Computational Graphics and Geometric Modelling

Project report: Hand sanitizer station

Carles Bada Fernández, nº 110085

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1 Introduction

The following project report describes the work done during the second semester for the subject of Computational Graphics and Geometric Modelling of Biomedical Engineering. The aim of the project was to develop an engineering project from the idea to the proof of concept with the prototype.

The chosen project has been the development of a hand sanitizer station, since due to the Covid-19 pandemic, hand cleaning and temperature control has been the new normality. For this reason, the idea of this project was to develop an autonomous hand sanitizer station with temperature control, portable, easy to use and with battery powered supply.

This project report is organized in four different parts: Design, Programming, Prototyping and Improvements and Conclusions.

2 Design

The design of this project was conducted using SolidWorks2020, a very powerful CAD software for the mechanical modelling in 2D and 3D. The objective of this part of the project was to develop the virtual structure of the device, and the component assembly for the further printing of the pieces using 3D printers.

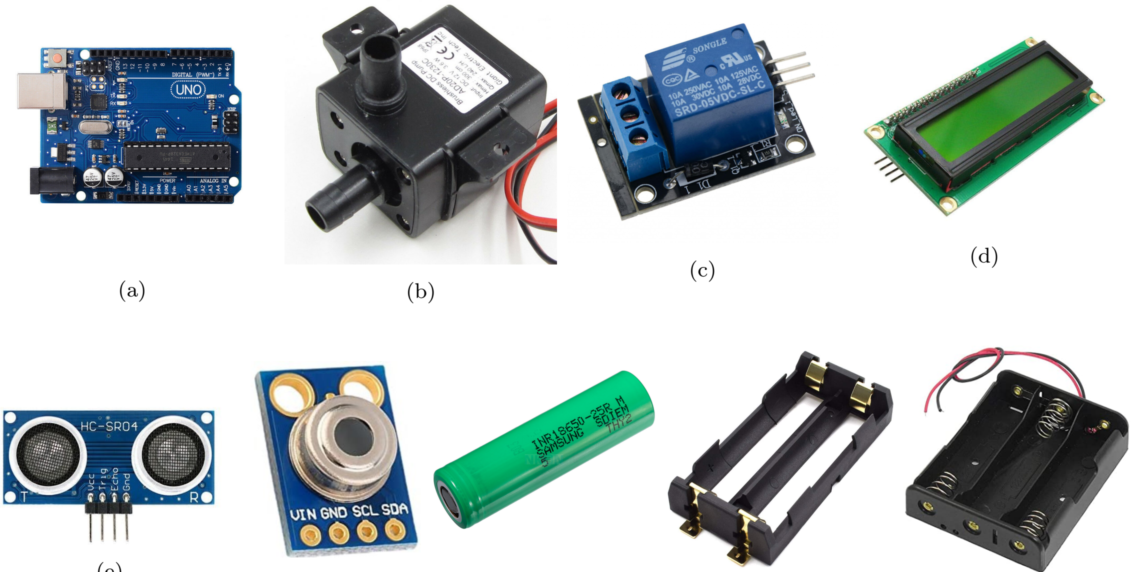
The main parts that the hand sanitizer device should be:

- **Brain:** part where the electronic components should be stored.
- **Gel tank:** part where the hydro-alcoholic gel will be stored. It has to be isolated from the electronics.

Besides these two different parts, there are more components which had to be taken into account such as covers, or the dispenser. However, before starting with the design of the structure, it was necessary to identify which were the different electronic components which would be used in the station. The components can be seen in figure 1 and are the following:

- **Arduino UNO (a):** Arduino micro-controller board which will be the brain of the device.
- **Pump (b):** 12V pump which will transport the gel from the tank to the dispenser
- **Relay (c):** magnetic relay which will control the opening and close of the electric circuit to power the pump.
- **LCD screen (d):** LCD screen (16x2) with the I2C connection module which will display the information.

- **Distance sensor (e):** Ultrasonic Sensor HC-SR04 which can measure distance.
- **Temperature sensor (f):** MLX90614 thermal sensor which can measure temperature at distance.
- **Batteries (g):** battery model 18650 of 3.7V rechargeable Li-ion of 3800mAh. Will be used to power the Arduino board and the pump.
- **Battery case 2 (h):** Battery case for two batteries, have to be connected in series to obtain 7.4V and power the Arduino board.
- **Battery case 3 (i):** Battery case for three batteries in series to obtain 10.1V to power the pump.



(a) (b) (c) (d)

(e) (f) (g) (h) (i)

Figura 1: Electronic devices used in for the project

Once given the electric components that will be used to make the device work, it was necessary to design the structure to hold the whole device. For this design the main limitations where the size of the pieces(no more than 200x200mm due to 3D printer size) and to have printable shapes. For this reason the design has been divided in 6 different pieces: 3 structural, 2 covers and 1 tube for the dispensing.

2.1 Piece 1: Tank

This piece is the one that will contain the gel inside. The piece consists of a hollow cuboid with all the faces except the top one. With this configuration it is possible to print it without the need of making support columns. Dimensions are 170x150x70 mm, with a useful capacity of 1.092 litres. Initially, the pump was thought to be outside this part, but due to its dimensions, finally was also installed in the top of this part to be able to save space and material in other parts. It has a small hole in the upper part to be used as the input gel hole. This piece has wholes for M3x12 screws to be attached with piece 2 and piece 4, and also to support the pump.

