Article **Journal Architecture and Design**
June 2022, Vol.6 No.15 32-39

Implementation of a home automation system to automate the functions of a community centre due to the sanitary measures implemented by the COVID-19 pandemic

Implementación de un sistema domótico para automatizar las funciones de un centro comunitario debido a las medidas sanitarias implementadas por la pandemia del COVID-19

ECHANDI-PACHECO, Rodolfo*†

Universidad Fidélitas, San José, Costa Rica.

ID 1st Author: *Rodolfo, Echandi-Pacheco* / **ORC ID:** 0000-0001-6807-0679

DOI: 10.35429/JAD.2022.15.6.32.39 Received January 25, 2022; Accepted June 30, 2022

Abstract

Current technology has led to solutions that seem taken from science fiction, cars with semi-automatic pilots, traffic lights with sensors to control traffic jams and one of the most important and the main focus of this article, the automation of buildings and homes for the management and monitoring of general services. This automation is called home automation and it offers many facilities to manage buildings remotely or automatically, which currently helps a lot with the global pandemic of COVID-19. This project is aimed at the implementation of a home automation system in a community center in Tres Ríos, La Unión, Cartago, which would facilitate and help restore the normal operation of said center. The system will turn the lights on and off, control the temperature, measure distance and verify gas or smoke leaks in order to facilitate management and help maintain the sanitary protocols required by law for the normal operation of the center.

Computing, Home automation, Arduino, Automation, COVID-19

Resumen

La tecnología actual ha permitido llegar a soluciones que parecen sacadas de la ciencia ficción, automóviles con pilotos semiautomáticos, semáforos con sensores para controlar los atascos y uno de los más importantes y el foco principal de este artículo, la automatización de edificios y viviendas para la gestión y monitorización de los servicios generales. Esta automatización se denomina domótica y la misma ofrece muchas facilidades para gestionar edificios de forma remota o automática, lo cual puede ayudar mucho en diversos casos como por ejemplo en la pandemia mundial de COVID-19. Este proyecto se orienta a la implementación de un sistema domótico en un centro comunitario en Tres Ríos, La Unión, Cartago, Costa Rica, con el fin de facilitar y ayudar a restablecer el funcionamiento normal de dicho centro. El sistema encenderá y apagará las luces, controlará la temperatura, medirá distanciamiento y verificará fugas de gas o humo para de esa forma facilitar la gestión y ayudar a mantener los protocolos sanitarios exigidos por la ley para el funcionamiento normal del centro.

Computación, Domótica, Arduino, Automatización, COVID-19

Citation: ECHANDI-PACHECO, Rodolfo. Implementation of a home automation system to automate the functions of a community centre due to the sanitary measures implemented by the COVID-19 pandemic. Journal Architecture and Design. 2022. 6-15:32-39.

* Correspondence to Author (E-mail: rechandi@ufidelitas.ac.cr)
† Researcher contributing as first author.

Introduction

The technological revolution that the world has been experiencing over the last 50 years has impacted every facet of human beings' daily lives, according to Schwab (2016) in his book The Fourth Industrial Revolution. After the marked development of electronics, starting in the 1960s, as well as the development of new technologies oriented towards communications and applied to life, a change has been generated in the majority of people living in a globalised environment, where connectivity plays a predominant role and even the simplest element such as a mobile device functions as a mechanism of transition to the dynamics of global interconnectivity.

Because of this, in recent years society has been undergoing one of its greatest economic and social revolutions, which focuses on information and connectivity as elements of development; sociologist Alvin Toffler (1979) calls it the Third Wave, other authors call it the communications age or the information revolution and it is proving to be a complex phenomenon in constant evolution. These changes introduce a technification of society and, in particular, the use of computers to transmit and process data.

