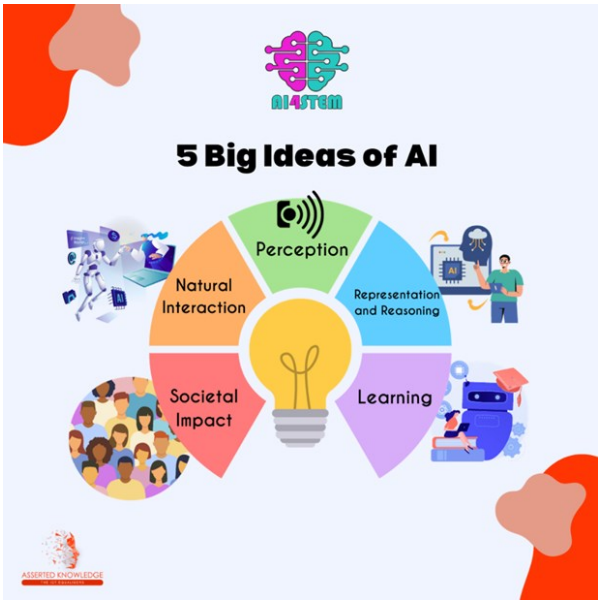
Chapter 1: Introduction

Artificial Intelligence (AI) nowadays has a wide range of applications in many aspects of our daily lives. From voice assistants like Siri and Alexa to self-driving cars, AI has revolutionized various industries and transformed the way we interact with technology. AI has also been introduced in the field of education, with its potential to enhance learning experiences and improve educational outcomes.

The AI applications presented here have been divided into 4 categories depending on the function they serve and how they can be used in an educational environment. Examples of AI apps will be presented for each category, along with the AI features that can facilitate STEM learning in each case. Also, each of the 4 categories will be analysed under the prism of the 5 Big Ideas of AI:

- Perception
- Learning
- Representation & Reasoning
- Societal impact
- Natural interaction

To understand the applications of AI in education, it is helpful to explore how they relate to the five big ideas of AI, as defined by AIK12 (AI for K-12) – Perception, Representation and Reasoning, Learning, Natural Interaction, and Societal Impact. These big ideas provide a framework for understanding the capabilities and potential of AI in education:



Perception refers to the ability of AI systems to gather information from the environment using sensors or other means. In education, AI can perceive student behaviour and engagement through data collection

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methods like eye-tracking, facial expression analysis, and even biometric measurements. This enables educators to gain insights into students' learning patterns and adapt their teaching strategies accordingly.

Representation and Reasoning involve the ability of AI systems to understand and manipulate information. In education, AI can analyse large amounts of data to identify patterns and make predictions about student performance. This can help educators identify areas where students may need additional support and tailor instruction to meet individual needs.

Learning is a fundamental aspect of AI, and it plays a crucial role in education as well. AI-powered adaptive learning platforms can personalize learning experiences based on individual student needs and preferences. By analysing data on student performance and behaviour, AI algorithms can provide targeted recommendations, resources, and feedback to support student learning and growth.

Natural Interaction as a Big Idea of AI refers to the development of AI systems that can interact with humans in a way that feels natural and intuitive, resembling human-to-human communication. The goal is to create AI systems that can understand and respond to human language, gestures, emotions, and context, enabling seamless and meaningful interactions.

Lastly, **Societal Impact** acknowledges the ethical considerations and potential consequences of AI deployment. In education, it is crucial to ensure that AI systems are designed and used ethically, respecting student privacy and promoting equity. AI should be a tool to enhance education and not exacerbate existing inequalities.

AI applications in education align with the five big ideas of AI – Perception, Representation and Reasoning, Learning, Natural Language Processing, and Societal Impact. By leveraging AI's capabilities, educators can personalize learning experiences, identify student needs, and provide targeted support, ultimately enhancing educational outcomes for all learners.

Chapter 2: Glossary – Key Notes

5 Big Ideas of AI: The 5 Big Ideas of AI refer to the core concepts that encompass the field of artificial intelligence. These ideas include perception (machines understanding and interpreting the world), learning (machines acquiring knowledge and improving performance), representation & reasoning (machines making decisions and solving problems), and societal impact (considering the ethical and social implications of AI). Problem-solving (machines using algorithms to solve complex tasks) is also an aspect of AI.

AI applications: AI applications are specific uses or implementations of artificial intelligence technologies in various fields. These applications can include machine learning, natural language processing, computer vision, robotics, and more. Examples of AI applications include virtual assistants, autonomous vehicles, recommendation systems, and medical diagnosis systems.

Algorithm: An algorithm is a set of step-by-step instructions or rules that guide the execution of a task or problem-solving process. In the context of AI, algorithms are used to process data, make predictions, and perform computations. They serve as the core building blocks of AI systems, enabling machines to perform specific tasks or learn from data.

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Augmenting Textual Content: Augmenting textual content refers to enhancing or improving written text using AI techniques. This can involve tasks such as grammar and spelling correction, generating summaries, or providing suggestions for improving the clarity or coherence of written content. Tools like Grammarly and Quillbot are examples of AI-powered platforms that augment textual content.

Cognitive functions: Cognitive functions refer to the mental processes involved in acquiring knowledge, understanding, and problem-solving. These functions include perception, attention, memory, language processing, reasoning, and decision-making. In the context of AI, cognitive functions are replicated or simulated in machines to enable them to perform tasks that require human-like intelligence.

STEM learning: STEM learning stands for Science, Technology, Engineering, and Mathematics learning. It refers to an educational approach that focuses on integrating these four disciplines to foster critical thinking, problem-solving, and inquiry-based learning. STEM learning aims to prepare students for careers in fields related to science, technology, engineering, and mathematics by providing hands-on experiences and promoting interdisciplinary thinking.

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Chapter 3: AI applications

AI applications refer to the practical use of artificial intelligence technologies to perform specific tasks or solve problems. AI, or artificial intelligence, involves the development of intelligent machines that can mimic human cognitive functions such as learning, reasoning, problem-solving, and decision-making.

AI applications can be found in various fields and industries, including healthcare, finance, transportation, entertainment, and more. These applications leverage AI techniques like machine learning, natural language processing, computer vision, and robotics to automate processes, analyse data, make predictions, and provide intelligent solutions.

In education, AI applications have the potential to revolutionize the learning experience. They can provide personalized learning pathways, intelligent tutoring, automated grading, data analysis, and virtual assistants. AI technologies can help educators tailor instruction to individual student needs, provide immediate feedback, and analyse vast amounts of educational data to inform decision-making.

AI applications are constantly evolving and have the potential to transform various aspects of our lives. However, it's important to consider the ethical implications, data privacy concerns, and the need for human oversight and guidance in the development and deployment of AI systems.

Before we go into detail about each AI app category it is worth mentioning the benefits of AI applications in STEM education. AI-powered apps and platforms offer personalized learning systems, also known as adaptive learning platforms or intelligent tutoring systems, that are one of the most common and valuable applications of AI to support students and teachers. Also, Automated assessment systems are becoming one of the most prominent and promising applications of machine learning in K-12 education.

AI applications can greatly enhance STEM education for kids between 5-12 years old. There have been numerous AI applications in the market over the years. Here we are going to present 4 distinct categories and some indicative examples. Also, how they can promote and assist STEM learning is going to be discussed, as well as how they relate to the 5 Big ideas of AI.

3.1 AI Applications Suitable for K12 Education

Virtual assistants and chatbots

Virtual assistants and chatbots are increasingly being utilized in STEM (Science, Technology, Engineering, and Mathematics) learning environments to enhance the educational experience for students.

Advanced AI models developed by OpenAI

For example, DALL·E is an advanced AI model developed by OpenAI that generates images from textual descriptions. While DALL·E is primarily focused on image generation, it can indirectly support STEM education by providing visual representations of complex concepts.

Learning Apps and platforms with AI features: for teaching STEM subjects (Robotics, Coding and machine learning and Mathematics)

Learning platforms with AI features and study tools have a significant impact on STEM (Science, Technology, Engineering, and Mathematics) learning. STEM learning becomes more engaging and

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interactive with these apps. Math, Physics, Coding and other subjects are presented with the help of virtual assistants, videos, walkthroughs and other interactive means. These AI apps and platforms provide a hands-on approach and allow children to explore STEM and AI concepts, develop problem-solving skills, and understand how AI interacts with the physical world. AI-powered learning platforms can adapt to each child's unique learning style and pace. These platforms can provide personalized lessons, interactive activities, and real-time feedback, making the learning experience engaging and tailored to individual needs.

AI-powered natural language processing (NLP) platforms (Grammarly, Quillbot, Quizlet) & computational knowledge engines (Wolfram Aplha)

Learning platforms along with AI-powered writing tools and studying companions leverage AI technologies to enhance the understanding and application of STEM concepts, assist learners in their written speech, help them with tasks and homework, and provide them with solutions. Overall, learning platforms with AI features and study tools greatly facilitate STEM education by making it more interactive, personalized, and impactful. Lastly, by providing personalized support, feedback, and resources, AI study assistants and writing tools promote active engagement, deeper understanding, and improved performance in STEM learning.

AI-powered Toys and Games-Puzzles, Virtual Reality (VR) & Computer games:

AI can be integrated into educational toys and games to make learning more enjoyable and interactive. For example, AI-enabled toys can respond to a child's actions, adapt to their preferences, and provide personalized challenges. These toys can teach coding, problem-solving, and critical thinking skills while keeping kids entertained. AI features can provide immersive experiences that bring abstract STEM concepts to life. Using AI, virtual environments can be created where kids can explore scientific phenomena, conduct virtual experiments, and visualize complex concepts more interactively and engagingly.

By incorporating AI into STEM education for kids aged 5-12, we can provide them with valuable skills and knowledge that will prepare them for the future. AI can make learning more interactive, personalized, and engaging, fostering curiosity, creativity, and critical thinking skill

Learning with AI involves the use of AI-driven tools in teaching and learning, and includes:

- the use of AI to support learners directly, involving tools such as those known as intelligent tutoring systems, dialogue-based tutoring systems, exploratory learning environments, automatic writing evaluation, learning network orchestrators, chatbots and AI to support learners with disabilities.
- the use of AI to support administrative systems (such as recruitment, timetabling and learning management).
- the use of AI to support teachers directly (although, except for smart curation of learning materials, there are few examples)

3.1.1 Chatbots & Virtual assistants

Chatbots (Chat GPT) & Virtual Assistants (Siri, Alexa, Xiaoice): Chatbots and virtual assistants can play a significant role in enhancing STEM learning in education for both teachers and young students.

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Chatbots can provide personalized learning experiences by tailoring content and activities based on a student's individual needs and preferences. They can adapt to the difficulty level of questions, suggest relevant resources, and provide targeted feedback, ensuring that students receive the appropriate level of challenge and support. The technology of Chatbots can also be incorporated into e-learning platforms (e.g., Photo2math and others).

Virtual assistants such as Siri, Alexa and Xiaoice can quickly provide answers to questions related to STEM topics. Kids can ask them about scientific facts, mathematical equations, historical events, or even coding concepts. This can help foster curiosity and provide instant access to information. Chatbots can offer immediate feedback on students' answers, helping them understand their mistakes and guiding them towards the correct solutions. This real-time feedback promotes active learning and allows students to adjust and learn from their errors. Additionally, chatbots can answer students' questions and provide explanations, offering support outside of the classroom. Chatbots can engage students in interactive practice sessions and quizzes, providing a dynamic and engaging learning experience. They can present questions, offer hints, and provide step-by-step guidance to help students solve problems. Chatbots can also reinforce STEM concepts by engaging students in interactive conversations. They can ask questions, initiate discussions, and present real-world examples to help students understand and apply theoretical concepts. This conversational approach promotes deeper learning and helps students connect abstract concepts to practical applications. This interactive format encourages active participation and helps students develop problem-solving and critical-thinking skills. Virtual assistants are available round the clock, enabling students to access learning materials and get assistance at any time. This flexibility accommodates different learning schedules and allows students to learn at their own pace. Teachers can also benefit from this availability by accessing resources and support whenever they need it.

Chatbots can also assist teachers by providing access to resources, lesson plans, and instructional materials. They can also support teachers in administrative tasks such as grading assignments, managing schedules, and organizing classroom activities. This support can save teachers time and allow them to focus on individualized instruction and student engagement. By leveraging chatbots and virtual assistants in STEM education, both teachers and students can benefit from personalized learning experiences, instant feedback, interactive practice, and continuous support. These AI-powered tools can enhance engagement, promote deeper understanding, and facilitate a more effective and efficient learning environment.

Cognii https://www.cognii.com/

Cognii works as an AI-based virtual learning assistant, utilizing conversational technology to aid students in constructing open-format responses and enhancing their critical thinking abilities. The virtual assistant also delivers personalized one-on-one tutoring and real-time feedback tailored to the individual needs of each child.

How Chatbots and virtual assistants facilitate the 5 BIG AI ideas:

Chatbots and virtual assistants like Alexa and Siri can facilitate the five big ideas of AI in education, benefiting both teachers and young students. Let's explore how they align with each big idea:

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1. Perception: Chatbots and virtual assistants can perceive and gather information from their environment through voice recognition and natural language processing. They can understand and interpret students' questions, commands, and responses. This perception capability allows them to engage in interactive conversations, understand context, and provide relevant information and resources.

2. Representation and Reasoning: Chatbots and virtual assistants utilize AI algorithms to represent and reason with information. They can analyse vast amounts of data to provide accurate and contextually appropriate responses. These AI systems can reason through complex problems, access databases, and retrieve relevant information to support learning and problem-solving.

3. Learning: Chatbots and virtual assistants can learn and adapt based on user interactions. They can remember past conversations, preferences, and learning patterns. This learning capability enables them to provide personalized recommendations, resources, and feedback to students. They can adapt their responses and content to match the individual needs and learning styles of each student.

4. Natural Interaction: Chatbots and virtual assistants aim to provide a natural and conversational interface for users to interact with AI systems. They are designed to understand human language, both spoken and written and respond in a way that feels intuitive and human-like. By employing natural language processing (NLP) techniques, these AI systems can interpret and generate text or speech, enabling seamless communication with users. Students can interact with them using voice commands or text-based inputs, making the learning experience more natural and intuitive. These AI systems can understand questions, provide explanations, and engage in conversations, fostering language development and communication skills. Lastly, Chatbots with special features can assist learners with disabilities and make their learning experience easier.

5. Societal Impact: The use of chatbots and virtual assistants in education raises important ethical considerations and societal impacts. Teachers can use these AI systems to discuss and explore topics such as data privacy, bias, and the responsible use of AI. By engaging with chatbots, students can develop an awareness of the potential societal impact of AI and the importance of ethical decision-making.

Overall, chatbots and virtual assistants like Alexa and Siri align with the five big ideas of AI by perceiving and understanding students' needs, representing and reasoning with information, learning and adapting to individual preferences, processing natural language, and raising awareness of the societal impact of AI. These AI tools can enhance the learning experience, provide personalized support, and foster critical thinking skills within the educational context.

3.1.2. Advanced AI models developed by OpenAI: Image generator tool with AI features- DALL·E

The application DALL·E is an advanced AI model developed by OpenAI that generates images from textual descriptions. While DALL·E is primarily focused on image generation, it can indirectly support STEM education by providing visual representations of complex concepts. Let us dive into some potential use cases and features of DALL·E in STEM education:

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- Visualizing Scientific Concepts: DALL·E can generate images based on textual descriptions, allowing students to visualize abstract or complex scientific concepts. This can aid in understanding topics like molecular structures, astronomical phenomena, mathematical equations, and more.
- Creating Visual Learning Materials: Teachers or students can use DALL·E to generate visual learning materials, such as diagrams, illustrations, or infographics. These visuals can enhance study materials and presentations, making them more engaging and informative.
- Designing Experiments and Simulations: DALL·E-generated images can be used to create virtual experiments or simulations, providing students with interactive and visually appealing learning experiences. This can be particularly useful in subjects like physics, chemistry, or biology.
- Augmenting Textual Content: By incorporating DALL·E-generated images alongside textual content, STEM textbooks or online resources can become more visually appealing and accessible to learners. This can help students grasp complex concepts more easily.

All these features of this application help kids to:

- Promote their creativity and Imagination: DALL·E can inspire students to think creatively and use their imagination when describing or visualizing STEM-related concepts. It encourages them to explore different perspectives and expand their understanding.
- Practice Problem-Solving: DALL-E can assist in problem-solving activities by generating visual cues based on textual descriptions. For instance, in a physics problem related to mechanical systems, students can describe the setup, and DALL-E can provide visual representations that help students understand a problem and devise a solution.
- Practice Computational Thinking: By leveraging DALL-E, students can develop computational thinking skills by understanding how textual descriptions are translated into visual representations. They can analyse the relationship between the input description and the generated image, fostering an understanding of algorithms and the underlying AI processes.
- Use the app in various disciplines of STEM: DALL-E's capabilities can be utilized in various STEM disciplines, allowing students to explore connections between different subjects. For instance, in biology, students can describe a cellular structure, and DALL-E can generate an image, enabling them to analyse its components and functions.

It's important to note that while DALL·E can generate impressive images, it should be used as a tool to support learning rather than a replacement for hands-on experimentation or practical experiences in STEM education. DALL-E can be a powerful tool in STEM learning, but it is still in the research and development phase. Teachers should guide students in understanding the limitations and potential biases of AI-generated images, promoting critical thinking and ethical considerations in their usage. By incorporating DALL-E in STEM education, teachers and students can enhance the learning experience, visualize abstract concepts, foster creativity, and develop computational thinking skills. It serves as a valuable tool to bridge the gap between textual descriptions and visual representations, promoting a deeper understanding of STEM subjects.

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DALL·E under the prism of the 5 big ideas in AI:

1. Perception: DALL·E showcases the potential of AI in perception by generating images from textual descriptions. It can perceive and understand the details, concepts, and visual elements mentioned in the text and translate them into coherent and visually appealing images. This demonstrates the model's ability to perceive and interpret textual information to create corresponding visual representations.

2. Representation & reasoning: DALL·E contributes to the idea of representation by mapping textual descriptions to visual images. It learns to represent the semantics and attributes of the text in a visual form, generating images that capture the essence of the given descriptions. This enables the model to bridge the gap between different modalities (text and images) and create accurate visual representations based on descriptions.

3. Learning: DALL·E is trained on a large dataset of text-image pairs, allowing it to learn the statistical patterns and associations between textual descriptions and visual features. Through this training process, the model acquires knowledge about the relationship between text and image content, enabling it to generate images that align with the given text. This learning capability demonstrates the model's ability to extract and utilize information from training data to generate novel and coherent visual outputs.

4. Natural Interaction: DALL·E contributes to natural interaction by generating images that correspond to textual descriptions. Users can interact with the model by providing descriptive text, and the model responds by generating images that align with the given input.

5. Social Impact: DALL·E's image generation capabilities can have a profound social impact. It opens up possibilities for creative expression, design, and visual storytelling. Artists, designers, and content creators can leverage DALL·E to generate visual concepts and explore new creative avenues. However, it is also important to consider potential ethical concerns, such as the responsible use of AI-generated content and the implications for copyright and ownership.

To sum up, DALL·E facilitates the five big ideas in AI by showcasing its capabilities in perception, representation and reasoning, learning, natural interaction, and social impact. Its ability to generate images from textual descriptions demonstrates the potential of AI models to bridge different modalities, understand context, and enable creative expression through human-like visual understanding.

3.1.3 Learning Apps & Platforms with AI features: for teaching STEM subjects

In this section, we refer to applications related to Robotics, Coding, Machine Learning and Mathematics

Cognimates: https://cognimates.me/home/

Cognimates An AI education platform for building games, programming robots & training AI models. It is an open-source platform, where parents and children (7 to 10 years old) can get creative with AI. Children can participate in creative programming activities where they learn how to build games, program robots, and train their machine-learning models. It offers a range of projects that learners can explore and create using AI technologies. While it is not specifically designed for STEM education, it offers features that can be applied to various educational domains, including STEM. Here are some potential AI features of Cognimates in STEM education:

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- Coding and Computational Thinking: Cognimates provides a coding environment that allows students to learn programming concepts and develop computational thinking skills. They can create interactive projects, design games, or build simulations related to STEM subjects, fostering creativity and problem-solving abilities.
- AI and Machine Learning: Cognimates introduces students to the fundamentals of AI and machine learning through hands-on activities. They can explore how AI algorithms work, learn to train AI models and develop projects that utilize AI technologies to solve STEM-related problems.
- Data Visualization: Cognimates offers tools for visualizing data, enabling students to analyse and interpret scientific data sets. This can help them understand patterns, trends, and relationships within STEM domains, such as graphing experiments or representing statistical information.
- Robotics and IoT Integration: Cognimates supports the integration of robotics and Internet of Things (IoT) devices, allowing students to create projects that involve physical computing. They can program robots or design smart systems to solve STEM challenges, enhancing their understanding of robotics and automation concepts.
- Community and Collaboration: Cognimates facilitates a community of learners, allowing students to share their projects, collaborate with peers, and receive feedback on their work. This encourages collaboration, peer learning, and knowledge sharing within the STEM education community.

While Cognimates is a versatile AI platform, it may require customization and adaptation by educators to align with specific STEM learning objectives and curriculum requirements.

Quizlet: https://quizlet.com/

Quizlet, a popular online learning platform, offers several AI-powered features that can benefit students in STEM education:

Flashcards and Study Sets: Quizlet allows students to create digital flashcards and study sets for reviewing scientific terms, formulas, equations, definitions, and other STEM-related concepts. The AI algorithms in Quizlet can assist in organizing and optimizing the flashcards for effective learning.

There are AI features in Quizlet that enhance learning and make it more interactive and fun:

- Magic Notes saves you time by turning your notes into flashcards, practice test outlines and more.
- Q-Chat: AI tutor in the form of Chatbox
- Personalized homework help through verified explanations with AI-powered tutoring that assists in homework assignments.
- The Quizlet Learn feature helps students prepare for exams and quizzes by creating personalized study plans. The AI algorithms analyse the student's progress and performance to generate a tailored study schedule, including targeted practice sessions and review activities.

Quizlet's AI algorithms can adapt to students' learning patterns and performance. It tracks their progress, identifies areas of weakness, and adjusts the difficulty level of questions accordingly. This adaptive learning feature helps students focus on areas where they need the most improvement. Quizlet also schedules the review of flashcards at optimal intervals. The AI algorithms determine the most efficient timing for reviewing concepts, ensuring long-term retention of STEM-related information.

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Quizlet Live: While not AI-specific, Quizlet Live is a collaborative learning game that can be used in STEM education. It promotes teamwork and engagement by allowing students to work together to answer questions related to STEM concepts.

Quizlet Diagrams: The Quizlet Diagrams feature enables students to create and study visual diagrams, charts, and images related to STEM topics. This can be particularly useful for subjects like biology, anatomy, or chemistry, where visual representation is essential.

These AI-powered features in Quizlet can enhance students' engagement, retention, and understanding of STEM concepts, providing them with effective study tools and personalized learning experiences.

Tynker for K-12 students: https://www.tynker.com/stem/

Tynker is an educational platform that focuses on coding and computational thinking skills through interactive and engaging activities, such as virtual games in Minecraft.

