Towards an Integration of "SmartHome" Technology in Education: Realization of a didactic platform

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***Abstract*—With the emergence of smart technologies, home automation becomes one of the most interesting fields. In this context, an educational platform of a smart home featured with a multi-sensors system and actuators is proposed along with all realization steps. The platform is resulted from didactic applications intended for higher education students. Configured functionalities and operation modes are explicitly presented in order to satisfy household requirements which are essentially home automation, energy management, comfort and safe access to the house. In this paper, sensors technology, embedded electronics tools and remotely communication modules are exploited to reach to these requirements.**

***Index Terms*—Smart home, didactic platform, Sensors, Data acquisition, Arduino, Experimental environments.**

I. Introduction

Recently, developed researches and studies are increasingly focusing on artificial intelligence, advanced technologies and smart systems. "Smart home" is considered one of the most promoting project in the last few years. The appearance of such technology came from the need to facilitate human quality of living and guaranty his comfort and security. It deals essentially with safe and remote control, home automation and energy management [8] [14].

Today, it becomes possible that a human interacts with his house and succeeds to network all household equipments and appliances to a unique central unit [5]. Furthermore, these applications can be monitored and controlled directly or remotely based on smart communication technologies which create the concept of the intelligent house. Indeed, the smart home integrates an electronic hardware platform that contains sensors, actuators, programming tools and devices communicating together and forming a smart automatic system. The automation level of any system depends on the type of used network method which has known a revolution through time [9]. In fact, two types of smart home networks can be distinguished: the wired and the wireless ones.

- In case of wired network, equipments are connected through wires like twisted pair or optical fiber directly to the power supply.
- In the other hand, wireless network is based on wireless communication protocols like bluetooth, radio frequency or Wifi, Zigbee or Laura to send and receive data and decisions [11].

Indeed, a smart home project regroups a variety of technologies and disciplines worthy of study and exploitation. Thus, it came the idea to design, realize and control a smart home platform for educational purposes [1] [3]. The didactic system will includes many applications and ensures their monitoring and control in an intelligent way.

The rapid development of new technologies in fields related to electronics and automation requires subsequently innovation in educational learning methods such as the Problem-Based Learning (PBL). This method proved its efficiency as it consists essentially on offering to the student the opportunity of learning by practice and discussion. The student's involvement with this type of methodology can ensure a high level of assimilation [4].

The rest of the paper is divided as follows: In section 2, the methodology of realizing such educational platform is presented proving the important role of applied technology in the educational field. Section 3 consists on a detailed description of the didactic platform where developed applications, chosen sensors, actuators and programming features for the platform are illustrated. In addition, the operating modes and functions utility are defined. In section 4, the resulted design of the didactic platform is given as well as a list of all components needed for the realization. Finally, conclusions are given as well as suggested future work.

II. METHODOLOGY

Increasing digitalisation and automation of all business sectors necessary requires a rethink of training requirements. In this context, this project was carried out within the Higher Institute of Industrial Management as part of a graduation project for students in the third year of applied license in automation, electronics and electrical engineering. The design of this model aims to prepare a platform for interactive

learning courses that combine didactic study and practice with practical tools which allows students to learns new methods and enlarge their capacities.

The first phase of the realization of this platform was inspired from literature reviews and a study of lifestyle needs [7] [10] [13] [15]. It consists essentially on recognition of the requirements of a smart house in terms of energy management, security and comfort. This step allowed us to develop different scenarios that meet the desired requirements. Therefore, the second phase consists of fixing the list of home automation applications in terms of programming card, communication module, sensors and actuators. The third step is to design a plan of a house's prototype that contains all the predefined functionalities as well as the realization and implementation of all components. Finally, the last phase is the implementation of developed programs which provide the desired comfort in this smart home and validation of the required operation.

In order to fulfill a solid link of home automation and embedded knowledge in the teaching process, experimental platforms, sensors and actuators systems and programming tools should be offered to the student. Within this purpose, the realization of "smart home" project offers to the user a rich and polyvalent academic training and prepares new graduates to be integrated into the modern industrial field which integrates new technologies.

Those resources will ensure realistic applications of the household and thus develop their skills appropriately, involving the use of actuators and sensors for these solutions. Approaches like energy consumption minimization and remote control will be subsequently mastered.

