A Revolutionary Interactive Smart Classroom (RISC) with the Use of Emerging Technologies

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***Abstract*—Nowadays, the traditional teacher-centered way of teaching seems to be anachronistic. Disabled people, and not only, face difficulties to follow the current educational methods. The evolution of technology can offer significant benefits in these problems. Cutting-edge technologies, such as as Internet of Things (IoT), Cloud Computing (CC), Wireless Sensor Networks (WSN), Big Data Analytics (BDA), Compressed Sensing (CS), Augmented Reality/Virtual Reality (AR/VR) and 5G Networking can contribute in the field of smart education. However, smart education is currently in an embryonic 2D data representational state. In this paper, we propose a new Revolutionary Interactive Smart Classroom (RISC) which will provide a virtual environment for enhanced learning experience, based on 5G Network. This classroom will also make use of 3D virtual services in combination with haptic equipment and sensors, in order to carry out augmented human sensing information and touch into the virtual class. The advantages of such a classroom will be the sustainability in many fields, such as Society, Education, Environment, Economics, Technology and Cultural Tourism.**

Keywords—5G, Haptics, Cloud, IoT, Smart Education.

I. INTRODUCTION

Education is a wide sector where all the cutting-edge technologies could be involved. A new field of technology related to education is called “Smart Education”. This new domain relies on emerging technologies such as Internet of Things (IoT), Cloud Computing (CC), Wireless Sensor Networks, Big Data Analytics (BDA), Compressed Sensing (CS) and 5G Networking. The integration of these recently developed technologies can provide beneficial functionalities which can be applied generally in Education [1], and specifically in a classroom. A “Smart Classroom” can be established in a Wireless Network, in which multiple functions can operate simultaneously. 5G Technology can offer an efficient, safe and high-speed wireless network in a smart classroom. This could be also supported with the adaption of haptic equipment and 3D virtual services.

The rest of the paper is organized as follows: Section II presents the related work in smart education, Section III analyzes the involved emerging technologies, Section IV describes our proposed approach for effective smart education, while Section V analyzes the sustainability impact of such a project. Finally, Section VI concludes the paper and gives some potential future directions.

II. RELATED WORK

There are many researches which have been conducted in the field of smart education in the last years. Moreover, some e-classes which make use of cutting-edge technologies have been developed. Although there are studies and proposals on Smart Education and various technologies have been used, it is fact that 5G Networking, which is the successor of 4G one, are not integrated yet in such a project, while the other cutting-edge technologies are not used all-in-one together widely.

An IoT-based smart classroom which uses Google assistant for primary and secondary education schools has been proposed by D. D. Borse and P. S. Patil [2] and promises improved teaching and learning experience. Li-Shing Huang et al. [3] presented a context-aware energy-saving smart classroom architecture for smart campuses, in which the application interfaces were implemented using Raspberry Pi. H. Bargaoui and R. Bdiwi [4] proposed the design of a gateway for ubiquitous smart classroom which enables teacher and students to have an interactional area where several devices, such as laptops, tablets and projectors are connecting through this gateway.

In addition, F. Bouslama and F. Kalota [5] recommend a framework for modeling and understanding the way that student-centered smart classrooms can be designed effectively and flexibly with the collaboration and sharing information capture to take benefits of social networking. A. Kellerman et al. [6] present a smart whiteboard for interactive learning by using Nintendo Wii remote and PC suite, as a replacement of the traditional chalkboard, which makes viewing sessions at another time and place possible. S. H. Mun and A. H. Abdullah [7] present a study on the Use of smart boards in the education field which analyze the effects of them towards students’ attitudes and achievement from preschool to high school, and additionally to teachers’ acceptance, difficulties, challenges and perspectives on smart board use.

Furthermore, C. Stergiou et al. [8] propose a high-level architecture of a modern, Smart, Interconnected and Interactive Classroom (SIIC) which outlines novel augmented and virtual services that can assist e-learning systems through virtual reality and real-time interactions. R. Bdiwi et al. [9] propose the integration of emerging technologies in the area of higher education, such as Information and Communication Technologies (ICT) and Radio Frequency Identification (RFID)-based indoor positioning system, in order to examine students' perceptions and the interaction of groups into this smart classroom.

Moreover, W. Van De Bogart and S. Wichadee [10] present a study which focuses on students' perceived effectiveness of educational technologies and motivation in smart classrooms. This research discovered that although the overall mean score of students' perceived effectiveness of educational technologies and all items were at high levels, and the smart classroom is very efficient, the students had a moderate level of motivation. J. Yushendri et al. [11] designed the smart board system in ubiquitous computing for teaching and learning process, which expected to be achieved and implemented in the educational environment in the future, offering many advantages both for learners and lecturers.

