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Domotic Wireless Control for Office Luminaires from a Virtual Tour of Professor´s Area

Oscar H. Salinas, Fernanda Diaz, Ernesto A. Moreno, Miguel Beltrán

***Abstract*— A home automation system (called domotic system) based on a virtual tour of the office professors area into the building one at the Technological University Emiliano Zapata of Morelos was designed and built. The virtual tour of the facility allows the on – off control of the luminaires of professor's offices as well as the hallways and common room. Technological development is novel and innovative due to the integration of virtual reality with the physical world was not founded at literature, at least not integrated with an office luminaries wireless control system, making it unique. Control systems of the luminaires are performed by an Arduino microcontroller with Wi – Fi shield for wireless telecommunication. Virtual tour was designed and built using the Unity software. Proof of concept was performed and demonstrated that it is possible to control any home or office element operating "on" - "off" or intermediate levels from the virtual tour.**

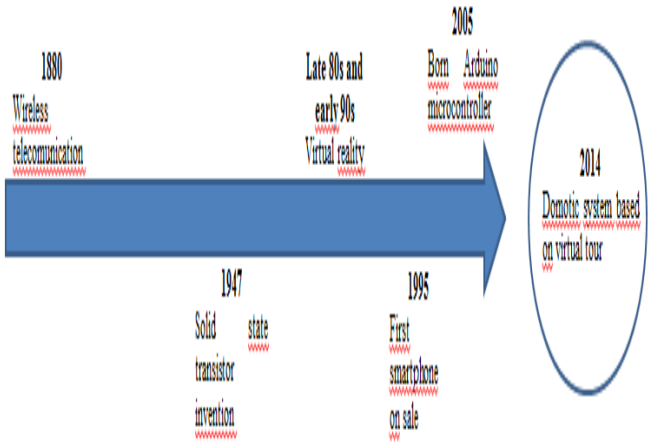
***Index Terms*— Virtual Tour, home automation system, energy saving, indoor security.**

I. INTRODUCTION

Remote control systems have solved various problems related no only with the comfort of the people, but with saving energy, security, difficult access areas, and to help disabled people to do things by themselves. Disabled people in most cases can not carry out the control of electrical controllers in a home or office because not in most cases designed not thinking about them. The manual controls of electrical installations have to be activated once the people are inside or close to facilities. Wireless remote control allows the person can control, switch on the lights for example, being outside the area which adds security to people entering or leaving their work area. Therefore wireless home automation systems cover needs and comfort in addition to providing security to users. The level of technological maturity and growing social and commercial demand, place the electronics industry (computer and telecommunications in this case) as the basis for any technological development or basic research. The current exponential technological revolution that we are experimenting nowadays, have started with the invention of solid-state bipolar junction transistor at 1947, Figure 1 [1]. This is the event that really triggered the continuous and fast developments in Electronics and therefore in computing and telecommunications. All areas of knowledge, scientific or not, have had an important and significant advance through of this historical step forward. J.K. Shi head of mobile Samsung said: "When a technology is introduced habits change. Innovation and people necessities will change at the same time". This is what William Schockley, John Bardeen and Walter Brattain was made at 1947.

Wireless telecommunications are not the same that those in their incipient years, Figure 1, and this is mainly due to the electronics evolution, mentioned above. Wireless communication is used for: low cost telecommunication for long distances and human comfort. Consumer's demands are increasing fast; they want to be able to download music, video and so on anytime, anywhere, using either fix or mobile device. Therefore currently telephone companies must provide two-way communications that include high speed Internet, video and VoIP (Voice over Internet Protocol) or Internet telephony, for instance.

Figure 1: Time line of technologies integrated



Wireless communication and all technologies and applications around them are going to significantly impact the future just as the telephone revolutionized the society when it was invented. Wireless technology is so interesting and is why it has a lot of applications in different fields of knowledge, for instance, there are promising advances about wireless power transfer [2], and its roots can be traced to the work of Nikola Tesla in the early twentieth century [3].

