TEACHING UNIT 1

Introduction to Artificial Intelligence

DEVELOPING AN ARTIFICIAL INTELLIGENCE CURRICULUM ADAPTED TO EUROPEAN HIGH SCHOOLS

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1. Introduction

This first teaching unit (TU) presents a general overview of the AI topics that will be covered in the curriculum. Students will receive an introduction to them, with the aim of providing a first view of all the themes involved in AI. Some of these topics are shared with other disciplines like robotics or programming, and students should be familiar with them, but others are new at this educational level because they require an important technological and mathematical background. This is why, in this curriculum, we have decided to introduce all the AI topics gradually, with more than one TU devoted to the same topic at different levels.

2. Context

In order for the student to adequately meet the learning objectives of this TU, he/she must have the following prior knowledge:

- Basic sensors in robotics.
- Basic knowledge about motors and movements in machines.

3. Learning objectives

Once students have finished this TU, they will have acquired the following knowledge:

SPECIFIC:

- Scope of perception and actuation in AI.
- Difference between perception and actuation in AI with respect to robotics.
- Understanding of the difference between perception and representation.
- Relevance of representation with respect to learning and reasoning.
- Why learning is the basic property of an intelligent system.
- What does learning mean in an artificial system and how it can be achieved.
- Understanding of the concept of reasoning, and differentiation with learning.
- Why motivation is the core element of the AI system that controls all the remaining processes.
- Importance of developing sustainable and ethical AI.
- Relevance of knowing and respecting the legal aspects of AI.

TRANSVERSAL:

- Summarize relevant information extracted from different sources on the internet.

4. Contents

Artificial Intelligence is a subject that has been taught in University degrees since more than 30 years, mainly in Computer Science. In the last 10 years, it has started to be included in other technical degrees, like physics or electronic engineering. But it has never been included in official pre-university studies because it requires a technical background that was not acquired in high school until now. But things are changing. On one hand, students

start learning programming in secondary schools right now. On the other, AI systems have improved remarkably in the last decade, so now students do not require to be technological experts in order to use them. As a consequence, AI teaching in pre-university education is feasible nowadays, but the specific topics that must be taught at this age, and to what extent, is an open issue that must be faced.

In this curriculum, keeping in mind the blocks displayed in the ***Fig. 2*** of the introductory TU, we propose the following 8 topics to be addressed:

1. Perception
2. Actuation
3. Representation
4. Learning
5. Reasoning
6. Collective Intelligence
7. Motivation
8. Sustainability, ethics and legal aspects of AI

