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Article

Implementation of an gel dispenser with LED traffic light for early fever detection in public spaces

Implementación de un despachador de gel con semáforo LED para la detección temprana de fiebre en espacios públicos

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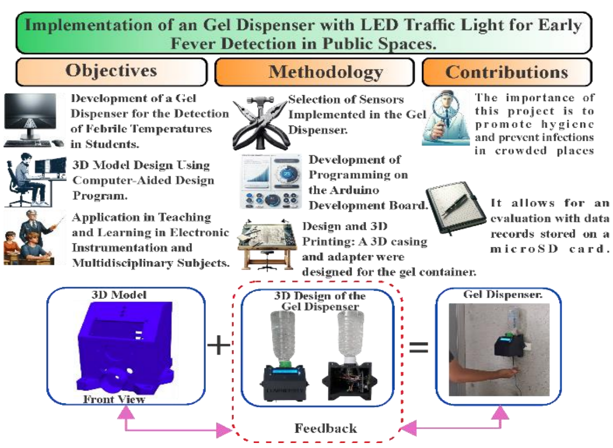
Abstract

This project introduces a Gel Dispenser with LED Traffic Light for Early Fever Detection in Public Spaces. The LED traffic light changes color based on detected body temperature: red indicates fever, amber indicates elevated non-fever temperature, and green shows normal temperature. It utilizes an MLX90614 infrared temperature sensor, which, along with the FC-51 sensor, detects a hand, measures the temperature, and activates a pump to dispense antibacterial gel. Data are recorded on a MicroSD card and displayed on a screen. Designed during the late stages of COVID-19, it promotes hand hygiene by encouraging the use of antibacterial gel and reducing water consumption. Additionally, it offers a more comfortable temperature measurement by taking readings from the palm rather than the forehead. It has been effective in detecting febrile temperatures in students, proving to be a valuable solution for future pandemics.



Thermometer, Dispenser, Hygiene

Resumen

Este proyecto presenta un Dispensador de Gel con Semáforo LED para la Detección Temprana de Fiebre en Espacios Públicos. El semáforo LED cambia de color basado en la temperatura corporal detectada: rojo indica fiebre, ámbar indica temperatura elevada sin fiebre y verde muestra temperatura normal. Utiliza un sensor de temperatura infrarrojo MLX90614 que, junto con el sensor FC-51, detecta una mano, mide la temperatura y activa una bomba para dispensar gel antibacterial. Los datos se registran en una tarjeta MicroSD y se muestran en una pantalla. Diseñado durante las etapas finales de COVID-19, promueve la higiene de manos al fomentar el uso de gel antibacterial y reducir el consumo de agua. Además, ofrece una medición de temperatura más cómoda al tomar lecturas desde la palma de la mano en lugar de la frente. Ha sido efectivo en detectar temperaturas febriles en estudiantes, demostrando ser una solución valiosa para futuras pandemias.

Termómetro, Dispensador, Higiene

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Introduction

Implementing technological solutions for early fever detection and hygiene promotion, utilizing infrared sensors and visual alert systems. Both devices offer practical and effective solutions for use in public spaces, contributing to the prevention of disease spread.

The device promotes hand hygiene, encourages the use of antibacterial gel, reduces water consumption, and provides a more comfortable temperature measurement from the palm of the hand. It has proven effective in detecting febrile temperatures in students, offering a valuable solution for future pandemics. Both projects share significant similarities in terms of their purpose and technological approach. Early disease detection is crucial and greatly benefits from rapid technological advancements.

Detailed studies provide replicable solutions, helping to establish methodologies and costs. For example, Scott et al., (2024) mention the implementation of infrared sensors for the rapid detection of respiratory infections, although they do not specify the exact type of sensor.

This work underscores the importance of sharing knowledge to respond quickly to events like the SARS-CoV-2 outbreak in late 2019. Another relevant study is by Zou et al., (2024), which describes the development of a dual-signal fluorescent immunosensor combined with a machine learning system to detect specific pathogen antigens.

These sensors are noted for their high precision and represent a cost-effective and efficient solution for the rapid detection of pathogens in clinical and public settings, significantly improving detection and response capabilities to infectious diseases, although it does not specify if it is low-cost. However, some studies, such as Tantely et al. (2024)., do not provide specific cost details but employ procedures that can be very expensive. This study uses specific sensors designed to detect pathogen biomarkers, capable of providing quick and accurate results by detecting changes in fluorescence or absorbance in the presence of pathogens.

Meanwhile, Kamel et al., (2024) developed a modified lateral flow test strip based on streptavidin-biotin, demonstrating a significant improvement in sensitivity and specificity for the detection of the SARS-CoV-2 S1 antigen in saliva samples.

The use of smaller quantities of nanobodies and ACE-2, as well as the elimination of the conjugate pad in the test design, contribute to cost reduction. Finally, **Jin** et al., (2024) highlight that colorimetric sensors are generally inexpensive due to the low cost of materials. Their study explores the application of colorimetric sensors in various translational contexts, from the use of colorants to detection mechanisms, demonstrating that they are effective for the precise detection of a wide range of analytes in practical applications.

They aim to develop devices that allow for contactless temperature measurement to prevent the spread of diseases such as COVID-19 (Inayah et al., 2022). The effectiveness of hand hygiene is relevant, as Gozdzielewska et al., (2022) states, in preventing the transmission or acquisition of coronavirus or influenza infections in the community.

Hand hygiene for the general public is a recommended measure to prevent these infections. This study systematically reviewed the effectiveness of interventions for preventing the transmission or acquisition of coronavirus or influenza infections in the community. Other relevant works have developed where the need to measure body temperature without contact and quickly during the COVID-19 pandemic is addressed.

This need has led to the widespread use of infrared thermometers, cameras, and thermal scanners as alternatives to traditional clinical thermometers.

These studies examine the issues and limitations of these non-contact temperature measurement devices from clinical and metrological perspectives, with the aim of improving the accuracy of body temperature measurements and estimating the uncertainty of these measurements in the field. Both traditional sources of instrumental uncertainty and clinical and medical variables related to the subjectivity of the measured object are analyzed**.**

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Studies have been conducted that focus on recent changes and challenges in hand hygiene according to Boyce (2023), especially in the context of the pandemic, which led to a temporary increase in hand hygiene compliance rates and a shortage of alcohol-based hand sanitizers. New recommendations from non-regulatory agencies have been issued, and guidelines have been revised in response to the pandemic.