The AI features on Tynker that promote STEM learning are the following:

- AI-Driven Personalization: Tynker uses AI algorithms to personalize the learning experience for each student. It adapts to the difficulty level of coding challenges and provides targeted feedback based on the student's progress.
- AI-Powered Coding Assistance: Tynker offers AI-powered coding assistance that helps students when they get stuck. It provides hints, suggestions, and debugging support to help them overcome coding challenges.
- AI Projects and Challenges: Tynker provides AI-focused projects and challenges that allow students to explore and apply AI concepts. They can build AI models, train them, and use them to solve real-world problems.
- AI Simulations and Virtual Labs: Tynker includes AI simulations and virtual labs that enable students to experiment with AI concepts in a safe and controlled environment. They can interact with virtual AI agents and explore AI algorithms.
- AI Curriculum and Courses: Tynker offers an AI-focused curriculum and courses designed specifically for K-12 students. Tynker's self-paced coding curriculum lets students learn by applying coding to core subjects. These resources cover various AI topics, such as machine learning, computer vision, natural language processing, and robotics.

Overall, Tynker's AI features aim to make STEM education more accessible, engaging, and interactive for kids, allowing them to learn about programming and develop problem-solving & critical-thinking skills.

Kodable: https://www.kodable.com/

Kodable is an educational platform that introduces coding to young learners. While Kodable does not prominently feature AI, it incorporates certain AI-related elements to enhance the learning experience in STEM education. The features in Kodable that can be utilized to elevate STEM learning can be:

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Kodable provides teachers with tools and reports to monitor student progress, track their coding skills development, and identify areas where they may need additional support. These reports often include information about completed levels, coding concepts mastered, and time spent on different activities.

It can also provide guidance and support to students while studying a specific STEM topic. It fosters creativity and critical thinking, through interactive lessons and creative activities

It provides gamified elements like badges, levels, and rewards to engage and motivate learners. Depending on the student's performance the difficulty level of the challenges is adjusted accordingly. Kodable's primary focus is on teaching coding and computational thinking to young learners.

Khan Academy: https://www.khanacademy.org/

Khan Academy does not currently have AI features in the traditional sense. However, it is an online learning platform focused on K-12 that offers personalized learning experiences. This platform uses data and analytics to track a student's progress and provide recommendations for future learning. It adjusts the difficulty and pace of the content based on the student's performance, allowing for a more customized learning experience. While this is not considered true AI, it does incorporate some elements of adaptive learning and personalization.

Classic computer science unplugged https://classic.csunplugged.org/

This website is a resource provided by CS Unplugged, a project that offers a collection of free, offline, and interactive computer science activities for teaching concepts without the need for computers. The specific link provided here: **"https://classic.csunplugged.org/activities/sorting-algorithms/"** directs to an activity called "Sorting Algorithms" on the CS Unplugged website. This activity aims to teach students about different sorting algorithms, such as Bubble Sort, Selection Sort, and Insertion Sort, without the use of computers. In this activity, students physically simulate the sorting algorithms by moving and arranging themselves in a specific order, replicating the steps of the algorithms. This hands-on approach helps students understand the underlying concepts of sorting algorithms and how they work. The CS Unplugged project is designed to make computer science accessible and engaging for students, even in environments without access to computers. It provides various activities and resources for teaching fundamental computer science concepts through interactive and unplugged methods.

- **Learning Platforms focused on Machine learning:**

Google Teachable Machine: Teachable Machine is a web-based app by Google that allows kids to train their machine learning models using their webcam. Kids can teach the model to recognize and classify different objects or gestures, providing a hands-on introduction to machine learning. https://teachablemachine.withgoogle.com/

TensorFlow Playground is a graphical application that allows high school and undergraduate students to experiment with neural networks and backpropagation learning. https://playground.tensorflow.org

Machine Learning for Kids is another website that offers online demonstrations in which kids can train classifiers using web applications or Scratch extensions. https://machinelearningforkids.co.uk/

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How Learning Apps and platforms with AI features facilitate the 5 Big Ideas of AI:

Whether the aim is to teach kids coding, machine learning or traditional subjects like math, or physics, all these apps that fall into this category utilize AI features in various ways and contribute to the 5 big ideas of AI in similar ways:

1. Perception: These apps and platforms use AI technologies to perceive and understand educational content. They can analyse and interpret programming code, mathematical equations, scientific principles, and textual information, providing a deeper understanding of the subject matter.

2. Representation and reasoning: By leveraging AI, these tools can represent complex concepts in a more accessible and interactive manner. They use visualizations, simulations, and interactive elements to present information, making it easier for learners to grasp and engage with the material.

3. Learning: These apps and platforms employ AI algorithms to personalize the learning experience. They adapt to each learner's progress, preferences, and needs, providing tailored recommendations, adaptive exercises, and targeted feedback. AI-powered tools optimize the learning process, enhancing knowledge acquisition and retention.

4. Natural Interaction: Many of these apps and platforms incorporate AI-based chatbots or virtual assistants that enable natural and interactive communication. Learners can ask questions, seek explanations, and receive immediate responses, creating a more engaging and conversational learning experience. Learning applications can also assist learners with disabilities, by interacting with them in the most convenient ways, adapted to each user's needs.

5. Social Impact: Apps and platforms that teach programming, machine learning, and traditional subjects have a significant social impact. They make education more accessible by providing learning opportunities to a wider audience, irrespective of geographical or socioeconomic barriers. By utilizing AI to deliver high-quality educational content, these platforms contribute to reducing educational disparities and promoting lifelong learning. When it comes to AI There are always ethical concerns about the privacy of personal info, biased algorithms and depersonalization of education.

In summary, apps and platforms that teach programming, machine learning, and traditional subjects, with AI features facilitate the five big ideas of AI. They enhance perception, provide adaptable representations, personalize the learning experience, enable natural interaction, and have a positive social impact by making education more accessible and effective.

A very interesting example in this category is Cognimates:

Cognimates is an AI learning platform that aims to empower learners to explore and engage with AI technologies. It facilitates the 5 Big Ideas of AI in the following ways:

1. Perception: Allows learners to work with AI technologies like computer vision and natural language processing. Through hands-on activities and projects, learners can develop an understanding of how machines perceive and interpret the world. For example, they can use computer vision algorithms to recognize objects or use natural language processing to build conversational agents.

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2. Learning: In the case of cognates the platform learns from the data that it receives from each student, analyses the data and gains insights into how students are engaging with the platform. This can include tracking their progress, measuring completion rates of activities, and identifying patterns in their learning behaviours.

3. Representation & Reasoning: Analyses the data that it gathers and provides informed solutions to students about their learning needs.

4. Natural interaction: It doesn't directly facilitate natural language interaction, but it does provide an interactive and engaging learning environment for students to interact with AI technologies in a hands-on manner. Cognimates enables learners to create projects and activities that involve AI technologies. For example, there is a project offered on the platform where learners can learn how to teach Alexa about their favourite things, and then ask her about them. Although the interaction may not be in the form of natural language conversations, learners can engage with AI systems and develop a deeper understanding of how these technologies work.

5. Societal Impact: Fosters an understanding of the societal impact of AI. It encourages learners to consider the ethical, social, and cultural implications of AI technologies. By engaging in discussions, projects, and reflections, learners can explore how AI can be used responsibly and contribute positively to society.

Overall, Cognimates facilitates the 5 Big Ideas of AI by providing a learning platform that enables learners to explore, learn, reason, problem-solve, and consider the societal impact of AI technologies. It empowers learners to become active participants in the AI era and encourages them to think critically and creatively about AI's potential. Cognimates also provides opportunities for learners to engage in problem-solving activities using AI technologies. It offers coding environments where learners can create AI-powered projects and solve real-world problems.

3.1.4 AI-powered natural language processing (NLP) platforms & computational knowledge engines

Wolfram Alpha: https://www.wolframalpha.com/

Wolfram Alpha is a computational knowledge engine that provides answers and generates reports for a wide range of topics. It uses algorithms to automatically answer questions, do analysis and generate reports. It can perform calculations, provide information on various subjects, solve equations, analyse data, and more. It is designed to understand natural language queries and provide accurate and complete answers.

It offers information on a vast range of topics and can enhance STEM learning by assisting students when studying at home, by providing examples, information on-demand, and solutions by guiding learners through an exercise or problem.

Photo2math https://photo2math.com/?utm_source=ai-search.io

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Photo2Math.com utilizes AI-powered optical character recognition (OCR) technology to recognize and convert handwritten or printed math equations into digital text. Students can snap a photo of a math problem, upload an image or sketch a math formula with their finger or pen. The app will solve it and guide the student through the solution. This AI feature has several benefits for STEM learning:

- Equation transcription: Photo2Math's AI can accurately transcribe complex math equations from physical sources like textbooks, handwritten notes, or whiteboards. This makes it easier for students to digitize their equations and work with them in digital formats.
- Timesaving: Instead of manually typing out equations, students can simply take a picture and let the AI do the work. This saves time and allows students to focus on understanding and solving the equations rather than spending time on transcription.
- Accessibility: For students with learning disabilities or difficulties in writing or typing, Photo2Math's AI can provide a more accessible way to convert equations into digital text. This ensures that all students have equal opportunities to engage with and learn from math materials.
- Integration with digital tools: The converted equations can be easily copied and pasted into various digital tools, such as word processors, math software, or online platforms. This allows students to seamlessly incorporate equations into their assignments, presentations, or collaborative projects.
- It's important to note that while Photo2Math's AI is advanced, it may not always provide perfect results, especially for complex or poorly written equations. Therefore, it's recommended to review and verify the converted text for accuracy before using it for calculations or further work.

Grammarly, DeepL and Quillbot can be categorized as AI-powered natural language processing (NLP) platforms. NLP is a subfield of AI that focuses on the interaction between computers and human language. These platforms utilize AI algorithms to analyse and understand written text, providing various language-related services such as grammar and spelling correction, writing enhancement, and paraphrasing. They leverage machine learning and deep learning techniques to process and generate language-based outputs, making them valuable tools for writers, students, and professionals in various domains.

Grammarly: https://www.grammarly.com/

Grammarly, an AI-powered writing assistant, may not have specific features tailored specifically for STEM education. However, it can still be a valuable tool for students and educators in various ways:

- Grammar and Spelling: Grammarly can help students improve their writing by identifying and correcting grammar and spelling errors. This is beneficial for STEM students when writing lab reports, research papers, or technical documentation where precise language is crucial.
- Clarity and Conciseness: Clear and concise communication is essential in STEM fields. Grammarly can suggest improvements to sentence structure, word choice, and overall writing style, ensuring that students convey their ideas effectively and succinctly.
- Vocabulary Enhancement: Grammarly offers suggestions for enhancing vocabulary, providing synonyms or alternative word choices. This can be useful for students who want to expand their technical vocabulary or find more precise terms for scientific concepts.

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- Plagiarism Detection: Grammarly's plagiarism detection feature can help students avoid unintentional plagiarism by highlighting potential instances of copied content. This promotes academic integrity when students are conducting research or referencing external sources.
- Writing Style and Tone: Depending on the context, Grammarly can analyse the writing style and tone to provide suggestions for maintaining a consistent and appropriate voice in STEM writing.

While Grammarly may not have specific STEM-focused features, it can still be a valuable tool for students in STEM education to enhance their writing skills and improve the clarity and accuracy of their scientific communication.

Quillbot: https://quillbot.com/

While Quillbot is primarily known as a writing tool, it can also be used in STEM learning to support students in generating explanations, summaries, and paraphrases of complex scientific concepts or technical information. It can help students understand and communicate STEM ideas more effectively by providing alternative versions of their writing or helping them rephrase and simplify complex texts. Quillbot's AI-powered capabilities can assist students in improving their scientific writing skills, enhancing their understanding of STEM concepts, and facilitating clearer communication in technical fields.

DeepL: https://www.deepl.com/translator

https://www.deepl.com/write

DeepL is primarily known as an AI-powered translation platform that provides high-quality translations for various languages. It uses deep learning techniques to analyse and understand the context of text to generate accurate translations. While DeepL is a valuable tool for language translation, it does not provide tutoring or educational features such as personalized learning, feedback, or interactive instructional content. Nevertheless, it can assist students in STEM learning. For example, providing accurate translations, allows students to access a broader range of STEM resources and expand their knowledge base. DeepL can assist students in understanding and translating complex technical terms and jargon commonly used in STEM fields. DeepL can be used as a tool to enhance language comprehension and communication in the context of STEM learning.

Gizmo https://gizmo.ai/

Gizmo is an AI education tool that helps kids remember everything they learn but in a simple and fun way. The app uses AI to transform notes and study materials into fun quizzes. Children tend to learn better when they have fun. All you need to do is paste in study notes into the app, then Gizmo transforms them into a fun quiz.

AI-powered natural language processing (NLP) platforms and computational knowledge engines facilitate the 5 Big Ideas of AI in the following ways:

1. Perception: NLP platforms enable machines to understand and interpret human language or math equations. They can analyse text, and numbers, identify patterns, and extract meaning. For example, Grammarly can perceive grammar and spelling errors in written text, helping users improve their writing

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skills. Quillbot can perceive the context and rephrase text to enhance clarity and coherence. Another example from photo2math is that the application can perceive the content of a photo with a math equation and transcribe it into numbers and equations.

2. Representation & Reasoning: NLP platforms enable machines to reason and make sense of human language. They can understand the context, infer meaning, and generate responses. DeepL uses deep learning algorithms to reason and generate accurate translations.

3. Learning: Most of the applications in this category gather data from students' answers and input and provide them with answers, solutions and guidance.

4. Natural interaction: NLP platforms and computational knowledge engines enable natural and intuitive interaction between humans and machines through language. Users can communicate with some of the platforms in the category conversationally, making queries, asking questions, and receiving responses in a human-like way. For example, users can input questions or requests into Wolfram Alpha using natural language, and the engine will provide relevant and understandable answers. It also provides detailed explanations and solutions to complex problems, enabling students to learn and understand various subjects. Photo2math has "AlbertBro" a virtual tutoring assistant that interacts with the student providing answers to questions regarding math problems and equations. Platforms like Quizlet offer interactive study materials, flashcards, and quizzes, allowing students to learn and review concepts.

5. Societal Impact: NLP platforms and computational knowledge engines have a significant impact on society. They promote accessibility, inclusivity, and collaboration in education. These technologies break down language barriers, assist students with learning differences, and enable global communication and collaboration. They also empower educators by providing tools to enhance teaching practices and create educational material in a time-effective manner.

By leveraging AI techniques such as natural language processing, machine learning, and computational power, these platforms and engines contribute to the 5 Big Ideas of AI, enhancing perception, supporting learning and reasoning, facilitating a more user-friendly interface, and promoting positive societal impact.

3.1.5 AI-powered Toys and Games-Puzzles, Virtual Reality (VR) & Computer games

The last category of Apps with AI features that can be used to elevate STEM learning includes games puzzles and animations, that promote creativity and offer engaging content that can be used in education.

BrainPOP https://www.brainpop.com/

BrainPOP is an educational platform that offers a wide range of animated videos, interactive quizzes, and activities across various subjects. While it does not prominently feature AI, it utilizes certain AI-related technologies to enhance the learning experience. BrainPOP, an educational platform designed with learner variability in mind, offers digital content in subjects across the curriculum in the form of animated movies, student creation and reflection tools, coding projects, learning games, and interactive

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assessments. BrainPOP also hosts a site for educators that supports them with various forms of planning resources and professional development opportunities.

The application analyses the learner's responses and adapts the difficulty level and content recommendations based on their performance, ensuring a customized learning path. BrainPOP's AI algorithms analyse the learner's progress, interests, and previous interactions with the platform to provide personalized content recommendations. This helps students discover new topics and areas of interest that align with their learning goals. BrainPOP incorporates natural language processing (NLP) to enable interactive chat features.

For example, students can ask questions or engage in conversations with the AI-powered characters within the platform to enhance their understanding of the concepts presented. Tim and Moby are the main AI characters in BrainPOP. Tim is a curious student, while Moby is his robot friend. They appear in animated videos that cover a wide range of educational topics across various subjects. Tim and Moby present information, ask questions and guide students through the learning content. Annie and Ben are a pair of AI characters that often appear in BrainPOP Jr., which is tailored for younger learners.

In some instances, BrainPOP utilizes speech recognition technology to allow students to interact with the platform using their voice. This feature can be used for pronunciation practice, language learning activities, or speaking exercises. BrainPOP collects and analyses data on student interactions, progress, and performance to provide insights to educators. This data can help teachers identify areas where students may need additional support or interventions, enabling more targeted instruction. While BrainPOP incorporates AI-related features to enhance the learning experience, it primarily focuses on engaging educational content and interactive activities.

Minecraft Education: https://education.minecraft.net/en-us

In collaboration with Microsoft AI for Earth, five new lessons for Minecraft: Education Edition have been created, designed to explain the principles of AI and help students take their first steps in the realm of computer science. Learners will use the power of AI in a range of exciting real-world scenarios, including the preservation of wildlife and ecosystems, helping people in remote areas, and research on climate change. Many of these lessons are based on real-world projects developed by Microsoft partners and feature learning connections to their work:

Lightbot: https://lightbot.com/

Lightbot is a puzzle game app that teaches coding and programming logic to children. It presents challenges where students have to program a robot to light up tiles on a grid. The app gradually introduces concepts like loops and functions, fostering computational thinking in young learners.

Quick, Draw! https://quickdraw.withgoogle.com/

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Quick, Draw! is an online game developed by Google built with machine learning. You draw, and a neural network tries to guess what you're drawing. The game prompts players to draw a specific object within a limited time frame, while an AI system tries to recognize and guess what the player is drawing.

Code.org AI Activities: https://code.org/ai

Code.org provides a range of AI-related activities and lessons for kids. These activities introduce concepts like pattern recognition, machine learning, and AI ethics through interactive games and puzzles.

AI-powered toys and games, such as puzzles and virtual reality (VR) experiences, can facilitate the 5 Big Ideas of AI in the following ways:

1. Perception: AI-powered toys and games can utilize computer vision, speech recognition and sensory input or simply typed text to perceive and understand the environment. They can recognize objects, interpret gestures, and analyse audio cues, providing an immersive and interactive experience for users.

2. Representation & Reasoning: AI-powered toys and games can represent complex concepts and scenarios more tangibly and interactively. They can use visualizations, and simulations, to create a more engaging and understandable representation of AI-related concepts, such as neural networks or robotics.

3. Learning: These applications can adapt to the user's progress, customize challenges, and provide feedback to promote learning and skill development. Through interactive gameplay and problem-solving scenarios, users can enhance their understanding of AI principles and applications.

4. Natural Interaction: AI-powered toys and games can incorporate natural language processing and gesture and speech recognition technologies to interact with the user. Users can communicate with virtual characters or control game elements using voice commands or physical movements, creating a more natural and engaging experience.

5. Social Impact: AI-powered toys and games have the potential to promote social engagement and collaboration. They can facilitate multiplayer experiences, allowing users to interact and learn together. Additionally, these toys and games can spark interest in AI-related topics and inspire young learners to pursue careers in STEM fields.

In summary, AI-powered toys and games, including puzzles and VR experiences, facilitate the five big ideas of AI by enhancing perception, providing interactive representations, promoting learning, enabling natural interactions, and creating a positive social impact. They offer engaging and immersive experiences that help users develop a deeper understanding of AI concepts and their real-world applications.

3.2 Ethics perception about using AI Apps in STEM Education

The use of AI apps in education brings about several ethical concerns that need to be addressed. One major concern is the potential for bias and discrimination in AI algorithms. If these algorithms are trained on biased data or programmed with biased instructions, they can perpetuate existing inequalities and reinforce stereotypes in educational settings. It is crucial to ensure that AI algorithms used in education are fair and unbiased and promote equal opportunities for all learners.

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The use of AI in K-12 education raises significant ethical concerns, particularly regarding the privacy of students and teachers. Privacy issues arise when individuals share excessive personal information on online platforms. AI apps often collect and analyse large amounts of personal information from students, such as their performance data, behaviour patterns, and even sensitive information like their social and emotional well-being. It is essential to have robust data protection measures in place to safeguard this information and ensure that it is not misused or accessed without proper consent. While there are laws and standards in place to safeguard sensitive data, the violations by AI-based tech companies in terms of data access and security have heightened privacy concerns. To tackle these concerns, AI systems now seek users' consent before accessing their data.

Furthermore, there is a concern about the depersonalization of education, through the use of AI apps. While these apps can provide personalized learning experiences, there is a risk of replacing human interaction and individualized support with automated systems. It is crucial to strike a balance between the benefits of AI technology and the need for human guidance and social interaction in education.

Lastly, there are ethical implications related to the transparency of AI algorithms. Students and teachers should be able to understand how AI apps make decisions and recommendations. Transparent and explainable AI systems are necessary to build trust and enable users to challenge or question the outcomes generated by these apps.

Addressing these ethical concerns requires a comprehensive approach that involves clear guidelines and regulations, transparent algorithms, responsible data handling practices, and ongoing monitoring and evaluation of AI apps in educational settings. It is crucial to ensure that AI is used ethically and responsibly to enhance, rather than hinder, the educational experience for all learners.

3.4 Conclusion

In conclusion, AI applications in STEM education have the potential to revolutionize the way students learn and engage with complex concepts. By incorporating the five big ideas of AI - perception, representation & reasoning, learning, natural interaction, and social impact - AI-powered tools and technologies can provide immersive and interactive learning experiences.

AI-powered toys and games, such as puzzles and virtual reality experiences, facilitate perception by utilizing computer vision and sensory input to understand the environment. They also enhance representation by creating tangible and interactive representations of AI concepts. Through adaptive learning and personalized experiences, AI systems promote learning and skill development.

Natural interaction is facilitated through AI's ability to understand gestures and natural language, allowing for intuitive and immersive interactions with virtual characters or game elements. Lastly, AI applications in STEM education have the potential to create a positive social impact by promoting social engagement and collaboration among learners.

Additionally, measuring learning progress becomes more effective. However, these intelligent assessment systems may overlook correct but rare unique solutions as they rely on statistical data. Therefore, AI-based assessment systems cannot be completely accurate in every situation without human guidance.

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Furthermore, personalized learning environments not only improve the quality of the educational process but also benefit students with difficulties like dyslexia or students with disabilities and other health issues, enabling them to study more effectively. These environments also facilitate the adaptation of educational content to students' needs, allowing for more individualized study plans.

However, it is crucial to address ethical concerns such as privacy, the bias of algorithms, and the risk of depersonalization of education. By implementing responsible data handling practices, transparent algorithms, and clear guidelines, we can ensure that AI applications in STEM education are used ethically and responsibly.

Overall, AI applications in STEM education, when aligned with the five big ideas of AI and with careful consideration of ethical implications, have the potential to transform the learning experience, enhance understanding, and prepare students for the future.

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Chapter 4: Case Studies

1. **RAISE: Robotics & AI to improve STEM and social skills for elementary school students** https://www.frontiersin.org/articles/10.3389/frvir.2022.968312/full

In this research, a virtual learning environment is designed to assist children with autism (ASD) in learning STEM skills and improving social-emotional and communication skills. The project incorporates a virtual AI companion (AIC) that adapts to students' varying levels of support needs. Puppetry control is used to guide the AIC's actions, helping students with ASD learn to code and practice social skills. The AIC's actions, including speech, facial expressions, gestures, and physiological changes, are based on observed behaviours and aim to support the student in coding a robot. The paper presents exploratory findings from the first two years of a five-year research study, using a single-case study design. The focus is on evolving AIC technology and supporting students with ASD in STEM environments, rather than student learning outcomes.