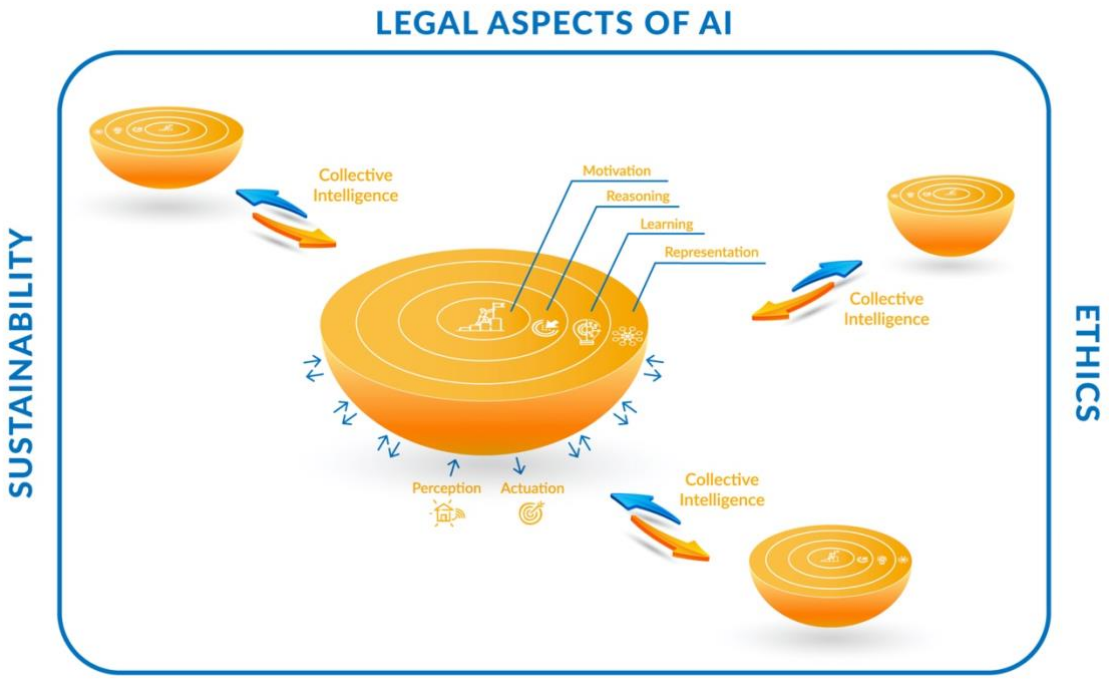


Fig. 1. Topics included in the curriculum over the AI ecosystem

The diagram shown in ***Fig. 1***, displays a representation of the approach followed in this curriculum to an AI ecosystem, based on the 8 topics established above. *Legal aspects, ethics and sustainability* surround the ecosystem, because they are relevant in many different aspects of AI. Inside the square, our ecosystem has been represented as a sort of cellular system, with individual cells representing AI systems that can communicate between them in a sort of fluid. The idea is that, in the near future, many AI systems will "co-exist" in the same environment, in this case, the internet virtual environment, and they will communicate between them to coordinate their operation. Regarding to this coordination, we will study the *collective intelligence* topics in this curriculum.

Each "cell" in the diagram takes information from the environment (*perception*), and performs actions on it (*actuation*). Inside it, we have created a sort of layered structure, being the most external one the *representation* layer, then the *learning* one, then *reasoning*, and in the core of our AI system, we have the *motivation* that controls the overall operation.

5. Temporary organization

This unit is designed to be studied in a session of 2 hours. The first hour is devoted to the topics presentation by the teacher, and the other hour for students to watch the video and solve the challenge.

6. Necessary resources

The only resource that is required in this TU is a laptop or computer with internet connection and one text editor software installed to carry out the report involved in the challenge.

7. Bibliography

https://mitpress.mit.edu/books/how-smart-machines-think

https://www.capstonepub.com/library/products/world-of-artificial-intelligence-4d/

https://artint.info/2e/html/ArtInt2e.html

8. Group organization

In this TU, students will be organized in groups of 2, which will have the same role.

9. Challenge / Project

FINAL OBJECTIVE: Each group will be assigned with a real AI system. They have to read the information regarding the system on the internet, and **develop a brief report explaining how this system implements the 8 topics** that will be covered in the curriculum. Both students will contribute to the report writing and to the information search.

To achieve this objective, the TU has been organized in **2 activities**:

Activity 1

The first activity of this TU implies attending to the teacher's explanation about the 8 topics that make up this curriculum, which includes watching some videos and reading some pages. To start, students should watch the following video, that contains an introduction to AI (we recommend to activate English subtitles): What Is Artificial Intelligence? Crash Course AI #1

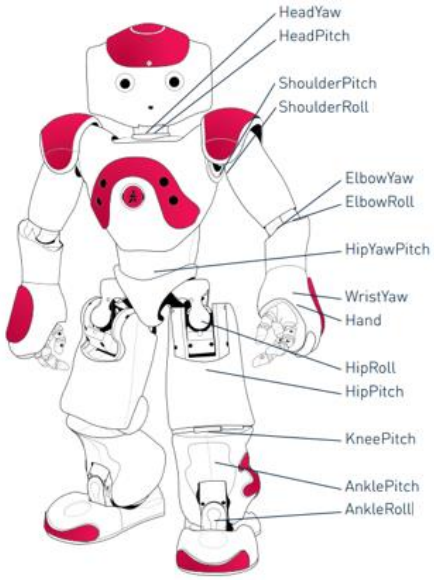
In what follows, we provide a brief explanation of the concepts teachers should transmit to students. It must be highlighted that this TU is just and introduction, so the main objective is to extract an overall idea of the differences between topics.

9.1 Perception

Perception and sensing are synonyms in this scope, and they refer to the information the AI system can obtain from its sensors. This is a very general topic that has been studied in many different fields, all those that use some type of electronic system equipped with sensors. In this curriculum, we will focus on those sensors that are currently more widely used in AI, which provide high level information, leaving most classical types for other subjects like robotics. For instance, students will learn, in future teaching units, how **cameras**, **microphones** or **tactile screens** work in detail. With them, tasks such as face recognition, object detection, speech recognition or tactile interaction can be achieved. Moreover, perception must be generalized in this scope to other remote sensors that can be accessed through the network, like IoT sensors or simply the information that can be obtained from a web server. To better understand the basics of sensors in the scope of AI, students should read the following page focused on computer vision and speech recognition: Areas of AI. Watching the following video regarding autonomous driving and sensors would be highly recommendable too: Autonomous car.