These include periodic audits of alcohol dispensers to ensure adequate volume and effective rubbing times. Challenges in Hand Hygiene Technique: Proper alcohol rubbing technique, including duration (at least 15 seconds) and coverage of all hand surfaces, is crucial for antimicrobial efficacy. However, many healthcare professionals do not meet these standards.

Automated Monitoring Systems: The need for complementary strategies to improve compliance rates is evident. Hand sanitizers with at least 60% ethanol have been shown to be effective against various emerging pathogens, including SARS-CoV-2 and Candida auris. Proper placement of dispensers is essential to improve hand hygiene compliance rates.

Hand sanitizers during the COVID-19 pandemic highlight the importance of hand hygiene in preventing the transmission of infections. The use of hand sanitizers has seen a significant increase in global demand due to their effectiveness in reducing pathogenic microorganisms. According to Gloekler et al., (2022), alcohol-based sanitizers are notable for their mechanisms of action and effectiveness.

The study emphasizes the need to develop effective and safe sanitizer formulations to prevent future pandemic outbreaks. The implementation of technological strategies is highly relevant in places with crowds or high flows of people to avoid contact with objects that could cause the spread of viruses or bacteria, such as the system implemented by Venkataramanan et al., (2023) for an automatic door opening system with contactless temperature detection.

This system reduces the risk of COVID-19 infection by avoiding direct contact with traditional door handles and performing automated temperature control.

The system uses an MLX90614 infrared temperature sensor, a PIR sensor, an LCD screen, servomotors, and LEDs for motion detection, and an Arduino Uno microcontroller. It highlights the need for precautionary measures such as wearing masks, social distancing, and disinfecting hands and arms to prevent the spread of COVID-19.

The system has been tested in various scenarios, showing 100% accuracy in motion and temperature detection. Currently, the safety and efficacy of hand sanitizers marketed for children during the COVID-19 pandemic are being examined, according to Dell'Isola et al., (2021). Studies have been conducted addressing concerns about the safety and efficacy of alcohol-based hand sanitizers due to temporary FDA recommendations that modified the allowable impurity limits in these products.

A survey was conducted from January to April 2021 in physical and online stores to identify hand sanitizers appealing to children. Thirty-one selected products were analyzed to detect impurities and measure ethanol content. Impurities were evaluated using a gas chromatography-mass spectrometry method. Out of 139 identified products, 31 were analyzed for impurities. Impurities such as acetaldehyde, benzene, and acetal were found in some products, exceeding the FDA's recommended limits.

Handwashing is essential during pandemic times. According to Szczuka et al., (2021), in her work "The trajectory of COVID-19 pandemic and handwashing adherence: findings from 14 countries," the World Health Organization (WHO) guidelines were analyzed across 14 countries. The study observed 6,064 adults and analyzed how the total number of COVID-19 cases relates to deaths and handwashing frequency.

This work proposes a study that should conclude with a trajectory of how the pandemic significantly affects hygiene behaviors and suggests that future research should consider these indicators to better understand health prevention behaviors during a pandemic.

Applications have been developed such as the work on experimental data of push and pull forces using automatic liquid dispensers.

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These experiments are essential for design and data collection using sensors. In this project, three types of liquids (water, soap, and hand sanitizer) were used at three volume levels (50 ml, 150 ml, and 250 ml) and tested at six servo motor rotation angles (30°, 60°, 90°, 120°, 150°, and 180°).

During the experiment, push and pull force data on the automatic liquid dispenser were recorded and transmitted to cloud servers using internet networks. The collected data provide a valuable reference for industrial engineers in calculating electrical power requirements and predicting the recharge period of automatic liquid dispensers.

The dataset can be reused in future studies to design and develop new prototypes of automatic liquid dispensers, avoiding over-design or under-design and optimizing energy consumption (Sitorus et al., 2021). The work developed by Kumar (2021) describes the design and development of a compact, contactless infrared thermometer.

This device is intended to assess body temperature and maintain physical distancing in social environments. It uses infrared technology to measure temperature without physical contact, reducing the risk of spreading diseases such as COVID-19. Additionally, the device is designed to be portable and convenient, facilitating its use in various spaces such as schools, offices, and public hospitals.

The article also details the device's fabrication, including component selection, circuit design, and microcontroller programming. Test results showed that the contactless thermometer is accurate and reliable for fever detection, providing an effective tool for early symptom detection in community settings. Kumar mentions that the use of such devices can significantly contribute to the prevention of the spread of infectious diseases and the maintenance of public health.

The work developed by Vandika and Ranham (2020) presents a prototype based on the MLX90614 sensor and an Arduino development board for a system that measures body temperature using the infrared sensor, which has generally been used for health monitoring.

The device is designed for individuals with normal physical conditions but can also be useful for those with disabilities, such as blindness. The developed system measures temperature without contact and transmits the data to an Android application.

The sensor's accuracy, combined with the Arduino's capability to process and send data, allows for efficient and precise body temperature measurement, maintaining an error margin between 0.3°C and 0.6°C compared to analog thermometers. Additionally, the device includes additional sensors to monitor other vital signs such as blood pressure and pulse, providing a comprehensive health assessment.

The MLX90614 sensor can be adapted to various microprocessors or development boards, one of which is the STM32F107. This project, developed by Jin et al., (2015), was employed to identify security liquids in places such as subways, airports, and train stations, preventing contamination and injuries from corrosive or toxic liquids.

The hardware design, PCB creation, and programming were done using a software called Keil C, allowing the measurement of the temperature of liquids in bottles of various shapes, materials, sizes, and wall thicknesses at different distances. The project ensured high reliability, low cost, low power consumption, and real-time response. The project enabled the analysis of the effects of measurement distance, bottle material, and wall thickness on the accuracy of the measured temperature. The results showed that the measurement accuracy varies with distance and bottle material, highlighting that the optimal measurement distance is 5 mm to minimize errors.

Objetive

Develop and implement a gel dispenser with an integrated LED traffic light for early fever detection in public spaces, aimed at enhancing preventive measures against contagious diseases and promoting hygiene among the population.

Hypothesis

In Mexico, socioeconomic disparities significantly limit access to education and healthcare, a situation that became evident during the SARS CoV2 pandemic.

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Despite the efforts of the media and healthcare personnel, many people ignored recommendations to wash hands, wear face masks, and maintain social distancing. Additionally, the fear of forehead temperature checks, due to the erroneous belief that it could cause brain damage, contributed to the spread of the virus in crowded places.