The exponential rise of mobile devices has caused more and more users prefer them instead of desktop computers. For example, to have the first 1000 million mobile subscribers passed 20 years, and only 15 months to get the other 1 billion. CISCO company predicted that this year 2015 will have the same number of mobile phones that human beings on the

Oscar H. Salinas, Information Technologies and Communication Academic Division, Technological University Emiliano Zapata of Morelos State/ Emiliano Zapata, Mexico, 52 777 3681165/ Professor at Faculty of Chemical Sciences and Engineering : Electrical Engineering, Universidad Autónoma del Estado de Morelos (FCQeI – UAEM).

María Díaz, Information Technologies and Communication Academic Division, Technological University Emiliano Zapata of Morelos State/ Emiliano Zapata, Mexico, 52 777 3681165

Miguel Beltrán, Industrial and Mechanic Academic Division, Technological University Emiliano Zapata of Morelos State/ Emiliano Zapata, Mexico, 52 777 3681165

Ernesto A. Moreno, Information Technologies and Communication Academic Division, Technological University Emiliano Zapata of Morelos State/ Emiliano Zapata, Mexico, 52 777 3681165/

planet, and by 2020 there will be around 50 000 million of mobile devices users connected to the network, an average of three for each human being [4]. Also there is the growth of the so-called App Economy, which is of 1 000 million smartphone users. This is an economy that generated 20 000 million of United States dollars at year 2011 [4]. Therefore is very important to keep in mind this data, when every technological development, actually every kind of product, is going to be developed to be innovative and launch to the market. Referring again to Shi, Steve Jobs changed people necessities and their habits when he introduced the iPod into the electronic market at year 2001, all electronic world has been changing to be compatible with the iPod. The fact that the proposed technological development presented in this work can be used from mobile devices is an interesting value added, both technological and marketing points of view.

Virtual Reality (VR) is a way for humans to visualize, manipulate and interact with computers and extremely complex data [5]. It is able to immerse people into a world generated by computers that could be: a room, a house, a building, a city, the interior of human body, a non visited planet, deep into the ocean and so on. It means people are able to visit and actually explore any uncharted place of the human imagination. VR roots can be traced to 1950 about the work of US Air Force [5]. However its commercial development began at 1988. Virtual tour is an interesting and commercial application of VR, and it is part of the Immersive VR type. The novel concept and technological innovation of this research lie on the integration of old and current technologies, Figure 1, in a unique technological development. A successful example of the integration of technologies into a new development is that done by Johann Gutenberg, when he invented the printing press he found an interesting similarity between the print fabrics and coinage.

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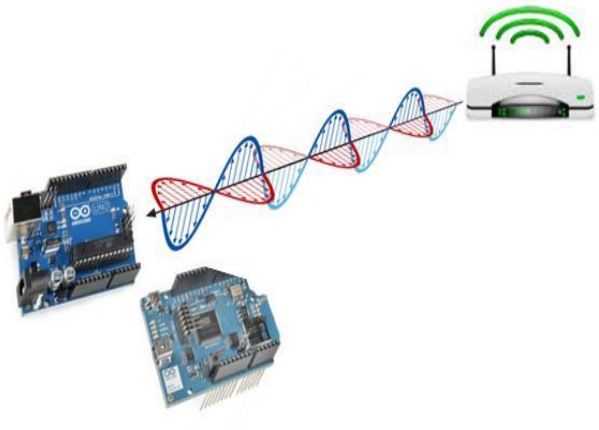
II. Theoretical Perspective

A. *Technical view*

In this work wireless Telecommunication is performed by an Arduino one with Wi – Fi shield and one Access Point (AP), which may be the current network of the university or one placed specifically for technology development, Figure 2. Here the formal definitions (IEEE Standard, 2012):

- The Wi-Fi Alliance defines Wi-Fi as any "wireless local area network" (WLAN) product based on the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards".
- Access point (AP): An entity that contains one station (STA) and provides access to the distribution services, via the wireless medium (WM) for associated STAs.
- Access point (AP) path: Path between two Tunnelled direct-link setup (TDLS) peer stations (STAs) via the AP with which the STAs are currently associated.