9.2 Actuation

An actuator is a component of a machine that is responsible for moving and controlling a mechanism or system, like a motor. In simple terms, it is a "mover". Actuators are very common in electro-mechanical systems, as it can be seen here. For instance, the NAO robot has the following 8 motors:



In the scope of our curriculum, we will consider a more general concept of actuator. It is every component of the AI system capable of performing an action in the environment. Most of the typical actuators will also be used here, like **motors**, but others will be introduced to students, like **speakers**, **LCD screens** or others that could be accessed remotely. With them, students will be able to make AI systems talk to humans, show them information or act over a motor that is placed in a different room.

9.3 Representation

The information that is internally used by the computational system that supports AI can be stored in different ways. This representation is very important in order to simplify the remaining processes that are carried out, like learning and reasoning. Students will learn the basics of representation, and how the raw sensorial information must be processed in order to be properly managed by the computational system. This includes the simplest approaches of representation in AI like trees, two dimensional grids or topological maps. As this topic is clearly new for pre-university education, we just recommend to teach students about simple representations in computers, for instance, those used in google maps:

How Does Google Maps Work?

If teachers are interested in more information about representation, we recommend the following free references, apart from the books provided in the references section:

What is knowledge representation?

Google Maps–it's just one big graph

Knowledge Representation

9.4 Reasoning

The process of selecting the action that must be applied to fulfill the system goals can be simple, a reaction or rule that selects the action from the perception, or it can be more complex, implying a search process over models and representations. This topic is very important in classical AI, and students will learn the basics of deliberative, reactive and hybrid approaches, using techniques from **planning**, **optimization**, and **search**. Again, this is a completely new topic for students and teachers in pre-university education, so we only recommend to provide students with basic concepts, for instance, how a route is calculated from a map:

How Google Maps Calculates The Shortest Route

If teachers are interested in knowing how the Dijkstra's algorithms work, although it is not necessary for students, we recommend the following references:

Dijkstra's algorithm in 3 minutes

The Simple, Elegant Algorithm That Makes Google Maps Possible

9.5 Learning

Learning is a key property of an AI system, which must be able to learn from its experience, generalizing the information it perceives. This way, situations that were not experienced previously can be addressed, and even anticipated. In this topic, students will learn the main approaches and methods of machine learning: **supervised**, **unsupervised** and **reinforcement learning**. With them, models will be created to perform classification, regression and clustering over data collected by the system. Moreover, students will learn how to use Deep Learning libraries that were previously learned, and which perform high level processing like face detection, speech recognition, object recognition, and others.

Finally, students will receive basic formation about big data, that is, models that are learnt from large amounts of data, and that imply a specific treatment to be manageable. This is a topic with many references and videos that could be used to introduce it to students. We recommend to show students the following page during the class, including the videos contained in it:

AI techniques

For teachers who want to obtain a more detailed background about learning, we recommend watching:

Supervised Learning: Crash Course

Unsupervised Learning: Crash Course

Reinforcement Learning: Crash Course

9.6 Collective Intelligence

Future AI systems will be interconnected creating a collective intelligence network. The field of Internet of Things (IoT) summarizes this concept, with many electronic devices sharing information and reacting in a coordinated fashion to it. In fact, in the coming years, IoT will be removed by AIoT, that is, Artificial Intelligence of Things. In this topic, students will learn how to communicate information between AI systems so they improve their response, and how to coordinate their actions to operate in a more reliable way. We recommend to watch the following video at class, to better understand the concept of AI ecosystem we will manage in this curriculum:

How will Artificial Intelligence and Internet of Things change the world?

Moreover, teachers can show students specific solutions in this field, like those displayed in these videos to better understand what an AIoT looks like in technical aspects:

What is the future of IoT?

