2022 年臺灣國際科學展覽會
優勝作品專輯

作品編號 **100044**

參展科別 **工程學**

作品名稱 **Susanito, autonomous robot body temperature meter: support to reduce infections in rows**

得獎獎項

國　　家 **Mexico**

就讀學校 **CENTRO DE BACHILLERATO TECNOLÓGICO industrial y de servicios No. 91**

指導教師 **Blanca Elia Jimenez Guzman**

作者姓名 **Uriel Arturo Gomez Garcia**

關鍵詞 **robot, covid-19, autonomous**

作者照片

Abstract

A variant of the coronavirus (2019-nCoV or COVID-19) was reported in Wuhan, China on December 31, 2019, spreading rapidly around the world. Owing to a plan to reactivate the economy, the Mexican government, requested to implement protective measures to enter establishments with confined spaces: wear a mask, provide alcohol-based hand rub and the measurement of body temperature, allowing problem when not have a fever; however, these measures cause long waiting lines, causing contagion risk.

To support this problem, applied and experimental research was used, generating as a result, the creation of a robot that moves autonomously thanks to a line follower sensor. Dispenses alcohol-based hand rub and determines the temperature by means of an infrared sensor, checking that the distance is adequate, with an ultrasonic sensor, using a buzzer that emits a sound of half a second when it performs a normal detection, but, if it is equal to or greater 1os 38 ° C, emits a sound for 10 seconds asking the person to leave the line and go to a medical service, helping to reduce problems infections in lines.

Introduction

On the 31st of December 2019, The World Health Organization (WHO, 2020) reported the outbreak of a coronavirus disease in Wuhan, China, for the first time. They called it COVID-19, cataloguing it in the Pan American Organization of Health (PAHO, 2020), as a "severe acute respiratory disease presenting fever and at least one sign/symptom of a respiratory disease (for example: a cough or shortness of breath); and that it requires hospitalization".

Despite the different measures adopted by the governments of different countries, growth in the number of infections has been exponential. Some of the restrictions which have been introduced include a) proper use of face masks, b) closure of establishments that are not essential, c) restricted entry to only one person, of legal age to closed establishments and d) at the entrance of the premises , body temperature measurement, generally with an infrared thermometer, which is operated by an employee, to confirm that the person does not have a fever and only then, allow access, thus generating long lines outside the premises, waiting for authorization.

For these reasons, we are putting forward the project: "Susanito, the autonomous body temperature measuring robot: support to reduce infections in lines", made with sensors and Arduino technology, which measures the body temperature of people waiting to access restricted establishments, as a measure of security in the face of the health contingency due to COVID-19, using the applied and experimental methodology, focused, firstly on a controlled population, in the Heroic City of Juchitán de Zaragoza, Oaxaca, Mexico (hereinafter, Juchitán), with a view to improve it and serve as a basis for increasing its implementation.

To document this project, it initially has the following sections: problem statement, justification, hypothesis, leading to the formulation of objectives, continuing with the technical aspects described in the theoretical framework, to later detail in the description of planning and development of the project and the steps performed. Continuing with the descriptions of the degree of innovation, feasibility, social and technological impact, until reaching an analysis of the results, conclusions, annexes, and bibliography used. We would like to thank C.B.T.i.s. No. 91 for their support.

Problem statement

The 2019-nCoV or COVID-19, is derived from a wide family of viruses, which come under the name coronavirus, such as the cause of the Middle East respiratory syndrome (MERS-CoV) and the one that causes the severe acute respiratory syndrome (SARS-CoV), which mutate into new strains, causing everything from the common cold to more serious illnesses. This variant was reported for the first time in Wuhan, China, on the last day of 2019, and may have been transmitted to humans by a bat, rapidly spreading throughout the world (OPS, 2020).

As of the 30th of April 2020, according to an international report, COVID-19 had infected 3,090,445 people and caused 217,769 deaths; While in Mexico, as a result of the first case detected on the 27th of February, 2020, 64 days later, there were 19,224 confirmed cases and 1,859 deaths were registered.