If a user-friendly and easy-to-use gel dispenser is implemented, it could significantly reduce the transmission of infectious diseases in enclosed spaces by promoting hand hygiene and detecting fevers early. Placing these devices at strategic points such as schools, shopping centers, hospitals, and public and private transportation systems could establish effective control that prevents potentially ill individuals from entering, similar to measures observed during the pandemic, where guards at entrances checked temperatures and provided hand sanitizer, denying access to those showing symptoms of illness.

Methodology and development

The project was developed in the Measurement and Instrumentation Laboratory at the Technological Center of the Facultad de Estudios Superiores Aragón, with the objective of designing an LED traffic light system that changes color based on detected body temperature, using an MLX90614 infrared temperature sensor.

A proximity sensor was integrated to automatically activate the dispenser when a hand is detected. Additionally, a data storage system was implemented using a MicroSD card to record temperatures and the usage of the attached antibacterial gel. An LCD screen was integrated to display the current temperature and the device status.

The collected data allows the evaluation of the device's effectiveness in detecting febrile temperatures and its acceptance in public spaces such as schools, transportation centers, and other crowded places.

The Arduino module used in the project for temperature measurement was the GY-906, an infrared thermometer with an MLX90614 sensor from Melexis (2006).

Melexis has developed a whole family of these thermometers, but the AXX model was selected for its easy adaptability to a project with an Arduino UNO board, as it includes a voltage regulator from 5V to 3V. This sensor can operate at ambient temperatures from -40°C to 125°C (COMPONENTS101, 2020) and detects temperatures between -70°C and 380°C with a minimum accuracy of ±4%. However, its highest accuracy is between 0°C and 50°C of ambient temperature, detecting objects between 0°C and 60°C with a variation of ±0.5%. Additionally, it has a measurement resolution of 0.02°C (UNIT ELECTRONICS, 2023). The schematic diagram of the circuit designed for the Gel Dispenser XXI shows power supplied through a Jack power input providing 12V.

This voltage powers the system's motor, and in parallel, a regulator is used to convert the power to 5V, thereby energizing the Arduino UNO board and most of the system components, except for the MicroSD module which operates at 3.3V directly obtained from the Arduino. On the same side of the board, the analog inputs connect the SCL and SDA pins of the I2C adapter for the LCD screen and the MLX90614 temperature sensor. On the lower right side, where key processes are controlled, PWM outputs were used to send signals to the LEDs, buzzer, and IRF3205 transistor.

The PWM pin was also employed to read the output from the FC-51 Proximity Sensor, which activates the mentioned components. Finally, on the upper right side, the specific pins for the operation of the MicroSD module are configured according to the programmer's library specifications, ensuring correct functionality as illustrated in Figure 1.

Box 1

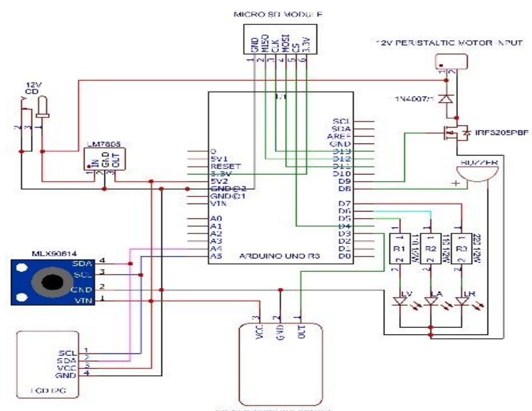

Figure 1

Schematic Diagram of the Electrical Circuit for the Dispenser XXI

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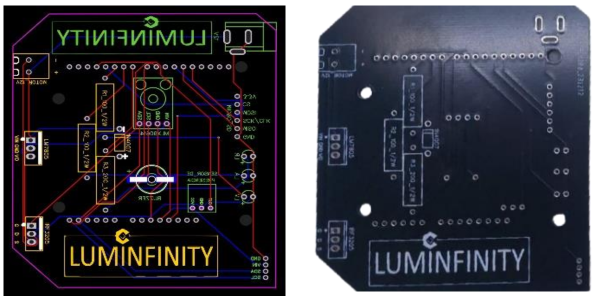
In Figure 2a, the traces of the printed circuit board (PCB) are shown in relation to the schematic diagram presented in Figure 1. This figure illustrates both layers of the PCB: the top layer is represented by blue and green colors, while the bottom layer is represented by red and yellow colors. On the other hand, Figure 2b presents a view of the physical PCB from its underside.

Box 2



(a) (b)

Figure 2

a) Printed circuit board PCB. b) Printed circuit design

During the PCB soldering process, various tools were used, as shown in Figure 3. These tools include a board holder with a magnifying glass, solder wire, solder paste, an aluminum fiber for cleaning the soldering iron, a solder sucker, insulating tape, a soldering iron, a soldering iron stand, and a sponge with water.

Box 3

Figure 3

Materials Used for Soldering the Board

Figure 4 shows all the materials that make up the electronic system of the dispenser. These materials include the PCB, an Arduino Uno, red, yellow, and green LEDs, a MicroSD memory module with its corresponding MicroSD card, an IRF3205 MOSFET, an LM7805 voltage regulator, a buzzer, two 100Ω resistors and one 200Ω resistor, a connector, a 1N4007 rectifier diode, a Jack connector, a 16x2 LCD screen, an I2C adapter for the LCD, the MLX90614 infrared temperature sensor, the FC-51 proximity sensor, nuts and bolts for the components, and a 12V 3A AC-DC regulator with Jack output.

Additionally, extra tools such as screwdrivers and pliers were used for the assembly process.

Box 4

Figure 4

Electronic Components and Tools Used During Assembly

The selected switch for activating the peristaltic pump was the IRF3205 MOSFET, due to its great adaptability to low voltage and current electronic systems. According to the datasheet of this transistor from International Rectifier, its main characteristics are as follows: it is an N-channel MOSFET transistor of the IRF3205 series, with a TO-220AB package. It has three connection pins, which from left to right are arranged as Gate, Drain, and Source respectively for through-hole technology (THT) mounting.

The maximum drain-source voltage (VDS) it can withstand is 55VDC, the maximum gate-source voltage (VGS) is ±20V, and it supports up to a drain current (ID) of 110A. Additionally, it has a power dissipation (PD) of 200W, making it necessary to attach a heat sink.

Figure 5 illustrates the assembly and mounting process of the components on the PCB. In the background, the board holder can be seen, while the PCB is in the middle of the assembly process in the center.