The transformation of traditional homes into smart homes, through the incorporation of certain tools, transcends the limits of comfort towards efficiency and environmental sustainability. The aforementioned is known as home automation and according to Sánchez (2017) it is understood as the automation of as many systems as can be found in a home, relating them to each other, with specific technological products for this purpose. Now, it is important to mention that the automation of environments was considered for many years a technological vanity within the reach of the most privileged groups of society, but nowadays its massive use is the reason for multiple investigations such as the use of robots that clean the house, attend to sick people or simply automatically notify the authorities when there is an emergency in the home.

The applicability of this project is aimed at the automation of a community centre in processes such as: temperature control, smoke control and social distancing control; this in order to help control the health measures implemented due to the COVID-19 pandemic. It seeks to limit human involvement in the management of the venue in order to provide a safer environment for attendees. This research also represents a significant advance in terms of the appropriation of new technologies from a current perspective, opening the possibility of strengthening the local home automation industry.

Theoretical development

The 20th century was characterised by a great advance in all the fields where the human being has developed, this era has been described in many different ways: atomic era, television era, computer era, space era, computer era. This shows that the human race has come a long way in just a few years, and there is no doubt that informatics and computing have played a major role in this development.

Also, in recent years, driven by computing, other branches have emerged that are gaining momentum and have enabled human beings to carry out unimaginable activities. One of these branches is electronics, through which human beings use machines to carry out productive processes, playing a very important role in companies, as it helps to achieve maximum efficiency in the operations carried out (Villar Bonet, 2017). The revolution achieved by electronics has not only reached large industries that manufacture products on a large scale, but there is now a machine for almost every kind of work, in medicine, education, meteorology, industrial design, etc., and all this based on a component that was introduced in 1964 in the IBM system 360 computer called an integrated circuit (Long, 1999).

These circuits are a board composed of certain semiconductor materials (Espino, 2019), which function depending on the flow of electrons they obtain for the generation, transmission, reception or storage of information, among other functions.

ISSN 2531-2162

Such circuitry is found in absolutely all modern technology and can be capable of receiving a wide variety of types of information, such as voice or music on a radio receiver, or an image on a television screen, or numbers on a computer.

This whole process of electronic transformation begins with the first generation of computers, which is marked by the use of vacuum tubes, a device consisting of a glass tube with electrical components that is sealed in a vacuum. The first computer to use this type of component was the ENIAC, which carried out its storage, calculation and control operations by means of electronic circuits (Long, 1999).

Vacuum tubes made it possible to amplify radio signals and weak sounds, and to superimpose sound signals on radio waves.

Due to the breakthrough in the use of tubes at the time, they were specialised for different functions and this made possible the rapid advancement of computer technology before and after World War II.

In the years following World War II, progress in semiconductor technology is attributed in part to the intensity of research associated with the space exploration initiative, which led to the development of the first integrated circuit in the 1970s.

These simple, yet complex, electronic circuits are what are found today in devices such as microcomputers, microwaves, sound and video equipment, and communications satellites.

With the origin of integrated circuits and their main functions clear, we can move on to explain the heart of the project that was developed, i.e., the Arduino.

Figure 1 Arduino UNO R3
Source: https://www.amazon.com/

The Arduino, as shown in Figure 1, is one of the most popular boards in the world when it comes to creating electronic circuits. Another quite similar board on the market is the Raspberry Pi, but the Arduino differs in that it offers an open hardware foundation for other manufacturers to create their own boards.

In general terms, the Arduino is an open source electronics creation platform and is based on free hardware and software, flexible and easy to use mostly by creators and developers (Torrente, O., 2013).

This platform makes it possible to create different types of circuits from a single board with which different applications can be developed according to the use that is needed. As mentioned above, Arduino is a free platform, since at the hardware level it is considered as a device whose specifications or diagrams are publicly available, so anyone can replicate them. This means that Arduino openly offers the basis for any other person or company to create their own boards, being different from each other, but being created from the same base.

Free software refers to computer programmes whose code is accessible to anyone who wants it, and can be used and modified without any problem with the original author (Zamora, 2016).

