Internet of Things & Augmented Reality App for Education

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Abstract: - This paper advocates the use of the Augmented Reality (AR) as a gateway to allow humans to become an active part inside the Internet of Things (IoT). This technology mixture changes the IoT from its classical pattern, a network of smart objects intercommunicating mostly without us, to an environment of exchanging information where we detain the power to understand, react and amend our surroundings. The first section is a presentation of the general concepts concerning the IoT and AR. The next sub-chapter will refer to some examples of the combined use of AR and IoT already operational. The third paragraph will present the implementation of a teaching application mixing AR & IoT to obtain a better student’s access to information. Concluding remarks, containing the authors’ opinion on the future development trends in this field of research, will be added at the end.

Key-Words: - Augmented Reality, Internet of Things, Education

1 Introduction

The Internet of Things is one of the most promising progresses in nowadays technology and research because it has the real potential to fundamentally change our economy, our society and ultimately our whole civilization. IoT is not a fresh idea. It was first put to work at Carnegie Mellon University (Pittsburgh, PA, USA) in 1982 when a Soft Drinks Vending Machine was improved in order to be able to automatically send reports via the Local Area Network on its inventory and its drinks’ current temperature.

During the next two decades, the theoretical concept was better defined by Mark Weiser, Bill Joy, Reza Raji and others. The name “Internet of Things” was proposed in 1999 by Kevin Ashton, Executive Director of the AutoID Centre in Massachusetts Institute of Technology (Cambridge, MA, USA).

There are various theoretical definitions available for IoT, based on alternate views over this complex technology’s actual stage and its future development’s trends. [1] A discussion on this could be interesting, but it surely exceeds the topic of this paper. Thus, basically, the “Internet of Tings is an extension of the network connectivity and computing capability to objects, sensors and everyday items not normally considered computers, allowing these devices to generate exchange and consume data with minimal human intervention”. [2]

It looks relatively simple at first glance to realize a “device to device communication” in the era of cheap microcontrollers and sensors attached to almost everything around us. However, the real implementation proved to be challenging. Even now, after almost 40 years, there are no unanimously accepted solutions for “details” like: optimal inter-connection between various appliances from miscellaneous producers, best communication protocols among a multitude of smart devices, efficient security shield against viruses and hackers and many others. [3]

However, recent developments are a step forward in the good direction and nowadays some limited IoT implementation became feasible with adequate functionality and affordable costs. These scientific & technologic breakthroughs are:

- Electronic devices miniaturization accompanied by prices’ drop;
- IP-based Networking and Ubiquitous Connectivity;
- Mobile telecommunications’ advancement to 5G;
- Progresses in Cloud computing. [4]

Therefore, some experts, analysing the IoT's future developments' trends for the next decades, turn very optimistic. It is expected that the IoT implementation in economy and society will produce 11bn $ profits before 2025 and this growth will furthermore accelerate after that.

Moreover, they preview that half of the technologies that will be in use in 2050 are yet to be discovered. [5] If so, this 'hyper-connected world" around us will soon change into a technological environment having a significant potential to essentially alter not only our work, but also our private life and even our mind (see Figure 1). The IoT empowered by the Artificial Intelligence will revolution our society in the near future. [6]

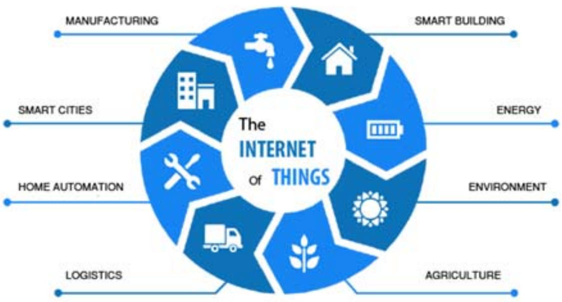

Fig.1 IOT's main applications [7]

These great changes will gradually affect each working place from all relevant human activity fields. Industry, Agriculture, Public Services, Education and Health Care Systems etc. will evolve to a better level of performance and effectiveness. Some of these evolutions have already started. [5]