2. **Children's Digital Art Ability Training System Based on AI-Assisted Learning: A Case Study of Drawing Colour Perception** https://www.frontiersin.org/articles/10.3389/fpsyg.2022.823078/full

This study introduces a children's digital art ability training system with AI-assisted learning to enhance children's drawing abilities. AI technology was introduced for outline recognition, hue colour matching, and colour ratio calculation to machine-train students' cognition of chromatics and smart glasses were used to view actual augmented reality paintings to enhance the effectiveness of improving elementary school students' imagination and painting performance through the diversified stimulation of colours. The research subjects are the Grade 4 students at an elementary school in Taitung City, Taiwan. The test tools included an imagination test and an evaluation of painting performance ability.

The study utilizes a quasi-experimental research design with pre-test and post-test assessments for different groups of Grade 4 students in Taitung City, Taiwan. The test results, along with qualitative data such as student feedback and teacher reflection notes, are analysed to evaluate the impact of the training system on students' imagination and painting performance.

3. **Machine learning for middle schoolers: Learning through data-driven design** https://www.sciencedirect.com/science/article/pii/S2212868921000222

The article presents a pedagogical framework that enables middle school students to become co-designers of their own ML applications. The framework is applied in a case study conducted in a Finnish elementary school with 6th-grade students. The study analyses the students' evolving ideas and explanations related to ML through their artwork, design ideas, co-designed applications, and structured group interviews. The study reveals that hands-on exploration with ML technologies supports students in developing design ideas that utilize face recognition, gestures, and voice recognition to solve real-life problems. The study suggests that co-designing ML applications helps students develop a conceptual understanding of ML principles and their role in their everyday lives. The article concludes with a

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discussion on supporting students to become innovators and software designers in the era of machine learning.

4. **Personalizing homemade bots with plug & play AI for STEAM education** https://dl.acm.org/doi/abs/10.1145/3283254.3283270

This study presents a framework for hands-on educational modules that introduce AI and robotics concepts in a casual, quick, and effective manner. Many existing robotics courses focus on basic skills and lack the incorporation of exciting AI applications like image recognition. As a case study, an educational module involving creating a toy car with a camera controlled by Raspberry Pi is introduced. The framework combines physical and digital environments, allowing participants to drive their toy cars on a physical track using a convolutional neural network trained based on their virtual game-play style. The proposed framework can be extended to other robotics projects, making AI and robotics ideas more accessible to learners. The study aims to demonstrate AI's personalization capabilities and foster curiosity and motivation among participants.

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Chapter 5: Classroom Activities

Activity1: Exploring STEM Concepts with DALL·E, Tynker, Khan Academy, and Lightbot

Objective: To engage students in STEM learning by integrating creativity, coding, math, and programming logic using DALL·E for image generation, Tynker for coding, Khan Academy for math concepts, and Lightbot for programming logic.

Materials:

- Computers or tablets with internet access
- DALL·E access (if available)
- Tynker accounts for each student
- Khan Academy accounts for each student
- Lightbot game (online or app version)

Instructions:

1. Introduction to AI and Creativity (30 minutes):

- Begin by discussing the concept of AI and its applications, including DALL·E's ability to generate images based on text descriptions.
- Show examples of images created by DALL·E and engage students in a discussion about the creative potential of AI.

2. Image Generation with DALL·E (30 minutes):

- If available, allow students to experiment with DALL·E by providing them with a text prompt and generating images based on their inputs.
- Encourage students to explore different prompts and discuss the generated images as a group.

3. Coding with Tynker (60 minutes):

- Introduce Tynker as a coding platform and guide students through a coding tutorial or project related to a STEM concept of your choice (e.g., simple robotics, environmental science, or physics).
- Assign a coding challenge where students use Tynker to create a program that incorporates the STEM concept and also use an image generated by DALL·E to complete the presentation of the project.

4. Math Concepts on Khan Academy (30 minutes):

- Introduce Khan Academy as a resource for learning math concepts relevant to the chosen STEM topic.
- Assign math-related exercises or lessons on Khan Academy that align with the student's grade level and reinforce their understanding of the STEM concept.

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5. Programming Logic with Lightbot (60 minutes):

- Introduce Lightbot as a game that teaches programming logic and problem-solving skills.
- Assign students to play Lightbot individually or in pairs, completing levels that incorporate the STEM concept introduced earlier, reinforcing programming logic skills.

6. Integration and Application (30 minutes):

- Bring together the concepts learned from DALL·E, Tynker, Khan Academy, and Lightbot to create an integrated project.
- Assign students to design a project that incorporates the STEM concept, coding with Tynker, math concepts from Khan Academy, and logical problem-solving from Lightbot.
- Students can present their projects to the class, showcasing how they integrated the different tools and concepts.

Learning Objectives:

- Students develop an understanding of AI, creativity, and its applications through DALL·E's image generation capabilities.
- Coding with Tynker enhances students' computational thinking and problem-solving skills while applying STEM concepts.
- Khan Academy reinforces math concepts relevant to the chosen STEM topic, fostering a deeper understanding.
- Lightbot introduces students to programming logic and strengthens their logical reasoning abilities in a STEM context.

Note: DALL·E access may not be widely available, as it is a research project by OpenAI. However, you can still discuss its potential and showcase pre-generated images as examples. The STEM concept chosen for Tynker and Khan Academy integration will depend on the specific topic you wish to explore in your classroom.

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Chapter 6: Assessment Quiz

Question 1

How Chatbots and virtual assistants serve the Big Idea of "Perception" in AI?

a. They gather information from their environment through voice recognition and natural language processing

b. Analyse data to provide accurate and contextually appropriate responses

c. They can remember past conversations, preferences, and learning patterns

Correct: **A**

Question 2

How the DALL-E app contributes to the Big Idea of "Learning" in AI?

a. It can perceive and understand the details, concepts, and visual elements

b. It opens up possibilities for creative expression, design, and visual storytelling

c. It is trained on a large dataset of text-image pairs, allowing it to learn the statistical patterns and associations between textual descriptions and visual features.

Correct: **C**

Question 3

AI-powered learning platforms can adapt to each student's unique learning style and pace.

True / False

Correct: **True**

Question 4

In NLP platforms the system provide predefined answers in questions and doesn't gather data from students' answers.

True / **False**

Correct: **False**

Question 5

AI applications refer to the practical use of artificial intelligence technologies to perform specific tasks or solve problems.

True / False

Correct: **True**

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Application of AI in Educational Robotics

Introducing the 5 Big Ideas in Artificial Intelligence using Internet of Things in STEM education

28.07.2023 | EDUMOTIVA
PROJECT NUMBER: 2022-1-FR01-KA220-SCH-000085611

AI4STEM Educational Framework Topic: Application of AI in Educational Robotics

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Summary

Robotics is a branch of engineering and computer sciences revolving around the production of machines (i.e., robots) that are programmed to perform several tasks and actions. Nowadays, there are many types of robots, used in various sectors such as industry and construction, medical science, agriculture and education.

The present document focuses on the role of AI in robotics, through the lens of STEM education and educational practices, as well as in the light of IoT. In the beginning of the module the key aspects of robotics in AI and IoT are briefly presented, to familiarize educators with critical notions and concepts regarding these topics and disciplines. Then several indicative tasks inspired by real life, accompanied by learning objectives, are presented to exemplify methods and practices of how these disciplines can be gradually introduced in primary and secondary schools, thus facilitating educators in teaching and explaining these aspects. The tasks revolve around the concept of intelligent robots (What is an intelligent robot? How an intelligent robot can be created? How an intelligent robot learns?) and its connection with IoT (How can internet connectivity improve intelligent robots?).

Through the tasks, and by correlating the core ideas of AI, but also IoT to daily examples, learners become aware of the main principles and the core mechanisms underpinning AI and IoT. Towards this direction, several learning scenarios that could be implemented in class are suggested. The proposed scenarios are trying to blend the 5 Big Ideas with IoT and STEM practices, through the lens of robotics. Therefore, implementation examples for all the ideas are presented revolving around fictional characters who are trying to introduce their students to AI and IoT through project-based learning practices.

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Chapter 1: Introduction

In this module, the role of AI in robotics, through the lens of STEM education and educational practices, as well as in the light of IoT, is highlighted and explained. This will be done by presenting briefly key aspects of robotics in AI and IoT, as well as by exemplifying methods and practices of how these disciplines can be gradually introduced in primary and secondary schools. Towards this direction several indicative tasks are presented, accompanied by learning objectives aiming to facilitate educators in teaching and explaining these aspects. Then several scenarios will be presented on how all these fields and disciplines can be approached and introduced through the lens of the 5 Big ideas (as proposed by the AI4K12 initiative).

Chapter 2: Glossary – Key notions and concepts

Robotics and robots: Robotics is defined as a branch of engineering and computer sciences revolving around the production of machines (i.e., robots) that are programmed to perform several tasks and actions [1] [2] [3]. Nowadays, there are many types of robots, used in various sectors such as industry and construction, medical science, agriculture and education. Regardless of their utility, all robots share three basic features: 1) they are comprised of some mechanical parts, 2) they contain several electrical components and circuits, enabling them to be powered and controlled, while 3) they are coded (at least to some extent) through a programming environment to be able to perform specific tasks [4] [5]. Based on the task that robots are designed to perform, Artificial Intelligence (AI) might need to be incorporated.

AI in Robotics: AI is applied in robotics, when there is a need to produce machines that can operate as human beings, namely constructing and programming robots that can sense, perceive, and resonate about their environment, process incoming information, make decisions and act accordingly [1] [3] [6]. To act as an intelligent entity, a robot should be equipped with several sensors that permit interactivity and exchange of information with the environment. Also, it should be able to learn and improve its performance based on newly acquired skills and knowledge, thus enhancing its cognitive capabilities. Towards this aspect, a key method is Machine Learning (ML). ML is a branch of AI and a method that – through algorithms – allows computing systems to learn from data, identify patterns and consequently "predict new output values" [14]. In a way, data is used as a historical database that allows AI to gradually improve the accuracy of the predictions. And if AI can be described as the neuron system of a robot, then ML can be considered as the imitation of the way that humans learn.

Educational robotics: During the last few years, educational robots have often been implemented in class as tools for teaching STEM-related courses, as well as for producing more engaging and meaningful learning experiences that help students develop valuable 21st-century skills, such as critical thinking, creativity, collaboration and problem-solving [15] [16] [12] [7]. Through educational robotics, students are engaged in hands-on learning practices (through which they are taught how to design, construct, program and operate robots), while being introduced to rather complex – but significant for the future – concepts like AI and IoT.

IoT and Robotics: Unlike Robotics and AI which are considered inextricably related fields, IoT and Robotics are rather perceived as separate domains [8] [9]. IoT is about internet-connected devices that gather and transfer over wireless networks, large amounts of data to other (connected) devices to perform specific tasks, while Robotics (especially with the help of AI) are programmed to learn from the environment and

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act accordingly (even to unforeseen conditions) [8]. However, a new concept merging both of these has been shaped, and it is called the "Internet of Robotics Things" (IoRT) [11].

"*The IoRT enables robotic things in different environments to become active participants in various applications and exchange/share information with other robotic things, IoT/IIoT devices and humans.*" [10]

In this sense, robotics and IoT devices are producing a smart environment in which several events and changes are monitored, and a number of actions (perceived as the best possible) are determined (autonomously or manually by the user), based on data that is gathered (through different sensors and multiple sources), as well as the system's capabilities [11]. Both IoT and IoRT share data and establish some kind of communication. Their main difference is that the devices belonging to the latter can move and interact with other entities in the physical world [11].

IoRT applications: The devices that belong to this domain have various applications in our daily lives, allowing people to make data-driven decisions [8]. For instance, through IoRT applications, someone can monitor several conditions in her/his house (e.g., temperature, humidity, lightning) and adjust the way that several robotic devices act. Another field in which IoRT is implemented is transportation systems especially driverless cars which combine robotics, IoT, AI and ML. Among others, these cars are capable of measuring distance and speed, as well as selecting the most convenient route towards a destination, but also to predict traffic prevent accidents, and communicate all the gathered data to other cars [8].

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Chapter 3: Short tasks towards introducing students to the key aspects of AI in Robotics

To properly address all the aforementioned key aspects in school education, and help students to better comprehend all these concepts, several short tasks demonstrating or/and exemplifying the role of AI and IoT in robotics can be presented or/and assigned to students. In this way, you can gradually familiarize your students with all these notions, and make sure that all of them are on the same page regarding how these concepts are perceived. The tasks as well as their order are indicative. Therefore, feel free to choose those that are appropriate for your students (based on their age and their level).

Task 1: Intelligent or not, robot?

This first task aims to help your students understand the difference between robots with and without integrated AI, thus realizing the presence of robotics and AI in their everyday lives. Show your students several robots used daily such as a robotic vacuum cleaner, a remote-controlled toy, an intelligent assistant (e.g. Alexa) etc. (*Figure 1*) and ask them to identify which of them are just machines that are pre-programmed to perform a specific task, and which can be considered as intelligent one (i.e., machines that have - at least to some extent – the ability of thinking).

Figure 1: examples of robots frequently or daily used

Based on their age and their level you can pose simple or more complex/advanced questions, such as:

- Which robots can be identified as intelligent?
- What are the benefits of having an intelligent robot?
- In which cases the use of an intelligent robot can make the life of some people better or/and easier?
- What are the differences between a robot that merely senses the environment and a robot that senses and makes decisions based on the incoming information?
- Can you name some disadvantages of using intelligent machines/robots?

Learning objectives:

Through this task, and regarding the notions and concepts of robotics and AI, students should be able to:

- Define/identify what robots are and which are their basic features
- Recognize the difference between an intelligent robot (i.e., a robot with integrated AI), and a robot which is not enhanced with AI
- Identify the presence /and applications of AI robotics in everyday life

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Task 2: How can we create an intelligent robot?

This task aims to familiarize your students with the concept of AI, and its application in robotics, and help them understand how the integration of AI affects the operation and performance of a robot. To do that show them an example of a robot, and an example of the same robot enhanced with AI (e.g., a robotic toy car that follows a line and avoids obstacles by using an ultrasonic sensor, and a robotic toy car that follows a line and by using a camera decides where to go based on the recognition of traffic signs) and discuss about the role of AI, the different AI services, and their immanent advantages and risks when used in real life. To initiate the dialogue between your students, and based on their level and their age, here are some indicative questions that you can pose:

- Can both of the robotic cars be considered intelligent?
- Each one of the robotic cars is equipped with some sensors. Can you identify how these sensors work and in which ways they help the robotic cars perceive their surroundings?
- Which AI service (image recognition, voice recognition etc.) is used by the second robotic car, and how do you think that this service works?
- Can you name some advantages that the AI-enhanced robotic car has (in comparison to the simpler one)?
- Can you name cases in which such technology (i.e., a driverless car that recognizes traffic signs) is used in real life?
- Can you name some limitations or/and disadvantages of using such technology in real life?

Learning objectives:

Through this task, students should be able to:

- Discuss and understand the role of AI in robotics
- Identify how sensors help robots perceive their surroundings
- Identify different kinds of AI services
- Highlight and discuss about advantages and immanent risks of integrating AI into robots

*Through this task, you can also introduce your students to the 1st Big Idea, namely the idea/notion of Perception.

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Task 3: How do intelligent robots learn?

This task is an extension of task 2. Ask your students to think of ways that the aforementioned driverless car can be further enhanced with AI services to improve its operability and performance. Make a short introduction to ML and explain to your students how ML environments can be used to train an intelligent robot (you can consider using some free tools such as the Teachable machine, or the Scratch AI-ML extension (*Figure 2*) to familiarize your students with this concept). Encourage them to think about what kind of AI services would they have to apply to implement their idea (e.g., enhancing the car with a pose or face recognition service to recognize pedestrians crossing a road) and what kind of data should they use to train a model. Also, you can consider using this task as an introduction to the 3rd Big Idea, namely "Learning"

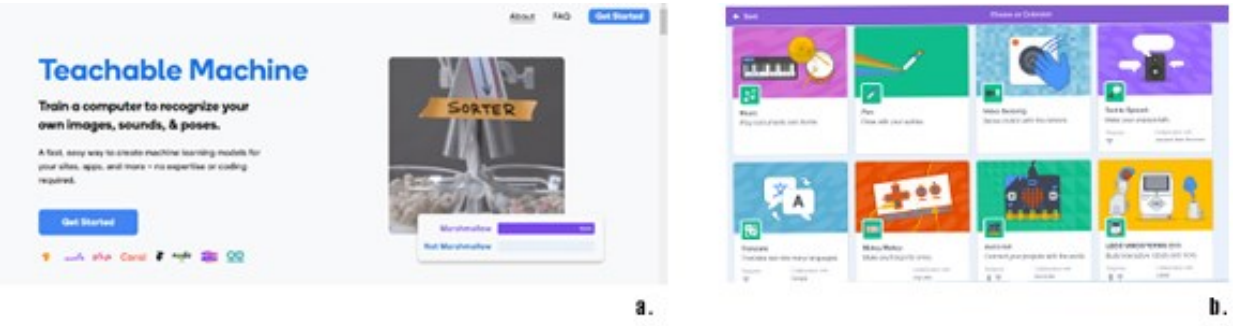

Figure 2: a. home page of Teachable Machine, b. Scratch extensions including extensions for AI applications

To facilitate the implementation of this task in class, you can consider splitting your students into small teams of 2 or 3, and inspiring them by posing some of the following questions:

- Based on your idea and the AI service you are planning to apply, what kind of data should you provide to your robot to properly function?
- What kind of sensors or equipment do you need to record/gather this data?
- How many categories of data should you create to properly train your model?
- Based on the results provided by the trained model, which decisions are you expecting your (intelligent) robot to make?
- What would be the impact of these decisions?
- How can a mis-trained model affect some people's lives? How could you avoid training a biased model?

Learning objectives:

Through this task, students should be able to:

- Discuss about the role of machine learning (ML) in AI robotics
- Identify the main ideas underpinning ML
- Use an ML environment to train a model
- Discuss the impact of a trained model in the formation of cognitive skills/capabilities of an intelligent robot
- Understand and discuss the social impact of a biased trained model

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Task 4: How can internet connectivity improve intelligent robots? (Part 1)

This task aims to familiarize students with the concept of IoT, and function as a starting point towards the introduction of IoT in robotics. Use a familiar to your students' example, such as the Google Maps application, a weather monitoring system, or a smartwatch application (*Figure 3*), to introduce the concept of IoT, and discuss the idea of monitoring the (wireless) exchange of data between devices, to make data-driven decisions.

Figure 3: A smartwatch/smart band that wirelessly transmits data to the respective application

In this sense, you can consider posing some of the following questions:

- What kind of data does each one of these applications record/gather?
- How this data is gathered and where do you think they are stored? Do you think that is important to store data in a secure web space?
- How can we monitor this data and, based on the results, what kind of decisions could we make?
- Are you using such kinds of applications (Google Maps, smart watch etc.) in your life? Are you making decisions based on the depicted/received data (e.g., traffic on roads, data regarding the daily level of exercise etc.)?
- Can you think of other examples that IoT would be helpful?
- Can you think of any disadvantages or limitations of such kind of applications?

Learning objectives:

Through this task, your students will be able to:

- identify IoT applications
- understand the main concepts underpinning IoT
- understand the impact of monitoring data on our daily life
- identify cases in which data-driven decisions are made

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Task 5: How can internet connectivity improve intelligent robots? (Part 2)

This task is an extension of the 4th task and aims to introduce students to the concept of IoRT by focusing on examples of smart environments built by IoT devices and intelligent robots. Use an example from everyday life to discuss with your students, ways that IoT devices can communicate with intelligent robots by providing data gathered from sensors, leading the latter to perform several actions that are considered as the best possible. An example you can use is a smart irrigating system that measures data such as soil moisture, temperature and humidity, and based on the gathered data, instructs a robot to accordingly water several plants. You can consider splitting your students into teams of 2 or 3 and encourage them to explore these concepts through several questions such as:

- What kind of data will be gathered?
- How this data can be used by the robot that will water the plants?
- If you had to think of different scenarios based on different environmental parameters, how many different solutions would you have (*note: students can try to sketch a decision path tree with all the possible combinations*)?
- Do you think that AI can be integrated into the robot to improve its performance? If yes, which AI service would you use, and for which purpose?
- In your opinion, should the entire system be programmed to learn from data and after a while to act completely autonomously or there should be a manual control?
- Can you think of other sectors in which such technology would be useful?
- Can you identify any disadvantage or limitation of such kind of technology?

Learning objectives:

Through this task, your students will be able to:

- identify IoRT applications and their underpinning concepts
- understand how such applications function
- understand how different parameters can lead to different decisions
- think of ways of combining AI with IoRT, and in a meaningful way
- identify advantages and disadvantages or/and limitations of such technologies

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Chapter 4: Case Studies

Case study 1 - The Edu4AI project

In the framework of the Edu4AI Erasmus+ project, several projects combining robotics with AI, for introducing AI in school education, were proposed, piloted and evaluated by schools in Germany, Greece, Italy and Spain. One of them was "the device that turns sounds into visual signs". This project revolves around sound recognition and audio classification methods coupled with hands-on practices, and it is oriented towards the creation of an electronic device – for domestic use – that can visually notify people with hearing loss of significant audible events happening in their house (e.g., the sound of an alarm, a doorbell etc.). Through this project, the students learn how to create and program an Arduino-based electronic device, how to create a taxonomy of sounds by recording and classifying them into different categories, as well as how to develop an application that will establish communication between the physical environment and the electronic device, by enabling the user to record environmental sounds. This and all the proposed projects in the framework of the Edu4AI Erasmus+ project were perceived as successful methods and strategies for introducing students to AI and ML while helping them to develop critical skills such as creativity, collaboration and problem-solving.

Case study 2 – The project "We Are the Makers"

The WeMakers Erasmus+ project revolved around designing, manufacturing, and programming intelligent objects while introducing – among others – IoT in school education. Towards this direction, several learning scenarios included in "The Educational IoT Manual" were developed and proposed. One of them was "The fire management system in the forest". This learning scenario was about the creation of a system (comprised of several Arduino-based devices equipped with heat, smoke and IR sensors) that can detect fire in the forests and notify the corresponding authorities to act. Through this real-case scenario, the students were introduced to robotics and IoT and how the latter can be implemented towards environmental protection.

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Chapter 5: Becoming familiar with AI and IoT in robotics through the lens of the 5 Big Ideas

In "The AI4STEM framework" for implementing the 5 Big Ideas using IoT in STEM education, it was argued that to turn the context of the 5 Big ideas into more concrete and tangible learning experiences (for both educators and learners), it is crucial to use scenarios and examples from real life. By correlating the core ideas of AI, but also IoT (as was proposed in the tasks of the previous section) to daily examples, learners can become aware of the main principles and the core mechanisms underpinning AI and IoT. Towards this direction, several learning scenarios that could be implemented in class are suggested in the present section. The proposed scenarios are trying to blend the 5 Big Ideas with IoT and STEM practices, through the lens of robotics. Therefore, implementation examples for all the ideas are presented in the following sections. The examples revolve around fictional characters (allegedly working on primary or secondary education) who are trying to introduce their students to AI and IoT through project-based learning practices.