III. Description of the didactic platform of the smart home

A. Presentation of the platform functions

The technology of smart home opens multiple possibilities in the field of home automation. It offers to the user means and privileges to control and manage his living environment. The user himself will be able to fix his own terms of comfort, safety and communication mode.

The realization of this model is in order to guarantee a versatile and enriching training and to prepare new graduates to integrate into the modern industrial environment which integrates new technologies.

This paper deals with designing and controlling of a didactic smart home model through implementation of home automation applications. Treated applications are essentially:

- Lighting management
- Access control to the house and the garage
- Air conditioning and heating management
- Management of alarms and alerts in real time: temperature alert, gas alert and smoke alert
- Management of opening and closing of window shutters
- Management of irrigation system
- Fire and gas leak detection

B. Sensors system

The smart house platform is controlled by the central which receives all delivered information from installed sensors and then sends the appropriate actions to actuators.

1) Safe opening of the main door: In order to open the main door of the house, an identification step is required to allow to the user to get into the house. When the owner is present in front of the main door he must type his code using a TFT tactile display-Keyboard module. In addition, he can order the opening of the door for another person who must imperatively be present in front of it by sending a SMS message. This scenario helps to avoid sharing the access code and hence the need to change it each time.

2) Lighting function: A presence detector is used to control the light in front of the house door. This function helps to economize the electric energy and facilitates the entry to the house.

3) Cooling and heating functions: Inside the house, a temperature sensor is placed to measure the ambient temperature value. Compared to adjusted values, the control central proceeds to activate the ventilation system to cool the space or the radiator to heat it. Both cooling and heating systems are remotely turn on if a Short Message Service (SMS) is received by the GSM module. Besides temperature, the used sensor DHT22-AM230x measures also the humidity value of the room. Both values are then displayed by the dashboard to be monitored by the user.

4) Opening of the garage door: The garage door can be controlled whether if a SMS message has been sent to the control central and by presence of the car in front of the house. The garage door will be automatically closed only after making sure of the car passage by the infrared sensor.

5) Detecting gas and emitting alarm: Gas leak is one of the most common kitchen accidents that a user can encounter and which could lead to a fire. Subsequently, a gas detector is placed to avoid catastrophic outcomes. In this case, the kitchen window will be instantly opened, an alarm sound is then emitted and a SMS message is sent to the owner.

6) Measuring humidity and irrigating the garden: To avoid any water profusion and maintain the garden grass, irrigation has to be programmed. A sensor measures the humidity outside the house. In case of necessity, the irrigation system will start for a fixed period in significant times of the day. The used water in a tank is equally controlled by a level sensor.

C. Actuators system

To ensure the automation of the smart home platform, different types of actuators are needed. Each actuator must translate decisions made by the control module that are convenient to the operating mode or defined function. Some actuators are directly connected to the programming card and other ones are linked to shields or relays. Both of garage and front doors are opened by DC motors, a stepper motor is used for the patio door, the kitchen window is also controlled by a DC motor. The ventilation and heating systems are controlled by a fan

and a radiator via relay cards and the irrigation system runs using an electro valve.

D. Programming module

The Arduino Mega 2560 module is used to control the smart home platform. Arduino is an open source microcontroller integrating the microprocessor Atmega328p. It is programmed to perform the monitoring of the house states, sensors information and then making decisions and control household appliances by producing electrical signals. The most advantage of the Arduino card is its compatibility with many shields. A shield is a different type of module that connects to an Arduino card to increase its functionality like Ethernet, GPS, L 298, GSM, Wifi...

E. Platform control system

During its operating mode, all data sensors of the didactic platform are gathered and exploited in real time by the control board. The user will be able to control remotely the house states whether inside it by selecting the preferred options from the dashboard or even in case of absence via a Global System for Mobile communication module (GSM). Four modes of the operation system have been suggested in order to facilitate the home automation routine for the user. The defined modes are:

- Winter mode
- Summer mode
- Automatic mode
- Configuration mode

Our system consists of a home automation control unit which manages the other units which will have to be controlled remotely. The home automation control unit is connected to the GSM SIM900 module to ensure that the system works for all four modes as follows:

1) Winter mode: If the winter mode is activated by an text message or directly via the keyboard, the system controls the various related actuators according to a defined scenario and its parameters cannot be modified by the user. The heating function is considered when reaching a fixed temperature value. In addition, irrigation is triggered for 30 minutes.