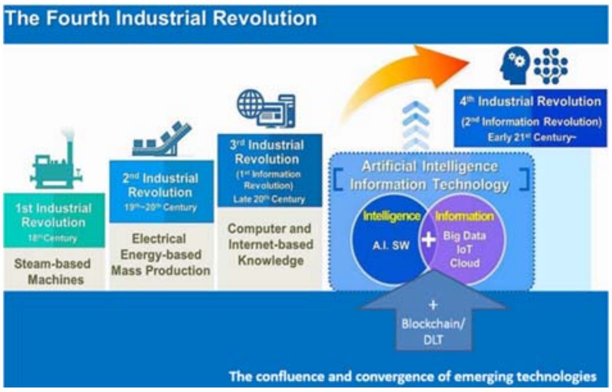

Fig.2 Industrial revolutions [6]

The nowadays industry is based on highly automatized production lines with complex equipment. The maintenance activity for this needs a large human and financial effort. A 2017 IBM's report states that more than 80% of the maintenance time is spent to repair/change broken parts and about 44% of production stoppages are produced by old machinery.

Important resources are also spent to keep spare parts and preserve optimum level storage's inventory for all scenarios. IOT can perform real time machinery's monitoring; therefore "soon to be damaged" warnings are issued some days before the apparatus becomes non-functional.

Large companies like Volkswagen, Mercedes, Toyota etc. are already using this modern solution. [8] It could be the first step to Industry 4.0 where IoT and Artificial Intelligence combined will revolution manufacturing as shown in Figure 2.

Promising IOT answers to resolve cities management tasks are also already available. The municipality of Santander (Spain) provides a free application for all its inhabitants allowing them to receive live information on traffic situation, available parking places, water consumption, municipality's offices program etc. This real-time information is available because a large IoT network with sensors and local data processors covers the whole town.

Citizens also contribute to the system with accidents' notification or even ideas for app's improvement. This solution proved to be a success not only for improving public services, but also to strengthen the link between the City Hall and the people. [9] In fact, all over the modern world, local administrations spend energies to upgrade the public services and advance towards the Smart City.

Modern Education proved to be a space were the Internet of Things was welcomed from the very beginning. Perhaps, many will not identify the well-known Smart Board as a simple form of IoT, but it has all the main elements to be classified so. The teacher's laptop, the video projector, the webcam and the sensitive surface of the board itself are inter-related in a permanent data exchange.

Fig.3 Smart board system

In some cases, there is also a set of individual remote controllers which are distributed to the learners (e.g. when pupils/students are submitted to a quiz test), thus more interaction is added. Another possible improvement (when the classroom has a computer for each student) is to connect the whole network to the Smart board via a multiplexing application; hence any of the student's screens can be displayed on the board.

One more sophisticated approach to employ IoT in the learning process is related to a new proposed method for English language interactive teaching. It is based on the integration of voice and visual sensors to capture relevant data regarding student's pronunciation. Using this information, the teacher can adapt his strategy to each learner according to his/hers abilities. The final better performances are also due to the fact that youngsters find modern technology attractive and this gives them a supplemental motivation. [10]

Near future will bring many more IoT solutions to the requirement of different economic or social activities to gain more quality and efficiency. These new technologies will become further complex, thus humans will necessitate help to adapt and stay connected.

One possible answer for this need is the use of Augmented Reality. Augmented reality (AR) is one of the most significant current development trends, and it will get even important more as AR ready mobile phones, tablets and other similar devices will become more popular.

AR uses our surrounding reality and superimposes new information on top of it as sown in Figure 4. It can be currently experienced through a wide range of apps running on our smartphones. Therefore, AR has become a trendy and accessible technology nowadays.

Fig.4 The AR browser enhances camera display with contextual information [11]

The earliest public usage of AR was the "yellow <<first down>> line" employed in TV broadcasted football matches in 1998. Today all sport TV shows are filled with overlaid visual info enhancing all kind of details from ball "in or out" in tennis to finish line in athletic running. It is aimed to help both referees or commentators and simple watchers to better apprehend critical phases.