Likewise, the Arduino has the Arduino IDE platform, which is a programming environment that makes it possible for anyone who wants to create applications for Arduino boards, so that they can be given all kinds of utilities.

ISSN 2531-2162

Methodology

In order to build the home automation system in the community centre in the town of Tres Ríos, which is used by people of all ages in the community, the following electronic elements were needed and were used as primary inputs or instruments in the construction of the main circuit:

- 1 Arduino UNO board.
- 1 small protoboard.
- 1 temperature sensor TMP36.
- 2 servomotors.
- 1 ambient light sensor (phototransistor).
- 1 10kΩ resistor.
- 2 light bulbs.
- 1 ultrasonic distance sensor (HC-SR04).
- 1 Wisen gas sensor.
- 1 100kΩ resistor.
- 2 buzzers for the alarms.

Because the system was made virtually, we also made use of the AUTODESK Tinkercad web software for the simulation of the programme, this is a free software that allows us to work and make controlled simulations with the Arduino UNO R3 board.

It should be noted that because the board is not capable of performing multiprocesses, each sensor was programmed one after another, and what is done to simulate a multiprocess, is to avoid long times to congest the program, and avoid redundant programming so that, in case of a change detected in any of the sensors, it acts quickly with its due process. Figure 2 shows the complete circuit assembled in the AUTODESK Tinkercad software.

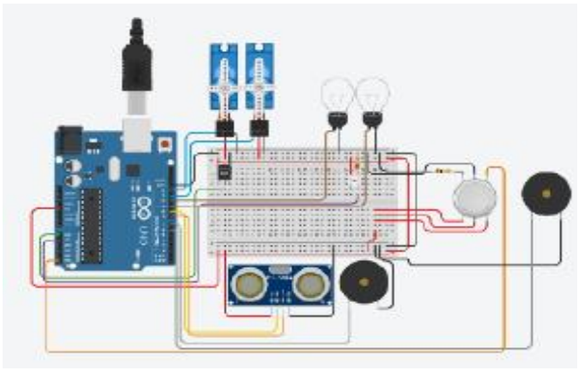

Figure 2 Developed circuit
Source: own elaboration

The following is a detailed description of how the system was assembled:

To begin with, the temperature sensor was connected to the Arduino board and programmed so that when the temperature is higher than 25 degrees Celsius, it opens the windows and turns on the ventilation (the servomotors perform the simulation of these) and when the temperature returns to be less than 25 degrees Celsius, the windows are closed and the ventilation is turned off to maintain the temperature. The Arduino board, through the analogue pin A0, reads the voltage received by the TMP36 sensor and by means of a mathematical operation, calculates the temperature and displays it on the serial monitor. The TMP36 sensor is an analogue input component, that is to say, its operation consists of delivering the information corresponding to the temperature of the environment by means of the voltage on its signal pin, the Arduino board in turn receives the signal and reads it with one of its analogue input pins. It should also be remembered that servo motors are part of a closed-loop system and are made up of several parts, namely a control circuit, servo motor, shaft, potentiometer, drive gears, amplifier and an encoder or resolver. A servomotor is a self-contained electrical device that rotates parts of a machine with high efficiency and high precision.

ISSN 2531-2162

For the illumination sensor, it sends the reading to the A1 analogue pin and when the sensor receives some illumination, the light bulbs are switched off, to reduce the light consumption as it is daylight or there is some external illumination. If the amount of illumination received is reduced, the Arduino board turns the bulbs on. In this case a simple phototransistor was used, which detects ambient light. It is the opposite of an LED: when light hits the interior, it causes current to flow from the long pin to the short pin. This sensor has a built-in optical filter so it will do a good job of detecting light levels just as the human eye does.

For the distance sensor, what was done was to use the HC-SR04 sensor which sends a pulse through the trigger, and by means of a mathematical operation, plus the time it takes to receive it, the distance it is measuring is calculated; now, if the distance is less than 180 centimetres, an alarm will sound through the buzzer, indicating that the social distance is below the required distance due to the measures against COVID-19. It should be remembered that a buzzer is a device that converts electrical energy into sound, producing a sound of a specific tone depending on its use, generally used for alerts or warnings.