2) Summer mode: Once the summer mode is activated, the cooler will be activated when the limit temperature is reached. Irrigation also starts in a specific time for a period of 60 minutes.

3) Automatic mode: The automatic mode can be selected for moderated seasons (spring and autumn). The control panel compares the measured temperature value to new limit values and activates the appropriate options to managing the temperature and irrigation process.

4) Configuration mode: This mode offers to the user the chance to navigate between options and configure them according to his preferences using the touch screen. There are other features that are not particularly related to a predefined mode but the user activates them freely in the configuration mode as opening doors and windows, triggering alarms, detecting water level ...

Figure 1 describes the layout of the operation mode of the platform.

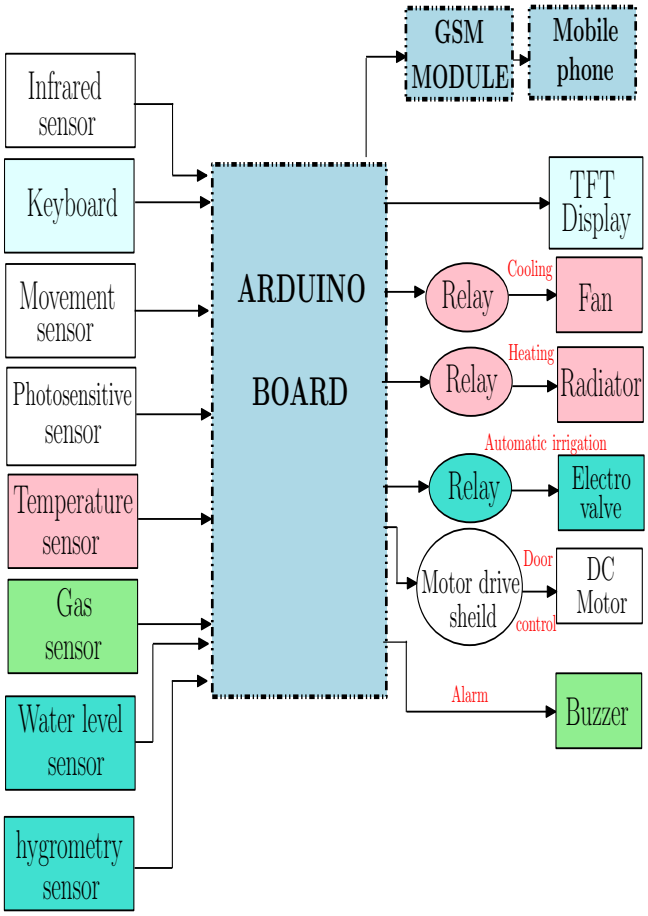

Fig. 1. Architecture of the smart home platform

IV. Realization of the didactic platform

A. Design of the didactic platform

The prototype of the didactic dashboard has been designed with dimension of 50x50 cm and composed of 4 units each has a different functionality.

- The first unit is a living room: in this unit, the air conditioning system is installed which includes a DHT22 sensor with a 12v fan for air conditioning and a 12v radiator for heating. In this room, a patio−door mechanism is also active as it is controlled remotely by the user.
- The second unit is the kitchen: for this unit, a gas detection system is configured which includes an MQ−2 sensor. In case of gas leak detection, the kitchen window should be opened and a 5v buzzer for the audible alert is activated.
- The third unit is the garage: an infrared sensor in this unit is integrated to capture the exit and the entry of the car to perform the automatic closing and opening of the door. In addition to this condition, the opening of the garage door should be ordered by SMS.

- The fourth unit is the garden: for this unit, an automatic irrigation system is installed. This system includes a soil hygrometry sensor, a water level sensor for the tank, and an electro-valve.

Outside the platform, a motion detection sensor has been installed to manage the lighting functionality when a person is present.

The advantage of the design phase is the fact that it permits to define and fix the location of all elements of the smart home model. Subsequently, testing and validating various sensors and actuators become possible as well as adding other functionalities to the system.

In figure 2, the developed design for the platform using the 3D modeling software SolidWorks is presented.