Based on the above figures, the US National Library of Medicine National Institutes of Health (PMC, 2020), reported that governments implement restrictions on mobility, such as the measure adopted by the Ministry of Public Education (SEP) to extend the Easter holidays in educational institutions throughout the country for a month, from March 23rd to April 20th, 2020. In addition, other measures were introduced, such as: social distancing, proper use of facemasks, entry control to closed establishments, one person per family and only when their temperature body temperature is lower than 37.5 ° C. This, however, causes another problem: long lines outside the establishments, causing longer exposure time (Chaca, 2020).

For this reason, and considering the technological advances which help to alleviate different everyday situations, the following research question is posed:

Will it be possible to assemble a robot that moves forward in a straight line and automatically performs temperature measurements on people, from the moment they queue up in line, in order to help reduce the contagion of COVID-19?

Justification

Derived from the economic reactivation plan, the government of Mexico, through a publication in the Official Gazette of the Federation (DOF, 2020), has requested, as a security measure to enter closed establishments, the use of face masks, provide 60% alcohol-based gel, measurement of body temperature, among others, allowing access when they do not have a fever.

To comply with this standard, different public venues measure body temperature, generally with pistol-shaped thermometers, without the need for direct contact, however, they do it when the person reaches the door. , after have lined up for several minutes or even hours.

These infrared thermometers to measure temperature are easy and fast to use, you just have to place them perpendicular to the forehead, at a distance between 3 and 5 cm (Nasanovsky, 2020), which implies that, if someone wanted to perform the measurement of many people in a row, it would have to be moving between it and in turn, be breaching the recommended distance of 1.5 m between one individual and another, proposed by the Government of Mexico (GobMex, 2020), based on: "When we speak, shout, sing, cough or sneeze we emit small drops of saliva that travel up to one meter."

Due to the above, it is proposed to create a prototype of a robot with Arduino technology, with a cart base, capable of moving autonomously, in parallel with the row, to be able to measure the temperature of the people, once they are lined up, and thus notify with an alert sound, if the sensor indicates that it has exceeded 38 ° C. In this case, the measurement will be verified, by a person in charge, and the user will be invited to leave the line, suggesting that they seek medical assistance. Also, the robot must be constantly disinfected to provide security.

Objectives

General Objective

To assemble an autonomous robot, using sensors and Arduino technology, that measures the body temperature of people lining up to access closed establishments, in Juchitán, Oaxaca, as a security measure to reduce the risk of contagion in the event of a COVID-19 contingency.

Specific Objectives

1. To research Arduino technology and type of sensors.
2. To Analyse the logic to be used for correct operation.
3. Design of the prototype.
4. Search for materials, connection, and assembly of the prototype.
5. Software programming.
6. Test of the prototype operation with people in Juchitán de Zaragoza, Oaxaca, in a controlled space.

Hypothesis

The Arduino Mega hardware development board and its free license software allow the creation of an autonomous robot prototype, capable of adequately measuring the body temperature of people queuing up in a line, moving forwards in a straight line, in such a way that, when the result of the measurement is greater than 38 ° C, it emits an alarm, thus, this robot could contribute to the measures to reduce the risk of contagion of COVID19.

Theoretical framework

Autonomous robot: "they have the applicability and ability to be able to execute activities and tasks without the need for some type of directly explicit command and control from humans." (RIPIPSA, 2019).

Robot architecture:

Microcontroller (UC): is a complete computer occupying such a small space that it fits on a single chip. It is defined as: "an Integrated Circuit with VLSI technology, which contains a Central Processing Unit (CPU), memory for code, memory for data, in addition to other resources necessary for the development of applications, such as timers, ADC, I / O ports. O" (Santiago, 2019, p. 10).

Arduino: is a free platform that includes both hardware and software, with the characteristic of being comfortable, fast and intuitive, so there is a large community of users who share examples and tutorials, providing a facility for the development of projects of various types, using appropriate sensors, modules and accessories. In addition, it provides a very friendly Integrated Development Environment (IDE) to program, debug and load them to the boards via USB (paraarduino, 2019).

Arduino Mega 2360: "is a development motherboard based on the ATmega2560 microcontroller. It has 54 digital inputs / outputs (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs, a 16Mhz crystal, USB connection, DC power jack, ICSP connector, and a reset button. The Mega 2560 motherboard is compatible with most of the compatible shields for Arduino UNO "(Arduino, 2019).