Figure 2: Wireless communication using IEEE Standard 802.11b/g



Arduino Wi – Fi shield works under 802.11b/g networks [6], it works at 2.4 GHz either with 22 or 20 MHz of Bandwidth. This frequency belongs to Industrial Scientific and Medical (ISM) band, Bluetooth and HomeRF technologies work with ISM also [7]–[8]. IEEE 802.11b standard are part of the most generally used for Local Area Networks (LAN) products working in the ISM bands. To use the communication channel in an optimum and safety way Direct Sequence Spread Spectrum (DSSS), 802.11b/g, and Orthogonal Frequency Division Multiplexing (OFDM) [9], 802.11g spreading and multiplexing respectively are applied. DSSS and OFDM are used to spread the bandwidth in a safety way for commercial applications including 4G mobile communications for many reasons: increasing protection to natural noise and jamming, to limit power flux and to prevent detection, and so on. Arduino Wi – Fi shield uses the Wired Equivalent Privacy (WEP) and Wi – Fi Protected Access 2 (WAP2) encryption types. The second one used to protect better the information, however nowadays both are vulnerable [10].

Currently high level of computer graphics is needed to support versatile used in many domains of our life. Currently is difficult to think about any professional performing its work without the help of a power graphic computer. Games, virtual tours, imaging processing, virtual instruments programming, buildings profiles, film industry, and so on, have had a great advance base on the high level of data processing. High level of data processing needs faster and faster microprocessors, and the speed of them rely on the scale of integration for Integrated Circuits (IC). At 1965 Gordon Moore established a law that can be regarded as prophecy saying that level of integration of transistors in an integrated circuit would double every two years [11]. Each increase in level on the scale of integration implies some interesting things, such as reducing the area occupied by each transistor; the voltage level is lower, so it has lower energy consumption. Double scaling of transistor integration implies having 40 percent more processing of information with the same power consumption [12]. It brings to the market computing equipment faster and faster every year. This has better and faster graphics boards and their prices fall down rapidly. Virtual reality is one example of taking advantage of this exponential pace. Unity 3D is a licences software used to export or import the modelled 3D structures of any kind of type and material. Models are converted into a software format called “FBX”

which can be interpreted by the game engine. For interactivity travel is necessary, make instruction blocks of JavaScript code, then coding example shown in JavaScript for Unity 3D that allows you to move objects [13].

Java [14] is a programming language that allows the development of applications for both fixed and mobile devices. Android is a kernel-based Linux operating system designed primarily for touch screen mobile devices such as smartphones or electronic tablets [15]. Java and Android are compatible software therefore applications that are designed and done in Java can be tested and deployed to mobile or fixed devices using Android Operative System. Android Operative System [15] are the most open source one used to design and develop mobile devices application. It have been used to develop different kind of applications due to it is free, is not so complicated to program and very friendly user interface can be designed [16]–[17]. The interface can be developed either using a simulator or real devices. Programming is performed with Android Application Programming Interface (API), which has diverse icons to design user visual interfaces, providing a rich ground of options for programmers of visual user interfaces.

B. Hypothesis approach

Since VR is a very attractive software development because people actually can visit places without moving from their place; Arduino is an open source microcontroller with a big variety of applications and easy to use and program; And mobile devices are currently the most used electronic gadget because of their usability, the following hypothesis can be wrote:

Hypothesis: A domotic wireless system based on virtual tour can be designed using open source hardware and software to be controlled by fixed or mobile computing equipment or electronic mobile devices.