Finally, a gas sensor was installed, which is responsible for alerting in the event of a leak, whether it is gas or smoke. This, likewise, sends a signal to the board via an analogue pin, and if the board detects that the signal is above it triggers the alarm, and sends a warning through the serial monitor. Gas sensors are devices that indicate the presence of a specific gas, in some cases they can be configured or, in case of more accurate sensors, they measure the gas concentration. Gas sensors are used to prevent exposure to combustible and toxic gases.

Results

The results obtained with the four sensors used within the system reflected optimal performance within the system and this was of great benefit to the performance of the entire circuit.

The first results that were observed were obtained with the temperature sensor, as the servomotors (ventilation simulation) were properly activated according to the temperature range needed as shown in figure No.3.

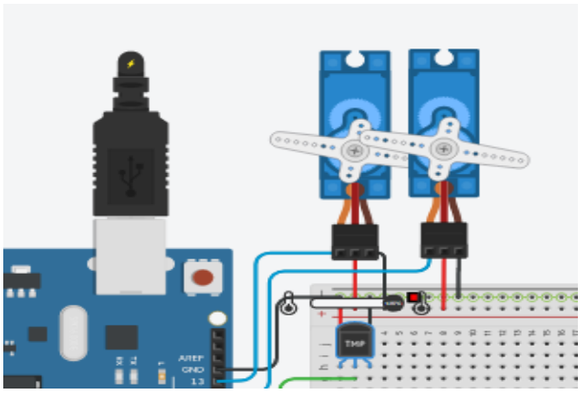

Figure 3 Use of servomotors and temperature sensor
Source: Own elaboration

With regard to the lighting sensor, its function of receiving the lighting and sending a signal to the analogue pin so that the Arduino performs the logical operation of activating or deactivating the lights was totally successful and ensured that this functionality of the system performed well, as shown in figure 4.

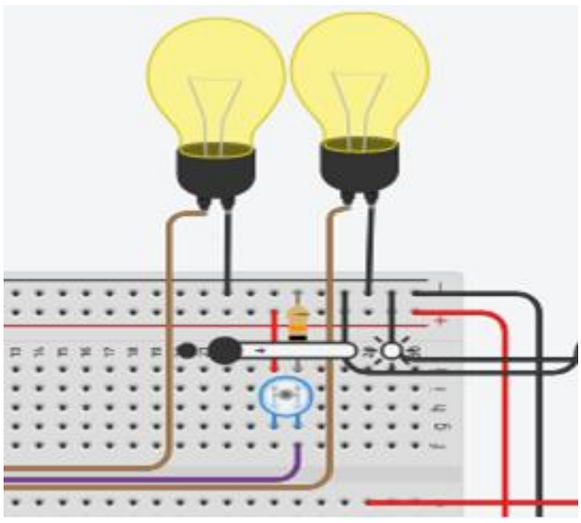

Figure 4 Lighting sensor
Source: Own elaboration

Consequently, the HC-SR04 sensor is the most widely used sensor of its type due to its versatility. It is a low-cost distance sensor that uses ultrasound to determine the distance of an object in a range of 2 to 450 cm.

ISSN 2531-2162

And in this case it had an acceptable and accurate performance when measuring the distance required by the social distance, i.e. 180 cm, to then trigger the alarm or buzzer that gives the indication to people about the disrespect of the allowed distance. It should be noted that the buzzer has a very high-pitched sound that can be annoying, so it should be investigated how to improve the sound of the buzzer. Figure 5 shows how the sensor worked and the buzzer was activated at a distance of 198 centimetres.

