Specialized and updated training on supporting advance technologies for early childhood education and care professionals and graduates

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e-EarlyCare-T

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MODULE VII.1

Early care and intelligent resources application: Internet of things and Artificial Intelligence

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I. Introduction

This module presents the main aspects of the Internet of things and artificial intelligence concepts. Both disciplines, that are independent, can be used together thus one can benefit from the other in some aspects of the human being's life.

In more detail, this module explains what these concepts are, some applications to healthcare and how their use can be beneficial for therapists and patients. More specifically, their use will be explained and their applications to early care.

II. Objectives

1. What Internet of things (**IoT**) is and its applications to early care.

2. To know the applications and uses of the Artificial Intelligence (**AI**) to early care.

III. Specific contents of the module

3.1. Internet of things (IoT)

Internet of things, **IoT** hereinafter, is an emergent topic that has been evolving since more than two decades and it has a great relevance in the societies and consumers.

The **IoT** term usually refers to those scenarios where the connectivity and the computation capabilities extend to objects, sensors, and elements that are not usually considered computers. This makes possible to these devices to produce, interchange, and consume data with a minimal human interference (Rose et al., 2015).

3.1.1. History of Internet of things

Even though **IoT** was initially proposed in 1999 by Kevin Ashton to refer to those systems in which the real-life objects can be connected to Internet by sensors (Li et al., 2015), it was not until the new century when the miniaturization and the costs production cut made possible that this technology took off.

Although **IoT** term is, indeed, relatively recent it is not novel the task, since in the end of seventies decade existed ad-hoc equipment able to remotely monitor the electric network. In the following years, advances in the technology made possible that solutions called “machine-to-machine” (M2M) got popular. However, these technologies usually depended on proprietary communication networks (without specific standards). The broad adoption of Internet Protocol (**IP**) for the communications set the basis of what nowadays is called Internet of things (Rose et al., 2015).

3.1.2. Reasons that explain IoT popularity

In general, several factors have made possible that **IoT** has gained so much relevance along the last years. The confluence of technological advances and market trends made possible the connection of small devices in a cheap, fast, and easy way:

- Ubiquitous connectivity: high-speed and low-cost network connectivity makes possible that everything can be connected to networks (via the Internet).
- Widespread adoption of **IP**: the Internet Protocol has become the standard for networking, it provides solutions that can be incorporated into a broad range of devices in an easy and affordable way.
- Computing economics: the development of manufacturing of electronic equipment confirms the Moore's law, offering great computing power at lower price and consumption.
- Miniaturization: the miniaturization of electronic equipment makes possible to incorporate devices in almost everything, since household appliances to clothes.
- Advances in Data Analysis: it is closely related with the 3.2 section of the present document, the fast increase in computing power, storing, the development of new algorithms, among others, offer new opportunities for the analysis and exploitation of data.
- Cloud computing: the rise of cloud computing is unstoppable nowadays. Cloud computing consists in delegating expensive computation (hardly affordable by a small-size devices) to huge data centres. This makes possible for small devices to be responsible only for gathering data instead of the analysis of data.

3.1.3. Communications models of IoT

As it was previously explained, the basis and the fundaments of the **IoT** devices are how they communicate each other. In March 2015, the *Internet Architecture Board (*IAB) published a document that serves as a guide for the device networks and/or intelligent elements (RFC 7452), in the document four models used for **IoT** devices are published. Below are briefly explained each of them:

- Device-to-device: in this communication, the devices are connected each other without any intermediary (such as a server, for example). An example of this communication is Bluetooth technology.
- Device-to-cloud: in this case the devices are connected to a server that is on the Internet and it is the server the responsible of the communication between them. In this case, traditional networks (such as Wi-Fi) and standard protocols

(such as **IP**) are commonly used. An example could be an intelligent thermostat.
- Device-to-gateway: it is similar, in some aspects, with the previous but in this case the devices are connected to a local gateway (via Bluetooth, for example) and it is the gateway itself which connects with the application service in the cloud (via **IP** for example).
- *Back-end data-sharing*: it can be seen as a more modularized device-to-cloud. In this case, the device connects with a service on cloud that interchanges information and uses services of the other providers on the cloud. In this case, the data of the user/device are shared with third parties for its analysis.

3.1.4. IoT applied to healthcare

The architecture of **IoT** devices applied to healthcare consists basically in three layers: capture layer, network layer, and application layer (Kelly et al., 2020; Sethi & Sarangi, 2017).

- Perception layer: as it was previously explained, the perception and identification technologies are the basis of IoT. Sensors are those devices able to capture changes on the environment, such as infrared, **GPS**, medical sensors...
- Network layer: data gathered by sensors must be shared between devices and/or applications. These data can be locally stored or uploaded to the cloud depending on the specific application. Examples of networks are *Bluetooth*, Wi-Fi, Zigbee, among others.
- Application layer: this layer is the one in charge of interpreting data, being the responsible of giving the processed data to user. Is in this point where **IoT** and **AI** are mutually benefited. The **AI** is able to process data (including those gathered by **IoT** devices or stored in medical databases), contextualize them, and give answers to the questions that arise in medical context.

An exhaustive compilation of **IoT** applications applied to healthcare is out of the scape of this document, for more information we recommend the following publications (Scarpato et al., 2017; Mishra & Rasool, 2019).