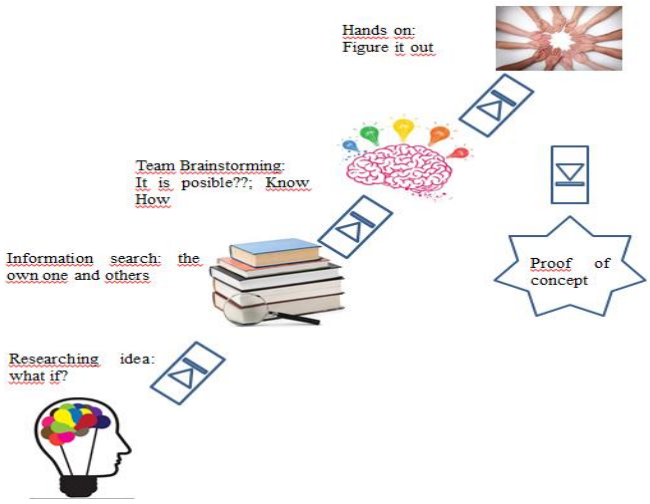
C. Methodology

Researching process to build a prototype of this technological development is very simple, Figure 2. The researching idea [18] was: What if the luminaries wireless control system is controlled from the virtual tour? A three-research professor's team was formed to figure it out the way if this is possible. A group of students joined the team for the fieldwork, students are from technological areas: multimedia and e-commerce; networking and telecommunications; and software development.

Search for similar technological developments in the databases was conducted by Google scholar [19], and free access databases provided by the "Consorcio Nacional de Recursos de Información Cientifica y Tecnológica (CONRICYT)": EBSCO and GALE Cengage Learning [20]. No similar technological developments were found reported in these databases. The novelty is not either the virtual tour or domotic system by themselves, but the integration of technologies for wireless control of physical facilities from virtual facilities using fixed or mobile devices.

The next steps of the process of research and development are well illustrated in Figure 3. Team brainstorming is a good practice to bring together ideas with different point of view [21]. The members of the core team come together and share knowledge, concerns, suggestions, needs, ie they identify the weaknesses and strengths of the team for the project. Besides executing the main tasks are defined and these are allocated in this exercise all stakeholders are also identified in the project, and other potential members who can contribute to the successful development of the project.

Figure 3: Time line of integrated technologies.



Hands on means running the technological solutions proposed. Each task is performed with the goal to acquire knowledge and develop every part of it. It is not a trial and error exercise, but rather is to implement the ideas and testing them, making the necessary adjustment at every stage. In this team members face and solve technical and administrative issues that were not covered by brainstorming.

Technological solutions were put together to shape the prototype of technological development. This is the proof of concept of the integration of different technologies in an integrated engineering solution. The proof of concept prototype is part of the final stage of development of the prototype, and based on the success of this stage it is also the beginning of the installation of the system in the offices of professor´s area.

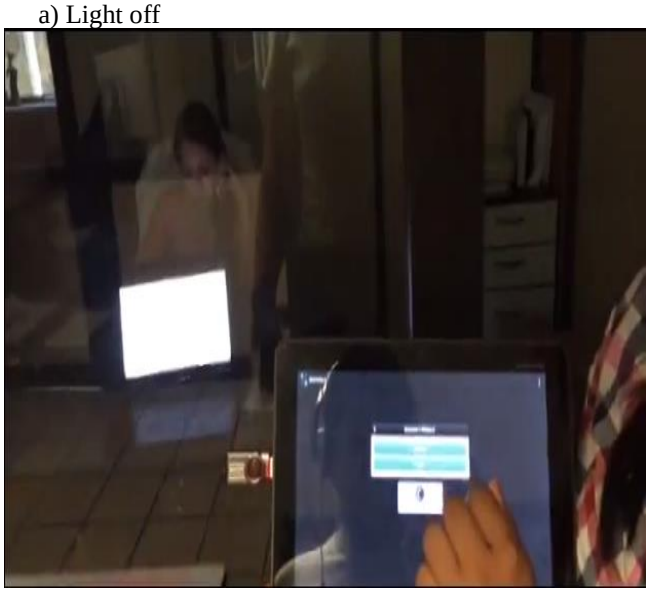
III. RESULTS

Proposed prototype is working successfully; the proof of the concept was performed and the results are according with the expectation. The proof of concept was done not in the home automation system already installed at offices area, but an emulator of real electrical installations, with a lamp, a fan, the switching on and off of these is made with three-way switches, one way for manual control and other for mobile device control [22]. At this phase the virtual tour of the offices area is designed to be displayed by mobile devices, with Android operative system; however the proof of concept of the proposed technological development was performed using one version for computer equipment, either laptop or fixed; iOS or Windows operative system [23]. Previous of this researching work, a wireless domotic system based on Android mobile devices was developed and installed at specific area of building number one of UTEZ [23]. The visual interface to be used was designed for any cellular phone with Android onwards 2.1 versions. Some problems