At the front, the green LED is highlighted. On the board, the MOSFET and the LM7805 Voltage Regulator, resistors, rectifier diode, buzzer, green LED, MicroSD memory module, and the LCD screen cables with the I2C adapter are already soldered.

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Box 5

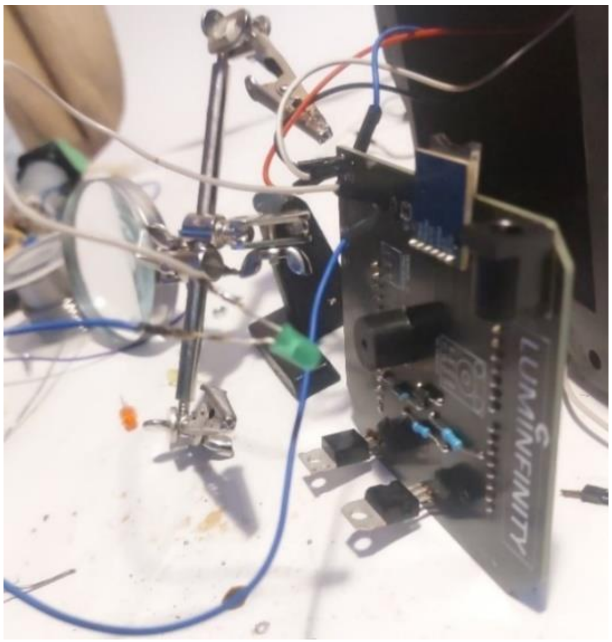

Figure 5
PCB of the Dispenser During the Soldering Process.

In Figure 6, most of the components are already soldered, allowing for a better view of how the I2C adapter is connected to the LCD screen and the distribution of components on the board. It also shows how the PCB is mounted on the Arduino UNO, achieving the connection through headers soldered to the PCB.

Box 6

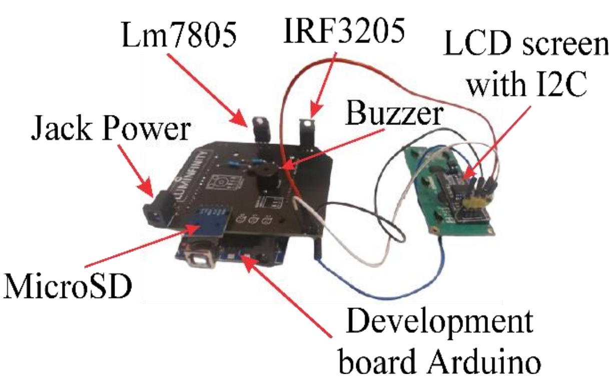

Figure 6
Components That Make Up the System's PCB and LCD Connection via I2C.

Figure 7 illustrates the internal operation of the peristaltic motor and its components. In the upper left part, the liquid inlet is connected to a plastic tube. Thanks to the rotation of the motor and the movement of the roller, a vacuum is generated in the tube that sucks the gel and transports it to the outlet located in the upper right part.

Box 7

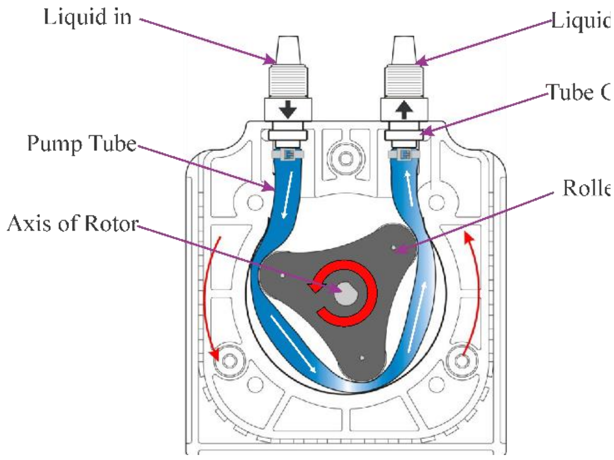

Figure 7
Internal Structure of the Peristaltic Motor

The following describes the external parts of the peristaltic motor. The power pins, the liquid inlet and outlet connected to a tube and an adapter, the metal housing of the motor, and the plastic housing of the peristaltic motor can be observed, as shown in Figure 8.

Box 8

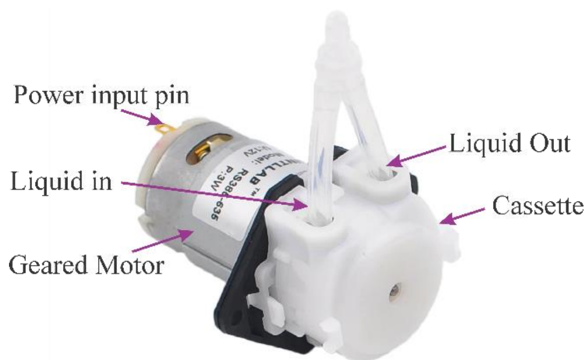

Figure 8
External Parts of the Peristaltic Motor

Results

The image shows the distribution of peripheral components related to temperature measurement and gel dispensing within the dispenser housing.

The design was based on the familiar use of commercial gel dispensers, where one typically places their hand underneath and waits for the presence sensors to detect and activate the system. However, by adding a third element, the temperature sensor, it was necessary to ensure that the sensor measured the warmest part of the hand, i.e., the palm. The sensor is positioned as shown in Figure 9.

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Box 9

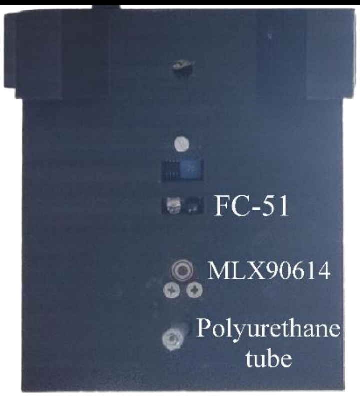

Figure 9

Bottom View of the Dispenser XXI Housing

Here, the 3D model of the housing is shown, designed in Fusion 360 with the license provided by UNAM, and the 3D printed model as seen in Figure 10.

The distribution of components within the housing is observed, including the spaces allocated for the LCD screen and the traffic light LEDs on the front. At the top, there is space for the peristaltic motor and the coupler for the gel bottle. On the sides, the "wings" with screw holes are highlighted, allowing the dispenser to be mounted on the wall.