The best known example of AR technology is the mobile app Pokemon Go. It was released in 2016 and rapidly turned into a trendy social game. For several months a great number of players become virtual characters hunters searching the virtual pokemons hided everywhere in the real world. Currently there are more widespread AR apps such as: Google Sky Map, Lookator, AcrossAir, Layar, SpotCrime etc. [11]

Fig.5 AR maintenance in a smart factory [8]

But AR is no more just a fun toy; it reached the stage of usefulness in many important fields of activity, like:

- Industry – complex machinery in high tech manufacturing maintenance is improved by using AR technology as seen in Figure 5;
- Medicine – 3-D brain AR projection help neurosurgeons to gain precision in their delicate operations;
- Air Transportation – AR glasses help ground crews in some airports instantly see data about cargo containers, thus efficiency is increased and error is minimized;
- Shipping – AR enhanced navigation systems overlay the optimal path over the route's live view;
- Defence – fighters' pilots have an AR image of their flight data superimposed on their helmet visor, thus their speed reaction grows better;

- Commerce – IKEA provides an AR app (IKEA Place) helping you fit the furniture into your space;
- Tourism – views of ancient civilizations superimposed over today's ruins enhances some historical sites attractiveness (e.g. Pompeii in Italy, Terracotta Army in Xi'An, China etc.).

The AR offers an easy way to use and understand interface to IoT, because the superimposed virtual information added to the real world. People can interact directly, by eyesight, with the nearby smart objects' info controlled by a context aware middleware. The smartphones' large spread-out and the software released both by Google and Apple, open the real possibility that mobile AR interface to IoT will become very popular in only a few years.

This current stage is a required step for the AR technology in order to allow time for apps improvement and to gain wide public acceptance. The efficacy of using AR in IoT environments will grow obvious and consequently their combination will become common. Soon, when head mounted devices will evolve to an easy to wear form (e.g. similar to our present-day sun glasses) the transition to hands free will be natural. [12]

Later, if the recent promising researches in Computer - Brain Interfaces will arrive to the desired results, a direct link to our cortex could become feasible; hence AR will turn into a permanently added fragment of our environment's perception. [13]

2 AR inside the IoT Environment

The AR is already a presence into our daily life, therefore its integration with IoT is more commonly found than people can identify.

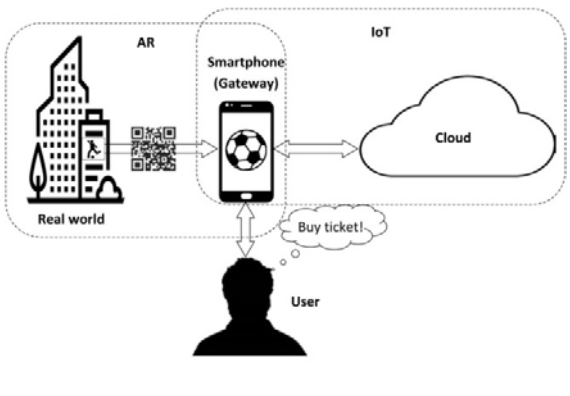

Fig.6 Smartphone as a gateway among user, AR and IoT

This section presents some of the most important cases of this mixed technology implication in both our work and our life.

IoT is mainly concerned with device-to-device communication, thus humans need a tool to interfere into this. As illustrated in Figure 6, our smartphones with AR software installed on are now the best gateway to mediate access to the objects network, because smartphones are our closest computer-friend accompanying us every day. QR and 2D bar codes are currently a popular solution to bond man with IoT

There are a lot of services on the market becoming available only by scanning such an encoded identifier. A well spread application is using QR codes for advertising products, services, or events. The mobile phone is the double gateway both to the AR (the encrypted information in the code's image) and to the IoT cloud, hence after scanning the label you are automatically led to a site on the Internet where different choices become available with only one screen touch.