Introducing Amazon Go

9.7 Motivation

Typically, in AI systems, the goal or objective to be reached has been imposed by the human designer. But to obtain systems with a higher degree of autonomy, they must be capable of discovering their goals, and in the case of having more than one, choosing the best one in a given instant of time. Although *motivation* is a new topic in AI, still under development, students should understand how a motivated AI system will work, and how it can be controlled by the human. As a consequence, in this topic, we will address aspects like **learning by demonstration**, **intrinsic motivation** and **human-machine interaction**. This last sub-topic is very important in AI, so we will pay attention to it in terms of perception, actuation and motivation, so students can learn how a human-machine interaction system operates, and what is behind it. The following videos should be watched by students in order

to have an overall idea of how to introduce a new objective in the robot just by replying the owner's actions:

Learning by demonstration

PAL Robotics – learning for demonstration

To deepen in this topics, we recommend teachers the following references:

Human-computer interaction

Intrinsically motivated machines

9.8 Sustainability, ethics and legal aspects of AI

The impact of introducing AI in different aspects of future societies will bring up new problems that must be faced, some of them of high relevance, and students must be aware of them. The legal aspects of AI must be presented and discussed in classes, together with the ethics behind the intelligent systems that will be introduced in many fields. Moreover, the high computational demand of AI systems imply that their sustainability must be analyzed in detail, because the consequences could be important. Students should check during the class, the main information provided in this page:

Benefits, Risks and Ethical Considerations

Activity 2

After attending to the teachers' explanation of the previous topics, students will be assigned by the teacher with a real AI system. They have to search for information about it on the internet, summarize it, and **develop a brief report explaining how this system implements the 8 topics** that will be covered in the curriculum. For instance, students could fill the following table:

TOPIC	IMPLEMENTATION
Perception	
Actuation	
Representation	
Reasoning	
Collective intelligence	
Motivation	
SEL (Sustainability, Ethics and Legal aspects)	

Here we propose a possible list of real AI systems to be provided to the groups, although many others could be included:

1. **Tesla Autopilot:** https://www.tesla.com/autopilot
2. **Amazon GO:** https://towardsdatascience.com/how-the-amazon-go-store-works-a-deep-dive-3fde9d9939e9
3. **AMP robotics for recycling:** https://www.greenbiz.com/article/how-artificial-intelligence-helps-recycling-become-more-circular
4. **Computer game:** https://aiandgames.com/facing-your-fear/
5. **Conversational AI:** https://georgianpartners.com/investment-thesis-areas/overview-conversational-ai/
6. **Agricultural robotics:** https://harvestcroo.com
7. https://www.leewayhertz.com/ai-applications-across-major-industries/
8. https://barnraisersllc.com/2019/05/19/artificial-intelligence-success-stories-brands/

Appendix 1 contains the solution of 3 real cases to serve as a guide, although the important aspect here is that teachers are capable of evaluating the student's solutions by themselves.

It is recommended that students fill all the cells in the previous table, even in case they do not find specific information about all the topics. In such case, with their knowledge about the system, they should be able to suppose the correct answer. Remember that the main objective of this TU is that students can distinguish between the different topics, and think about those that are newer to them.

10. Evaluation

The specific rubrics we propose to evaluate students' progress in this TU are specific to it, being the following:

LEVEL (score) / ASPECTS TO BE EVALUATED	EXPERT (4)	COMPETENT (3)	PARTIALLY COMPETENT (2)	NOT YET COMPETENT (1)
Adequate selection of information: appropriate sources and capacity for synthesis				
Time management				
Design and construction of the solution: ability to understand the objective				
Creativity				
Attitude: active participation				
Clarity of report writing				

11. Complementary activities

As complementary activities for interested students or for those that finish the activity quickly, we recommend to watch the following documentaries about AI:

The Rise of AI

The age of AI

12. Annex 1. Solutions to activity 2

The following cases are possible solutions to activity 2 for different real cases. Students could propose other options, that could be valid too. Students should provide the main references (web pages, videos, etc) they have used to extract information, because their capability to select the relevant information is very important.

Tesla Autopilot:

https://www.tesla.com/autopilot

TOPIC	IMPLEMENTATION

Perception	• 8 Cameras, 1 radar, ultrasonic sensors (provide 360 degrees of visibility around the car at up to 250 meters of range) for safe driving.
	• GPS for navigation.
	• Internet connection (4G) for maps and music.
	• Modern cars are equipped with many sensors that students can find in this model too, like:
	  • Wheel tick sensors.
	  • Wheel pitch sensor.
	  • Microphone.
	  • Accelerometer.
	  • Ambient lighting sensor (may be part of the 9th camera) for Model 3.
	  • Torque and position sensor on the steering wheel.
	  • Seat occupancy sensors (5). Passenger weight is used in controlling deployment of the air bag.
	  • Seat position sensor (position is saved in driver profile). Seat position is used in adjusting deployment of the air bag.
	  • Seat belt latch sensors.