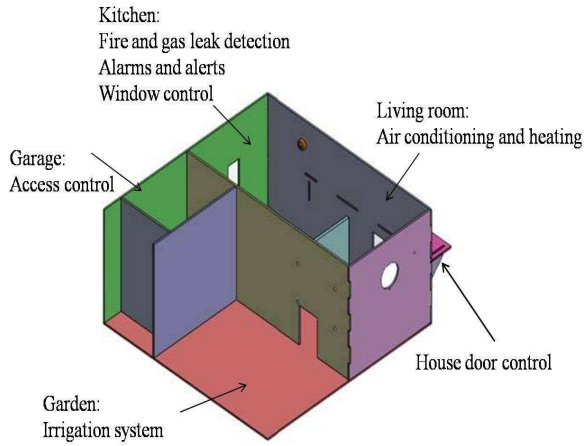

Fig. 2. 3D design of the smart home platform

Thereafter, all parts of this prototype are manufactured with the CNC machine. After the assembly of all elements as well as the wiring of all electrical components, the final appearance of home automation system is presented by Fig. 3.

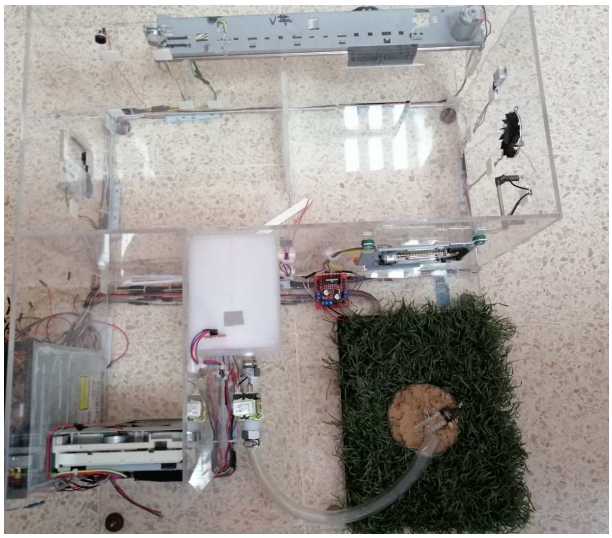

Fig. 3. Final smart home platform

B. Experimental realization

In order to realize the smart home didactic platform, electronic components, communication modules and programming cards have been chosen to fulfill all predefined tasks.

In TABLE I, the list of used sensors, actuators and control modules are mentioned with a description of each one's purpose.

TABLE I
SMART HOME DIDACTIC PLATFORM COMPONENTS

Hardware	**Role**
Arduino Mega 2560	Data acquisition and control
GSM Module Sim900	Receiving and sending messages
TFT display 2.8inch	Display of the platform states
Relay module HL-52S	Control of the platform actuators
Movement sensor HC-SR501 PIR	Detection of movement
Motors Drive Shield L293D	Control of DC motors
Photosensitive sensor	Detection of light intensity
Infrared sensor	Control of car presence
Gas sensor MQ-2	Detection of gas and smoke
Water level sensor	Measures the water level
Soil hygrometry sensor	Detects the humidity level
Electro valve	Ensures the automatic irrigation
Keyboard 4x4	Identification of the user
Temperature sensor DHT22	Measuring the temperature
RTC Module Ds1307	Setting the operational mode time
Fan	Accomplish the cooling mode
Radiator	Accomplish the heating mode
Buzzer 5v	Emits alarm sound

Figure 4 shows the result of the smart home control system. The user is asked to choose the preferred mode. He is also able to monitor all sensors data and states of all the system.Experimental tests on the didactic platform have been performed successfully.

Fig. 4. Resulted menu on the screen of the control panel

V. Conclusions

In this paper, we have come to explicit the realization steps of a smart home platform based on electronic and embedded features allowing the user a full automation performance. The designed and developed model was intended for academical applications in order to reinforce applied electronics and programming knowledge for higher education students. The main result of this project is an operational domotic board. The development of the smart home prototype presents an academic contribution on the educational level. Indeed, it presents to the students an opportunity to master and practice the software and hardware tools which make it possible to solve problems of automation and technology management. The main advantage of such didactic platform that it is compatible with many recent applications especially the integration of the Internet of Things IoT technology in the step of data acquisition which is considered as the next information revolution [2] [12].

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