Box 10

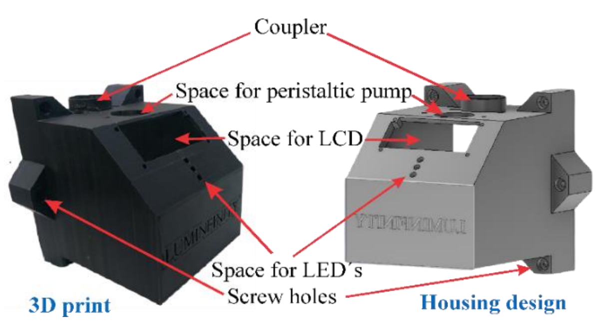

Figure 10

Parts of the Dispenser Housing

Figure 11 presents the flowchart designed for the coding in the Arduino Sketch for the so-called Dispenser XXI. The flowchart includes the declarations of the most important pins in the system.

Next, the conditions for reading and storing data on the SD card are shown. Subsequently, the conditions that determine the behavior of the dispenser based on the detected temperature are described, including the screens corresponding to each case and the activation of the motor to dispense gel. Finally, the system returns to the waiting welcome screen.

Box 11

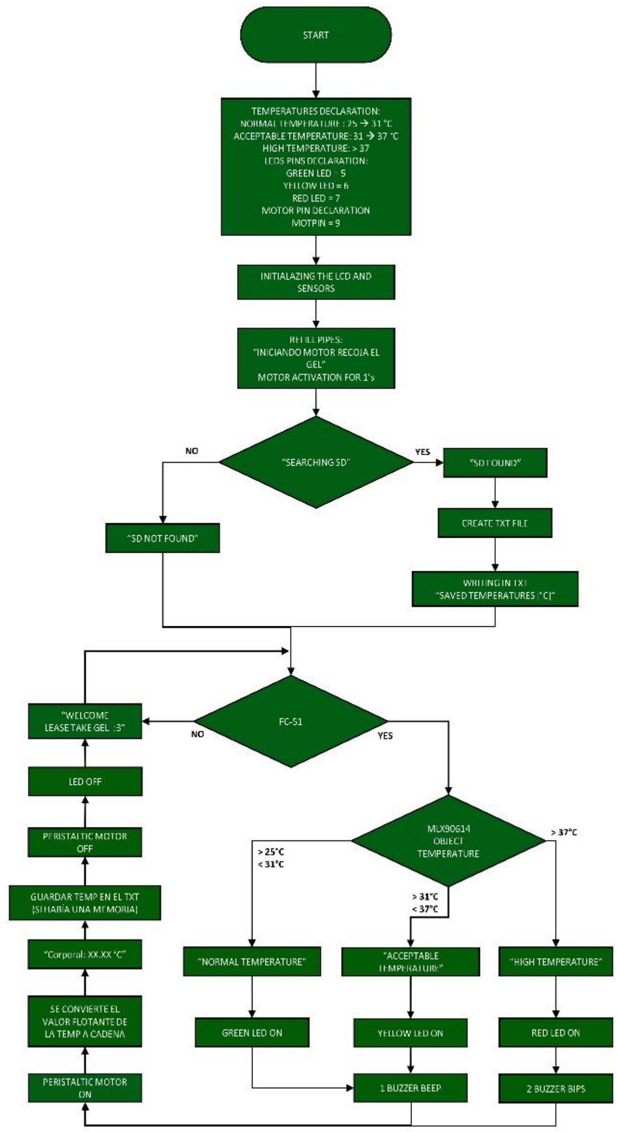

Figure 11

Flowchart of the XXI System Operation

Figure 12 provides a closer look at the distribution of components in the sampling area. The 16x2 LCD screen is secured to the housing using four screws and nuts that fit perfectly with the holes in its board. The green, yellow, and red LEDs, which indicate body temperature, are also present. Each LED is assigned to a specific temperature range and is activated according to the temperature detected by the sensor.

Utilizing the adapters for the peristaltic motor tube, an SMC brand polyurethane tube, model TU0604C, was used to transport the gel from the bottle to the motor and from the motor to the gel outlet for dispensing.

The tube gauge is 4 mm, and a total of 30 cm was used: 10 cm from the bottle to the motor and 20 cm from the motor to the outlet.

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Box 12

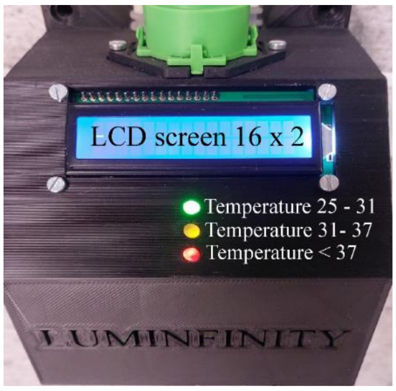

Figura 12
Sampling Area of the XXI Dispenser and Temperature Ranges Corresponding to Each LED

The antibacterial gel dispenser shown in Figure 13, equipped with a temperature measurement system, is installed at the entrance of the laboratory. As people enter the laboratory, the device automatically takes their temperature and dispenses antibacterial gel.

This system has been fundamental in maintaining strict hygiene control within the facilities, allowing for the early detection of students and visitors with symptoms of illness. Its use has been so significant that the gel container has required refilling over the past three months. During this period, approximately 1,200 people have used this system to record their temperature, demonstrating the effectiveness and high demand of the XXI dispenser in our work environment.

Box 13

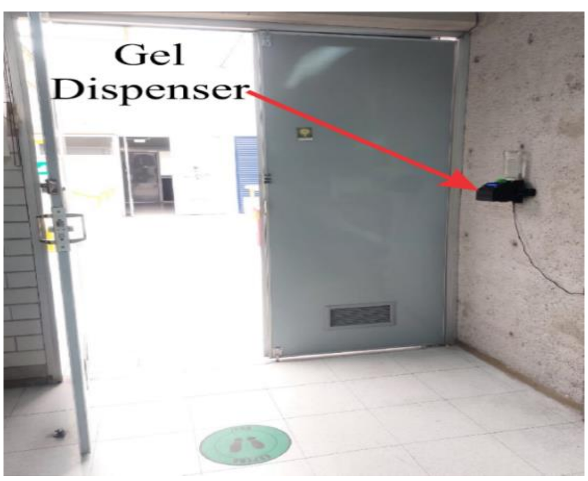

Figure 13
Dispenser XXI Installed and Operated in the Measurement and Instrumentation Laboratory of FES Aragón UNAM

The XXI Dispenser system includes a detailed organization of its parts, both internally and externally. In the front and rear views, it can be seen how the gel container is connected via a tube to the peristaltic pump, LCD screen, LED traffic light, housing, polyurethane tube, printed circuit board, Arduino UNO development board, MLX90614 infrared thermometer, and FC-51 proximity sensor, facilitating the continuous flow of gel to the dispensing mechanism. Additionally, the interconnection between the detection and gel dispensing system peripherals and the sampling area is observed.