Power Supply: "supplies the energy to the different electronic components of the robot so that it works. The operating time of the robot will depend on the type and capacity of batteries used". They use 12V batteries as sources of energy. It should be noted that it is necessary to know the voltage and amperage inputs of the components to be able to occupy them to the maximum without damaging or burning them. Also used are a lead acid battery, a lipo battery and an XL4016 Step Down voltage regulator, which is a step-down switch type regulator, selected because it reduces the use of external components by simplifying the design of power supplies, in addition to regulate the voltage, obtaining 5V, 3.3V, 1.8V from a 12V source or battery (Naylampmechatronics, 2019).

Communication: because Arduino digital systems work with binary logic (0 and 1), it requires elements that facilitate communication, using for this purpose, a lcd1602 display, a breadboard and a Bridge h L298n.

Sensors: they are made up of "both the units that emit an analog signal, and those that emit a binary signal (on or off, HIGH or LOW). In all those places where it is not possible to

detect electrical quantities, sensors are required. Converts a physical quantity to an electrical quantity. These are very useful because thanks to them you can make a robot work".

Infrared sensor: "are specially designed for the detection, classification and positioning of objects; the detection of shapes, colors and surface differences, even under extreme environmental conditions" (Protejandopersonas, 2018).

Ultrasonic sensor: "performs measurements using ultrasonic waves. The operation of the ultrasonic sensor is simple: when the wave impulse encounters an object, it is reflected and thus it is measured in distance"(Gandhi, 2019).

Line tracker: "they are mobile machines capable of detecting and following a line, which is located on the ground of a surface" (Carrillo, Cardona, Rodriguez, & Arvizo, 2016, p. 116). Although they generally must follow a path marked by a black line on a white surface, in this prototype, it is programmed backwards, moving forward as long as it does not find the black line.

Motors: the movements of the robot are achieved with the help of the motors. There are different types: direct current (DC) motors, stepper motors, and alternating current (AC) motors. The prototype has 4 motors, which consume from 3V to 12V each, although 6V to 8V is the recommended voltage.

Chassis: is the structure on which all the pieces that make up the prototype are founded and supported, also called mechanical structure, this is usually used to place everything that the prototype carries. They can be purchased from any store and can even be self-made with any material, the only condition is that it supports all the weight of the gears, batteries, screws, and other elements.

Wheels: the wheels are attached to the axles of the motors. In the prototype, one wheel is used for each motor. When the motors are activated, the energy is transformed into movement and this in turn causes the wheels to turn.

Electronics: these are all the components that allow the robot to function. Some of these components are: resistors, capacitors, voltage regulators, H bridge circuit, among others. In the case of this prototype, an H bridge, a protoboard, a voltage regulator and jumpers are used.

Design methodology

a) Experimental design

For this prototype, applied and experimental research is used. Performance tests are carried out and components are changed according to the needs. The applied method is a type of focused research, therefore, the type of field to which it is applied is very specific and well defined, since it does not try to explain a wide variety of situations, but rather tries to address a specific problem (Tam, Vera, & Oliveros, 2008, pp. 147-149).

The technical and financial considerations that were implemented for this project are shown in table 1.

Table 1. Technical and financial feasibility data.

Material	Cost	Quantity	Unit	Cost*Quantity
Computer equipment	$8,000.00	Proportional	Piece	$200.00
Arduino Mega mother board	$253.00	1	Piece	$253.00
Jumpers	$35.00	1	Packet	$35.00
Software Arduino	free			
H Bridge	$58.00	1	Piece	$58.00
Prototype body	$130.00	1	Piece	$130.00
Gear motors	$30.00	4	Piece	$120.00
Tires	$15.00	4	Piece	$60.00
Voltage regulator module (optional)	$120.00	1	Piece	$120.00
Ultrasonic sensor	$40.00	1	Piece	$40.00
Infrared temperature sensor	$300.00	1	Piece	$300.00
Line follower module	$30.00	1	Piece	$30.00
Metal or plastic tube	$150.00	1	Meter	$150.00
Buzzer	$10.00	1	Piece	$10.00
Display with I2C module	$90.00	1	Piece	$90.00
Screws	$30.00	1	Kit	$30.00
Mini water pump	$130.00	1	Piece	$130.00
Servomotor mg995	$101.00	1	Piece	$101.00
Relay module	$31.00	1	Piece	$31.00
Infrared proximity sensor	$85.00	2	Piece	$170.00
Tools and electronics	$5,000.00	Proportional	Pieces	$100.00
			Total	$2,158.00