Finally, X. Zhong et al. [12] conducted research and practice on interactive teaching support systems in smart classrooms, which enhances teaching outcomes and supports educational model reform by diversifying instructional techniques.

III. Involved Emerging Technologies

There are some emerging technologies which can offer many advantages in the educational method. Such technologies are the following:

A. *Internet of Things (IoT)*

IoT is the new revolutionary network of connected physical objects and things, embedded with software, electronics, sensors and connectivity that enables them. IoT achieves a greater rate and service by exchanging data with manufacturers, operators and many other connected devices [13]. IoT can be widely used in the educational system so as to enhance the Quality of Experience (QoE) of both students and teachers.

B. *Cloud Computing (CC)*

As an emerging technology, CC integrates multiple technologies for maximizing the capacity and performance of the existing infrastructure [14]. Furthermore, CC is a technology that can be set as a base technology in the use of IoT too [15]. It provides computing, storage, services, and applications over the Internet to all the connected users. Some of the main features of the CC technology which are related to the characteristics of IoT include: a) Storage over the Internet, b) Service over the Internet, c) Applications over the Internet, d) Energy efficiency and e) Computationally capable [16]. CC can be used in education to provide many additional resources and assistant services.

C. *Wireless Sensor Networks (WSN)*

A typical WSN is a group of spatially dispersed and dedicated wireless sensors which are used for monitoring and recording the physical or environmental conditions of an area, such as temperature, humidity, sound, pressure etc. These sensors cooperatively organize and pass their collected data through the network to a main location [13]. This technology can be supportively used in education for courses from distance.

D. *Big Data Analytics (BDA)*

In modern telecommunication systems, BD usually uses CC as the main technology in order to operate [17, 18]. BD often refers to the use of predictive analytics or certain advanced methods to extract value from data. Rarely, it also refers to a specific size of data set [14]. Precision in BD could result in more confident decision making, and better decisions may lead to increased operational efficiency, reduced costs, and minimized risk [18, 19]. Big data analytics is the use of advanced analytic techniques for examination of large and diverse data sets which include structured, semi-structured and unstructured data, from various sources, and in various sizes, so as to uncover information which can help businesses make informed decisions. BDA could be a good method which can be applied in Smart Education for analyzing the collected data from the wireless sensors in the cloud server during an e-course.

E. *Compressed Sensing (CS)*

Compressed or Compressive Sensing (CS), also known as Compressive or Sparse Sampling, is a signal processing method for effective acquisition and reconstruction of a signal with the use of solutions for underdetermination of linear systems. This technique follows the principle that, the sparsity of a signal can be exploited to recover it from far fewer samples than required by the Nyquist–Shannon sampling theorem, through optimization [20]. CS can face the Big Data challenges of huge storage and bandwidth costs in Smart Education.

F. *Artificial Intelligence (AI)*

Artificial Intelligence (AI) could offer new type of services that are based on the integration of Virtual Reality and Augmented Reality [21]. Virtual Reality (VR) is the interaction with the virtual world through haptic devices that can offer to the user the opportunity to see and sense things, objects, and places that are somewhere else or in another virtual world. On the other hand, Augmented Reality (AR) is a virtual world into the real world [22]. These technologies in combination with robotics can bring a new generation in the Education field.

G. *5G Networks*

The 5G of mobile networks allows haptic applications to take life, in combination with the haptic data communication protocols, bilateral teleoperation control schemes and haptic data processing needed [23, 24]. According to the 5G White Paper, 5G quotes 300Mbps of downlink, 50Mbps of uplink, an end-to-end latency from 10ms to less than 1 ms [25]. 5G is a new type of wireless network which provides all the benefits of its past versions and improves some issues which its predecessors had [19], [26]. By using this technology, we achieve a high transmission data rate, which is important for data sent by sensors. The transmission rate exceeds the value of 100 Mbps or 12.5 MB/sec [27]. Therefore, data from students' devices can be sent to the teacher's device, such as exam answers, or more simple answers to questions put in the classroom at the time of the course [28].

IV. Proposed Approach

In this paper, we propose a novel Revolutionary Interactive Smart Classroom (RISC) which makes use of the most emerging technologies. Figure 1 depicts our proposed classroom in which students interact with the professor using wireless sensors, haptics and wearables.

A. Description of the RISC

Specifically, a data learning system will be settled in a classroom and operated in 5G Wireless Network. This type of network provides limited Internet access to the students and offers great safety of the sensitive personal data that are exchanged during the course. Moreover, in order to achieve the data learning scenario from all the processes and the interactions of the course, a Sensor Surveillance System will be installed. A Surveillance System has the ability to respond to an activity in real-time, by gathering the important information at much higher resolution [13]. The data from the various sensors will be transferred through the 5G network to a Cloud server, where all the valued information will be stored in order to be managed and studied at the end of the course. Thus, all the data stored in the Cloud server can be treated as large-scale data, known as Big Data (BD) [29].