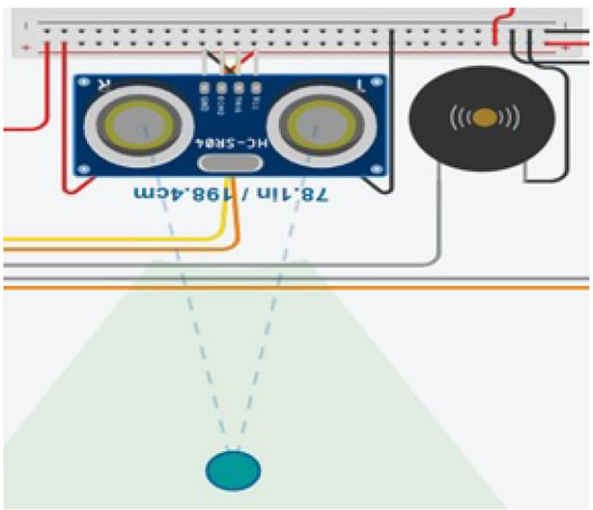

Figure 5 Use of the distance sensor
Source: Own elaboration

Next, the system used a gas sensor whose function is to detect if there are gas leaks, or if there is a high presence of smoke and thus send an alert if the presence is slight, and if there is a high presence, activate an alarm or buzzer to alert and make the people present in the community centre evacuate immediately. As with the other sensors, the performance of this sensor was adequate and caused the buzzer to sound at the slightest detection of smoke as shown in figure 6.

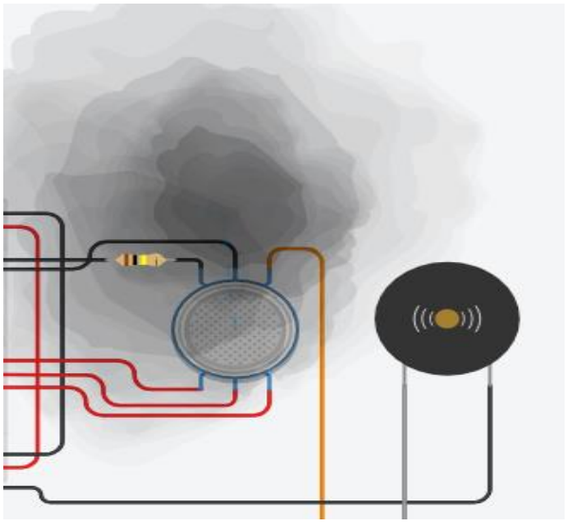

Figure 6 Use of gas sensor
Source: Own elaboration

Consequently, quite a few lines of code were used in this system, as it had to control electronics elements that not only have programming, but also mathematical formulas for precise calculations. All the code was written in the C++ language, which is very similar and contains many of the same functionalities as the Java programming language. In general terms, it can be said that all the proposed objectives were met, as the whole system worked satisfactorily.

Likewise, once the circuit was assembled and tested in the simulator, a demonstration was given to the staff of the community centre and some potential users. At the beginning, the use of the domotic circuit represented a challenge for the employees and assistants of the centre, since they were not used to the handling and interaction with a similar system, there were moments in which the employees did not know how to handle the sensors or the users did not understand the reason for the alarms, but once the functioning of the circuit was explained to them, positive comments and feedback were received from them, indicating that thanks to this type of initiative they feel more confident to attend work or the activities that are carried out. This represents an important step towards the implementation of home automation systems in other government buildings, as it demonstrates their effectiveness.

ISSN 2531-2162

The use of this type of domotic circuit in a community centre can bring advantages to the different administrative areas of this, since due to the use of sensors such as ambient light and temperature, a reduction in the payment of the electricity service is generated, actions such as: dimming lights, regulating the temperature or activating air conditioners automatically also avoid the waste of resources of the community centre. The gas and ultrasonic sensors were able to take preventive measures against possible fires and crowds, which makes the administration of the community centre, in an economical and simple way, facilitates the creation of a safe environment for attendees and workers.