The costs involved in the construction of the prototype is low, when using affordable components and materials, which is positive both in technical terms and for the economic

feasibility of the study. In addition, all the components used can be easily acquired, both the hardware and software, which, being freely distributed, does not increase operating costs and becomes a prototype that is easy to program, and most importantly, feasible to replicate, not only locally, but on international scale.

b) Procedure

This project grew out of a problem that was observed in Juchitán, where long lines of people outside restricted establishments (due to the security measures adopted in the event of the COVID-19 contingency), made us realize that the time these people spent in lines makes them vulnerable. This presented us with the opportunity to create a prototype to measure body temperature, as a way to detect any signs of the virus more rapidly.

First stage

We made contact with the advisors, starting off a process of technical and methodological training, to learn more about robots; how to achieve their autonomy, as well as the development of projects, detailing the activities and showing the process in images shared in the annexes section. A doctor was interviewed to obtain data on body temperature, supplemented with information from reliable sources on the internet.

Subsequently, the types of sensors, motors and chassis were investigated, selecting the creation of their own chassis, the use of 4 gear motors and different sensors. The components are acquired, the chassis is designed and prepared, placing the gearmotors in the appropriate spaces, as well as the wheels on each axle, testing their operation and polarity, soldering the cables to the motors to provide stability.

Then it was the turn of the Arduino programming, of the motors through the H bridge, which is responsible for reversing the polarity and making it walk forward, backward, or in the desired direction. Subsequently, a Bluetooth card was installed, to control the prototype from a mobile device, as well as, the design of a mobile application, creating it on the online platform APP Inventor, making it free to use, with an intuitive interface and handling of blocks, which you can see in the annexes section.

The Arduino programming was installed, allowing the Display to show body temperature through the ultrasonic and infrared temperature sensors. Libraries downloaded from GitHub were later used to test the 2 sensors with the Display, showing the temperature and the distance to the person they approached.

In the assembly of the robot, the parts were placed on the chassis, adding a tube screwed onto the base, to carry cables inside and serve as a support for the head of the prototype. For the prototype head, after several tests, it was chosen, based on the weight and ease of cutting, for

plastic material, placing the programmed Arduino board inside and screwing it to make it more stable.

Afterwards, the batteries were placed on the base of the chassis, verifying the adequate voltage, accommodating the cables that go from the motors to the H-bridge, inside the tube, for better aesthetics.

The use of the line follower sensor was programmed and configured, adapting it to stop when it detected a black line and placed under the chassis. In addition, a buzzer was used, so that it emits a sound for 2 seconds, informing you that it has taken a normal temperature and then advances onwards, until the next mark. If it detects a temperature higher than 38 ° C, it emits a sound that lasts for 10 seconds.

These tests were carried out internally, simulating a rise in temperature by rubbing a test subject's hands together hard and continuously. To conclude the design, the external elements were painted and lined, and other tests are carried out in a controlled way, resulting in an autonomous robot able to measure the body temperature of people lining up to enter a restricted establishment, with the prior authorization of the subjects.

Second stage

The chassis and supports were modified to provide greater stability, as well as the implementation of a device that automatically provides antibacterial gel.

Another pair of infrared and temperature sensors were also added so that you can measure people of smaller stature, including children and users in wheelchairs, if any, complementing both the connection diagram and the programming in the Arduino software, performing the tests again in a controlled environment and with the authorization of those involved.

Conclusions

The necessary research was carried out, and we were able to obtain the necessary data about the operation of the temperature, ultrasonic and line follower sensors, using Arduino Software and Hardware, which, being freely distributed, allowed its use without the need for payment. We also took advantage of the libraries hosted on GitHub, necessary for the handling of the components, as well as the use of diagrams for the hardware connections, since preset pins are handled, which are adapted to the project, as shown in figure 1.