This interaction is essential for the coordinated operation of the device and is managed through an electronic board linked to the Arduino UNO, as shown in Figure 13. This arrangement allows for the effective integration of all dispenser functions, ensuring precise and reliable operation.

Box 14

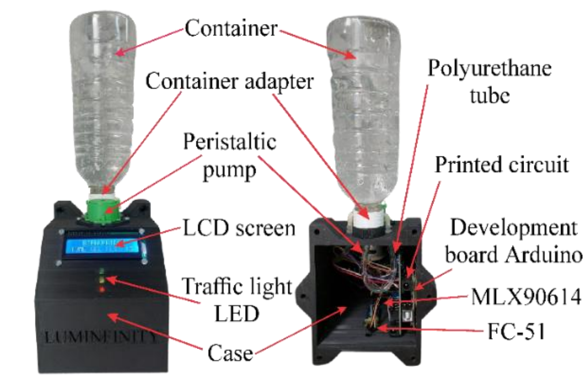

Figure 14
Front (Left) and Rear (Right) View of the Dispenser

Figure 15 presents images of users interacting with the XXI Dispenser in the Laboratory.

Thanks to these sessions, it was possible to collect and store temperature data for subsequent analysis. These data allowed for the graphing and visualization of the recorded temperatures' behavior and the performance of statistical analyses.

From these analyses, average temperature values were determined and programmed into the device to establish appropriate temperature ranges. Additionally, a specific test was conducted to evaluate the sensor's accuracy at different distances.

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González-Galindo, Edgar Alfredo, Fernández-Acosta, Luis Eduardo, Juárez-Gutiérrez, José de Jesús and Domínguez-Romero, Francisco Javier. [2024]. Implementation of an gel dispenser with LED traffic light for early fever detection in public spaces. Journal of Physiotherapy and Medical Technology. 8[19]1-15: e3819115.
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Placing the hand at a distance of seven centimeters where the sensor began to detect temperature, a variation of 1.39 °C was detected.

This result was compared with measurements obtained using a mercury thermometer to validate the accuracy of the MLX90614 sensor.

Box 15

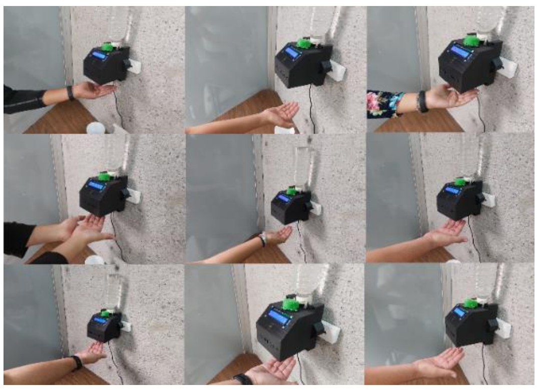

Figure 15

Students and Staff Who Have Used the Dispenser XXI in the Measurement and Instrumentation Laboratory of the Technological Center Aragón

In Table 1, the statistical data from the graph in Figure 16 is shown, which records the behavior of hand temperature measurement at distances between 0 cm and 10 cm. It was detected that at distances from 7.1 cm to 10 cm, the sensor fails to measure the hand's temperature.

To verify this behavior, several measurements were taken, of which three samples are presented, showing consistent behavior.

Box 17

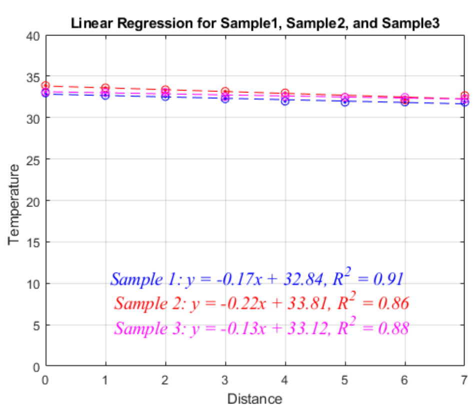

Figure 16

Behavior of the linear regression of the MLX90614 sensor measurements

The data was collected from students of both genders entering the laboratory. These data, shown in Graph 16, were recorded by the gel dispenser named Dispensador XXI. The microSD memory was extracted to visualize the data graphically.

The observed behavior indicates that the MLX90614 sensor shows a difference of at least three degrees Celsius, suggesting the need to adjust it to accurately detect febrile temperatures. This device also includes a buzzer that emits an audible alert if a high temperature is detected.

Box 16

Table 1

Statistical data of the MLX90614 sensor readings.

	Sample 1	Sample 2	Sample 3
mean	32.248	33.91	32.678
median	32.115	34.075	32.54
std	0.43236	0.75895	0.32884
var	0.18694	0.576	0.10814
range	1.12	2.21	0.84

Figure 16 shows the graph that visualizes temperature detection with the MLX90614 sensor. The data comes from students entering the laboratory. Before taking their temperature, they were asked to stay in the laboratory for at least 10 minutes to avoid measurement variations.

This precaution was taken because some students might have arrived after walking in the sun or carrying objects in their hands that could alter the measurements.

Box 18

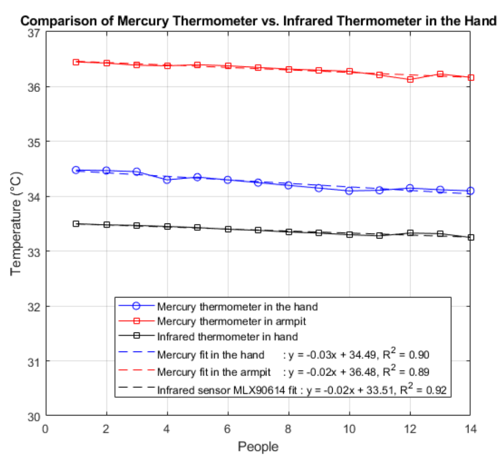

Figure 17

Behavior of the linear regression of the temperature measurements with the MLX90614 sensor for students entering the laboratory

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Conclusions

This study describes the development and implementation of a gel dispenser with an LED traffic light, specifically designed for early fever detection and to promote hand hygiene in public spaces.