Figure 1. The proposed RISC project.

Essentially, our contribution the "evolution study" that can be accomplished in the education classes by settling the proposed system framework of this work. Through the proposed network, the teacher can be easily connected with the students in an isolated and secure network, where they can interact with each other and exchange information during the course.

More specifically, the objective of this proposal is the achievement of a better environment in the classroom with the use of multiple new technologies, and the ensuring both students and instructors of the ability to be more capable of learning and teaching respectively, more relevant and adaptive educational content through an easier, more fun and accessible way. This project is achieved by establishing direct networking of the teacher with the students' devices and the ability to communicate through a network which is initialized by the teacher at the beginning of the course and closed at the end of the course by him/her.

The proposed educational model will be pilot developed and tested in an experimental lab at the University of Macedonia for first time in Greece by using initially 4G networking in combination with the other emerging technologies, and then the proposed 5G adaption. The reason for this future upgrade is the fact that 5G Network provides higher downlink/uplink data rate (as it is mentioned in the previous Section) compared to 4G one, and a large connection density in a specific area. Furthermore, 5G supports uninterrupted video streaming, simultaneous devices' interoperability, and instant haptics reaction, and thus, it is suitable for our proposed interactive smart classroom. It is notable that 5G also offers low battery consumption, low latency and energy efficiency.

Potential future directions include the release of a demo software version which will provide to the teacher the opportunity to establish a Local Wireless Network and its distribution to other teachers which are interest to adopt our proposed type of Smart Classroom.

B. Methodology & Implementation Plan

The implementation of the proposed RISC will consist of 3 components:

a) A cloud computing Learning Management System (LMS) cloud server that will store real-time the different data of both the users and the sensors they use, from a set of haptic devices and interconnected sensors, over a local wireless network [30, 31].
b) Appropriate data-transfer-application protocols will be designed and implemented.
c) Connected components, such as haptic devices, virtual reality headsets and student sensors, will be located in the proposed class RISC, where tests of protocols and human-machine interoperability will be performed as a single set.

The services that are planned to be tested and implemented as part of this project are:

Virtual Classroom Service: This service will enable students to immerse themselves in an interactive three-dimensional classroom environment from an artificial virtual display through the LMS. Interaction between members of the classroom will be possible with the use of haptic devices.

Augmented Sense Service & Cognitive Service: The expression service will be supportive of the virtual presence-order service. This service will provide real-time through EMG, temperature, and sweating sensors augmented information of the student's mental and psychological state. The use of sensor data, and the application of appropriate artificial intelligence methods, and data mining algorithms, will identify if the student is in the classroom, understands the course delivery, as well as his current perception and interest for the lesson. The service that implements the intelligent algorithms, it is the logging service of student status, and will be provided by the LMS [30, 31].

Position Service: This service will check the student's current position in the virtual classroom, based on a set of Wi-Fi/BLE transceivers (iBeacons) - indoor positioning, and a set of positioning algorithms which will provide accurate positioning of the student in the classroom.

Touch Interaction Service: This service will provide the ability to visualize the touch using gloves fitted, with appropriate analog press force sensors and infrared transceivers. Thus, this service will be used to interact with the class of people with visual impairments as well as to enhance the students' experience through touch.

3D Design and Modeling Service: This service will enable the student to have their own virtual lab where they can design objects using appropriate toolboxes. This service will enable the student through a 3d-scanner to be able to transfer real-world material to the virtual, while using 3D printers to implement virtual-world constructions [31].

Virtual reality recording service: This service will enable the audiovisual recording of the virtual classroom.

Virtual reality on-demand replication service: This service will enable on demand playback, either in the real world of past virtual reality audiovisual material, recording service data, using a 3D projector, or via playback [31].

Student assessment/virtual lesson service: This service will use intelligent algorithms as well as clustering-classification techniques, based on sensor data, to capture virtual classroom virtual information to evaluate students' response and overall performance in the lesson. Moreover, there will be the possibility of evaluating the lessons in terms of their completeness and the satisfaction of the virtual classroom audience [30, 31].

Through the proposed interactive classroom, the teacher will be able to connect and interact through the connected wireless devices (laptops, tablets, mobile phones) of the students and the interconnected sensors on them, via an isolated and secure network. Thus, students will also be able to interact with each other and exchange information during the virtual lesson. The main purpose of this work is to achieve a virtual-class environment, and interact with the real-virtual one, in which multiple interconnected new technologies are safely integrated and the quality of the services involved is ensured with low complexity and cost.