Finally, another positive change brought about by the implementation of the proposed domotics system is to be able to resume the activities that could not be carried out due to the COVID-19 pandemic, and this obviously generates the return of clients and, consequently, an increase in economic income. This improvement that can be achieved thanks to the efficiency of the system makes it possible to achieve the corresponding health measures, in addition to the fact that many people are more interested in attending the activities carried out by this community centre because they feel safe.

Conclusions

The administrators of the community centre can continue with other tasks while the Arduino-based home automation system is in charge of controlling the different sensors so that the cultural centre continues to function in the best possible way.

Thanks to the automation that can be achieved through the home automation system, a great improvement in the performance and administration of the community centre can be achieved. It is important to keep in mind that the use of this technology is of great help to work in a better way in any place, or in case you want to implement a system that helps to perform different tasks at home in a simpler way, since its use is growing dramatically.

It is also important to take into account the use of this type of sensors with Arduino to control the health measures implemented by the government due to the pandemic of COVID-19, is something very new that not only assists in the administration of the community centre, but provides a safe environment for those interested in attending activities and is also quite useful to prevent accumulations of people. If more of these systems were implemented in different venues that have a large number of customers, it would prevent contagions, save more lives and make people feel safer when entering these venues, so it is important to continue to encourage the creation of such systems.

Acknowledgements

The author would like to thank the Faculty of Systems Engineering of the Universidad Fidélitas campus San Pedro de San José, Costa Rica. In addition, deep gratitude is extended to the students Alexander Soto Vargas, Andrey Trejos Solano, Emiliano Rivera and Leonel Solís Méndez for their contribution.

References

Espino, M. (2019). Conductores, aisladores, semiconductores y superconductores eléctricos. Universidad Nacional de Cajamarca. https://d1wqtxts1xzle7.cloudfront.net/61046341/CONDUCTORES_ELECTRICOS_ESPINO20191028-105975-1l9b862-with-cover-page-v2.pdf?Expires=1638805371&Signature=Vl0Y-PDijqYbsLTEyGaFj76RNpDT27k8jOwQUE58fChWyzStb2Z6DSCvWzIPExu40KOHeC0xfXepoZEc-GzgHFDTx-CzZFLRehM4uxjDjH4FIkXCukb8E~TxRSK1pwwtyCNjE3c2LRpCo6feq1SeMxWG9SSUAkX-zBJCPw4lyLWbcKOfHpSUwRzZ1VQZRA~nM-LfP17HlyPChkpRgyMklg6TTmTFt5qo2sf5C2--ucRkrH-y9AJvmTOYZAfWX-n5KCSOTgaiYGFf34PRcTjeIo8-4Rtkbie1q4KAZ~Z5UUqXi6rzXSup6vgmqEY56Ga1-6nj4u7k3Pld0QMXFIT0JQ__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA

ISSN 2531-2162

Long, L. (1999). Introducción a las Computadoras y al Procesamiento de Información, Editorial Prentice Hall Hispanoamericana. Clásico.

Sánchez, M. (2017). Planificación de la gestión y organización de los procesos de montaje de sistemas domóticos e inmóticos. RA-MA Editorial. https://elibro.net/es/lc/ufidelitas/titulos/106575

Schwab, K. (2016). La Cuarta Revolución Industrial. Foro Económico Mundial. http://40.70.207.114/documentosV2/La%20cuarta%20revolucion%20industrial-Klaus%20Schwab%20(1).pdf

Toffler, A. (1979). La Tercera Ola. Editorial Bantam Books. Clásico.

Torrente, O. (2013). Arduino. Curso práctico de formación. Alfaomega Grupo Editor, S.A.

Villar Bonet, E. (2017). La revolución electrónica. Editorial de la Universidad de Cantabria. https://elibro.net/es/lc/ufidelitas/titulos/53400

Zamora, J. (2016). Hardware libre: la evolución al software libre. Diario El Español. https://www.elespanol.com/elandroidelibre/20160408/hardware-libre-evolucion-software/115738780_0.html.

ISSN 2531-2162