1st Idea: Perception

The idea of Perception revolves around helping students realise the difference between mere sensing and perceiving. As was explained in task 2 on the present document, even though there are many electronic devices equipped with sensors, however not all of them can be acknowledged as intelligent. Intelligent are those that use sensors and sensory signals to extract information and perceive their surroundings. The following scenario presents an indicative way of introducing students to Perception, in the light of AI and IoT.

Scenario:

Lucy is a primary school IT teacher in the upper class. She wants to start familiarising her students with AI and IoT, through the lens of robotics. To do that, she decides to begin by introducing her students to the 1st Big Idea, namely perception. She is splitting her students into teams of 3 and 4 and gives each team a micro:bit board and several extra sensors (e.g., ultrasonic sensor, PIR sensor, heat sensor etc.), since micro:bit has already embedded some sensors such as light sensor and accelerometer. After that, she encourages her students to connect the extra sensors to the micro:bit, and through the Makecode programming environment to start recording all the received data and how the results are affected by different conditions. Then she tries to initiate a dialogue with her students on ways that these sensors could be used, not only for sensing the environment and recording data but for leading to the creation of intelligent robots that could be useful in different sectors of daily life.

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2nd Idea: Representation & Reasoning

The idea of Representation & Reasoning reflects the ways that AI can "think", based on the constructed representations of the world, in the form of data. Therefore, for students to become familiar with this idea, it should be kept in mind that AI and intelligent agents can "think":

a. by constructing representations of the world in the form of data structures, and
b. by using algorithms which help them to make sense of these data structures (reasoning).

Note: *An agent is defined as an "independent program or entity" that can perceive its surroundings through the use of sensors, and then act by using actuators or effectors [13]. In the framework of the present document, agents are perceived as various robots, equipped with cameras, sensors and actuators such as servos and motors.*

In this sense, and apart from learning what robotic agents are (which was explained and exemplified in previous sections), it is important for students to learn how data structures can be represented, and how algorithms can be used to extract specific information from the representations.

Data structures can be represented abstractly and symbolically. As such, the maps, the diagrams and/and the graphs, that are reflecting some kind of information in a rather coded way. To decide, a robot will use these representations, and with the help of algorithms will try to make sense of the encoded information. Students can perceive these processes by using different types of representations, and by sketching decision or search trees to understand the criteria for selecting an algorithm, leading to the best possible solution.

The following learning scenarios will try to present some indicative ways of introducing this idea to students, through the lens of AI and IoT

Scenario 1:

Claire is a secondary education teacher and is thinking of implementing with her students the scenario of the smart irrigating system, referred to as Task 5. Before starting to work on this project, she wants her students to understand how they will make some decisions to properly program the irrigation system. She is splitting students into groups of 2 or 3 and asks them to sketch a decision tree that will depict all the possible scenarios, that will lead to watering or not a plant. She encourages her students to begin the tree by posing the question of whether or not it is a rainy day and gradually adding nodes that lead to different decisions based on the level of soil moisture (*Figure 4*). Also, she encourages her students to use a micro:bit board and a soil moisture sensor to determine the level (of soil moisture) beyond which a plant should be watered. After finishing this task, she plans to ask her students to sketch a more complex decision tree, that will take more parameters into account, such as the temperature.

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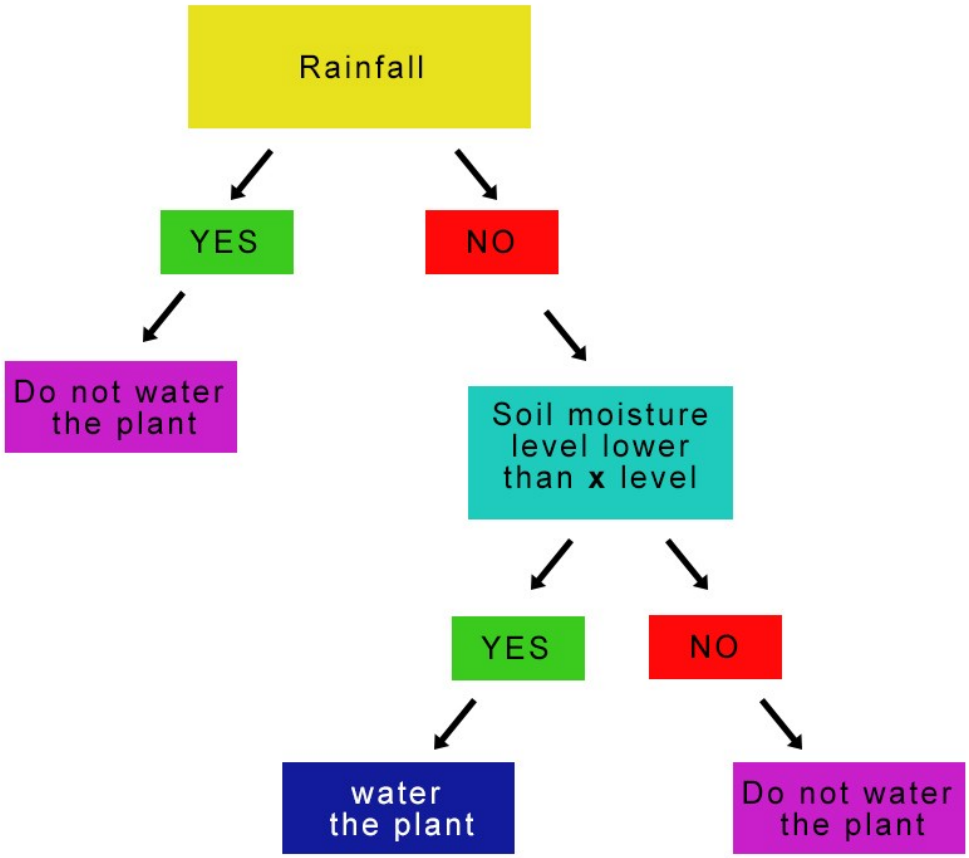

Figure 4: An indicative sketch of the decision tree towards deciding whether or not a plant will be watered

Scenario 2:

George is a secondary education teacher and is thinking of implementing with his students the "intelligent car" project; a robotic car that receives data regarding the road traffic and makes decisions regarding the best route to follow. To help his students realize how such an algorithm will work, he decides to do a warm-up activity. He creates a map (*Figure 5*) with some locations (i.e., home, gas station and grocery store) and gives his student the following information: "*We are at home, and we decide to go to the park for a picnic. Think of all the possible routes that we might need to follow based on different needs (i.e., if we need to go to the gas station, if we need to go to buy some food from the grocery store etc.) and try to depict all these information by creating a flowchart*". Then he splits the students into groups of 2 or 3 and asks them to sketch the flowchart that will represent all the possible routes that the car might need to follow (*Figure 6*). Through this warm-up activity George expects that his students will realize how an algorithm works, and (on the next level) which reasoning model (i.e., logic paths, operators) they need to adopt to help the intelligent car take the best possible route.

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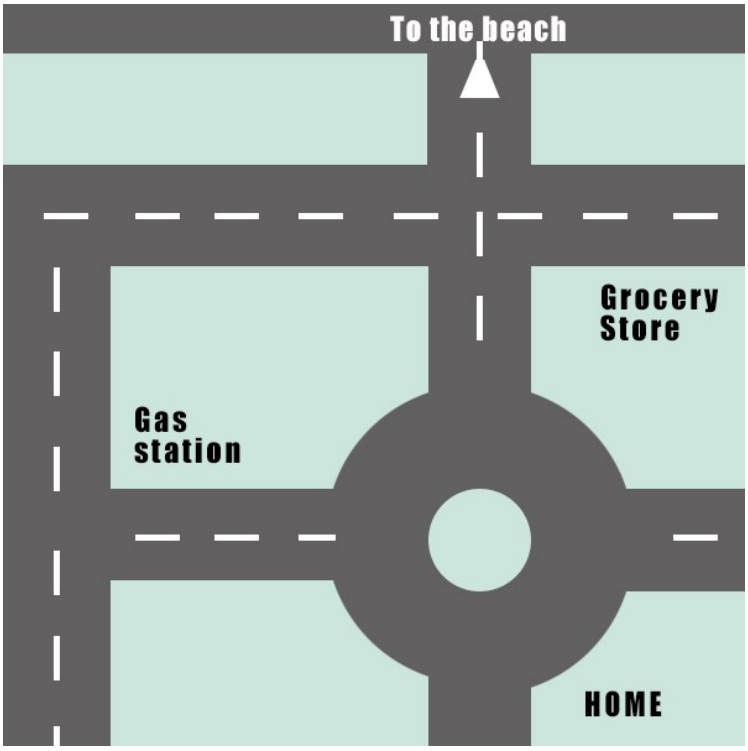

Figure 5: The map that George sketched

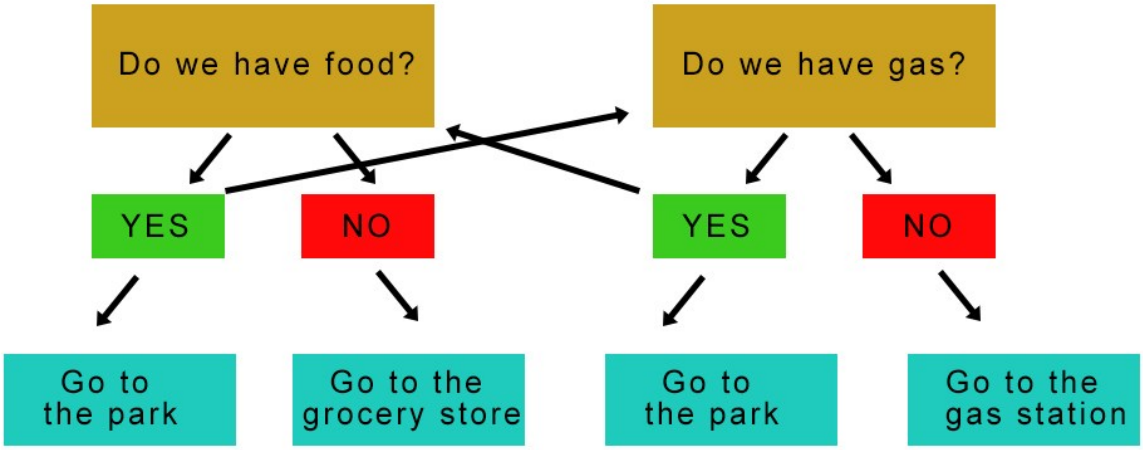

Figure 6: An indicative flowchart depicting the different choices based on the different needs

Scenario 3:

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Kate is a teacher in the upper class of primary school and is thinking of implementing with her students the "smart door garage" project; a door that receives data regarding cars reaching the house and opens when the cars of the householders approach. She explains to her students that the door needs to be trained to recognize specific images and act accordingly. Also, it should measure the distance to open only when the car of the householder is inside a specific metric range. She splits students into groups of 2 or 3 and asks them to sketch a decision tree that will represent all the possible logical paths that should be followed to decide whether or not the system will open the garage door (*Figure 7*). Through the decision tree, Kate expects that her students will realize how to create representations of data to better illustrate information.

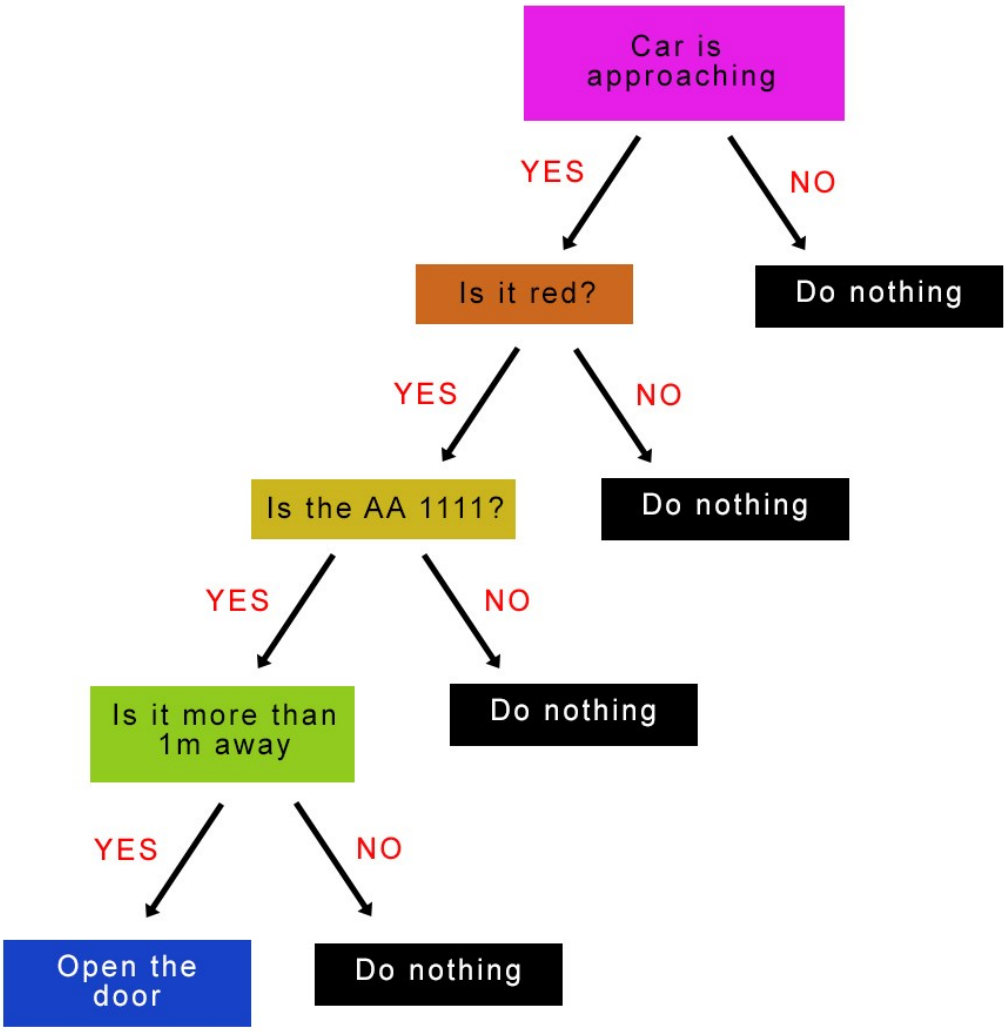

Figure 7: Indicative decision tree with some possible logical paths

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3rd Idea: Learning

The idea of Learning is about the role of Machine Learning and Machine Learning algorithms in helping computers to learn. Through this idea, the students comprehend that a computer can a. learn from data through proper training and b. use this gained knowledge in making decisions. Therefore, the students become familiar with the processes of training data, and how modification of trained models can lead the computer to adopt new behaviours. This idea can be introduced through practices highlighted in the 3rd task of the present document and through learning scenarios such as the following.

Scenario:

Jake is a secondary education teacher, and he is about to implement a project revolving around the creation of a rover (i.e., a driverless robotic car) that would be sent inside mines to check for valuable rocks while collecting several other significant data such as temperature, soil moisture etc. To enable the rover to identify specific rocks, Jake informs his students that they need to train the rover accordingly. He splits them into teams of 3 and asks them to find different images of rocks that can be found inside a mine. Then, by using the Google teachable machine, he encourages them to train the model and test the results by using a micro: bit board, that will display on the LED screen a smiley face, each time the rover comes across and identifies a valuable rock. Combined with other gathered data, the students will decide whether or not they can excavate a valuable rock.

4th Idea: Natural Interaction

The idea of Natural Interaction revolves around the barriers and limitations that current AI systems have on interacting in the way that human beings do. This happens due to the complexity of human nature, interaction and communication. Therefore, through this idea, the students are realizing how much work needs to be done towards creating an intelligent agent that could interact with humans in a rather natural way. This idea could be introduced through a similar to the following scenario.

Scenario:

Alex is a secondary school teacher and works with his students on a project about the creation of a smart vacuum cleaner that can be operated through voice commands. Working in teams of 3 or 4, his students have already created a trained model with several voice commands and now they are testing the trained model with a robotic automobile. Alex is testing the trained models produced by his students by using different accents and pronunciations. The students realize that the robotic automobile does not always follow voice instructions. Alex encourages them to think about why this happens, trying in this way to make them realize the limitations existing behind AI services while motivating them to think of ways that such barriers can be overcome.

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5th Idea: Societal Impact / Ethics

The Societal Impact is about the advantages and disadvantages lying beneath the use of AI systems from a societal and ethical point of view. In the context of Chapter 3 and the proposed tasks, several key topics related to this idea, such as biased data and data security have been highlighted. Students must understand that AI and IoT and the relevant tools and services are very powerful and can radically affect the lives of some people. A biased database used by an intelligent door, for instance, can deny access to people of different colour skin, or people with some kind of disfiguration. A database with a low-security level that is used for services predicting traffic could have several consequences (from causing minor delays to creating traffic chaos). So, keep in mind that apart from familiarizing your students with the fields of AI and IoT, it is equally important to raise discussions with them about all these disadvantages, limitations and immanent risks.

Scenario:

Alex – the teacher from the previous scenario – invites teachers of French, German and Spanish language to help his students produce some newly trained models that can work with these languages. During this process and the testing of the produced models, Alex – with the help of the other teachers – raise discussion about the ways that an AI system can exclude people from using them. To enrich the conversation, he also encourages his students to think about people with voice disorders and how they could alter their approach to create a more inclusive robotic artefact.

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Chapter 6: Assessment quiz

Question 1: Every robot that can sense the environment can be characterized as an intelligent robot [True / False]

Answer: False

Question 2: Which AI service should we add to a robotic car to enable it to be navigated through voice commands?

a) Sound recognition
b) Image recognition
c) Text recognition

Answer: a

Optional open question: How different pronunciations can affect the operation of the robotic car?

If the AI service is based on a rather limited or biased trained model (i.e., a model that mostly recognize English native speakers), a different pronunciation might affect the performance of the robotic car, leading to malfunctions on the navigation. Through this open question you can discuss with your students the importance of creating AI systems that are not biased and can naturally interact with human.

Question 3: Imagine that you want to train a model that will enable an intelligent door to open only for a specific group of people. Which AI service should you use?

a) Face recognition
b) Image recognition
c) Sound recognition

Answer: a

Optional open question: How a biased trained model can affect the way that such an intelligent door works?

There are examples of face recognition systems that are falsely trained to mostly recognize white-skin male faces. These biased systems lead to the exclusion of several group of people not belonging to this category. Such biased systems lead to discriminations and inequalities.

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Question 4: Which application is using IoT?

a) A calendar application
b) A calculator application
c) A smartwatch application

Answer: c

Question 5: A decision tree is comprised of some logical paths that will help a system to take the best possible decision [True / False]

Answer: True

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AI & Vision

Introducing the 5 Big Ideas in Artificial Intelligence using Internet of Things in STEM education

21.09.2023 | EMPHASYS CENTRE
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AI4STEM Educational Framework Topic: AI & Vision

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Summary

The module explores the intersection of artificial intelligence (AI) and vision applications, emphasizing its significance in enhancing human visual perception and its integration with the Internet of Things (IoT) for real-time data processing. It delves into various AI techniques employed in vision applications, such as image recognition, object detection, facial recognition, and medical imaging.

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Chapter 1: Introduction

Artificial Intelligence, also known as AI, involves the simulation of human intelligence, in machines. It enables machines to learn, reason and make decisions based on data and experiences. AI encompasses the development of algorithms and models that empower computers to perform tasks that traditionally require intelligence. These include understanding language recognizing patterns solving problems and making predictions.

On the other hand, Computer Vision is a field within AI that focuses on enabling machines to interpret and comprehend visual information much like humans do with their eyes and brains. It encompasses the creation of algorithms and techniques that empower computers to extract insights from images, videos and other visual data sources. Computer Vision enables machines to perform tasks such as image recognition, object detection, and facial recognition among others. It has applications, across industries including healthcare, the automotive sector entertainment industry and security.).

1.1 Importance of AI in Enhancing Human Visual Perception

The integration of Artificial Intelligence (AI) has brought about a revolutionary enhancement in human visual perception, expanding our capacity to understand and interpret the visual world. Through advanced machine learning algorithms, AI enables computers to process vast amounts of visual data quickly and accurately, uncovering intricate patterns and details that might elude the human eye. This technology aids professionals in fields like medicine, where AI-powered medical imaging can detect anomalies imperceptible to human clinicians. Moreover, AI-driven visual perception enhances safety and efficiency in industries such as autonomous vehicles, where real-time analysis of complex traffic scenarios is crucial. By automating repetitive visual tasks, AI liberates human potential for more creative and strategic endeavours, propelling us toward a future where machines and humans collaborate to unlock new dimensions of perception and insight. However, it's essential to tread thoughtfully, considering ethical implications to ensure that AI's perceptual prowess respects privacy, avoids biases, and empowers humanity responsibly.

Figure 1 - Computer Vision (image from Pixabay)

1.2 Overview of Different AI Techniques Used in Vision Applications

AI uses different methods to improve how machines see and understand images. One method, called CNNs - Convolutional Neural Networks, helps machines recognize patterns in pictures. Another, RNNs -

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Recurrent Neural Networks, is great for analysing videos. GANs - Generative Adversarial Networks can create new, realistic images, while Transfer Learning lets machines quickly learn new tasks using old data. Reinforcement Learning helps machines make decisions in changing situations, like for robots. These methods are changing many industries, from healthcare to entertainment. However, it's important to use them responsibly and fairly.

1.3 Integration of AI Vision with Internet of Things (IoT) for Real-Time Data Processing

The fusion of AI vision and Internet of Things (IoT) technologies marks a groundbreaking convergence that holds immense potential across industries. By combining AI-powered visual analysis with the vast network of interconnected devices, real-time data processing reaches new heights. IoT sensors and devices collect a torrent of visual information from the physical world, which AI algorithms swiftly interpret, extract insights from, and respond to. This synergy empowers applications like smart surveillance, where AI can detect anomalies in video streams and trigger immediate alerts. In healthcare, wearable IoT devices can monitor patients' vitals and use AI vision to analyse changes in their condition. Moreover, in smart cities, AI vision processes data from cameras, drones, and other IoT sensors to optimize traffic flow, enhance public safety, and manage infrastructure. As this integration advances, careful ethical considerations are essential, ensuring privacy protection, data security, and responsible AI use in the ever-evolving landscape of interconnected devices and intelligent visual analysis.

1.5 Ethical Considerations: Privacy Concerns Related to IoT-Enabled Vision Systems

With more cameras and sensors in public places, homes, and work, there are worries about privacy. These systems can accidentally record personal moments. This makes people wonder how much say they have over their data. We need to balance the good things, like better security, with privacy risks. Rules should be in place to prevent misuse and protect people's rights. It's important to handle data carefully and let users have control to build trust in these new technologies.

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Chapter 2: Image Recognition and Classification

Computer vision lets AI understand and sort pictures. It teaches machines to recognize things in images, like animals or cars. Image recognition spots specific things, while classification labels images, like telling if a picture shows a disease. Deep learning, especially using CNNs, helps in this by learning from many images. This technology is used in self-driving cars, health checks, and suggested content. But it's important to use it right, avoiding biases and making fair decisions.