Utilizing the MLX90614 infrared temperature sensor, the device has proven highly effective in identifying febrile temperatures. The functionality of the LED traffic light, which changes color based on the detected temperature, allows for direct and effective communication of health status to users, which is essential for controlling the spread of infectious diseases in crowded environments.

The automatic antibacterial gel dispenser not only promotes proper hand hygiene but also contributes to water conservation, offering a sustainable solution amid water scarcity exacerbated by high temperatures. This innovation has been successfully implemented in the Measurement and Instrumentation Laboratory at the Aragón Technological Center of the National Autonomous University of Mexico, where it has received positive feedback and shown significant impact in preventing disease transmission.

Initially designed in response to the COVID-19 pandemic, the dispenser highlights the importance of technological innovation in combating pandemics. Additionally, it stands out for its cost-effectiveness compared to other market options, offering an affordable approach to public health.

To expand the utility of this device, the integration of IoT technology is proposed, which would allow for remote monitoring of health statistics and dispenser usage, thereby broadening its applicability.

Furthermore, it is recommended to test and adapt the dispenser in a variety of public environments, such as shopping centers, hospitals, and transportation systems, to evaluate its effectiveness and acceptance in different contexts.

It is essential to conduct a longitudinal study to determine the actual impact of the device on the reduction of infectious disease transmission in the short and medium term.

The adoption of this type of technology could not only play a crucial role in preventing future pandemics but also promote continuous improvement of public health measures in crowded spaces.

Annexes

Code in C language for programming the development board of the Gel dispenser.

```
#include <Adafruit_MLX90614.h>
#include <LCDIC2.h>
#include <SD.h>
/////////////////////////////////////////////
Adafruit_MLX90614 mlx = Adafruit_MLX90614();
LCDIC2 lcd(0x27, 16, 2);
File myFile;
/////////////////////////////////////////////
byte MOTPIN = 9; //false=0FF 9=ON(pin)
byte BZ = 8; //false=0FF 8=ON(pin)
byte LUZ = 1; //LOW(0) - HIGH(1)

const int TBAJ = 25; //°C
const int TMED = 31; //°C
const int TALT = 37; //°C
const int TMPRELL = 5000; //ms
const int TMSERV = 3000; //ms
const int TESP = 3000; //ms

byte sensorPin = 3;
byte AZ = 5;
byte AM = 6;
byte RJ = 7;
/////////////////////////////////////////////
String TEMPERATURAS(float, String);
String TEMP;
String
floatToString(float,int=8,int=2,boolean=true);
String TO;
void GUARDARTEMPS();
/////////////////////////////////////////////
void setup()
{
  Serial.begin(9600);
  //-------PANTALLAS DE PRESENTACIÓN
  MENSAJESDEINICIO();
  //-------LEDS Y BUZZER
  INICIALIZARINDICADORES();
  //-------MOTOR PARA RELLENAR EL TUBO DE GEL
(SE QUITARÁ O COMENTARÁ CON EL NUEVO
DISPENSADOR DEPENDIENDO LA VRSIÓN)
  RELLENARGEL();
  //-------SECCIÓN DONDE SE INICIA EL MLX90614
Y EL SENSOR DE OSTÁCULOS
  INICIARSENSORES();

  //-------SECCIÓN DONDE SE VE SI HAY O NO
MEMORIA SD
  INICIARSD();
}
void loop()
{
  float obj = mlx.readObjectTempC();

  String TO;
  String TEMP;
/////////////////////////////////////////////
  int value = digitalRead(sensorPin);
```

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```
  while (value == 1)
  {
    lcd.setCursor(3,0);
    lcd.print("BIENVENIDO");
    lcd.setCursor(0,1);
    lcd.print("TOME GEL PLIS :3");

    delay(1000);

    return;
  }
//////////////////////////////////////////////
  //TEMPERATURA DEL OBJETO EN MONITOR SERIAL
  Serial.print(F("Temperatura:"));
  Serial.print(obj);
  Serial.println(F("°C"));

  //Regreso al While si la temperatura es
menor a TBAJ
  if (obj < TBAJ)
  {
    lcd.setCursor(3,0);
    lcd.print("BIENVENIDO");
    lcd.setCursor(0,1);
    lcd.print("TOME GEL PLIS :3");

    return;
  }

  //TIPO DE TEMPERATURA, LEDS Y BUZZER
  TEMP = lcd.print(TEMPERATURAS(obj,TEMP));

  //ENCENDER MOTOR
  digitalWrite(MOTPIN, 1);

  lcd.setCursor(4,1);
  //CONVERSIÓN DE TEMPERATURA FLOAT A CADENA
PARA EL LCD
  TO = lcd.print(floatToString(obj,0));
  lcd.print(0337);
  lcd.print("C");

  //-------GUARDADO DE TEMPERATURAS EN LA SD
  GUARDARTEMPS(float(obj));

  delay(TMSERV);
  lcd.clear();

  //APAGAR MOTOR
  digitalWrite(MOTPIN, 0);