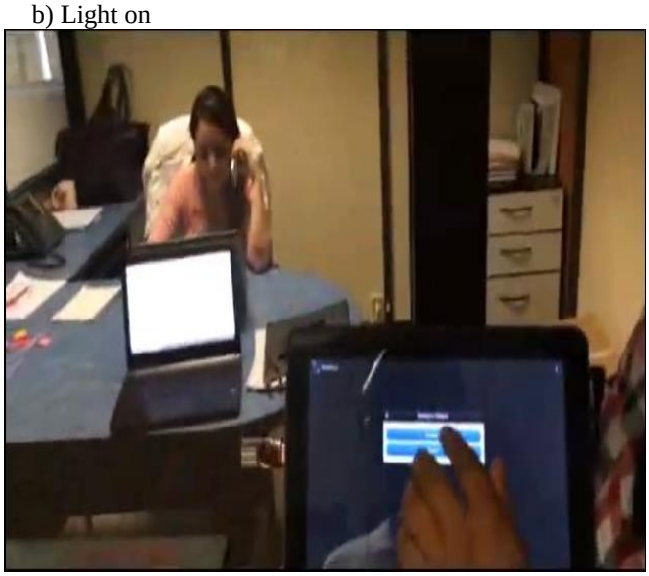
were faced about the communication between Arduino Wi – Fi shield, Android device and AP, most of them are related coupling open source and license software. Some of them were fixed with programming skills about software platform or network hardware [22]. Domotic system was designed and installed to control the office luminaries at professors area, which is located at building number one and belongs to División Académica de Tecnologías de la Información y la Comunicación (DATIC). Control is done using mobile devices with Android operative system [15]. Figure 4. A very simple to use visual interface was designed to control the on and off state for the luminary using a touch screen tablet mobile device, Figure 4 a) and b). A general user and particular user interface were designed. The purpose of this is to have one for each professor, the one that can control its own office, and a general interface to have a master control over all areas connected to the system [24].

Figure 4: Domotic system working with a tablet

a) Light off



b) Light on



Besides to the wireless domotic system, a virtual tour of university campus was previously designed and built [13]. Figure 5 shows an internal view of Virtual Tour of building number one from a computing equipment, Figure 5 a), and for mobile device, Figure 5b). In the middle of the pictures an on off slide bar can be watched. This is the one that act as a virtual switch; this is the virtual element to control both, virtual and physical office lighting.

Figure 5: Internal virtual view of building number one.

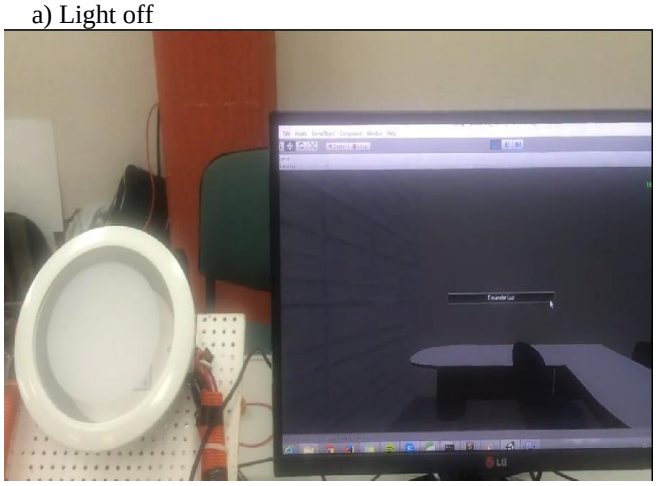
a) Virtual Tour view from a fixed computing equipment