TOPIC	IMPLEMENTATION
	• Door open sensor s (4). • Trunk open sensors (2). • Charge port open sensor. • External temperature sensor. • Cabin temperature sensor. • Battery temperature sensors (multiple). • Battery voltage sensors. • Accelerator pedal position sensors (2). • Brake pedal position sensor. • Tire pressure sensors - TPMS (4). • Glare sensor for automatic mirror dimming. • Key card sensor/reader. • Charging handle button press sensor. • Windshield washer fluid fill level sensor.

Actuation	• Electric motor to move the wheels: it is the main actuator of a car.
	• Others actuators are included in this car to allow for the actuation of different elements required for autonomous driving:
	  • Steering wheel.
	  • Brakes.
	  • Lights.
	  • Mirrors.
	  • Car seats.
	  • Doors.

Representation	• The maps required for navigation are stored in a computer, and the system uses Google maps to update de information, so the representation is the one used in this application. • The internal state of the car provided by all the sensors is stored too in order to maintain a proper functioning, but how it is represented internally is not provided by Tesla.
Reasoning	• The navigation system calculates the optimal route, navigate urban streets (even

TOPIC	IMPLEMENTATION
	without lane markings), manage complex intersections with traffic lights, stop signs and roundabouts, and handle densely packed freeways with cars moving at high speed. • All you will need to do is get in and tell your car where to go. If you don't say anything, the car will look at your calendar and take you there as the assumed destination or just home if nothing is on the calendar. • When you arrive at your destination, simply step out at the entrance and your car will enter park seek mode, automatically search for a spot and park itself. A tap on your phone summons it back to you.
Collective intelligence	• Traffic information: Tesla measures the road segment data of other Tesla vehicles to know the traffic density in real time, so they can update the optimal routes.
Motivation	• The objective of the autopilot is to drive the car towards the specified destination following the shortest path, while maintaining all the safety regulations.
SEL	• Sustainability: the company aims to accelerate the world's transition to sustainable energy. • Ethics: the company used data from other cars but in a way that doesn't identify the car owner. At no point is any personally identifiable information collected or shared during this process. • Legal aspects: autonomous driving has many new legal aspects that are explained in the company web page (https://www.tesla.com /about/legal).

Amazon GO:

https://towardsdatascience.com/how-the-amazon-go-store-works-a-deep-dive-3fde9d9939e9

https://www.youtube.com/watch?v=NrmMk1Myrxc

TOPIC	IMPLEMENTATION

Perception	• Cameras:
	  • Detect faces.
	  • Pose estimation.
	  • Object recognition.
	• QR code scanner for the Amazon app to enter through the gates.

Actuation	• Amazon app shows the virtual basket and receipt.
Representation	• The client is represented by a customer code in the Amazon app. • The products in the virtual basket are represented by their code and price.
Reasoning	• The system deletes the products that are returned to the desk. • The system takes into account that many members of the same family can enter.
Collective intelligence	• The store is connected to Amazon servers through the mobile app.
Motivation	• The objective of the system is to avoid lines and checkout, making the buying process as natural as possible.
SEL	• Sustainability: the huge number of data collected must be carefully managed and stored. • Ethics: the company could use the data to increase the user consumerism. The absence

TOPIC	IMPLEMENTATION
	of human employees makes the model more sustainable, but less ethical. • Legal aspects: the use of cameras tracking the user actions could be problematic, and the user must accept the legal terms.

AMP robotics for recycling:

https://www.greenbiz.com/article/how-artificial-intelligence-helps-recycling-become-more-circular

TOPIC	IMPLEMENTATION
Perception	• Cameras: • Real-time pattern recognition to identify materials.
Actuation	• 3 arms universally connected at the base to achieve precise, fluid movement.
Representation	• Data from the material stream is being captured in the cloud.
Reasoning	• The system optimizes sorting and picking depending on the user's preferences.
Collective intelligence	• It does not apply here, because the AI system is local to one installation.
Motivation	• The objective of the system is to sort and pick very specific items, as a human worker would do. This level of specificity could be valuable for consumer products companies seeking either to put their own product packaging back into circulation or to buy specific types of plastics.

TOPIC	IMPLEMENTATION
SEL	• The type of industrial task involved in this application, is not remarkable in legal or ethical aspects for AI, as it does not involve people but objects to be recycled.