2.1 Deep learning algorithms for image recognition

Deep learning, a subfield of artificial intelligence, has propelled image recognition to unprecedented levels of accuracy and sophistication. Convolutional Neural Networks (CNNs) are a prime example of these transformative algorithms, designed to emulate the visual processing capabilities of the human brain. CNNs excel in analysing the spatial relationships and intricate patterns within images through a hierarchical architecture of interconnected layers. Convolutional layers apply filters to detect features like edges and textures while pooling layers downsample and preserve important information. Fully connected layers then consolidate these features to classify images into different categories. This intricate architecture, combined with large-scale training datasets and efficient optimization techniques, empowers CNNs to learn and recognize complex visual patterns, making them the backbone of various image-centric applications, including self-driving cars, medical diagnoses, and facial recognition. As these algorithms become increasingly integrated into our lives, addressing ethical considerations related to biases, fairness, and accountability remains paramount to ensure the responsible and equitable use of AI-powered image recognition technologies.

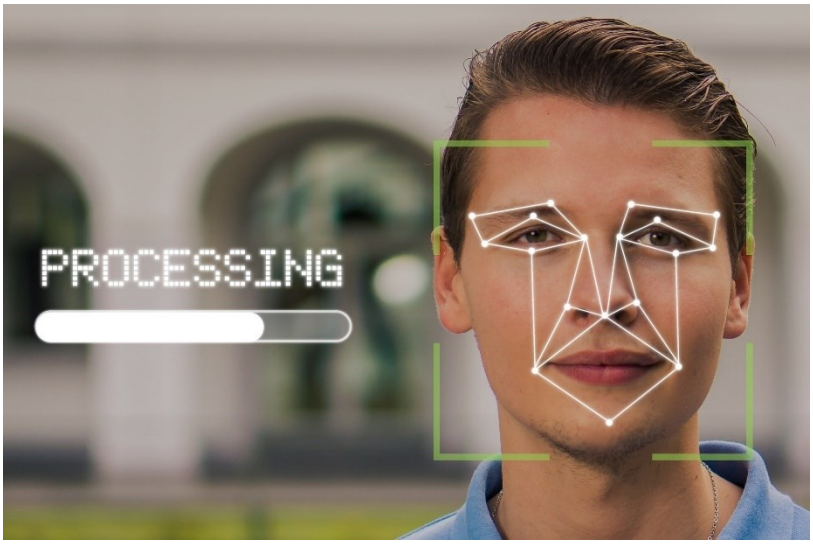

Figure 2- Face recognition (image from Pixabay)

2.2 Importance of Training Data and Data Augmentation for Model Performance

For machine learning models, especially in image recognition, the data used for training holds great significance. Good quality and a sufficient amount of training data are crucial. Another technique, data

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augmentation, is also valuable. It involves creating variations of existing data through techniques like flipping or resizing images. This helps the model become more adaptable to different situations and prevents it from becoming too focused on specific examples. While having the right training data and using data augmentation improves the model's accuracy, it's important to ensure fairness and accuracy in the data to avoid potential biases. Striking a balance between data quality and ethical considerations is key to building effective and fair image recognition models.

2.3 Boosting Model Performance with Training Data and Data Augmentation

Good training data is the building block of a strong machine-learning model, especially for things like image recognition. Data that's diverse and accurate helps the model learn well. Another helpful trick is data augmentation, where we make slight changes to the existing data, like flipping or rotating images. This helps the model handle different situations better. Having lots of good training data and using data augmentation stops the model from getting too focused on just a few examples. However, we need to be careful about biases in the data. Finding the right balance between enough training data and being fair and ethical is really important for making accurate and unbiased image recognition models.

2.4 Ethical Concerns: Bias in Image Data and AI Impact

When the data used to teach AI about images is biased, it can make the AI unfair. Bias means some things are shown more than others. This can affect AI decisions. For example, if an AI is taught using biased data, it might not recognize certain things well. This can lead to mistakes and unfair treatment. To fix this, we must choose data carefully and check for bias. Making sure AI is fair matters for making accurate and just decisions.

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Chapter 3: Object Detection and Tracking in Computer Vision

Object detection and tracking are fundamental aspects of computer vision that enable machines to identify and monitor specific objects within visual scenes. Object detection involves locating and categorizing objects of interest in images or videos. This task is crucial in applications like autonomous driving, where identifying pedestrians, vehicles, and obstacles is essential. Tracking, on the other hand, focuses on following the movement and behaviour of objects over time, allowing systems to understand their trajectories and interactions. These techniques rely on sophisticated algorithms, including region-based approaches like Faster R-CNN and anchor-based methods like YOLO (You Only Look Once). Object detection and tracking have diverse applications, spanning from surveillance and robotics to sports analysis and industrial automation. Addressing ethical considerations related to privacy and security becomes vital, especially when applying these techniques in public spaces or personal contexts.

3.1 Real-World Applications: Surveillance, Autonomous Vehicles, and Industrial Automation

The practical applications of computer vision extend across a spectrum of industries, transforming the way we interact with our surroundings. In surveillance, computer vision empowers intelligent security systems to identify and track potential threats, enhancing public safety. The realm of autonomous vehicles is revolutionized as computer vision enables cars to perceive their environment, interpret traffic signs, and navigate complex road scenarios. This technology advances road safety and the dream of self-driving cars. In the realm of industrial automation, computer vision facilitates quality control by identifying defects in manufacturing processes, optimizing production, and reducing errors. These applications illustrate how computer vision, fuelled by AI, is shaping our world by enhancing efficiency, safety, and accuracy. Amid these advancements, it's imperative to address ethical considerations, ensuring privacy and minimizing risks in surveillance, designing responsible autonomous systems, and fostering safe human-robot collaboration in industrial settings.

3.2 Ethical Considerations: Surveillance and Privacy Concerns in Object Tracking Systems

As object tracking systems become more sophisticated through computer vision and AI, ethical considerations around surveillance and privacy come to the forefront. While these systems offer benefits in security and situational awareness, they also raise concerns about the potential infringement on individual privacy. Continuous monitoring and tracking of people's movements in public spaces can lead to the collection of sensitive personal data without consent, giving rise to surveillance-related anxieties. Striking a balance between ensuring public safety and preserving personal privacy is a critical challenge. Responsible deployment involves transparent communication about the presence of surveillance systems, implementing anonymization techniques to protect identities, and adhering to legal and ethical guidelines. Respecting individuals' rights and maintaining a watchful eye on the implications of these systems on civil liberties is essential as technology continues to evolve.

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Chapter 4: Facial Recognition and Emotion Detection

Facial recognition technology has emerged as a transformative innovation in computer vision, enabling systems to identify and verify individuals based on their unique facial features. This technology finds diverse applications across various sectors. In security and law enforcement, facial recognition aids in identifying criminals, locating missing persons, and enhancing border control. In user experience, it facilitates seamless authentication for smartphones and digital services, streamlining access while maintaining security. Healthcare benefits from facial recognition for patient identification, aiding medical diagnostics and treatment. Entertainment and marketing sectors leverage this technology for personalized experiences and targeted advertising. However, along with its potential, ethical considerations regarding privacy, consent, and potential misuse have come to the forefront. Striking a balance between technological advancement and safeguarding individual rights is paramount as facial recognition continues to shape our interactions with technology and society.

4.1 Emotion Detection Using Facial Expressions and Micro-Expressions

Emotion detection through facial expressions and micro-expressions represents a captivating application of computer vision technology. By analysing subtle changes in facial features, such as muscle movements and expressions, AI systems can decipher human emotions, providing insights into a person's feelings and sentiments. These insights find application across a spectrum of fields. In marketing, emotion detection assists in understanding consumer reactions to products and advertisements. In healthcare, it aids in assessing mental health conditions and emotional well-being. Moreover, it enriches human-computer interaction by enabling systems to respond empathetically to users' emotions. However, ethical considerations include ensuring informed consent, safeguarding against potential misinterpretations, and addressing privacy concerns related to capturing personal emotional responses. The intersection of technology, psychology, and ethics shapes the responsible development and deployment of emotion detection systems, holding the potential to enhance various aspects of human interaction and understanding.

4.2 Use Cases: Security Systems, User Experience Enhancement, and Healthcare

The versatility of AI-powered computer vision extends to a myriad of impactful use cases across diverse domains. In security systems, computer vision bolsters surveillance by identifying intruders, tracking suspicious activities, and enhancing public safety. It acts as a vigilant digital eye that complements human monitoring efforts. User experience is elevated through computer vision as it enables intuitive interactions with technology. From facial recognition for swift device access to gesture recognition for hands-free control, computer vision creates seamless and immersive interfaces. Additionally, healthcare benefits from accurate diagnostics and treatment with the aid of computer vision. Medical imaging analysis assists in detecting diseases like cancer, while facial emotion detection aids in understanding patients' emotional states for tailored care. While these applications offer numerous advantages, ethical considerations are integral. Striking a balance between safety and privacy, ensuring fair AI decisions, and safeguarding against potential biases are crucial elements in harnessing the power of computer vision across these domains.

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4.3 Ethical Aspects: Biases in Facial Recognition Algorithms and Potential Misuse of Personal Data

The rise of facial recognition technology has unveiled significant ethical concerns, with biases embedded in algorithms being a central issue. These biases can lead to inaccuracies and unfair treatment, especially for underrepresented or marginalized groups. Inaccurate identification based on race or gender, for example, has alarming implications. Equally worrisome is the potential misuse of personal data collected through facial recognition. Unauthorized surveillance, tracking, and data breaches threaten individuals' privacy and personal freedom. Striking a balance between technological innovation and ethical responsibility is crucial. Transparent development practices, rigorous testing for biases, and continuous improvement are essential to ensure facial recognition is fair, and accurate, and respects privacy rights. Regulatory frameworks that prevent the unwarranted collection and misuse of personal data are essential to safeguard individuals' rights and maintain trust in these technologies.

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Chapter 5: Medical Imaging and Diagnostics

Artificial intelligence has revolutionized medical image analysis, becoming an indispensable tool in the healthcare sector. AI-driven algorithms can swiftly and accurately interpret complex medical images like X-rays, MRIs, and CT scans, aiding in the diagnosis and treatment of various conditions. These algorithms can detect subtle anomalies that might elude the human eye, enabling earlier and more precise diagnoses. Moreover, AI can help streamline radiologists' workflows by automating repetitive tasks, allowing them to focus on more complex cases and spend more time with patients. In this context, AI's role extends beyond enhancing efficiency; it directly contributes to improved patient care and outcomes. However, the integration of AI in healthcare also raises ethical considerations regarding data privacy, algorithm transparency, and the need for robust validation processes to ensure patient safety. Balancing the potential benefits of AI with these ethical concerns is crucial as medical image analysis continues to evolve, offering immense promise in the field of healthcare.

Figure 3 - X-Ray Assisted Image Analysis (image from Pixabay)

5.1 Automated Diagnosis and Detection of Diseases (e.g., Cancer, Retinal Diseases)

The advent of AI-powered automated diagnosis and disease detection represents a monumental advancement in healthcare. Machine learning algorithms, trained on extensive medical datasets, can now rapidly and accurately identify a wide range of diseases, including cancer and retinal diseases, from medical imaging such as CT scans, MRIs, and retinal scans. This technology offers several crucial advantages. It enables early detection, increasing the chances of successful treatment and improving patient outcomes. Moreover, it helps reduce the burden on healthcare professionals by automating repetitive tasks, allowing them to focus on patient care and more complex diagnoses. However, ethical considerations come into play in terms of algorithm fairness, data privacy, and the potential for overreliance on AI. Striking a balance between leveraging the remarkable diagnostic capabilities of AI and addressing these ethical concerns is essential to harness the full potential of automated disease detection in healthcare.

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5.2 Collaboration between AI, Medical Professionals, and Ethical Considerations

The synergy between AI and medical professionals holds the promise of revolutionizing healthcare. AI brings advanced diagnostic capabilities, data-driven insights, and automation to medical practice, augmenting the expertise of healthcare providers. However, ethical considerations are integral to this collaboration. Medical professionals must guide the ethical deployment of AI, ensuring that patient data is protected, privacy is maintained, and treatment decisions remain in the best interest of the patient. Furthermore, transparency in AI algorithms and decision-making is vital to maintain trust. Effective collaboration necessitates ongoing education for healthcare professionals about AI's capabilities and limitations and promotes a shared understanding of the ethical challenges and solutions. Ultimately, the partnership between AI and medical professionals, guided by ethical principles, offers the potential to deliver more accurate diagnoses, personalized treatments, and improved patient care.

5.3 IoT Integration: Remote Patient Monitoring and Real-time Diagnostics

The integration of Internet of Things (IoT) technology into healthcare is revolutionizing patient care by enabling remote patient monitoring and real-time diagnostics. IoT devices, such as wearable sensors and smart medical instruments, collect and transmit patient data to healthcare providers and systems. This continuous stream of information allows for the remote monitoring of patients' vital signs, chronic conditions, and overall health status, reducing the need for frequent in-person visits. Real-time diagnostics powered by IoT can quickly detect and alert healthcare professionals to abnormal changes in a patient's condition, enabling timely interventions. This not only improves patient outcomes but also reduces the burden on healthcare facilities. However, the implementation of IoT in healthcare also brings ethical considerations, particularly concerning data privacy and security. Striking a balance between the potential benefits of remote monitoring and the protection of patient information is essential for the responsible and effective integration of IoT in healthcare.

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Chapter 6: Ethical Considerations in AI Vision Applications

Transparency and Explainability of AI Decisions in Visual Tasks

As AI plays an increasingly central role in visual tasks, transparency and explainability become critical. Users, stakeholders, and the public have a right to understand how AI systems arrive at their decisions, especially when these decisions impact their lives. In visual tasks, such as image recognition or object detection, transparency means making the algorithms' functioning and data sources clear. Explainability involves providing human-interpretable justifications for AI decisions, allowing us to trust and verify the outcomes. This transparency and explainability are essential not only to ensure fairness and prevent biases but also to foster public trust in AI technologies. Achieving these goals requires a combination of clear documentation, model interpretability techniques, and regulatory guidelines to balance the benefits of AI-driven visual tasks with ethical and societal considerations.

Fairness and Bias Mitigation Strategies in AI Models

Ensuring fairness and mitigating biases in AI models is a paramount ethical concern as these systems increasingly shape decision-making processes. Bias can be unintentionally introduced during data collection and model training, leading to discriminatory outcomes, especially for underrepresented groups. To address this, researchers and developers are actively working on bias mitigation strategies. These include carefully curating training data to ensure it's diverse and representative, re-sampling techniques to balance data, and fine-tuning algorithms to reduce biases. Moreover, transparency in AI development is crucial, allowing for the identification and rectification of biases. The goal is to build AI models that make decisions that are equitable across different demographics and sensitive attributes. The ongoing commitment to fairness and bias mitigation is essential to building AI systems that uphold ethical standards and promote inclusivity in decision-making processes.

Accountability and Liability When AI Systems Make Critical Decisions

As AI systems increasingly play pivotal roles in critical decision-making, the issues of accountability and liability come to the forefront. Determining who is responsible for AI-generated decisions can be complex. It involves not only the developers but also the organizations deploying these systems and the regulatory bodies overseeing them. Establishing clear lines of accountability ensures that errors, biases, or unethical decisions are addressed promptly and transparently. Liability frameworks are evolving to accommodate AI technologies, aiming to protect individuals who may be affected by AI decisions. Striking the right balance between fostering innovation and safeguarding against unintended consequences is crucial in shaping responsible AI deployment. This includes robust testing, ongoing monitoring, and adherence to ethical guidelines, ensuring that AI systems make critical decisions that benefit society while minimizing risks and upholding accountability standards.

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Chapter 7. Future Trends and Challenges

As of 2021, AI-driven vision technologies are experiencing rapid advancements and diversification, reshaping industries and societal norms in the process. One of the emerging trends is the integration of real-time analytics into computer vision applications, providing instantaneous insights for use cases ranging from autonomous vehicles to surveillance systems. Advancements in edge computing are also enabling more efficient processing of visual data closer to the source, reducing latency and bandwidth usage. Moreover, generative algorithms like GANs (Generative Adversarial Networks) are becoming more proficient in synthesizing high-quality images and videos, opening up possibilities for virtual worlds, content creation, and even synthetic data generation for training more robust models. Ethics and privacy considerations are also coming to the forefront, as the proliferation of facial recognition and other biometric technologies raise significant societal concerns. Therefore, as AI vision technologies continue to evolve, they are likely to do so hand-in-hand with an increased focus on ethical guidelines and regulations.

7.1 Integration of AI and IoT in smart cities, smart homes, and industrial settings

The fusion of AI-driven vision technologies with the Internet of Things (IoT) is expected to be a game-changer for smart cities, smart homes, and industrial environments. In smart cities, this synergy could empower more sophisticated surveillance and traffic management systems. Real-time facial recognition, object detection, and even behavioural analysis could be employed for enhanced security and more efficient urban living. In the context of smart homes, AI vision combined with IoT can elevate home security systems, enabling them to identify family members, detect unusual activities, or even interpret gestures for human-machine interaction. In industrial settings, the amalgamation of AI vision and IoT is crucial for tasks like quality control, predictive maintenance, and automated manufacturing. Automated visual inspections can flag defects or irregularities in real time, significantly improving production quality and efficiency. Despite these advancements, challenges abound. Data security and privacy are escalating concerns, especially as more sensitive visual data is collected and analyzed. Ethical considerations, particularly related to surveillance and data collection, are also gaining attention. Lastly, technical challenges related to latency, bandwidth, and interoperability between different devices and systems are still to be fully addressed. As AI vision technologies continue to evolve and integrate with IoT, these challenges will need concerted efforts from technologists, policymakers, and ethicists alike.

Figure 4 - Smart City (image from Pixabay)

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7.2 Addressing challenges: Data privacy, regulatory frameworks, and public acceptance

As tech like AI and the Internet of Things become more common, we need to tackle some big issues: data privacy, laws, and what the public is comfortable with. In the future, we might see more "privacy-friendly" tech that lets companies analyse data without exposing personal information. We're also likely to see new laws that better manage these technologies, possibly even international rules that everyone can agree on. But getting people to accept and trust new tech is another challenge altogether. To do this, the public needs to be more involved in making decisions about how these technologies are used. This could mean public surveys or discussions to make sure new tech is fair, transparent, and matches what society wants and needs. Solving these problems will take teamwork from experts in different fields like science, law, and public policy.

7.3 Ethical implications of AI-embedded IoT devices in shaping urban environments

As cameras and sensors with AI vision become more common in cities, we face some ethical questions. While these devices can help with things like managing traffic and keeping people safe, they can also invade our privacy by constantly watching us in public spaces. This brings up concerns about who gets to see this data and what they can do with it. In the future, we might see new rules that help protect our privacy, as well as more public discussions about how and where these devices should be used. Balancing the benefits and ethical concerns of this technology will require input from experts, lawmakers, and regular people alike.

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Chapter 8. Case Studies and Practical Implementations

Real-world case studies showcasing successful AI vision applications

In healthcare, the company Zebra Medical Vision offers AI algorithms that analyze medical imaging to detect a range of diseases, helping doctors make more accurate diagnoses.

Discussion Points for Classroom:

- How might the use of AI algorithms in analyzing medical images change the role of radiologists and doctors in the future?
- What are the potential benefits and challenges of relying on AI for medical diagnoses?

In agriculture, Blue River Technology employs machine vision to recognize and treat individual plants in the field, reducing herbicide usage by targeting only weeds.

Discussion Points for Classroom:

- How does the use of machine vision in identifying and treating individual plants impact the environment and the overall sustainability of agriculture?
- What are the potential economic implications for farmers using this technology versus traditional methods?

In retail, Amazon's Go stores utilize computer vision to eliminate the need for checkout lines, allowing customers to pick items and walk out of the store with automated billing.

Figure 5 - Amazon Go shop in San Francisco (Photo by Nick Statt / The Verge)

Discussion Points for Classroom:

- How do computer vision technologies in retail spaces, like Amazon's Go stores, affect the customer shopping experience and the job market in the retail sector?
- Are there potential privacy concerns with such systems tracking customer movements and purchases?

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8.1 Practical considerations when implementing AI in vision projects

Tesla's experience with its Autopilot and Full Self-Driving features serves as a cautionary example. While its vision-based system aims to automate driving, real-world performance varies. The company faces challenges related to data quality, computational limitations, and public perception, emphasizing the need for rigorous testing, ethical considerations, and clear communication with end-users.

Discussion Points for Classroom:

Real-world Performance vs. Expectations:

How does the variability in the real-world performance of Tesla's Autopilot and Full Self-Driving features impact public trust in autonomous vehicles? What measures can companies take to bridge the gap between advertised capabilities and actual performance?

Challenges in AI-driven Systems:

Considering the challenges Tesla faces, such as data quality and computational limitations, how important is rigorous testing for AI-driven systems, especially when human safety is at stake? Can we ever achieve 100% reliability with such technologies?

Ethics and Communication:

Given the potential risks associated with autonomous driving, what ethical responsibilities do companies like Tesla have in communicating the capabilities and limitations of their systems to end-users? How can clear communication influence public perception and user behaviour?

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8.2 Balancing innovation with ethical responsibilities in project development

Clearview AI, a company specializing in facial recognition, presents an example of innovation clashing with ethical responsibilities. The company created a powerful facial recognition tool that scraped billions of public photos from the Internet. While effective for law enforcement, it raised serious concerns about consent, data privacy, and the potential for misuse, leading to legal challenges and public outcry.

Figure 6 - Tesla Autopilot (image from pexels)

Discussion Points for Classroom:

Consent and Data Collection:

How does Clearview AI's method of scraping public photos for facial recognition challenge our understanding of consent in the digital age? Should publicly available data be available for companies, or should there be stricter regulations on data collection?

Balancing Innovation and Ethics:

While Clearview AI's tool can be beneficial for law enforcement, how can companies ensure they have a balance between technological innovation and ethical responsibilities? What guidelines or standards should be in place to guide such developments?

Potential for Misuse:

Given the power of Clearview AI's facial recognition tool, what are the potential risks and consequences of misuse, especially in contexts outside of law enforcement? How can society safeguard against these risks while still leveraging the benefits of such technologies?

8.3 IoT-enabled AI vision systems: Benefits, challenges, and ethical dilemmas

Smart city initiatives like Singapore's Safe City Testbed employ IoT-enabled AI vision systems for public safety and operational efficiency. Cameras and sensors provide real-time data for traffic management,

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crowd analytics, and emergency response. While such systems offer many benefits, they also pose challenges around data security and raise ethical questions about constant public surveillance and individual privacy.

Figure 7 - Face recognition (image by freepik)

Discussion Points for Classroom:

Benefits vs. Privacy Concerns:

How can smart cities like Singapore balance the benefits of real-time data for public safety and efficiency with concerns about individual privacy? Where should the line be drawn between public interest and personal rights?

Data Security in Smart Cities:

With the vast amount of real-time data collected by IoT-enabled AI vision systems, what potential risks arise related to data security and breaches? How can cities ensure the protection of this data, especially when it pertains to the daily lives of its citizens?

Ethical Implications of Constant Surveillance:

Given the constant surveillance in smart city initiatives, what are the ethical implications of monitoring public spaces and the potential impact on citizens' behaviour and sense of freedom? How can cities address these concerns while maintaining the benefits of such systems?

Chapter 9. Becoming familiar with AI and Vision through the lens of the 5 big ideas

Artificial Intelligence (AI) in vision is a transformative domain that empowers machines to interpret and act upon visual data, similar to human sight. At its core, it aligns with the five foundational ideas of AI.