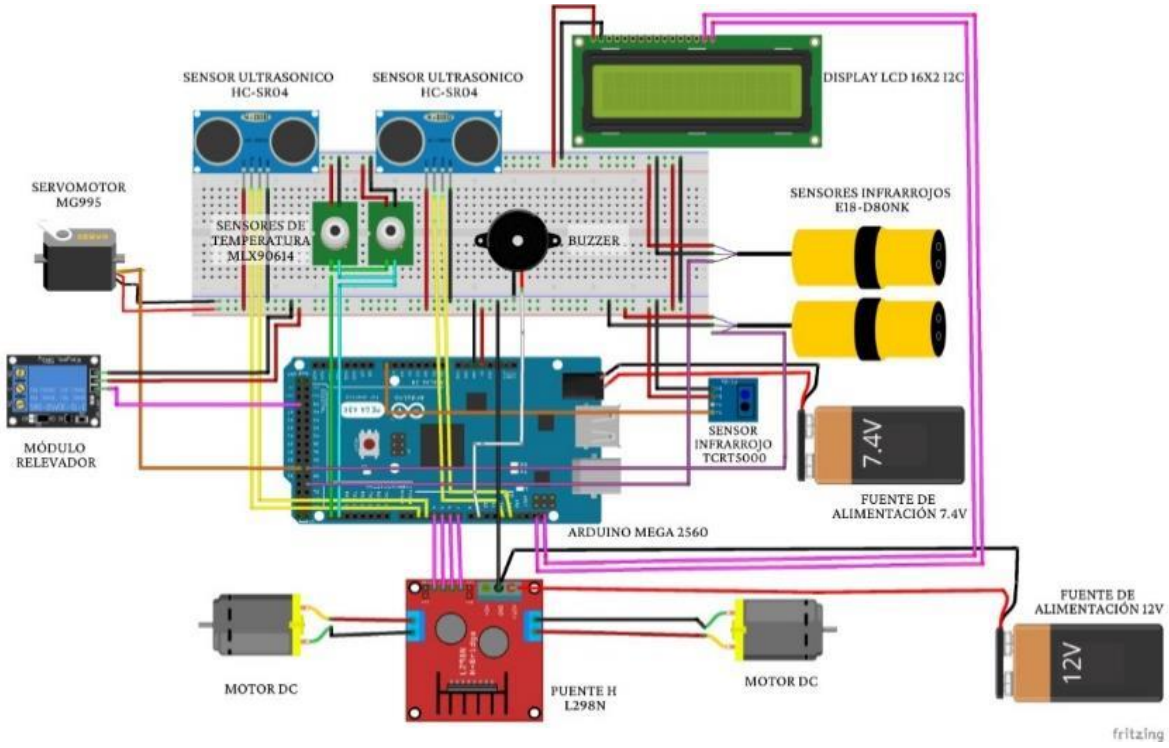

Figure 1. Diagram of connections. Own work.

The temperature sensors and the display were placed on the chassis itself, forming the head, managing to create the prototype of the autonomous robot: "Susanito, autonomous robot measuring body temperature: support to reduce infections in lines", as can be seen in figures 2, 3, 4 and 5, applying it to detect body temperature in a controlled population, with prior authorization.

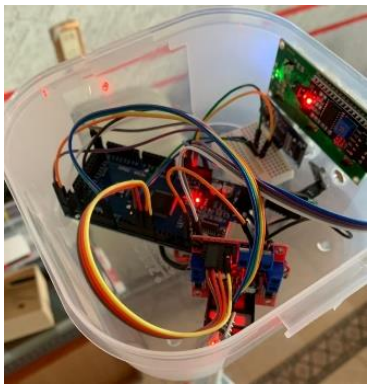

Figure 2. Internal view of the temperature sensors and display. Own photography.

Figure 3. External view of the temperature sensors and display. Showing a normal measurement. Own photography.

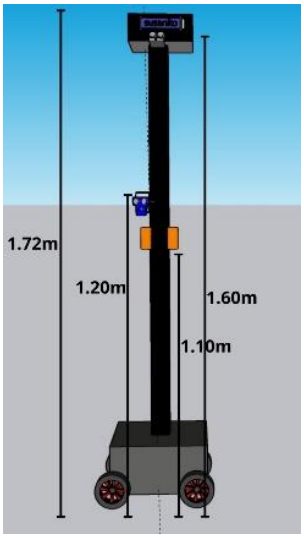

Figure 4. Dimensions of Susanito, an autonomous body temperature measuring robot: support to reduce infections in lines. Own work.