The practical implementation of such an interconnected environment can be achieved by establishing a real-time networking of the teacher with his students' devices. This requires the implementation of appropriate interoperability protocols, either at the application level (for each of the above services separately), or at the level of interoperability of sensor-systems and data transfer in the LMS [30].

The teacher will also have Internet access to the LMS of Virtual Context (LMSVC), where users' data will be stored in real time during the lesson. The LMSVC will be implemented as part of the project, and it will include, in addition to the capabilities of the conventional LMS, virtual components, such as virtual documents, virtual announcements, virtual self-assessment exercises, virtual tasks and questionnaires, forum wiki etc. The services of conventional LMS will be provided offline (no real lesson required), where the student will be connected to the virtual reality headset, and will download documents via his/her personal tablet/computer, connected to the LMSVC outside the narrow confines of the room [31]. The virtual reality headset application and data transfer protocols, and the pilot Android application that will connect the student to the LMSVC will be implemented as part of the project.

V. SUSTAINABILITY IMPACT

The proposed classroom will create sustainability impact in many fields, as follows:

A. Society

The benefits for the society are many. First of all, disable students and generally students with special needs will be able to have access and understand more easily the courses. This opportunity will be also given to students in remote areas who cannot have easy access to the school, and sick students. In addition, children and youths will be attracted to this lab for experimentation, due to the new cutting-edge technologies. Schools and institutions may want to visit this lab, which will be an attraction for all the society.

B. Education

The new smart interactive classroom will offer many advantages in the educational system. The use of the novel educational methods and the emerging technologies will provide better quality of education and more enthusiasm for study which will help to widen pupils' horizons. Moreover, the proposed classroom will attract researchers worldwide for various experiments to discover other unknown futuristic technologies. Our proposed model learning classroom may also have the potentials to become a paradigm for every learning institution of the future.

C. Environment

Our proposed scheme will present sustainability impact in the environmental field too. The courses will need less paper, which means less tree cutting, and therefore provide more oxygen in the atmosphere. Moreover, the courses will need less paper and stationery, which means less trash, and therefore a clearer environment. It is remarkable that according to the "State of the Global Paper Industry Report" in 2018, globally 400 million tonnes of paper production per year and a 26% corresponds to printing/writing.

D. Economics

Although the short-term budget, that is equipment supply, seems to be high, it is expected to be overcome soon, due to potential income from sponsorships, visiting fees and sell of innovative ideas developed within the classroom. In addition, it is fact that the less paper in our scheme means less paper buying, and therefore less economical cost. The project may be supported from potential sponsors from Greece or outside. There might be the opportunity for an institution or a company to use the lab, after some fee pay off, and hence profit for the owner/institution of the lab, which can be invested in other actions (e.g. technological equipment supply).

E. Technology

It is fact that 5G technology will be launched for first time in Greece, and can be adopted by mobile telecommunication companies in combination with the other emerging technologies. Therefore, our proposed lab may be established as a research center, and thus, it could attract researchers worldwide for various tests to discover other unknown futuristic technologies, which may lead to potential equipment upgrading in the long run.

F. Cultural Tourism

According to the United Nations World Tourism Organization (UNWTO), Cultural Tourism is defined as: "the movement of persons to cultural attractions in cities in countries other than their normal place of residence, with the intention to gather new information and experiences to satisfy their cultural needs". The RISC may attract foreign schools and institutions for educational purposes, and thus, it is an excellent chance for them to explore the cultural heritage of Thessaloniki too. It is remarkable that Thessaloniki has a history of more than two thousand years and produces culture. It is very close to historic ancient cities, such as Pella and Vergina, which belong to the wider geographical and historical region of Macedonia in Greece. In addition, Halkidiki, an area close to Thessaloniki City, is a place with many beaches which attract a lot of tourists from all over the world every year, mainly in the summer. This means profits for Greek businesses and stores. The availability of airport, only a few kilometres outside the city centre, known as Thessaloniki International Airport "Macedonia", makes the accessibility to the city of Thessaloniki, easier and faster.

VI. Conclusions and Future Work

A novel Revolutionary Interactive Smart Classroom (RISC) was proposed. This classroom makes use of all the available emerging technologies to offer new capabilities in the conventional educational system. The proposed laboratory class will be developed in an experimental lab at the University of Macedonia. The benefits are expected to be multiple in many fields, such as society, education, environment, economics, technology, and cultural tourism. Future work may include the integration of new educational methods for quicker and more effective learning by using additional sensors for psychometric tests for students and how they contribute in their attention to the lessons.

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