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Firstly, perception enables AI systems to capture visual information, much like our eyes do, leading to image recognition and facial detection advancements. Secondly, representation and reasoning involve the creation of algorithms, like convolutional neural networks, to process and understand this visual data. Thirdly, the principle of learning, especially through deep learning techniques, allows these systems to continually refine their capabilities, recognizing complex visual patterns. Natural interaction, the fourth principle, is exemplified as AI vision paves the way for more intuitive human-machine interactions, including gesture recognition and immersive augmented reality experiences. Lastly, the societal impact of AI on vision is profound, offering groundbreaking benefits, such as medical diagnostics enhancements, and posing challenges related to privacy and algorithmic bias. These ideas underline the vast potential and complexities of integrating AI into vision.

9.1 Perception

Perception is the starting point for AI in vision. In the same way that we use our eyes to see and understand the world around us, AI uses cameras and sensors to "see" and interpret visual data. This is similar to how our brain processes what our eyes see. AI vision includes techniques such as recognizing images, identifying faces, and spotting different objects. Some advanced AI systems can even tell how a person might be feeling just by looking at their facial expressions.

Case Study/Scenario: Automated Supermarket Checkout

Background: Imagine a supermarket of the future where there are no cashiers. Instead, there are smart cameras everywhere that watch what you pick up and put in your cart.

How it works:

1. As you enter, facial recognition technology identifies you and links to your shopper profile.
2. As you shop, cameras with object detection identify each item you pick up and add it to your virtual cart.
3. Image recognition can differentiate between different products, so it knows if you've picked up a regular apple or an organic one.
4. If you decide you don't want an item and put it back, the system recognizes this action and removes it from your virtual cart.
5. Once you're done shopping, the total amount is automatically deducted from your linked payment method as you walk out.

Discussion Points for Classroom:

1. How do you feel about a shopping experience like this? What are the pros and cons?
2. What happens if the system makes a mistake, like charging you for an item you didn't take?
3. How would this impact jobs in the supermarket?
4. What privacy concerns might arise from using facial recognition in public places like supermarkets?

This scenario showcases the potential of AI perception in real-world applications, emphasizing both its capabilities and the ethical considerations it brings up.

9.2 Presentation and Reasoning

When AI systems "see" or capture visual data, they need a method to process and understand it, much like how our brain interprets what our eyes observe. This involves using specific structures and rules in the AI, known as data structures and algorithms. A popular tool for this is the Convolutional Neural

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Network (CNN), which is tailored for handling images. CNNs can pinpoint specific features in an image, such as patterns or colours.

Case Study/Scenario: Lost Pet Finder App

Background: Imagine an app that helps people find their lost pets using AI. A user uploads a photo of their missing pet, and the app scans through a database of found animals in shelters or reported by other users, looking for a match.

How it works:

1. A pet owner uploads a clear photo of their lost pet, along with details like breed, colour, and any distinctive marks.
2. The app uses CNNs to analyze the image, focusing on unique features of the pet, such as patterns in fur or specific markings.
3. The CNN, having been trained on numerous animal images, scans the database for similar-looking animals.
4. If a potential match is found, the app notifies the user with details of where the animal was found or is currently located.

Discussion Points for Classroom:

1. How might this app change the way we handle lost and found pets?
2. What challenges might arise in ensuring the app correctly matches pets?
3. How would the app handle common pet breeds that look very similar?
4. What ethical considerations come up, especially if the app mistakenly identifies someone else's pet as yours?

This scenario emphasizes the potential of AI's representation and reasoning in everyday situations, while also highlighting the challenges and ethical considerations of such technology.

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9.3 Learning

Learning is a crucial part of AI, especially in vision. Just as we learn from experience, AI systems learn from data. The more data they get, the better they become at tasks like identifying images or detecting objects. Machine learning is a way for computers to learn from data without being explicitly programmed. A special type of machine learning called deep learning, uses structures called neural networks that are inspired by our brain's structure. These networks, especially when they have many layers, can recognize a wide range of visual details in images.

Case Study/Scenario: Smart Traffic Management System

Background: Imagine a city that uses AI-powered cameras at traffic intersections to manage traffic flow efficiently.

How it works:

1. Cameras at intersections capture real-time footage of traffic.
2. The AI system, trained on countless hours of traffic footage, identifies patterns like vehicle types, congestion levels, and pedestrian movement.
3. Over time, as the system processes more data, it learns to predict traffic bottlenecks, optimal green light durations, and the best times to allow pedestrian crossings.
4. The system then adjusts traffic light timings in real-time, ensuring smoother traffic flow and reducing congestion.

Discussion Points for Classroom:

1. How would such a system change the daily commute in cities?
2. What are the potential safety concerns, and how might they be addressed?
3. How would the system handle unexpected situations, like road accidents or parades?
4. What other data sources could be integrated to enhance the system's learning and predictions, such as weather data or special event schedules?

This scenario showcases the power of machine learning in AI vision to address real-world challenges. It also prompts students to think about the broader implications, potential limitations, and ways to improve such systems.

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9.4 Natural Interaction

Natural Interaction refers to the way AI in vision helps humans and machines interact in intuitive and natural ways. Instead of using keyboards or buttons, we can use gestures, like waving our hands, to communicate with machines. Technologies like Augmented Reality (AR) and Virtual Reality (VR) take this a step further, allowing us to immerse ourselves in digital worlds or overlay digital information onto our real world.

Case Study/Scenario: AR Museum Tour Guide

Background: Imagine a museum where visitors wear AR glasses as they explore exhibits. These glasses, powered by AI vision, provide an interactive and personalized tour experience.

How it works:

1. Upon entering the museum, visitors are given AR glasses.
2. As they approach an exhibit, the AI recognizes the artwork or artefact and overlays information, stories, or even re-enactments onto the visitor's field of view.
3. If a visitor is curious about a specific detail, they can point or gesture towards it. The AI responds by providing more in-depth information or related multimedia content.
4. For group tours, the AI can even create interactive quizzes or games, where visitors answer by gesturing or looking at the correct answer.

Discussion Points for Classroom:

1. How does this AR experience differ from traditional museum tours? What are the advantages and potential drawbacks?
2. How might this technology be adapted for other educational settings, like historical sites or zoos?
3. What privacy and security concerns arise when using AR glasses that track users' movements and interests?
4. How can designers ensure that the AR content enhances, rather than distracts from, the real-world exhibits?

This scenario illustrates the potential of AI vision in enhancing natural interactions in educational and cultural settings. It also encourages students to consider the broader implications, challenges, and opportunities of integrating such technology into everyday experiences.

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9.5 Societal Impact / Ethics

AI in vision, like many technologies, has both positive and negative effects on society. While it offers benefits like improved medical diagnosis, better security, and innovative entertainment, it also raises concerns. Issues like privacy invasion, unfair biases in AI decisions, and misuse of technologies like facial recognition are significant. It's essential to understand and discuss these impacts to use AI responsibly.

Case Study/Scenario: Public Safety vs. Privacy in Smart Cities

Background: Imagine a "Smart City" where AI-powered cameras are installed at every street corner to ensure public safety, reduce crime, and manage traffic.

How it works:

1. The cameras constantly monitor public spaces, identifying potential criminal activities or safety hazards.
2. Using facial recognition, the system can identify wanted criminals or missing persons in real-time.
3. The system also helps in traffic management, accident detection, and emergency response.
4. However, the same cameras also capture the daily activities of innocent citizens, tracking their movements, habits, and routines.

Discussion Points for Classroom:

1. How do you feel about living in a city with constant surveillance for the sake of safety? What are the trade-offs between safety and privacy?
2. What measures can be put in place to ensure that the data collected is not misused or accessed by unauthorized individuals?
3. How can biases in AI, such as racial or gender biases, affect the system's decisions? What are the consequences of these biases?
4. Should citizens have a say in how and where these cameras are used? How can cities ensure transparency in the use of such technology?

This scenario highlights the delicate balance between leveraging AI in the vision for societal benefits and the potential risks associated with it. It encourages students to think critically about the ethical and societal challenges posed by such technologies and to consider potential solutions and safeguards.

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Chapter 10. Glossary

1. **Artificial Intelligence (A**I): The simulation of human intelligence processes by machines, particularly computer systems. In the context of this module, AI is utilized in various vision applications to enhance human visual perception and enable tasks such as image recognition, object detection, facial recognition, and medical imaging.
2. **Internet of Things (IoT):** The network of interconnected devices embedded with sensors, software, and other technologies to collect and exchange data. In the context of AI vision applications, IoT is integrated to facilitate real-time data processing, enabling functionalities like remote patient monitoring in medical imaging and diagnostics.
3. **Deep Learning:** A subset of machine learning algorithms that uses artificial neural networks with multiple layers to learn representations of data. Deep learning algorithms are extensively utilized in image recognition tasks discussed in this module.
4. **Data Augmentation:** Techniques used to increase the diversity of training data by applying transformations such as rotations, flips, and scaling. Data augmentation is crucial for improving model performance in image recognition and classification tasks.
5. **Ethical Considerations**: Pertaining to the moral principles and values guiding the development and deployment of AI vision applications. Ethical considerations discussed in this module include privacy concerns related to IoT-enabled vision systems, biases in image data and algorithms, and potential misuse of personal data in facial recognition systems.
6. **Object Detection and Tracking**: Processes of identifying and locating objects within an image or video stream, often in real-time. Object detection and tracking have various applications such as surveillance, autonomous vehicles, and industrial automation, accompanied by ethical considerations regarding surveillance and privacy concerns.
7. **Emotion Detection**: The process of identifying and interpreting emotions from facial expressions, including micro-expressions. Emotion detection has applications in security systems, user experience enhancement, and healthcare, but raises ethical concerns regarding biases in algorithms and potential misuse of personal data.
8. **Medical Imaging and Diagnostics**: The application of imaging technologies in the diagnosis and monitoring of medical conditions. AI facilitates automated diagnosis and detection of diseases such as cancer and retinal diseases, fostering collaboration between AI systems and medical professionals while raising ethical considerations regarding patient privacy and data security.
9. **Practical Implementations**: The application of AI vision technologies in real-world scenarios, involving considerations such as project development, ethical responsibilities, and addressing the benefits, challenges, and ethical dilemmas of implementing IoT-enabled AI vision systems.
10. **Five Big Ideas**: A framework for understanding AI and vision applications through five key concepts: perception, presentation and reasoning, learning, natural interaction, and societal impact/ethics. These ideas provide a comprehensive lens through which to analyze the implications and potential of AI in vision-related fields.

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Chapter 11. Assessment Quiz

1. Question: What is the primary focus of Computer Vision within the field of AI?
A) Allowing computers to interpret and understand visual information like humans.
B) Enabling machines to perform mathematical calculations.
C) Empowering machines to produce visual graphics and designs.
D) Assisting computers in audio and sound recognition.
Answer: A) Allowing computers to interpret and understand visual information like humans.

2. **Question:** What does image classification do in computer vision?
A) Identifies specific objects in photos.
B) Assign a label to an image based on its content.
C) Creates new images.
D) Repairs damaged photos.
Answer: B) Assign a label to an image based on its content.

3. **Question:** What role does computer vision play in autonomous vehicles?
A) It helps in designing the exterior of the cars.
B) It enables cars to interpret traffic signs and navigate roads.
C) It assists in the audio system of the cars.
D) It focuses on the comfort of the car seats.
Answer: B) It enables cars to interpret traffic signs and navigate roads.

4. Question: What is the primary use of facial recognition technology in smartphones?
A) Improving camera quality.
B) Enhancing audio clarity during calls.
C) Streamlining access through authentication.
D) Increasing battery life.
Answer: C) Streamlining access through authentication.

5. Question: What is a significant benefit of AI in medical image analysis and automated disease detection?
A) It allows doctors to take more breaks.
B) It enhances the quality of medical images.
C) It enables early detection of diseases, improving patient outcomes.
D) It reduces the cost of medical equipment.
Answer: C) It enables early detection of diseases, improving patient outcomes.

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Application of AI in Speech

Introducing the 5 Big Ideas in Artificial Intelligence using Internet of Things in STEM education

25.07.2023 | ECAM-EPMI
PROJECT NUMBER: 2022-1-FR01-KA220-SCH-000085611

AI4STEM Educational Framework Topic: Application of AI in Speech

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Summary

This paper shows the role of AI in speech and voice recognition in STEM education and pedagogical practices. At the beginning of the paper, aspects of speech recognition techniques are presented in order to simplify the understanding of these types of techniques for educators.

Next, a state of the art on the best speech recognition software is given so that educators have a general idea of everything that is software. The ethical aspect of AI and speech is demonstrated.

Then, several examples on the application of AI to speech are described and several real applications are shown such as: ChatGPT, the disadvantages and advantages of these in teaching and education are demonstrated.

In another part of this paper, the five major AI tasks in correlation with speech recognition and speech are described. As a result, educators and students alike will have a broad idea of these five major tasks and how they relate to speech recognition.

Finally, case studies are presented in the last part of the document.

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Chapter 1: Introduction of AI in Speech

1.1 Introduction

The first speech system to be designed was Eliza, built at MIT in 1965, an intelligent system that dialogues in English and plays psychotherapist.

In 1965, the ELIZA system (developed by Joseph Weizenbaum at MIT) was able to conduct natural language dialogues by spotting key expressions in sentences and reconstructing ready-made sentences based on them. For a moment, it fooled people who thought they were dealing with a human psychologist!

However, ELIZA had no real understanding of the sentences it was processing. It was undoubtedly Terry Winograd's SHRDLU system which, in 1970, was the first to 'understand' something of natural language and to exploit this understanding in dialogues involving a simplified world made up of blocks.

1.2 Glossary

Word	Definition
Artificial Intelligence (AI)	Artificial intelligence (AI) is a process of imitating human intelligence, based on the creation and application of algorithms executed in a dynamic computer environment. Its aim is to enable computers to think and act like human beings.
IoT (Internet of Things)	The Internet of Things (IoT) is a network of connected objects and terminals equipped with sensors (and other technologies) enabling them to transmit and receive data between themselves and with other systems.
Micro:bit	The micro:bit card is an electronic card (nanocomputer) created by the BBC in 2016 to promote learning to code among schoolchildren. It is a programmable micro-controller card with integrated sensors and actuators.

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Chapter 2: Automatic speech recognition: state of the art and technical aspects

Siri, Alexa, Google Home, ... you already know them, you've probably already "chatted" with them, but who are they? Voice assistants are becoming a must-have for millions of people around the world. To work, they rely on voice recognition techniques based on machine learning.

Companies are investing heavily in this sector, and the result is rapid progress. It's true that when Apple launched Siri with iOS 5 in 2011, it sounded like a revolution, but it's important to remember that the first work on voice recognition dates back to 1952.

It has to be said that controlling systems by voice is a logical evolution in human-machine interfacing. Humans are more at ease with speech than with other means of communication: we've been talking for around 100,000 years, whereas we only started writing 10,000 years ago.

Gone are the days when we were the only ones to talk. Computers can now "listen" and respond. Google, Amazon, Apple, and Microsoft, as well as several start-ups from all over the world, have entered the market, and the results are improving all the time.

Nevertheless, you will see that even if voice recognition offers interesting possibilities, the design of an intelligent assistant in the true sense of the word is still only a utopian dream.

Many applications in health, administration and other fields.

2.1 Turning speech into text

One of the obvious applications of speech recognition is turning spoken words into written text. We have to admit; that it makes life a lot easier. For example, it allows you to do Google searches without touching your smartphone.

What's more, this application opens up a whole host of possibilities in administration and healthcare. Gone are the days when a secretary would transcribe the discussion between a doctor and his patient.

Similarly, voice recognition systems could help you take notes while attending a conference or make automated notes of exchanges during a meeting.

2.2 Security: recognizing a person by their voice

Advances in speech recognition mean that the voice can now be seen as a person's identity card. Some systems can recognize your voice with just 3 seconds of recording.

You can test this with "Google OK": if your phone is set up properly and someone other than you says, "Google OK", nothing will happen.

This could allow you to control the electronic devices that belong to you securely, manage your bank transactions, or even control the opening and closing of your front door!

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2.3 Making language learning easier

Today you can find many applications that allow you to improve your accent in several languages. You say a sentence and the application corrects your pronunciation and gives you advice.

This kind of application may work and give good results, but it may not be very reliable. In any case, it's an interesting application of speech recognition.

2.4 Deep learning for better performance

In practical terms, to train a speech recognition model, you need a large amount of data. The main problem you will encounter is that each person has a unique prosody. People have different voices and accents; their rhythm and intonation can vary.

All this makes the task a little complicated. That's why open-source pre-trained models, from Google or Nvidia for example, are the most reliable.

2.5 Still a long way to go

Voice assistants may be quite effective, but they are still limited. They recognize the words you say but are not capable of understanding the meaning of your sentences. You also need to be in a relatively quiet environment, otherwise, the noise could be a source of confusion.

What's more, their error rate is still too often high, which limits their possibilities. This makes them unusable for weapons or health applications. In these fields, the slightest error can have serious consequences.

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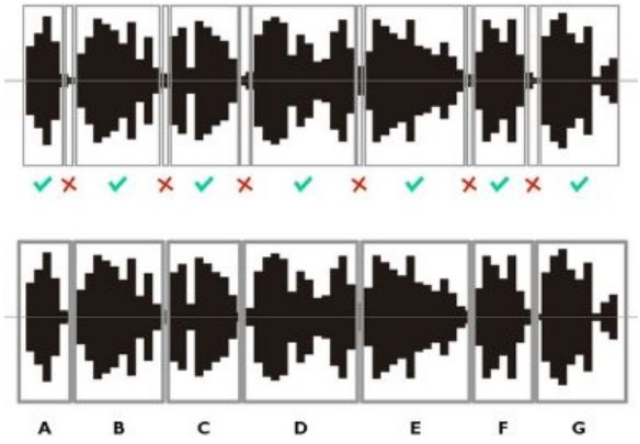
Chapter 3: Large Vocabulary Continuous Speech Recognition: a voice recognition technique

Based on the automatic identification of very short audio sequences, this technology can produce a transcription of excellent quality, provided the audio is recorded correctly. The state of the art of Automatic Speech Recognition ASR has evolved considerably in recent years. This method enables us to process recordings containing general vocabulary as well as more specific terms (technical, legal, medical, etc.).

To arrive at the final transcript, the process comprises 4 stages:

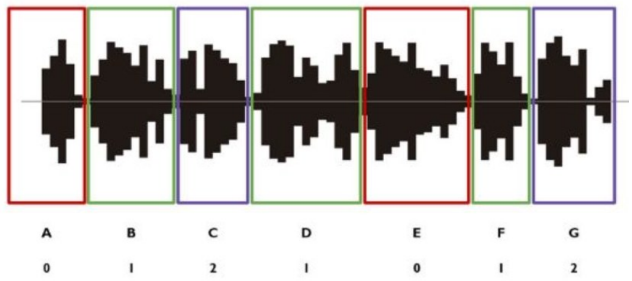
- **Voice Activity Detection**

To begin with, we need to identify at what points in the recording someone is speaking, to divide the soundtrack into segments. The machine then works on each of these segments.



- **Diarization**

The next step is to identify the different speakers in each segment, to match the segments of the same speaker, and to be able to correctly allocate the utterances in the transcription. To do this, the machine uses different engines, each of which has been fed with specific data (languages, voices). This enables it to consider subtleties of language, such as accents, for example. Note that at this stage, we are still dealing with "mathematical" data processing.



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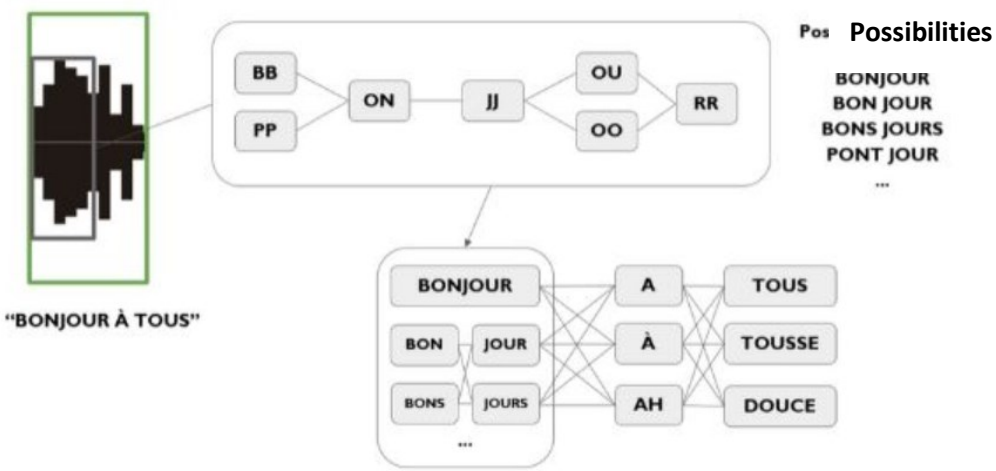
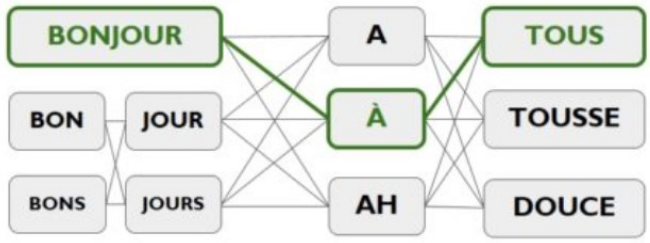
- **Decoding**

It is only at this point that the notion of transcription makes its appearance. A list of possible syllables (phonemes) is drawn up for each audio segment. For the moment, no sentence is written down, just a long list of possibilities, each with a score.



- **The Re scoring**

From all the phonemes and words learned during its initial training, the computer chooses those that form the most likely sentence (a bit like a GPS identifies the best route). It transcribes this sentence in its document. Recording, language model, what makes the most sense.



This mechanism is applied to all the segments of the recording to produce, in fine, the complete transcription.

3.1 The best speech recognition software

Over the decades, automatic speech recognition has evolved to become an indispensable tool in many fields. Whether it's to save time when taking notes, or for medical or other applications, speech recognition software will allow you to control or write content using your voice. We'll start by looking at what voice recognition software is and then take a look at the top 6 best voice recognition software.

Voice recognition or voice dictation software can transcribe a voice into written text.

It can also identify and understand human speech to execute a person's commands on a computer.

There are many applications for this technology, and they are becoming increasingly powerful, thanks in particular to artificial intelligence.

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1. Google Docs Voice Typing

Google Docs Voice Typing is free voice dictation software integrated into the Google suite. It's the ideal tool if you want to combine dictation and voice recognition with the Google Suite. Google Docs includes a dictation function that is both highly accurate and easy to use, called "Google Docs Voice Typing".

To access it, go to Google Docs and Tools > Voice Typing, and a microphone icon will appear on the left. Click on it and start talking. If you are idle for around 30 seconds, the microphone will automatically switch off. Click it again to resume.

If you need help or want a list of commands, click on the question mark in the microphone icon. Help is displayed on the right, where you can scroll or search for voice commands such as punctuation, text formatting, editing and even moving around your document. So, this solution is perfect if you're on a budget and want to use voice recognition functionality simply in Google Docs.