Figure 5. Final version of the prototype: Susanito, an autonomous robot measuring body temperature: support to reduce infections in lines. Own photography.

Looking at previous results, we can conclude that the proposed objectives were achieved, through reviewing existing information on digital media, which allowed us to design the prototype, search and select the most appropriate materials for its assembly, apply programming knowledge and search among the appropriate libraries for the integration of hardware and software in the assembly of the robot; first achieving a controlled result through a mobile application, and then later, making Susanito autonomous and adding an antibacterial gel dispenser.

The robot moves autonomously, thanks to a line follower sensor located at the bottom. It can take measurements, through an infrared temperature sensor, making sure that the distance is adequate, with an infrared sensor, both located in the upper part of the prototype, and also using a buzzer that emits a sound for two seconds when it detects a normal temperature. If it exceeds 38 ° C, it emits a sound lasting 10 seconds. If that happens, the person is invited to leave the line and advised to seek medical attention, avoiding both the people who are lined up, as well as the employees of the establishment, who may be at risk from being in proximity with someone who could be infected with COVID-19.

The experience and knowledge which we acquired in the development of this project was very useful for both personal growth and for professional development in the future. This project required the application of physics, mathematics, reading diagrams, programming and electronics, skills which were obtained in study of different subjects taken in the area of Programming Technician, and others collected in a self-taught way and through courses given by advisors, counting on their technical and methodological support at all times. Manual skills were also developed when connecting the circuits, and above all, there was a marked improvement in the ability to analyze, control emotions and make decisions.

References

Arduino. (2019). *arduino.cl*. Recuperado el 12 de abril de 2020, de ARDUINO.cl: https://arduino.cl/arduino-mega-2560/

Carrillo, M., Cardona, J. A., Rodriguez, F., & Arvizo, G. A. (Agosto de 2016). Sistema de control y arquitectura de un robot seguidor de línea. *Dialnet, Año 13*(59 Especial No. 2). Obtenido de https://dialnet.unirioja.es/descarga/articulo/7205676.pdf

Chaca, R. (4 de Mayo de 2020). *https://oaxaca.eluniversal.com.mx*. (E. U. Oaxaca, Editor) Recuperado el 24 de Mayo de 2020, de https://oaxaca.eluniversal.com.mx/municipios/04-05-2020/con-sana-distancia-por-covid-19-hacen-largas-filas-en-bancos-y-tiendas-de

CODEBENDER. (2019). Recuperado el 15 de mayo de 2020, de https://blog.codebender.cc/2014/03/07/lesson-1-inputs-and-outputs/

Custodio, Á., & Balza, Z. (Junio de 2006). Sistema de medición de temperatura sin contacto con el proceso. *SCIELO, 30*(38). doi:ISSN 1316-4821

DOF. (29 de Mayo de 2020). *nuevanormalidad.gob.mx/*. Recuperado el 12 de Junio de 2020, de Diario Oficial de la Federación: http://nuevanormalidad.gob.mx/

Gandhi, M. (27 de Noviembre de 2019). *www.autycom.com*. Recuperado el 17 de Mayo de 2020, de https://www.autycom.com/que-es-un-sensor-ultrasonico-y-para-que-sirve/

GDM. (2015). *www.gob.mx*. Recuperado el 10 de Julio de 2020, de Gobierno de México: hhttps://www.gob.mx/cms/uploads/attachment/file/63383/Resultados_ENDUTIH-Prensa_INEGI_rev_11032015.pdf

GobMex. (02 de abril de 2020). *www.gob.mx/*. Recuperado el 14 de mayo de 2020, de Gobierno de México: https://www.gob.mx/telecomm/galerias/susana-distancia-239604

Mandonado, A. (2015). *Kombot. Diseño y construcción de un mini robot móvil.* Universidad Carlos III de Madrid, Escuela Politécnica Superior. Ingeniería industrial. Dep. Automática y Electrónica. Madrid: Tutor: Ramón Barber Castaño. Recuperado el 15 de Junio de 2020, de https://core.ac.uk/download/pdf/288498537.pdf

Nasanovsky, N. (25 de Junio de 2020). *factual.afp.com*. Recuperado el 2020 de Julio de 10, de https://factual.afp.com/los-termometros-pistola-son-seguros-y-no-matan-neuronas