Moreover, you cannot think of any other better way than QR code to encrypt all the data linked to an airplane traveller: his seat, his priorities, his luggage, his itinerary etc. The same strategy is now applied by more and more service providers. [14]

Another simple example of nowadays implementation is the interaction between a user, his smartphone and a printer able to show QR codes on its display. This way, the printer gives to the human operator all useful help, from operating instructions & solutions for the current task, to direct access to the toner cartridge's vendor. Of course, the printer can also be controlled via the phone if an appropriate intercommunication app is installed.

Apart from these daily life sample cases, there are important implementations in the manufacturing industry. Great hi tech enterprises like IBM, NASA, Volvo, Caterpillar, Autodesk, Safran etc. use the AR & IoT technology to improve production, supply lines, maintenance, research and different other support services.

The most straightforward solutions are based on attaching personalized tags to every item involved in the process, thus both man and other smart objects can collect all needed information from the database about them. [15]These tags can be simple code labels or more elaborate, RFID stamps containing a minimal microcontroller device able to transfer detailed info about the object they are attached to. Such smart stamps are now available at only a few cents and their price is still dropping. In some cases, the conveyed information includes measurements from the attached sensors (e.g. temperature, pressure, mechanic tension etc.).

The first type of labels is applicable for example, in the production & maintenance of airplanes' cable systems, containing tens of thousands of distinct wires. The second is good for the automatic deliveries sorting system both in big industrial supply lines and in modern postal services. [16]

Much more complex computing and telecommunication technologies are employed when a collaborative design among distant people is necessary. Every member of the working team participates, from its own location in the interactive design process, being allowed to both try his adjustments and see colleagues' ones. The project is an AR object visible and changeable for all the involved designers in real time. [17]

Basically, inside the AR & IoT environment the most important item's feature is the access to its identification and current info. From this perspective, there are three classes of objects in the physical world:

- Smart objects – items with integrated micro-controllers & sensors, capable to fully communicate to other devices and having direct access to the Internet. Their digital identifiers are intrinsic part of the objects' structure and are unique. They are the smallest group now, but their number grows fast (CISCO estimates they will exceed 25 billion items by 2020);
- Tagged objects – items with an identifying tag attached. This label can be noticed optically or by Wi-Fi, but can give no information about the item's current state. The most common are the barcodes or RFID tags using the Global Trade Identification Number standard. Nowadays, different instances of the same product share an identic identifying tag, but due to the fight against counterfeiting it is a growing tendency to change to serial level identifiers (e.g. 10 billion clothing items are planned to be equipped whit unique identity tags by "Everything alone" in the future three years only);
- Plain objects – items not ready for IoT. They can only be labelled with pattern recognition software or context analysis. CISCO estimates they are, currently 99.4% of all items in the world. Future research will have to work hard and find suitable solutions to insert at least a part of them into the IoT. [17]

Consequently, there are two major research directions in this scientific and technological growth process:

- Develop further resourceful solutions capable to assure the transfer and processing of all relevant information among a multitude of smart and tagged objects,
- Find optimal strategies to include plain objects into the AR & IoT environment. A satisfactory answer on both these research topics is fundamental for the implementation of IoT on large scale in economy, society and humans' life.

3 AR & IoT application for teaching

This section presents an educational application using AR & IoT in laboratory activity. The tagging plain objects method was used in order to make them part of the technological bubble.

One academic year ago I tried together with my assistant professor to replicate and upgrade an experiment involving AR and IoT in teaching. The original research was performed in 2013 at University of Cordoba (Colombia) by a group of Spanish and local teachers. [18]

Fig.7 2D Barcode assigned to of computers' component in CA Lab

Our basic aim was to make use of AR & IoT in teaching the Computers' Architecture course (CA) to the first year Computer science students. Each internal structure component of computers in CA Lab was assigned a tag (2D Barcode) as shown in Figure 7. When a student scan a component's code with his smartphone a special app (CA learning tool) displays on his phone's screen a small section of text & figures containing the description and functionality of the respective component. This info is provided by a site available on the Lab's LAN which replicates the relevant sections of the standard CA course on CD.