  //INTERMEDIO
  lcd.setCursor(1,0);
  lcd.print("RETIRE LA MANO");
  delay(TESP);
  lcd.clear();
  lcd.setCursor(5,1);
  lcd.print("ESPERE");
  delay(TESP);
  lcd.clear();
}
////////////////////////////////////////////
//MENSAJES DE INICIO EN OBJETOS
void MENSAJESDEINICIO()
{
  lcd.begin();
  lcd.setBacklight(LUZ);
  lcd.clear();
  Serial.println(F("--------------------------
--------"));
  Serial.println(F(" "));
  Serial.println(F("UNIVERSIDAD NACIONAL
AUTÓNOMA DE MÉXICO"));
  Serial.println(F("FACULTAD DE ESTUDIOS
SUPERIORES ARAGÓN"));
  Serial.println(F("CENTRO TECNOLÓGICO
ARAGÓN"));
  Serial.println(F("LABORATORIO DE MEDICIÓN E
INSTRUMENTACIÓN"));
  Serial.println(F("LUMINFINITY BIOMEDICS"));
  Serial.println(F("LUIS (MILAN) EDUARDO
FERNANDEZ ACOSTA"));
  Serial.println(F("DISPENSADOR XXI"));
  Serial.println(F(" "));
  lcd.setCursor(6,0);
  lcd.print("UNAM");
  lcd.setCursor(3,1);
  lcd.print("FES ARAGON");
  delay(2500);
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("CTEC ARAGON");
  lcd.setCursor(1,1);
  lcd.print("LAB MED E INST");
  delay(2500);
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("LUMINFINITY");
  lcd.setCursor(3,1);
  lcd.print("BIOMEDICS");
  delay(2500);
  lcd.clear();
  lcd.setCursor(5,0);
  lcd.print("LEFDZA");
  lcd.setCursor(5,1);
  lcd.print("MILAN");
  delay(2500);
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("DISPENSADOR");
  lcd.setCursor(6,1);
  lcd.print("XXI");
  delay(2500);
  lcd.clear();
}
//////////////////////////////////////////
//INICIALIZAR INDICADORES
void INICIALIZARINDICADORES()
{
  //-------LEDS
  for(uint8_t i=0; i<3; i++)
  {
    digitalWrite(AZ, 1);
    digitalWrite(AM, 1);
    digitalWrite(RJ, 1);
    delay(1000);
    digitalWrite(AZ, 0);
    digitalWrite(AM, 0);
    digitalWrite(RJ, 0);
    delay(500);
  }
  //-------BUZZER
  pinMode(BZ, OUTPUT);
  digitalWrite(BZ, 1);
  delay(250);
  digitalWrite(BZ, 0);
  delay(2500);
}
//////////////////////////////////////////
//RELLENAR TUBO DE GEL
void RELLENARGEL()
{
  //-------MOTOR
  pinMode(MOTPIN, OUTPUT);

  lcd.clear();
```

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```
  lcd.setCursor(0,0);
  lcd.print("INICIANDO  MOTOR");
  lcd.setCursor(1,1);
  lcd.print("RECOJA EL GEL");
  delay(2500);
  digitalWrite(MOTPIN, 1);
  delay(TMPRELL);
  digitalWrite(MOTPIN, 0);
  delay(2500);

  lcd.clear();
}
////////////////////////////////////////////
//INICIALIZAR SENSOR DE TEMP Y DE PRESENCIA
void INICIARSENSORES()
{
  //--------SENSOR DE PRESENCIA
  pinMode(sensorPin, INPUT);

  //-------SENSOR DE TEMPERATURA
  mlx.begin();
}
////////////////////////////////////////////
//INICIAR MEMORIA SD
void INICIARSD()
{
  //-------MEMORIA SD
  lcd.setCursor(2,0);
  lcd.print("BUSCANDO SD");

  delay(2500);
  lcd.clear();
  if(!SD.begin(4))//ver si hay una sd
conectada
  {
    lcd.setCursor(1,0);
    lcd.print("SIN MEMORIA SD");
    delay(2500);
    lcd.clear();
  }
  else
  {
    lcd.setCursor(2,1);
    lcd.print("SD DETECTADA");
    myFile =
SD.open("archivo.txt",FILE_WRITE);
    myFile.println("TEMPERATURAS GURADADAS
[°C]:");
    myFile.close();

    delay(2500);
    lcd.clear();
  }
}
////////////////////////////////////////////
//CONDICIONALES DE TEMPERATURAS
String TEMPERATURAS(float obj, String TEMPE)
{
  lcd.clear();

  if (obj > TBAJ && obj < TMED)
  {
    TEMP = "  TEMP NORMAL";
    digitalWrite(AZ, 1);
    delay(250);
    digitalWrite(AZ, 0);
  }
  else if (obj > TMED && obj < TALT)
  {
    TEMP = "TEMP ACEPTABLE";
    digitalWrite(AM, 1);
    delay(250);
    digitalWrite(AM, 0);
  }
  else if (obj > TALT)
  {
    TEMP = "   TEMP ALTA";
    digitalWrite(RJ, 1);
    delay(250);
    digitalWrite(RJ, 0);
  }
  digitalWrite(BZ, 1);
  delay(250);
  digitalWrite(BZ, 0);
  return TEMP;
}
////////////////////////////////////////////
//GURDAR TEMPERATURAS
void GUARDARTEMPS(float obj)
{
  myFile = SD.open("archivo.txt", FILE_WRITE);
//abrir el archivo
  Serial.println("GUARDANDO EN LA MEMORIA");
  Serial.println("  ");
  myFile.print(obj);
  myFile.println(" ");
  myFile.close();
}
////////////////////////////////////////////
//CONVERSIÓN DE LAS TEMPERATURAS
String floatToString(float obj, int l, int d2,
boolean z)
{
  d2 = 2; //Decimales
  char g[l+1]; //Numero entero mas el punto
  String p;
  dtostrf(obj,l,d2,g);
  TO = String(g);
  return TO;
}
```

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Declarations

Conflict of interest

The authors declare that they have no conflicts of interest.

They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Author contribution

González-Galindo Edgar Alfredo: Contributed to the main idea of the project and the implementation of the methodology for early fever detection using a gel dispenser with an LED traffic light. Supervised the development of the prototype and the integration of the MLX90614 temperature sensors and the FC-51 proximity sensor.

Fernández-Acosta Luis Eduardo: Specialized in the design of the electronic circuit and the programming of the Arduino UNO, integrating the MLX90614 infrared temperature sensor and the FC-51 proximity sensor. Also developed the data storage system on the MicroSD card and configured the LCD screen to display fever temperature information.

Juárez-Gutiérrez, José de Jesús: Responsible for the physical assembly of the prototype, including the mounting of components and soldering on the PCB. Led the prototype testing process in different environments to validate its functionality and effectiveness, as well as the temperature data analysis. Additionally, contributed to the writing of the methodology and results sections of the article.

Domínguez-Romero Francisco Javier: In charge of the design and development of the test card system for power supply management of the device, including the management of the peristaltic motor. Also contributed to the schematic diagram of the circuit and the soldering of components on the PCB.

Availability of data and materials

The data for this research is available according to the sources consulted.

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Abbreviations

AC (Alternating Current)
DC (Direct Current)
PIR (Passive Infra Red)
PCB (Printed Circuit Board)
SD (Secure Digital)
SARS CoV2 (Severe Acute Respiratory Syndrome Coronavirus 2)
PWM (Pulse Width Modulated)
LCD (Liquid Cristal Display)
I2C (Inter-Integrated Circuit)
SCL (Serial Data)
SDA (Serial Clock)
MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor)
THT (Througth-Hole Tecnology)
VDS (Drain-Source Voltage)
VGS (Gate-Source Voltage)
ID (Drain Current)
PD (Power Disipation)

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