2. Braina PRO

Braina is an intelligent personal assistant, human language interface, automation and speech recognition software for Windows PCs. Braina is a multifunctional AI software that allows you to interact with your computer using voice commands in most of the world's languages. Braina also allows you to accurately transcribe speech into text in over 100 different languages worldwide.

3. Speech notes

Based on Google's speech recognition engine, Speech Notes is a simple online tool for dictation and voice transcription. As there's no need to download or install any software to use Speech Notes, it's by far one of the most accessible dictation tools on the internet.

Speech notes are also incredibly user-friendly, automatically capitalizing your sentences, saving your documents and allowing you to dictate and type at the same time.

You can then email your documents, print and file them, export them to Google Drive or download them to your computer.

4. Dragon

With a variety of software and mobile applications for different use cases (Dragon Legal, Dragon Medical, Dragon Professional), Dragon is a highly advanced voice dictation software that can handle the specialist vocabulary of many sectors, and it has some excellent features, such as the ability to transcribe text from an audio file that you download.

The software also offers audio shortcuts. In fact, by saying a specific word, you can trigger the writing of a sentence or a series of words. This can be a handy way of saving time.

Once you've completed a dictation, you can email it, share it (e.g. Google Drive, Dropbox), open it in Word or save it in Evernote. You can do this manually or by voice command (e.g. "save to Evernote").

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5. **Deeptranscript**

DeepTranscript is the voice dictation software powered by DeepL, the famous online translator. As well as being based on one of the best technologies on the market, DeepTranscript has a very attractive free plan with over 20 hours of free transcriptions.

6. **Happyscribe**

Happyscribe is speech recognition software that lets you transcribe your audio into text or even add subtitles to your videos directly and very simply. Happyscribe offers 2 different plans, the first using its AI with an accuracy rate of 85% which is not perfect but still saves precious time, and a plan that uses a human to transcribe. Depending on your needs, you may be interested in one or other of these options.

7. **Speechtexter**

SpeechTexter is free voice dictation software that works specifically on the Chrome browser or with Android. Although the application's privacy policy states that it doesn't store the text, it may be processed by Google's server (since you're doing it online via the Chrome browser or Android app). So, keep this in mind.

The application offers easy, highly accurate speech transcription. The platform allows live transcription, where you can click start and begin speaking. Once the transcription is complete, the text is displayed in the main window along with the 'result confidence wheel', which shows the estimated percentage of words transcribed accurately.

8. **Google speech-to-text API**

Google's speech-to-text API recognizes more than 120 languages worldwide, making it possible to integrate this speech recognition functionality into all your favourite applications. The fun fact is that this API is behind most speech recognition software because it's one of the most powerful on the market.

9. **Robotics**

Artificial Intelligence and robotics are digital technologies that will have a significant impact on the development of humanity. They have raised fundamental questions about what we should do with these systems, what the systems themselves should do, what risks they involve, and how we can control these.

While AI can be entirely software, robots are physical machines that move. Robots are subject to physical impact, typically through “sensors”, and they exert physical force onto the world, typically through “actuators”, like a gripper or a turning wheel.

An important sub-field of AI, robotics can be seen as an intelligent interconnection of the perception, action and operation of robots.

Used to maintain dynamic representations of their environment, it enables robots to acquire the ability to sense, move, reason and eventually communicate in natural language.

Robotics and AI can thus be seen as covering two overlapping sets of systems: systems that are only AI, systems that are only robotics, and systems that are both.

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10. Wakamaru

A talking robot, developed by Mitsubishi Heavy Industries, is designed primarily to look after the elderly. Designed to become an integral part of everyone's family life, its mission is to alert the hospital or health services if necessary.

This robot can connect to the internet via WiFi and has a synthetic voice. It has a built-in mobile phone, so it can call for help if its owner (an elderly person, for example) has a problem. It lives according to the daily schedule provided by its owner via the Internet.

Wakamaru has voice recognition and facial recognition of its owner(s) and family. It looks you in the face when it talks and incorporates body movements during the discussion. Wakamaru not only responds to commands from actors, as conventional robots usually do but also takes the initiative to talk to the family, using the information it has obtained through observation by staying in contact with the family or via its organizer. So, it won't forget to tell the cat to go and eat its bowl, or to celebrate your mother-in-law's birthday.

11. Dictation.io

Dictation.io is a newcomer to the field of speech recognition software. Dictation.io supports dozens of languages and is a great way to take notes without having to write. To use it, select your language, then click on the microphone icon and start speaking - that's all there is to it! Once you've taken your notes orally, you can simply export the content wherever you like.

12. Speechnotes

Speech Notes is another easy-to-use voice dictation application. The advantage is that you don't need to create an account, just open the application, press the microphone icon and off you go. The application is backed by Google's voice recognition technology.

When you're recording a note, you can easily dictate punctuation marks using voice commands or by using the built-in punctuation keyboard.

To make things even easier, you can quickly add names, signatures, and other frequently used text using a set of custom keys on the built-in keyboard. Capitalization is also automatic, and every change you make to a note is saved to the cloud.

13. E-speaking

E-speaking is downloadable voice dictation software. This software is available for Windows only and lets you control your computer by voice. This voice recognition tool lets you open your software directly by speaking, without having to click. Interesting features, but a bit old school.

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Chapter 4: Ethical aspects of AI in Speech

4.1 Ethical and critical issues surrounding massive data in IA in speech

Current developments in AI require massive data on which to train the AI and by means of which to ensure its operation. The resulting ethical and critical issues in the use of AI in speech can again be formulated in terms of representation and representativeness. The first of these concerns the potential biases in the massive data used to train and optimise AI. Several examples from real-life situations have illustrated the sexist and discriminatory effects of biased datasets. For example, a voice recognition algorithm can identify two similar people's voices differently depending on the degree of severity of the voice of the people represented. In the first case, it is a deep female voice, in the second a woman with a high-pitched voice. The algorithm correctly identified the second person as a woman, but identified the first person as a man.

4.2 AI in speech and data ethics

Ethical use of data and algorithms is about doing the right thing when it comes to the design, functionality and use of data in artificial intelligence (AI) applied to speech recognition.

This involves assessing how and why data is used, considering who has access to it and who should have access to it, and anticipating how data could be misused. Consideration should be given to what data should and should not be linked to other data and how it should be stored, moved and used securely. Ethical use considerations include confidentiality, bias, access, credentials, encryption, legal requirements and restrictions, and what could go wrong.

Data ethics is about asking tough questions about the risks and possible consequences for those affected by the data. It includes being more transparent about what data users have access to and what they do with it. It's also about being able to explain how technology works, so that people can make informed choices about how their data is used and shared.

4.3 Principles of data ethics in AI in speech

- **Transparency**

This means disclosing the voice data collected, respecting what can be collected and how it can be used. It also means being able to explain how algorithms work and what their results are based on. Transparency also means informing people about the type of data held and how it is used. Sometimes this means giving people the opportunity to correct or delete information.

- **Equity**

AI doesn't just provide information. Sometimes it offers opinions. This means that we need to think about how we use these tools and the information they give us. Since the data comes from humans and concerns them, it is important to look for biases in the data collected, what rules are applied and what questions are asked of the data. While there is no way to completely eliminate bias in tools created by and about people, we need to understand how tools are biased so that we can reduce and counter bias and correct it to improve our decision-making.

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- **Confidentiality**

In some cultures, confidentiality is fundamental to human rights and dignity. A growing number of privacy laws around the world recognise rights to confidentiality in relation to names and likenesses. A balance must be struck between confidentiality and the need to use so much personal data. But as more and more data are collected and linked, questions arise about how to preserve anonymity. Other privacy issues concern the security of information and what people should know about who holds data about them and how it is used.

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Chapter 5: AI in Speech and the 5 Big Ideas

5.1 Perception

Before we can create robots capable of speaking all the languages of the world, we must first be able to create a robot capable of communicating with a human being - in other words, an AI that masters each of the six branches of phonetics: Phonetics (sounds); Phonology (phonemes, which are combinations of sounds); Morphology (words, which are combinations of phonemes); Syntax (sentences and clauses, which are combinations of words); Semantics (the literal meaning of sentences and clauses); Pragmatics (the meaning of sentences in a given context).

Now, AIs such as Siri, Alexa and Cortana have only mastered one area: syntax. This enables them to recognize words, phrases and questions posed by humans, and to respond when the answers have already been pre-programmed; but they cannot yet "appropriate" a language or idiom and conduct a conversation that has not yet been planned by an engineer.

5.2 Representation & Reasoning

Natural language AI chatbots such as ChatGPT use vast amounts of text data to predict words or phrases in each context. They can be used to mimic natural human language and to aid a wide variety of language-related tasks in much more sophisticated ways than previously possible. Other emerging AI tools, also trained on large datasets, focus on producing computer code and images in response to user prompts. At the Center for Teaching and Learning (CTL), we have heard a lot of interest, concerns, and questions from the campus community. These tools are capable of offering support to learners and members of staff, regardless of the day or time. They facilitate contact with young people and are designed to meet a specific need—two examples of chatbots: FLO from Alloprof and ALI from Optania.

Many wonder how such tools might aid students in completing assignments or necessitate changes in how we assess student learning. Some are concerned about the impact these tools may have on academic integrity and issues of originality in writing. Others are interested in how such tools can aid instructors in teaching writing skills. And many are simply curious about AI tools, how they work, and what they can do.

We suggest several key teaching practices, some already familiar, to help faculty, lecturers, academic teaching staff, and teaching assistants navigate these emerging technologies and remain on the leading edge of developing pedagogic strategies, course designs, and curricula that integrate and address emerging technologies and understandings in the science of learning.

In many ways, teaching with AI tools in mind relies on a familiar concept: assignments that support students in developing linked thinking and writing (or other generative skills) are more effective. This includes the process of discussing, drafting and revising ideas about sources and evidence.

The recent release of ChatGPT, a new natural language processor that can write essays, spit out a Haiku, and even produce computer code, has prompted more questions about what this means for the future of society than even it can answer, despite efforts to make it try.

Faculty from the Stanford Accelerator for Learning are already thinking about how ChatGPT and other generative artificial intelligence will change and contribute to education in particular.

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5.3 Learning

Teachers can use AI voice recognition in their lessons. They can take dictation for their students, for example, or give instructions through an application. AI and speech can be used to translate languages at international conferences and process textual data such as books and articles, for example. AI and speech can be used in home automation: opening/closing windows, turning lights on or off, alerting if smoke is detected due to a fire, etc.

First, ChatGPT may help students use writing as a tool for thinking in ways that students currently do not. Many students are not yet fluent enough writers to use the process of writing as a way to discover and clarify their ideas. ChatGPT may address that problem by allowing students to read, reflect, and revise many times without the anguish or frustration that such processes often invoke.

Second, teachers can use the tool as a way of generating many examples and non-examples of a form or genre. Often, teachers have the resources and bandwidth to find or create one or two models of a particular kind of writing, for example, a personal narrative about a family relationship. As a result, students may come to believe that there is only one way to write such a narrative. ChatGPT allows teachers to offer students many examples of a narrative about a family where the basic content remains the same, but style, syntax, or grammar differ. With many examples to compare and analyse, students can begin to see the relationship between form and content. They can develop criteria for what makes a strong piece of writing, or how one verb might affect readers differently than another. For teachers, designing instruction has just become much easier. ChatGPT is essentially a tool for creating contrasting cases, and most teachers will be delighted that ChatGPT is doing a lot of the legwork for them.

Teachers are less delighted about the computer doing a lot of legwork for students. And students still need to learn to write. But in what way, and what kinds of writing? A third side effect of this new technology is that it requires all of us to ask those questions and probably make some substantive changes to the overarching goals and methods of our instruction.

5.4 Societal Impact

There is some consternation in the admissions space about these technologies and with obvious good reason. Access to the technology will make its use in admission trials more widespread among households of lower socio-economic status. Why is this? Because the more affluent, as they have shown in the past, are very savvy and know that (1) organizations that develop standardised tests for primary and secondary education are already working on algorithms to detect AI-written essays accurately, and (2) anything that is accessible to the many is something that should not only be avoided but countered with a more exclusive strategy. This might involve writing non-standard essays - poetry or a mini-scenario, for example - or something else. The desire to maintain social distinction and the privileges that go with it is very strong. And there will certainly be a profit-making cottage industry developing to meet the demand to help the wealthiest families in their quest. Things are moving fast, though, and perhaps so fast that the potential democratic effects of the technology will surface.

We need to remember that language, even from ChatGPT, is deeply linked to culture and cognition. The innovation centres on the capacity to replicate and, in some cases, enhance how human intelligence emerges in dialogue. On its merit, this advancement has the potential to improve how software supports students' learning through rich, computer-generated dialogue. This is an incredibly important technological advancement that must understand the cognitive and cultural benefits of dialogue as an

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educational tool. To replicate dialogue without an understanding of the cultural and cognitive benefits of dialogue runs the risk of centring a singular cultural lens: that of the designer.

Dialogue serves many purposes. Social science research indicates that dialogue represents cultural membership, gender identification, and group membership broadly. Said differently, how something is said sends multiple messages. On one level, all dialogic communications send a message of content. The message shares an idea. On another level, a message sends a message of belonging and identity. How the message is communicated sends a cue of who the message is for and who the speaker is. This subtle intersection of language cues and language identities embeds a message in every dialogical exchange. So, artificial intelligence must embed the power of cultural cues in its communicative pathways. They are already there. How something is said sends a message of who the speaker expects to be.

The dialogue serves as both an assessment tool and a tool for developing mastery. The AI developers must create opportunities for students to explain their way toward expertise, to use artificial intelligence for feedback and corrective support, while explicitly ensuring all students can receive cues of cultural belonging. In thinking this way, all kids may benefit from AI technologies if developers do the important work of centring the intersection of language, culture, and cognition.

In the area of disability, consider how we might use AI to code videos of teachers and other instructors to train them in pedagogical practices that have been shown to benefit children and how AI could potentially help us develop smarter tutoring that meets the needs of students.

We have a glimpse of new things that are going to be built with AI. What do we need students to know and understand about how these are built, how they work, and the costs and benefits (financial, ethical, environmental, social) of different technologies for different visions of what education is supposed to do? As a first step, we need to seriously examine how AI is changing how different fields and disciplines do their work and what ideas students need to develop to both build and use AI for humans rather than in place of humans.

The aim of Artificial Intelligence in education is to avoid cognitive overload for those involved in education while reducing repetitive tasks. Artificial Intelligence in education should give school staff back the time to build caring relationships with learners and help them reach their full potential.

5.5 Natural Interaction

Language is a complex concept with different elements to be considered. Building a speech recognition system therefore mainly involves three models: acoustics, pronunciation, and language. The acoustic model involves capturing speech in waveform and breaking it down into phoneme fragments. In terms of pronunciation, sounds are linked together to form words based on their phonetic representations. Finally, the language model links words to predict the sequence of words (sentence). Acoustic and linguistic modelling can be combined to propose the most likely sequence for a speech input.
Despite the wealth of databases used by software, they do not recognise all languages. In other words, the developers of these systems have to define the target regions to adapt their software to the languages and accents to be considered.
Punctuation is another element of language that can cause speech recognition algorithms to malfunction. There are an infinite number of sentences with different punctuation marks that can alter the meaning.

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Chapter 6: Case Studies and Practical Implementations

Throughout the development of this chapter, we have given concrete examples. But, in this part, we can also talk about the case studies and the practical aspects. In this frame, 4 main areas of practical application of AI in speech can be identified:

6.1 Predictive models

These are tools that help school staff to identify at-risk situations, such as students dropping out or failing at school, in a preventive manner. To do this, AIs generate a portrait of the student population to determine the "patterns" of failure and drop-out and to react before they occur.

6.2 Adaptive learning platforms

Adaptive learning platforms can be used to assess a learner's knowledge of a subject based on observable data. They can also be used to adjust the learner's learning path to address weaknesses and highlight strengths. The aim of all this is to encourage individualized teaching and lead to educational differentiation. An example of an adaptive platform: Adapt Coaching Actuaries.

6.3 Chatbots

These tools are capable of offering support to learners and members of staff, regardless of the day or time. They facilitate contact with young people and are designed to meet a specific need. Two examples of chatbots: are FLO from Alloprof and ALI from Optania.

6.4 Real-time statistical analysis tools

Designed for educational staff in direct contact with students, these tools provide a real-time picture of learners' learning situations. All this is done to carry out specific interventions as soon as a situation risks worsening. An example of an analysis tool: Mozaïk-Portail, which offers staff members an active monitoring module about students in real-time.

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Chapter 7: Quiz

1. The five big ideas in AI are:

Perception, Representation & Reasoning, Learning, Natural Interaction, Societal Impact

a. True

b. False

Answer: a

2. The process of Continuous Speech Recognition comprises 3 stages

a. True

b. False

Answer: b

3. The technology of Speech Recognition includes 4 stages? Examples?
a. True
b. False
Answer: a : Voice Activity Detection, Diarization, Decoding, The Re scoring

4. "Siri" and "Alexia" are a real-life applications of voice recognition?

a. True

b. False

Answer: a

5. What are the Principles of Data Ethics in AI in speech?

a) Technology and IA
b) dissemination of information and discrimination
c) Transparency, Equity and Confidentiality.

Answer: c

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Application of AI in Games and Puzzles

Introducing the 5 Big Ideas in Artificial Intelligence using Internet of Things in STEM education

28.09.2023 | ATERMON
PROJECT NUMBER: 2022-1-FR01-KA220-SCH-000085611

AI4STEM Educational Framework Topic: Application of AI in Games and Puzzles

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Summary

This module is crafted to provide learners with a comprehensive introduction to the multifaceted world of AI in the context of games and puzzles. As we navigate through the course, learners will be exposed to the diverse ways AI is integrated and utilized in games and puzzles. We will embark on a journey to understand the core aspects of AI, including perception, representation and reasoning, learning, natural interaction, and societal impact. By examining real-world examples and case studies, we will delve into the intricacies of AI's applications in games. We'll dissect popular games and puzzles that leverage AI, understanding how they are designed and the AI mechanisms that underpin their functionality. Furthermore, we will broach the challenges AI faces within this sphere, such as creating believable AI characters, ensuring fair gameplay, and maintaining player engagement. Ethical considerations will also be a focal point of our discussions, including issues around data privacy, AI bias, and the implications of increasingly realistic AI entities in games. By the end of this module, learners will not only have a robust understanding of the different applications of AI in games and puzzles but will also be able to critically analyse and discuss the associated challenges and ethical considerations. They will be equipped with the knowledge and skills to appreciate the complex dynamics between AI, games, and society.

The learning outcomes involve:

- Grasping and articulating the pivotal concepts and terminology related to AI in games and puzzles. This involves understanding the specific language and principles used in this dynamic field, enabling a comprehensive discussion and analysis of AI's role in game development.
- Recognizing the multifaceted applications of AI in games and puzzles and offering a nuanced evaluation of the advantages and limitations inherent to each approach. Learners will be able to identify the various AI techniques used, ranging from pathfinding to procedural generation, and critically discuss their potential impacts.
- Dissecting the challenges intertwined with the development and deployment of AI in games and puzzles. Learners will gain the ability to critically analyse complex issues such as AI bias, data privacy, and the ethical implications of AI's growing presence in our leisure activities.
- Harnessing the insights derived from case studies and successful instances to identify and propose innovative opportunities for the integration of AI in games and puzzles. Learners will develop the ability to extrapolate from existing AI implementations and creatively apply these learnings to new contexts and possibilities.
- Predicting future trends in AI's role in games and puzzles, considering advances in technology and shifts in societal attitudes. This will allow learners to stay ahead of the curve in the rapidly evolving intersection of AI and gaming.
- Formulating a well-grounded perspective on the societal impact of AI in games and puzzles, accounting for its influence on aspects like player behaviour, game design, and broader cultural implications. Learners will be encouraged to form informed viewpoints on how AI can shape our society and cultural norms, fostering a more thoughtful and responsible approach to game and puzzle design and consumption.

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Chapter 1: Introduction

Welcome to the Module "Application of AI in Games and Puzzles". This module is meticulously crafted to immerse learners into the intriguing world of AI within the realm of games and puzzles. Our journey will commence with an overview of the course content, beginning with a comprehensive introduction to the field followed by an in-depth exploration of the Five Big Ideas integral to AI. Each of these ideas will be carefully unpacked to provide a solid understanding of their relevance and application. As we progress, we will delve into practical examples, highlighting how AI shapes the landscape of games and puzzles through fascinating case studies and inspiring success stories. These real-world examples will illuminate the tangible impact of AI. The module concludes by addressing the ethical implications of AI in games and puzzles. As we navigate this rapidly evolving field, it's crucial to consider the ethical boundaries and responsibilities that accompany the use of AI. We will engage in thoughtful discussions around these considerations, fostering a responsible approach to AI applications in gaming.

Chapter 2: Glossary – Key notions and concepts

Game Agent: A type of program or algorithm specifically engineered to engage with a game environment and execute decisions based on the established game rules and objectives.

Computer Vision: A branch of artificial intelligence that employs machine learning algorithms to scrutinize images and videos to identify objects and discerning patterns.

Natural Language Processing (NLP) in Games Using AI: A technique that empowers game agents to comprehend and interpret spoken or written language.

Algorithmic Bias: A situation that arises when the decision-making process of an AI is swayed by biases present in the data from which it has learned.

Supervised Learning in Games Using AI: A method that involves training a game agent using labelled data, wherein each input is associated with a known correct output.

Unsupervised Learning in Games Using AI: A learning method that involves training a game agent on unlabelled data, where the correct output is not predetermined.

Reinforcement Learning in Games Using AI: A form of learning where game agents evolve from experience by receiving rewards or punishments for their actions.

NPC (Non-Player Character): These are the characters in a game that are not controlled by a human player. The AI determines their behaviour, which can range from simple to complex depending on the game.

Pathfinding: An essential AI concept in games, pathfinding algorithms help NPCs navigate the game environment efficiently, often used in strategy and role-playing games to find the shortest or most efficient path between two points.

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Chapter 3: The big Idea of Perception in AI and Games

Perception in AI, much like human perception, involves processing input from various sources to build an understanding of the surrounding environment. In games and puzzles, this could mean interpreting data from a virtual world, such as the locations of other characters, the layout of the terrain, or the state of various game variables. For instance, in a first-person shooter game, an AI character might use perception to understand the locations of cover, the positions of enemies, and the best trajectory for a shot. Similarly, in a puzzle game, AI might perceive the state of the game board to make optimal moves.

Perception plays a vital role in Game AI. Without perception, game AI would be unable to react to changes in the game environment or player actions. This would lead to static and predictable AI behaviour, which could reduce the challenge and immersion of the game. By perceiving the game world, AI can respond in a way that is more dynamic and engaging. For example, an AI enemy that perceives the player's actions can change its strategy in response, providing a more challenging and unpredictable opponent. Furthermore, perception allows for more complex game mechanics, such as stealth or deception, where the player must manipulate the AI's perception to succeed.

3.1: Examples of Perception in Game AI

The application of perception in Game AI has made significant strides over the years. This subchapter will discuss some prominent examples of how perception has been applied in games to enhance the gaming experience.