We used a standard methodology of research:

- Every student was primarily pre-tested before the teaching module start and it proved that the average level of knowledge was similar in both groups;
- The students were divided in two equal groups (25 individuals); Gr. A working in the Lab with the above described technology and Gr. B using a standard reference for learning about components (course on CD) The division between A and B group was made after the results of the Pre-test in order to have similar average initial knowledge on the computer's components & structure;
- After the teaching module ended each student responded to an evaluation multiple choice quiz test (Exam).

The evaluation scale used was the standard one in our national education system, 0 to 10, where 10 is the best possible result. The test passing threshold was 5. The Group A average result was 8.6 with no student failing to pass the Exam. The Group B average outcome was 7.2 and two students (8% of the total in the group) received less than 5 and were sent to re-examination.

These good results proved similar to the ones reported in Cordoba and it was no surprise for us, because even from the beginning of the Lab activity, the Group A students were really attracted by this learning method.

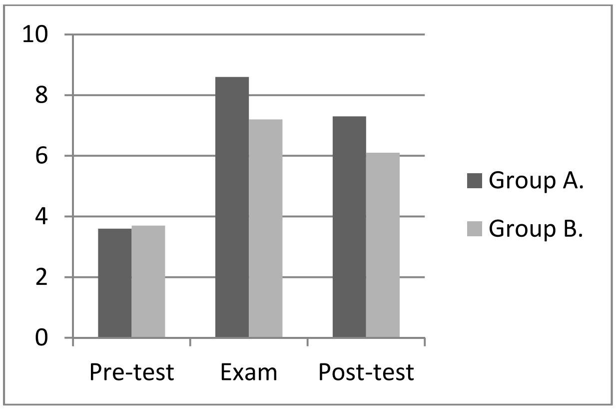

Fig.8 Average results of the two groups in the three tests

To upgrade the research, we added a supplementary later test to verify if learning was efficient on long term. Students in both groups where submitted to a Post-test in the beginning of the next semester (approximately a month after the Exam). The Group A average result was still superior to the Group B's one with more than 10%, thus knowledge proved more stable in first group students' memory. All the three tests' results are shown in Figure 8. Consequently, from this year we extended the AR & IoT teaching of CA to all first year students.

Therefore, this teaching application was not difficult to implement but proved quite effective. It can be also used with foreseeable good results in some other courses in different faculties' curricula; from Engines to Anatomy. It only needs for the teachers and assistants to be ready to spend small extra time & effort.

4 Conclusion

Experts, analysing human civilization current developments' trends expect that the IoT empowered by the Artificial Intelligence will revolution our economy, society and private life. The intelligent "hyper-connected world" around us will change not only the nearby devices, but also the whole way we understand and interact with our environment.

The smart objects will become able to directly interact among them and to decide the course of their actions independently of human will. Still, the idea of the man residing in this technological bubble as an "absent god", just receiving services and not meddling in, is an incorrect development strategy and is incongruent with the true human spirit.

The AR provides a natural way to interact with the IoT world. Humans have visual access to information about smart and tagged nearby object, thus direct interaction is made easier. Our own smartphones empowered with adequate software offers an optimal gateway to explore the relevant data around us and to take adequate decisions on our actions.

Thus, the efficacy of employing AR in our relation with the surrounding IoT will advocate for its extension to all fields of activity. The future development of better and easier to wear head mounted devices will add new reasons to make AR & IoT a popular approach to use and understand the new technologies in the next decades. Modern school has to find strategies to keep in touch with this evolution.

Currently there are available hardware & software solution to make this possible, but a development effort must be done both by the education system and by each teacher to find suitable and effective implementations able to upgrade training to the new digital era requirements. This will certainly be a difficult task, but due to the youngsters' eagerness over technology, the rewarding results promise to be worthy.

Acknowledgment
This work was partially supported by the strategic grant POCU/82/3/7/105846 "Entrepreneurial Start in West Romania" (2018) of the Ministry of Labour and Social Protection, Romania, co-financed by the European Social Fund – Operational Programme Human Capital.

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