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Artificial Intelligence in Pre-University Education: What and How to Teach †

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Abstract: The present paper is part of the European Erasmus+ project on educational innovation led by the UDC and entitled "AI+: Developing an Artificial Intelligence Curriculum adapted to European High School". In this paper, the progress achieved during the first year of the project will be presented. Mainly, the definition of the methodological approach for this future subject has been defined, and the AI topics to be dealt with at this age have been established. It has been a great effort to select the most appropriate focus for this subject considering the students' and teachers' technical background and the schools' equipment.

Keywords: artificial intelligence in education; STEM education; applied artificial intelligence; smartphone-based education

1. Introduction

The current society is starting to be connected to Artificial Intelligence (AI). Smartphones, social networks, voice assistants, are robots are just a few examples of AI devices used every day. As a consequence, the European Commission, as many other governments around the world, has initiated the creation of an AI plan for the EU states, in order to regulate how the transition to this new society will be performed [1]. In this process, education is a key field to assure that future generations are prepared for the new challenges.

Artificial intelligence has been a university subject for more than 30 years. Even so, it has never been included in official pre-university studies because it requires a technical background that was not acquired in secondary school, and the existing tools were not suitable for students at this level, until now. Currently, students have a good technological base thanks to subjects such as IT and programming. Moreover, AI systems have improved remarkably in the last decade, so now, students are not required to be technological experts in order to use them. An example of this is the TensorFlow Playground [2], which is an interactive neural network viewer that allows users unfamiliar with high-level coding to experiment with neural networks, considered a very advanced topic a few years ago.

Therefore, AI teaching in pre-university education is currently feasible, but the specific topics that must be taught at this age, and to what extent, is an open issue that must be faced. This is where the AI+ project comes in, as in the first year of the project's development, the methodological approach for this future subject has been defined, and the AI topics to be addressed have been established.

2. Teaching Organization and Methodology

The AI teaching approach to be followed here focuses on embedded intelligence, i.e., the programming of real-world devices that interact with real environments. Because access to embedded systems from schools is not easy, the use of the student's mobile phone (smartphone) as the central

technological element for all educational material to be developed has been established as a key premise in the project. Currently, smartphones can be considered as general public devices with a low cost. Moreover, they have the technological level required for AI teaching in terms of sensors, actuators, computing power, and communications; and they will have this in the future because they are continuously updated.

Furthermore, the subject follows a STEM methodology (Science, Technology, Engineering, Mathematics), which focuses on the integrated learning of different technical and scientific concepts through an engineering approach. AI is a technological field that fits perfectly in the STEM methodology, since it requires knowledge from different disciplines to solve problems, such as physics, mathematics, programming, and design.

Regarding the units, each one will present a challenge or project, following the PBL (Project Based Learning) and cooperative methodology, which students will have to solve, organized into groups, in a creative and practical way. This approach is based on totally proactive learning and through real-world problem solving (learning by doing), in accordance with the eminently practical approach of the curriculum.

3. AI Topics for Pre-University Education

To define the AI topics to be studied at this academic level, the main elements that make up an AI system, from an engineering point of view, were taken as a starting point. As shown in the diagram of Figure 1, an AI system is made up of five sub-systems linked to the sensing and actuation stages.

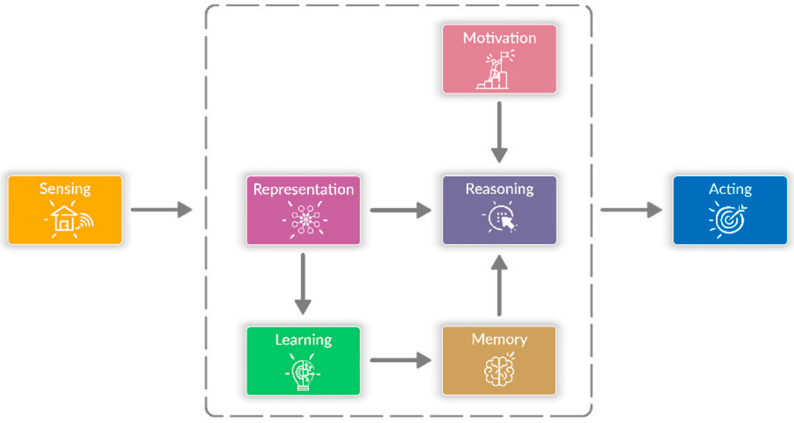

Figure 1. Main elements of an AI system.

Keeping this in mind, it has been decided that the eight topics to be addressed in the curriculum are: (1) perception, (2) actuation, (3) representation, (4) reasoning, (5) learning, (6) collective intelligence, (7) motivation, and (8) Sustainability, Ethics, and Legal aspects of AI (SEL). As can be seen, most of the implementation blocks displayed in Figure 1 correspond to specific topics that will be studied in the curriculum. It has been decided not to include the memory block as a topic and to add two new ones that are a fundamental part of AI from a didactic perspective: collective intelligence and SEL.

Firstly, it was decided that the first two topics would be those of perception and actuation, since they are part of all AI systems. This curriculum will focus on the sensors that are currently most used in AI, such as cameras, microphones, and touch screens. Regarding actuation, it will be focused on a more general approach beyond typical motors, and multiple actuators that can be found in AI systems, such as speakers or LCD screens, will be presented to students.

Representation and reasoning are two very relevant topics in AI, and completely new to students. For this level, basic concepts like topological or metric maps will be explained, and simple reasoning over graphs will be presented, included in the teaching units.

Learning is a key property of an AI system, which must be able to learn from its experience, generalizing the information it perceives. It is therefore a central issue to be studied in the curriculum, including supervised, unsupervised, and reinforcement learning fundamentals.

For the collective intelligence topic, students will learn how to communicate information between AI systems to improve their response and how to coordinate their actions to operate in a more reliable way.

Typically, in AI systems, the goal or objective to be achieved is imposed by the human designer. However, to obtain systems with a higher degree of autonomy, they must be able to discover their objectives and, in the case of having more than one, choose the best one at a given moment. That is what the motivation is focused on, and although it is an open issue in AI, students must understand how a motivated AI system will work and how it can be controlled by humans.

Finally, considering that AI's impact on different aspects of future societies will bring new problems, SEL is a topic that cannot be left aside in this curriculum.

4. Curriculum Organization

The AI curriculum will cover two academic courses. It has been decided to structure the curriculum to cover three fields of application in AI: intelligent smartphone apps, autonomous robotics, and smart environments. Although many other application fields could have been selected, these are very representative of the current AI domain, and all of them can be developed using a smartphone in classes.

To develop intelligent smartphone apps, it has been decided to use the App Inventor 2 environment [3]. In this interface, smart applications for the Android operating system can be developed using already existent AI modules, like [4]. Regarding autonomous robotics, the curriculum will include the use of the smartphone-based robot Robobo [5]. With it, students will practice their skills on most of the AI topics explained above, due to the technological capabilities of this platform [6]. Finally, for the smart environments field, it will be proposed to create an intelligent network with different devices, such as smartphones, smart speakers, and cameras, through which students will be able to create intelligent spaces and practice the collective intelligence topics in depth.

5. Conclusions

The topics to be included in a curriculum for teaching artificial intelligence in high schools and the most adequate methodology to present them to students have been defined as a part of the AI+ project. In the next two years, all the teaching units that conform to the curriculum will be developed and tested with students from the schools that are involved in the project.

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Conflicts of Interest: The authors declare no conflict of interest.

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