Pokémon Go: Pokémon Go is a popular mobile game that uses AR technology to merge the virtual world of Pokémon with the real world. The game uses the camera on the player's smartphone to perceive the real world and then overlays virtual Pokémon onto the camera feed. The game's AI uses this perception of the real world to decide where to place Pokémon. For instance, it uses GPS data to determine the player's location and places water-type Pokémon near bodies of water. This use of AI perception enhances the gaming experience by making the virtual Pokémon feel like part of the real world.

Fortnite: Fortnite is a battle royale game where players fight against each other in an ever-shrinking play area until only one player or team is left standing. The game's AI uses perception to control NPCs and to adjust the game's difficulty. The AI perceives the game environment and the actions of players to control the NPCs. For example, it uses perception to navigate the game world, locate players, and decide when to attack. The AI also uses perception to adjust the game's difficulty based on the perceived skill level of the players.

Forza Motorsport: Forza Motorsport is a racing game that features a system called Drivatar, which uses AI perception to create personalized AI opponents. The Drivatar system perceives the player's driving style, including their speed, handling, and aggression, and uses this information to create AI opponents that drive similarly. This use of AI perception creates a more personalized and challenging gaming experience. Players are essentially racing against AI versions of themselves, which can adapt and improve as the player does.

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Chapter 4: The big Idea of Representation & Reasoning in AI and Games

Representation in the context of Game AI refers to how the AI perceives and models the game world. It involves the data structures and models used by the AI to understand the game's state, which can include the positions of characters, items, or obstacles, and the status or health of the player character. Reasoning, on the other hand, is the process by which the AI makes decisions based on the game's state. It involves the AI using its understanding of the game world to determine the best course of action at any given time.

The representation and reasoning capabilities of a Game AI have a direct impact on the player's gaming experience. A well-designed representation allows the AI to understand the game world, while effective reasoning allows it to respond intelligently to the player's actions. In strategy games, for instance, the AI might represent the game world as a graph, with nodes representing territories and edges representing connections between them. The AI can reason on this representation to plan its moves, deciding where to deploy troops and where to attack. In role-playing games, the AI might represent characters' skills, health, and equipment. It can reason on this representation to decide how characters should behave in combat, what actions they should take, and how they should interact with the player.

4.1 Examples of Representation & Reasoning in Game AI

Several games have used innovative approaches to representation and reasoning.

Super Smash Bros. (SSB):

Engineers created an AI system called SmashBot for the game SSB, which can be chaotic with up to four players, multiple movements, and attacks occurring simultaneously. SmashBot is a rules-based system, employing if-then statements and a knowledge base that allows it to never be hit by a player, human or CPU. The system consists of four objectives: goals, strategies, tactics, and chains (combos) that enable SmashBot to play the game perfectly.

Chess

Chess, a perfect information game, was long considered too complex for AI to master. Chess engines like Stockfish use a combination of brute force calculation and alpha-beta pruning, which disregards negatively valued continuations before the system brute forces it.

Go

Google’s DeepMind project displayed its new machine learning system, AlphaZero, in 2017. AlphaZero was able to teach itself Go in a mere four hours. It was pitted against Stockfish in a 100-match series, soundly defeating the latter with twenty-eight wins, seventy-two draws, and no losses.

Chapter 5: The big Idea of Learning in AI and Games

At its core, learning in AI involves the transformation of data into actionable knowledge. AI systems use a variety of learning methods, including supervised learning, unsupervised learning, and reinforcement

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learning, to process data and learn from it. In supervised learning, the AI is trained on a dataset that includes both the inputs and the desired outputs. The goal is to learn a function that maps inputs to outputs, which can then be used to make predictions on new data. In unsupervised learning, the AI is given a dataset without any labels or categories. The goal is to identify patterns or structures in the data, such as clusters of similar data points. In reinforcement learning, the AI learns by interacting with its environment. It takes actions, receives feedback in the form of rewards or penalties, and uses this feedback to improve its future actions. This type of learning is particularly relevant to AI in gaming, as games often provide a clear feedback mechanism in the form of points, wins, or losses.

Learning plays a crucial role in Game AI. It allows AI systems to adapt to the strategies of human players, learn from their mistakes, and continually improve their performance. This can make games more challenging and engaging for human players, as the AI can provide a level of competition that scales with the player's skill level. Furthermore, the learning capabilities of AI can be used to test and improve game designs. By playing against a learning AI, game developers can identify imbalances or exploits in their games and address them before the game is released.

5.1 Examples of Learning in Game AI

There are numerous examples of learning in game AI:

AlphaGo

Developed by Google's DeepMind, AlphaGo is a computer program that plays the board game Go. It used machine learning and tree search techniques, along with extensive training from both human and computer play, to defeat the world champion Go player, Lee Sedol, in a five-game match in 2016.

OpenAI Five

OpenAI Five is a team of five neural networks which were trained to play Dota 2, a popular multiplayer online battle arena video game. The neural networks were trained using a variant of Proximal Policy Optimization and played the equivalent of 180 years of games against themselves every day.

DeepMind's StarCraft II AI

DeepMind, in collaboration with Blizzard Entertainment, developed an AI for the real-time strategy game StarCraft II. The AI used a combination of supervised imitation learning and reinforcement learning to train, and it is capable of playing the full game at a competitive level.

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Chapter 6: The big Idea of Natural Interaction in AI and Games

Natural interaction in gaming can be understood as the use of AI to enable game characters and environments to respond to a player's actions in a way that feels intuitive and lifelike. This could involve characters reacting realistically to events in the game, or game mechanics that change and adapt based on player behaviour. It is about creating a gaming experience that is not merely controlled by pre-defined rules, but one that dynamically responds to the player's actions and choices.

Natural interaction plays a key role in making games more immersive and engaging. By using AI to create more lifelike and adaptable game characters and environments, players can become more invested in the game, as their actions have a more noticeable and realistic impact on the game world. It also allows for more varied and unique gameplay experiences, as the game can adapt to different play styles and strategies. In games like "The Last of Us Part II", AI has been used to give NPCs more realistic reactions and behaviours, contributing to a more immersive gaming experience.

6.1 Examples of Natural Interaction in Game AI

In "Alien: Isolation", the alien AI is a prime example of natural interaction. The game's AI system is designed to learn from the player's actions and then adapt its behaviour accordingly. This creates an utterly unique experience for each player, as the alien becomes more unpredictable with every playthrough. The game's developers created two AI systems for the alien: one "director" AI that always knows the player's location and guides the alien in a general way, and another AI that controls the alien's moment-to-moment actions based on its immediate surroundings and what it's learned about the player's tactics. This use of AI to create dynamic, responsive gameplay is a key example of natural interaction.

In "The Last of Us Part II", AI is used to create lifelike behaviours in NPCs. These behaviours contribute to a more immersive gaming experience, with NPCs responding realistically to events in the game and exhibiting complex behaviours. For instance, the AI might direct an NPC to take cover during a firefight, search for the player if they've gone missing, or react believably to the player's actions. These complex behaviours, driven by AI, create a more engaging and realistic gaming experience.

In both games, the use of AI for natural interaction has significantly enhanced the gaming experience, creating more dynamic, unpredictable, and immersive gameplay. The AI does not just follow a set of pre-defined rules, but instead learns and adapts to create a unique experience for each player. AI for natural interaction is not just about creating lifelike behaviour in game characters, but also about adapting game mechanics and content based on player actions. This can result in a more personalized gaming experience, where the game world feels responsive and adaptable.

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Chapter 7: The big Idea of Societal Impact in AI and Games

The societal impact of AI in gaming can be understood from various perspectives. :

Economic Impact: AI has transformed the gaming industry into a multi-billion-dollar sector, promoting job creation and economic growth. Moreover, AI-powered games offer potential for new business models, including in-game purchases, advertisements, and subscription services.

Social Impact: AI in gaming can shape social norms and behaviours. Online multiplayer games, powered by AI, facilitate social interaction and community building across geographical boundaries. However, they can also contribute to issues such as addiction and cyberbullying.

Educational Impact: AI-driven educational games have the potential to revolutionize learning, making it more interactive, personalized, and engaging. Such games can foster problem-solving and critical-thinking skills.

Cultural Impact: Games, especially those with AI-powered storytelling and world-building, can influence cultural perspectives, promote diversity, and drive the discourse on various societal themes.

The societal impact plays a critical role in shaping the development and implementation of AI in gaming. Designing AI systems with consideration for societal impact can ensure that these systems are used responsibly and ethically. It can encourage the creation of games and puzzles that positively influence society, whether through promoting inclusive narratives, fostering educational outcomes, or encouraging healthy gaming behaviours. Furthermore, acknowledging societal impact can guide policymaking and regulation in the gaming industry.

7.1 Examples of Societal Impact in Game AI

Economic Growth

The development of the game "The Witcher 3: Wild Hunt", which utilized AI for in-game character development and procedural content generation, contributed significantly to the Polish economy.

Social Connections

Games like "Among Us", which employs AI for matchmaking, have fostered global communities and social connections during the COVID-19 pandemic.

Education

Minecraft's "Education Edition", which uses AI to create interactive learning experiences, has been used in classrooms worldwide to teach subjects ranging from history to computer science.

Cultural Change

The game "Life is Strange", with its AI-driven narrative, has sparked conversations around mental health and bullying, influencing cultural attitudes towards these topics.

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Chapter 8: Case Studies & Success Stories

Case Study 1: The Sims

The Sims franchise, specifically The Sims 4, has utilized AI extensively to improve gameplay and create a more immersive experience for players. The AI in The Sims is uniquely designed to replicate real-world behaviour and decision-making, allowing for the creation of a virtual world that feels real and complex. In Sims 4, the developers have built a more powerful character creator, and have improved the routing system, allowing Sims to navigate more naturally. The AI uses a system of commodities and utility curves to dictate a Sim's actions, which are randomized to avoid predictability. The AI in the Sims 4 also features an "autonomy hierarchy", allowing for more efficient decision-making and multitasking. Despite these advancements, the developers have had to balance making the AI too efficient, as this could result in the game playing itself. The AI in the Sims franchise models not just the efficiency of human life, but also its faults, resulting in a more authentic gaming experience.

Case Study 2: Space Engineers and Robotic Legs

The "Robotic Legs" project introduces AI features into video games, specifically into "Space Engineers", a sandbox game bound by real-world physics. In the context of Space Engineers, the construction of a multi-legged robot is achievable by seasoned players, but making it walk and navigate terrain with obstacles is a more complex task. The mechanics involved in this process include leg movement synchronization, the planning of leg trajectories for distinct types and speeds of gait, and in more advanced scenarios, adaptation to the terrain or reacting in real time to external control. To enhance this process, Robotic Legs employs a quality diversity algorithm (QD) derived from evolutionary computation. This algorithm optimizes inverse kinematics (IK), a mathematical process necessary for animating articulated subjects. With QD optimization, the calculation is automated, generating an array of high-performing solutions in a single run.

Case Study 3: Commit Assistant

Ubisoft, a renowned video game company, took a significant leap forward in the game development process by introducing Commit Assistant, an innovative AI tool. Leveraging the power of machine learning, Commit Assistant analyses vast amounts of historical data, including past coding errors and their subsequent fixes. This innovative technology enables Ubisoft to predict potential coding errors before they occur, thus streamlining the development process and increasing overall efficiency. By harnessing the capabilities of AI, Ubisoft not only enhances productivity but also significantly reduces costs associated with identifying and rectifying coding errors. The success of Commit Assistant serves as a testament to the transformative potential of AI in the gaming industry. Through Commit Assistant, Ubisoft demonstrates that AI has become an invaluable ally in revolutionizing game development, leading the way for future advancements in the field.

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Success Story 1: Sea Hero Quest and Dementia Research

The success of Sea Hero Quest in aiding dementia research can be attributed to its innovative approach and widespread popularity. By merging entertainment and scientific data collection, the game has engaged millions of players globally, fostering a vast database for analysis. Through tracking players' spatial navigation abilities, Sea Hero Quest offers valuable insights into the progression and patterns of cognitive decline associated with dementia. This collaboration between Deutsche Telekom and European universities exemplifies the power of partnerships in tackling complex societal challenges. The immense scale of player participation has enabled researchers to uncover the latest trends, refine diagnostic techniques, and potentially develop early intervention strategies. Sea Hero Quest stands as a testament to the potential of technology and gaming in revolutionizing healthcare and making meaningful contributions to scientific advancements. With its profound impact on dementia research, this mobile game has successfully merged fun and purpose, transforming it into a game-changer for understanding and addressing this debilitating condition.

Success Story 2: Personalized Experiences in Fortnite

Another remarkable success story in the realm of personalized experiences can be witnessed in the immensely popular game Fortnite. Epic Games, the mastermind behind Fortnite, has revolutionized the gaming industry by introducing a myriad of customizable features. Players can personalize their avatars, acquire unique skins, and even design their in-game environments. This level of personalization has fostered an immersive and engaging experience, capturing the hearts of millions of players worldwide. Moreover, Fortnite has transcended mere entertainment by serving as a platform for meaningful collaborations. The game has hosted virtual concerts featuring renowned artists, offering players an unforgettable and personalized live music experience within the game's virtual world. These groundbreaking collaborations have pushed the boundaries of interactive entertainment, blurring the lines between reality and the digital realm.

Success Story 3: AI in Puzzling Solving

AI has made significant strides in the realm of problem-solving, revolutionizing the way we approach complex problems and challenges. One remarkable success story in this field is the achievement of DeepMind's AlphaGo, an AI system designed to master the ancient board game of Go. In 2016, AlphaGo shocked the world by defeating the world champion Go player, Lee Sedol, in a five-game match. The success of AlphaGo was attributed to its ability to analyse and evaluate countless potential moves using advanced neural networks and deep reinforcement learning techniques. By training on a vast dataset of expert Go games, AlphaGo acquired an unparalleled understanding of the game, enabling it to make strategic decisions that surpassed human intuition. Beyond Go, AI has also excelled in other puzzling domains, such as puzzle-solving competitions. In 2019, an AI developed by the University of California, Berkeley, named Dr Fill, emerged victorious in the American Crossword Puzzle Tournament's computer-solving division. Dr Fill demonstrated its ability to tackle complex crossword puzzles by leveraging natural language processing and machine learning algorithms, swiftly filling in missing letters and completing the puzzles with remarkable accuracy.

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Chapter 9: Ethics in AI Games & Puzzles and IoT in Education

When examining ethics regarding AI in games and puzzles, several key topics come to the forefront. While the significance of each topic may vary depending on the specific context and perspective, the following seven areas represent important considerations in the ethical use of AI in gaming and puzzling:

Fairness and Bias: Ensuring fairness in AI algorithms is crucial to avoid perpetuating biases or discriminatory practices. Developers must be vigilant in preventing AI systems from favouring certain players or perpetuating stereotypes. Careful design, testing, and ongoing evaluation are essential to mitigate bias and promote equal opportunities for all players.

Informed Consent and Privacy: AI in games and puzzles often relies on the collection and analysis of player data. Respecting player privacy rights and obtaining informed consent for data usage are vital ethical considerations. Developers must be transparent about the data collected, and how it is used, and provide clear options for players to control their data and opt out if desired.

Player Well-being and Addiction: Game AI can create immersive and addictive experiences, raising concerns about player well-being. Ethical considerations involve implementing mechanisms to promote healthy gameplay habits, providing access to tools that manage playtime, and avoiding exploitative practices that encourage excessive engagement or addiction.

Inclusivity: Games and puzzles should strive for inclusive and diverse representations that reflect the realities of the player base. Ethical considerations involve avoiding stereotypes, and discriminatory content, and providing opportunities for players from different backgrounds to see themselves represented positively in the game world.

Transparency and Explainability: Players should have a clear understanding of how AI systems impact their gaming experiences. Developers should strive to make AI algorithms transparent and explainable, providing insights into decision-making processes. Transparent AI fosters player trust and empowers them to make informed choices.

Human-AI Collaboration: The integration of AI in games and puzzles should prioritize collaboration between AI and human players. Ethical considerations involve finding the right balance between AI assistance and human agency, allowing players to make meaningful decisions and ensuring AI systems enhance gameplay rather than replacing human creativity and problem-solving abilities.

Ethical Advertising and Monetization: AI can be utilized in targeted advertising and monetization strategies in games and puzzles. Ethical considerations include ensuring that AI-driven advertising practices are transparent, respectful of player privacy, and avoiding manipulative techniques that exploit vulnerabilities or engage in predatory practices.

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Chapter 10: Additional Materials & Resources

[Article] Fraud Detection in Pokémon Go

https://www.schneier.com/blog/archives/2017/11/fraud_detection.html/

[Article] 40 Years on, PAC-MAN Recreated with AI by NVIDIA Researcher

https://blogs.nvidia.com/blog/2020/05/22/gamegan-research-pacman-anniversary/

[Video] How AI Will Completely Change Video Games

https://www.youtube.com/watch?v=NPuYtHZud0o/

[Article] OpenAI Five Defeats Dota 2 World Champions

https://openai.com/research/openai-five-defeats-dota-2-world-champions/

[Video] MarI/O - Machine Learning for Video Games

https://www.youtube.com/watch?v=qv6UVOQ0F44/

[Article] How AI Can Empower The Future Of The Gaming Industry

https://www.forbes.com/sites/forbestechcouncil/2022/07/13/how-artificial-intelligence-can-empower-the-future-of-the-gaming-industry/

[Article] DeepMind's AI Can Defeat Human Players in Quake III Arena's Capture the Flag Mode

https://venturebeat.com/ai/deepminds-ai-can-defeat-human-players-in-quake-iii-arenas-capture-the-flag-mode/

[Video] AlphaGo - The Movie | Full Award-Winning Documentary

https://www.youtube.com/watch?v=WXuK6gekU1Y/

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Chapter 11: Tasks, Scenarios & Quiz

11.1 Tasks

Task 1: Identify AI Elements in Video Games

Description: In this task, students will either play a simple video game like "Pac-Man" or "Angry Birds," or watch a gameplay video of it. While engaged with the game, they are to look for instances where AI is at work. Examples may include enemy behaviour, automatic game adjustments, or even NPC (Non-Player Character) dialogues. After the game session, they will jot down their observations in a notebook or a digital document.

Procedure:

1. Watch or play a selected video game for 15-20 minutes.
2. Take notes on aspects where AI might be involved (e.g., enemy movements, level difficulties).
3. Discuss findings in class or small groups.

Learning Outcomes:

- Understand the basic idea of what Artificial Intelligence (AI) is.
- Recognize AI elements in everyday applications like video games.

Task 2: Flowchart of AI Behaviour

Description: In this activity, students will draw a flowchart to describe the decision-making process of a computer opponent in a game like Tic-Tac-Toe. They will identify conditions and decisions that the AI makes at each step.

Procedure:

1. Understand the rules of Tic-Tac-Toe.
2. Identify key decision points for a computer opponent (e.g., where to place its marker).
3. Draw a flowchart using paper and markers or a digital drawing tool.

Learning Outcomes:

- Learn the fundamentals of decision-making in AI.
- Develop basic flowcharting skills, relating actions to decision points.

Task 3: The Rules Behind Chatbots

Description: Students will interact with a simple chatbot like ELIZA or a customer service chatbot on a website. They will then analyse the chatbot's responses and try to understand how the chatbot decides what to say.

Procedure:

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1. Interact with a selected chatbot for about 10-15 minutes.
2. Take notes on the types of questions the chatbot can answer and how it responds.
3. Share observations with the class and try to deduce the underlying rules.

Learning Outcomes:

- Understand the basics of Natural Language Processing (NLP), a subfield of AI.
- Develop critical thinking skills by analysing the functions and limitations of a chatbot.

Task 4: Create Your AI-powered Puzzle

Description: Students will use a block-based programming tool like Scratch to create a simple puzzle game that incorporates at least one AI element. For instance, they could design a maze game where an AI opponent tries to catch the player.

Procedure:

1. Plan the puzzle game and decide where AI will be implemented.
2. Use Scratch or similar tools to code the game.
3. Test the game and adjust as needed.

Learning Outcomes:

- Learn basic coding and game design concepts.
- Understand how to implement a rudimentary AI element in a game environment.

Task 5: Debate on Ethical Implications

Description: In this task, students will engage in a debate about the ethical implications of using AI in games and puzzles. They will be divided into groups and each group will be assigned a topic to research and debate.

Procedure:

1. Divide the class into small groups and assign each a debate topic.
2. Allow time for research and preparation.
3. Conduct the debate, ensuring each group presents its points and counterarguments.
4. Summarize key points and ethical considerations at the end of the debate.

Learning Outcomes:

- Develop skills in critical thinking and debate.
- Understand the ethical considerations related to the use of AI in games and puzzles.

11.2 Scenarios

Scenario 1: AI Detective in a Whodunnit Game

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Description: In this scenario, students will play a simplified Whodunnit game (like Clue) where an AI serves as the detective. The AI will try to deduce who the culprit is, based on clues gathered during the game. Students will also have to make their deductions and compare their conclusions with the AI.

Procedure:

1. Students get introduced to the game's characters, locations, and potential "weapons."
2. The game unfolds with a mix of human and AI players. Clues are revealed one by one.
3. Students make their deductions in parallel with the AI.
4. At the end of the game, the AI's deductions and the students' deductions are compared.

Scenario 2: AI as a Music Composer in a Puzzle Game

Description: Students are introduced to a simple puzzle game where the background music changes according to the level of difficulty or the environment in the game. This music is generated by an AI in real time. Students are then asked to analyze how the AI might be making these musical choices.

Procedure:

1. Students play the puzzle game, or watch a demo, paying close attention to the changing background music.
2. They discuss in groups how they think the AI composer is making its choices.
3. Students share their theories with the class and try to produce a general understanding of how AI can be used creatively in games.

Scenario 3: AI-Driven Storyline in an Adventure Game

Description: In this advanced scenario, students will engage in a text-based adventure game where AI dynamically generates the storyline. Choices made by the players affect the outcome of the story, and the AI adjusts the plot accordingly. After playing, students will discuss how the AI could be programming these dynamic changes.

Procedure:

1. Students play a short session of a text-based adventure game where the AI generates the story.
2. Students jot down the choices they made during the game and how the storyline changed as a result.
3. Class discussion focuses on how AI can make storytelling dynamic and responsive to user choices.

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11.3 Assessment Quizzes

Question 1: True/False - In games, game agents must only represent the game environment but do not need to reason about possible actions and outcomes. [Correct Answer: False]

Question 2: True/False - Logical representation, semantic networks, and frame-based representation are types of representation used in artificial intelligence. [Correct Answer: True]

Question 3: True/False - Natural language processing is a technique used for game perception. [Correct Answer: True]

Question 4: True/False - Reinforcement learning is not a type of learning where game agents learn from experience by receiving rewards or punishments for different actions. [Correct Answer: False]

Question 5: True/False - Perception is interpreting sensory information to interact with the environment. [Correct Answer: True]

Question 6: Multiple Choice - What is the main difference between supervised and unsupervised learning?

a) Supervised learning involves labelled data, while unsupervised learning involves unlabelled data.

b) Supervised learning involves unsupervised data, while unsupervised learning involves labelled data.

c) Supervised learning involves reinforcement, while unsupervised learning does not.

d) There is no difference between supervised and unsupervised learning.

Question 7: Multiple Choice - Why is ethical consideration important in game development with AI?

a) To ensure that the game is harmful to the players and society as a whole.

b) To ensure that the game is addictive and promotes violence.

c) To ensure that the AI's decision-making process is biased.

d) To ensure that the game does not harm players or society and that it is transparent about the role of AI in the game.

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