b) Virtual Tour view from a mobile device

The first communication and control tests were made with a LED diode, a breadboard and Arduino one working with wired connection, it means no Wi – Fi shield was used at this step. This was done to implement the interaction of virtual electrical switches with an external light element to the virtual tour. At this step must prove that at the time of actuating the virtual switch two things must happen: starting of virtual animation lighting inside the virtual tour and at the same time the LED lights. The next step is relatively simple, is just plug in the current electrical circuit [22] with this new interface to get the novel tool. A prototype that emulates the behavior of an electrical installation, previously constructed, was used to demonstrate that the technological innovation proposed really works, Figure 6 a) and 6 b).

Figure 6: Prototype of domotic and virtual tour.

a) Light off



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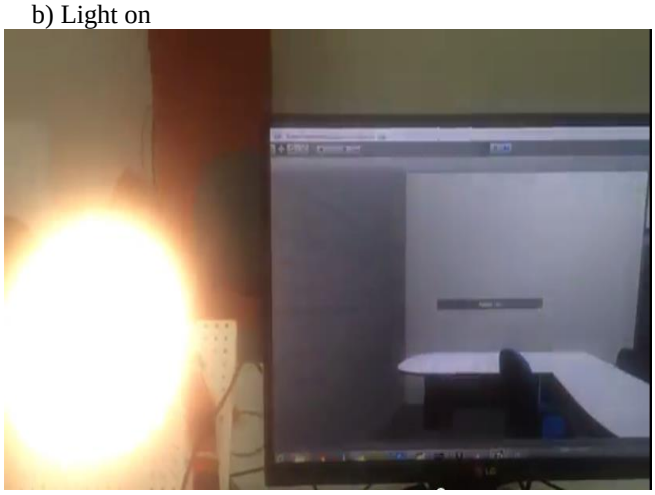

Virtual Tour of Using a mobile device user is going to be able to control luminary on and off state. User cans observe the same action in both the virtual and the physical world.

IV. Conclusion

The integration of different tools has to do with the paradigms used as metaphors analogies. The analogy is one of the most important instruments of human knowledge.

Innovative and creative tools can be developed based on Hardware and Software open sources tools. In this case domotic wireless control system had been integrated into a virtual tour, using Arduino.

The usefulness of mobile devices is increasing day by day due to the development of creative and useful applications. Therefore it is important for designers of any kind of creative or novel product, take this into account, because there are going to be more mobile devices than humans in earth planet by 2020.

Work of multidisciplinaries teams produce smart and integral solutions for an specific issue or for improvement opportunities. The integration of different knowledge areas inside of a coordinate and management project is a favorable scenario for useful products and quality work.

Future work is to move from the prototype stage, designing the interface for mobile devices, in which the virtual tour is used to control the ligths already included in the previous technological development. Once this is done, the plan must implement the system in other areas of university building one. The control of any appliance or device that has "on – off" performance can be aggregate to the system, for instance the electronic doors locks or air conditioning, thinking about office area.