3.1.5. IoT applications to early care

As it has previously noted, regarding healthcare, the main objective of **IoT** for medical personnel and therapists is to provide a low-cost user experience and to improve the quality live of the patients (Islam et al., 2015). The **IoT** technologies provide connectivity to medical devices and services of healthcare reliable, effective, and intelligent (Nazir et al., 2019). Whereas **IoT** devices have been broadly accepted and popularized, and also, they are impacting gradually in how children and teenagers play, learn, and grow (Ling et al., 2022), the use an application of **IoT** technologies in early care is still scarce and almost inexistent.

One of the few applications of **IoT** related with early care was proposed by (de Vicente et al., 2016) in which they provide a new model of "Internet of toys" that aims to improve the health of children, strengthening the prevention and the attention disorder in childhood development. These toys have a spatial location system based on radio frequency identification (**RFiD**). Nevertheless, the **IoT** technologies have a great potential on early care such as the study of (Xing-Rong et al., 2021) highlighted. In it, they identify a group (*cluster*) of scientific papers that suggest that the promotion of the practice of smart education is needed to consider the students' attitude and the fathers and mothers ones, in the same way that it must be considered the early care of boys and girls.

3.2. Artificial Intelligence

The Artificial Intelligence (AI) is defined as the study of the computational methods that can make possible to sensing, reasoning, and acting (Winston, 1984). In a broader sense, it is usually assumed that **AI** studies the processes that make possible to computers to have behaviours that are observed in the human intelligence (Maddox et al., 2019). In general, it is considered that the main purpose of **AI** is to develop conceptual models, formal rewriting procedures of these models, and to develop programming strategies and physical machines that reproduce cognitive tasks of the biological systems that we consider intelligent (Mira & Delgado, 1995). In the last decade, the **AI** advances have overcome the humans in several tasks that were commonly assumed as intractable. The advances of the last times in the field have been reached thanks to the exponential increase of the available information (huge datasets to learn), combined with new algorithms and optimizations (Došilović et al., 2018).

A common problem of some **AI** methods and algorithms is their interpretability and their lack of transparency (Markus et al., 2021). Frequently, the best methods (the ones that achieve the best accuracy) perform as black boxes which for an input offers an output/prediction, but it is extremely hard or even difficult to determine how the system has found the solution. Because of this, the explainable **AI** is gaining special interest in the community, especially when these methods are used in medical issues and related with healthcare. For methods' interpretability and explainability two groups are usually found: integrated interpretability (based on transparency) and post-hoc (Došilović et al., 2018).

- Integrated (transparency-based): it is based in transparency, that is one of the features that makes possible the interpretability. Some models, such as decision trees, can be interpreted by themselves, but unfortunately other more complex methods (usually the ones that achieve the best results, such as neural networks or ensembles) are hard to understand.
- *Post-hoc*: it is based in interpretability, extracting information from trained models. These methods do not depend on how the model performs internally. The advantage of these methods is that they use the models already trained

and treat them as black boxes. They offer predictions or explanations about how the method works by using other forms such as plots, text, examples... In this way, a single decision tree can offer a summary of how the predictions are being performed by models much more complex, as for example support vector machines (**SVM**).

3.2.1. Machine learning

Into the **AI** discipline, the machine learning (**ML**) is a subdiscipline that, using big datasets, can identify patterns between the input variables (Noorbakhsh-Sabet et al., 2019). Inside **ML** three groups are usually stablished: supervised learning, unsupervised learning, and reinforce learning. Datasets of supervised learning have several input variables and one (or more) output/target variable, its aim is to identify the relation between input variables and the output one for predicting the target variable of a never seen before instance/example. On the other hand, unsupervised learning datasets do not have any target variable, thus the aim of unsupervised learning is to find associations or hidden patterns between the examples of the dataset. Finally, reinforcement learning is inspired in conductist learning and tries to identify the actions that an agent must choose for maximizing its benefit or reward.

3.2.2. Artificial Intelligence healthcare related

AI is changing healthcare systems in several ways, the development that is suffering has been fostering by the huge data available and the application of new and more accurate methods (Schwalbe & Wahl, 2020). There is a myriad of **AI** applications healthcare related, focusing only on **ML**: the most common tasks of supervised learning are classification (predict the output variable of a certain categories) and regression (predict the output variable when this is numeric/continuous). Examples of supervised learning include cancer prediction from X-rays, anticoagulation therapy models, strokes damage identification... Regarding unsupervised learning, clustering is the task most popular. This can be used for profiling drug for patients.

3.2.3. Applications of AI to early care

AI can be applied in many aspects related with early care, since policy development to specific applications. Nevertheless, early care applications are still scarce (Sierra et al., 2022). In (Park & Hassairi, 2021) proposed how the machine learning can help to the development of education policies focusing on childhood, more specifically, early care. In their study, they analyse massive legal political documents on education in the USA for identifying those aspects more relevant for conducting education policies.

Recently, (Sierra et al., 2022) presented a proof-of-concept in early care that includes several **ML** algorithms. Their study tries to help, by comparing several algorithms, to the diagnosis and assignation of therapy and treatment on below 6 years-old children. The study was conducted on San Juan de Dios hospital, Sevilla (Spain). One of the most difficult tasks was the natural language processing (NLP) for extracting features from clinical history with which train the **AI** models.

Summary

This module has presented two concepts: Internet of things and Artificial Intelligence, that makes possible to understand how them work and their applications to early care.

Glossary

GPS: Global Positioning System.

AI: Artificial Intelligence.

IoT: Internet of things.

IP: Internet protocol.

ML: Machine learning.

RFiD: Radio frequency identification.

SVM: Support Vector Machine.

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