Naylampmechatronics. (2019). *naylampmechatronics.com*. Recuperado el 18 de Septiembre de 2020, de https://naylampmechatronics.com/conversores-dc-dc/127-convertidor-voltaje-dc-dc-step-down-8a-300w-xl4016.html

OMS. (2020). *www.who.int/es/*. Recuperado el 24 de Mayo de 2020, de Organización Mundial de la Salud: https://www.who.int/es/emergencies/diseases/novel-

coronavirus-2019?gclid=CjwKCAiAg8OBBhA8EiwAlKw3kjh8LZJJiS94RNYtC4Hwjecxrtp8Ilc9qIuFxAqKTmFLWCwQHYbF8BoCzwEQAvD_BwE

OPS. (2020). *www.paho.org/es*. Recuperado el 24 de Mayo de 2020, de Organización Panamericana de la Salud: https://www.paho.org/es/documentos/covid-19-comorbilidades-americas-antecedentes

OPS. (2020). *www.paho.org/es*. Recuperado el 4 de Mayo de 2020, de Organización Panamericana de la Salud: https://www.paho.org/es/temas/coronavirus

paraarduino. (2019). *paraarduino.net*. Recuperado el 12 de MAyo de 2020, de https://paraarduino.net/

PMC. (20 de Mayo de 2020). *www.ncbi.nlm.nih.gov*. Recuperado el 30 de Mayo de 2020, de US National Library of Medicine. National Intitutes of Health: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7250750/

Protegiendopersonas. (10 de Julio de 2018). *protegiendopersonas.es*. Recuperado el 12 de Junio de 2020, de https://protegiendopersonas.es/sensores-infrarrojos-que-son-y-para-que-se-utilizan/

RIPIPSA. (2019). *ripipsacobots.com*. Recuperado el 15 de mayo de 2020, de Tenología al servicio de la industria: https://ripipsacobots.com/robots-autonomos/

Santiago, F. (15 de Octubre de 2019). *www.utm.mx*. Recuperado el 2020 de Junio, de http://www.utm.mx/~fsantiag/Micros_Meca/1_Introduccion_MCU.pdf

Tam, J., Vera, G., & Oliveros, R. (08 de Abril de 2008). Tipos, métodos y estrategias de investigación científica. En *Revista de la escuela de posgrado* (págs. 147-149). Recuperado el 12 de Mayo de 2020, de http://www.imarpe.pe/imarpe/archivos/articulos/imarpe/oceonografia/adj_modela_pa-5-145-tam-2008-investig.pdf

UNAM. Univesidad Nacional Autónoma de México. (2019). *www.personal.unam.mx*. Recuperado el 8 de julio de 2020, de https://www.personal.unam.mx/Docs/Cendi/termometros.pdf

Annexes

Figure A.1. Soldering gearmotor cables. Own photography.

Figure A.2. Encoding of motors to control from the Bluetooth device. Own photography.

.

Figure A.3. Search for the box for the head of the prototype. Own photography

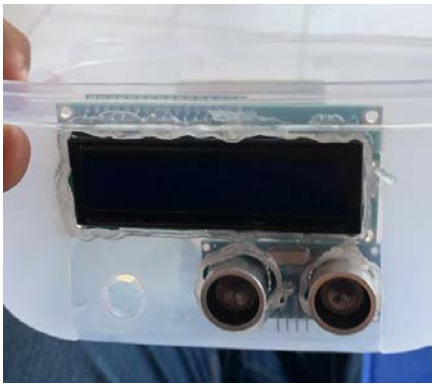

Figure A.4. External view of the temperature sensors and display. Own photography.

.

Figure A.5. Mobile App and Inventor App Blocks. First test of the components. Own work.

.

Figure A.6. Temperature sensor and display communication test. Own photography.

Figure A.7. First test version of the prototype. Own photography.

Figure A.8. Second test version of the prototype. Own photography.

Figure A.9. Final version of the prototype. Own photography.

【評語】100044

The authors created the autonomous robot body temperature meter to reduce infections in rows. The robot is composed of the Arduino board with the ultra-sonic sensors,IR sensors,DC motors, servo motors, temperature sensors, battery and display unit. The robot is well constructed with a reasonably programmed control sequences so that the robot can carry out the required tasks and achieve the goal of autonomous temperature measuring task without human intervention. The authors have done a great job.