Acknowledgment

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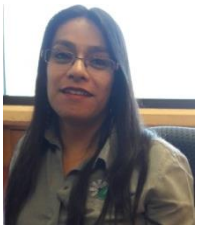
Oscar H. Salinas. He received the B.S. degree at Escuela Superior de Ingeniería Meánica y Eléctrica del Instituto Politécnico Nacional (ESIME – IPN) in 1998, in Mexico city. He received the M.S. In electrical engineering, area physics of solid state at the department of electrical engineering of the Centro de Investigación y Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV – IPN), In 1998 in Mexico city, and his Doctor en Engineering at Centro de Investigación en Energía of the Universidad Nacional Autónoma de México (CIE – UNAM) In 2007, in Temixco, Morelos, Mexico. He made a postdoctoral work at the department of electrical engineering of the CINVESTAV – IPN in 2008, in Mexico city, working as researcher assistant at the department of materials of physics of solid state area, developing solar cells based on fullerene and polymers. He worked as device engineer at Motorola de México, planta Guadalajara, from 1998 to 2006. During this time he was part of the team to transfer to wafer fabs: rectifiers fab from Arizona USA to Guadalajara Mexico, in 2000; Guadalajara wafer thyristors and rectfiiers fab from Guadalajara, Mexico to Keelung, Taiwan in 2002. He is an IEEE member since 1996. He has been working as a researcher professor at Technical University of Emiliano Zapata of Morelos State (UTEZ) and Autonomous University of Morelos State (UAEM), in the area of Information Technology and Electrical Engineering respectively, since 2003 to now. He was the leader of the team what won the State energy saving award in 2015, for UTEZ. Currently is working about sustainability, in building energy saving, solar cells design and build, wireless networks, and innovation on education techniques.



M. Fernanda Díaz. She received the B.S. in Electronics and Communications Engineer at the Instituto Politécnico Nacional in 2003, in Mexico City. She received the M.S.in Engineering and Applied Sciences, area electrical technology of the Centro de Investigación en Ingeniería y Ciencias Aplicadas de la Universidad Autónoma del Estado de Morelos (CIICAp – UAEM), in 2006 in Cuernavaca, Morelos, Mexico, and his Doctor in Engineering and Applied Sciences of the Centro de Investigación en Ingeniería y Ciencias Aplicadas de la Universidad Autónoma del Estado de Morelos (CIICAp – UAEM), in 2010, in Cuernavaca, Morelos, Mexico. She worked in the Secretaría de Comunicaciones y Transportes (SCT) of the state of Morelos, as a monitor of the frequency spectrum from 2001 to 2002. She was a professor at the TecMilenio University, in Cuernavaca, Morelos, Mexico, in the engineering area, from 2012 to 2015. Since 2015, she has been working as a researcher professor at Technical University of Emiliano Zapata of Morelos State (UTEZ) in the area of Information Technology. Currently she is working on the development and implementation of a Grid Computing along with the Universidad Autónoma del Estado de Morelos (UAEM) that aims to transfer knowledge and application of Converged Network Technologies through the implementation of computer security mechanism.

Ernesto Adán Moreno. Currently, I am a full time professor at UTEZ Technological University Emiliano Zapata in Morelos State, working in the Digital Design Animation area TSU. Some of my activities are to generate Human Resources, leading Staying Projects and Research Projects. I am a founder of the responsive Web Portal at UTEZ; I have collaborated in the creation of new careers, some of these are online and other in an open system at the University, in addition I developed the curriculum for those. I was recognized by the State System of Researchers in 2014. Some of the articles I have published are Virtual Tour at UTEZ facilities for NOUITZ magazine and projects about Virtual Reality, such as Domatic System which helps to turn on and off lights, this system has led UTEZ to obtain the State Energy Saving Award.

Miguel Beltrán. He received the Master of Science degree in Electronic Engineering from the Centro Nacional de Investigación y Desarrollo Tecnológico (CENIDET) in 2011, in Cuernavaca city. He received the B.S. degree in Electromechanics Engineering by the Instituto Tecnológico de Zacatepec (ITZ) in 2006, in Zacatepec Morelos México. In the last five years he has been a full-time professor in the Universidad Tecnológica Emiliano Zapata del Estado de Morelos. He has participated in projects focused on the control and automation of dynamic systems, He has participated in projects focused on the control and automation of dynamic systems, he has also taken trainings and courses focused on the management of software tools such as LabVIEW and visual programming as well as the management of control and monitoring systems with equipment of the brand National Instruments, SIEMENS, ALLEN BRADLEY, among others. He is currently performing teaching activities as well as the direction of robotics and control projects at UTEZ. Teaching activities have been carried out since 2010, teaching mechatronics and information technology, among which we can mention control systems, electronics, virtual instrumentation, linear systems, mathematics for mechatronics engineering, among others.