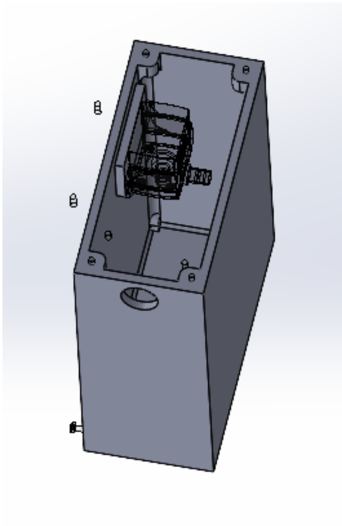


Figura 2: Gel tank of the device.

2.2 Pieces 2 & 3: Brain and cover

This is the piece which will contain the Arduino Uno board, the relay and the batteries. As these components are big, the piece was done in front of piece 1 but less width, measuring 170x150x35 mm. This piece will be screwed to piece 1 and piece 4, and also to the cover of the piece. For all the components have been designed supports to screw them to the piece. Finally, we have also designed 3 holes in the upper part to have space for passing cables to connect with the devices in piece 4. For the cover, a rift has been done and also prepared some screw supports. Finally, in the lateral, holes for the connections of Arduino Uno with USB or supply power was done, as well as a hole for installing a switch button.

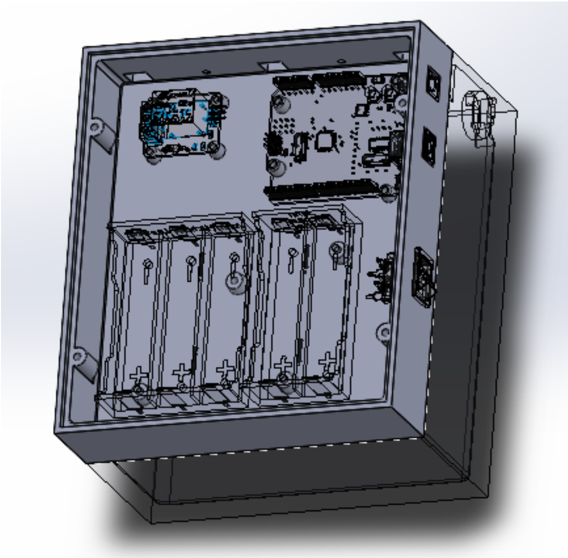
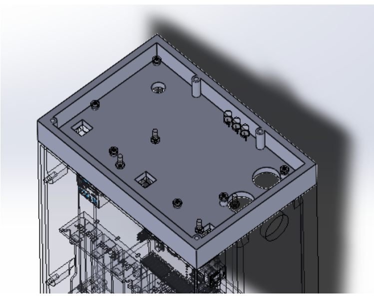


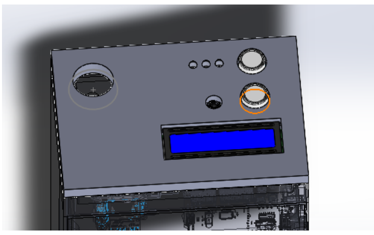
Figura 3: Electronic core of the device.

2.3 Pieces 4 & 5: Sensors and display and cover

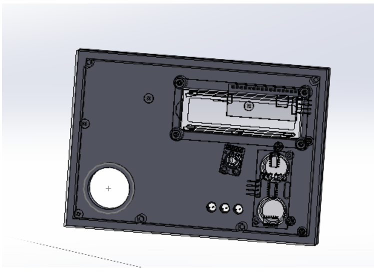
This is the piece that will contain the interaction with the user of the device, regarding the distance sensor, the temperature sensor, the LCD screen, the information LEDs and the tube for the gel dispensing. It is placed at the upper part of the device, and it is made of the bottom piece (piece 4) with more a more structural function, joining the tank and the brain, and the cover (piece 5), supporting the electronic components. Piece 4 contains the wholes for the plastic tube of the pump, for the screws and for the electric cables, while piece 5 contains the screw supports for the components and the support for the tube (piece 6). These last support was initially though to use a thread to combine both, but finally, has been done using a simple face-to-face union (join with pressure).



(a)



(b)



(c)

Figura 4: Piece 4 (a), upper view of piece 5 (b), bottom view of piece 5 (c).

2.4 Piece 6: Tube

This is the part which will contain the plastic tube that comes from the pump and will dispense the gel. For this reason it is hollow with an internal diameter of 9 mm, because a plastic tube of 8 mm will be used. This part will be attached to piece 5 with pressure.

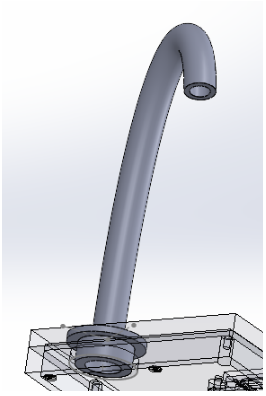


Figura 5: Tube for the gel dispensing.

2.5 Assembly

Finally, to combine all the different pieces, an assembly was performed, using relations, we have joined all parts and electric components. We have modelled the screws as well, in order to determine the number of needed screws, it there was any type of overlaying between all the components and if there would be space for the cables and the plastic tube. The final result is shown in the following images:

(a) (b) (c)

Figura 6: Assembly of the device (a), and without covers (b, c).

3 Programming

In this part the software of the device will be described. The programming of the Arduino UNO board has been conducted using the Arduino IDE software, provided for free from Arduino and based in C++ programming language.

The Arduino coding is based in two different parts. The first one is void setup(), which is the code that will be only running one time at the start of the execution. This part is used for the initialization of the different sensors and actuators. Then the infinite loop that will be running constantly is called void loop and is the part that will contain the execution protocol of the sanitizer station.
The proposed working protocol for the station is described in the following figure.

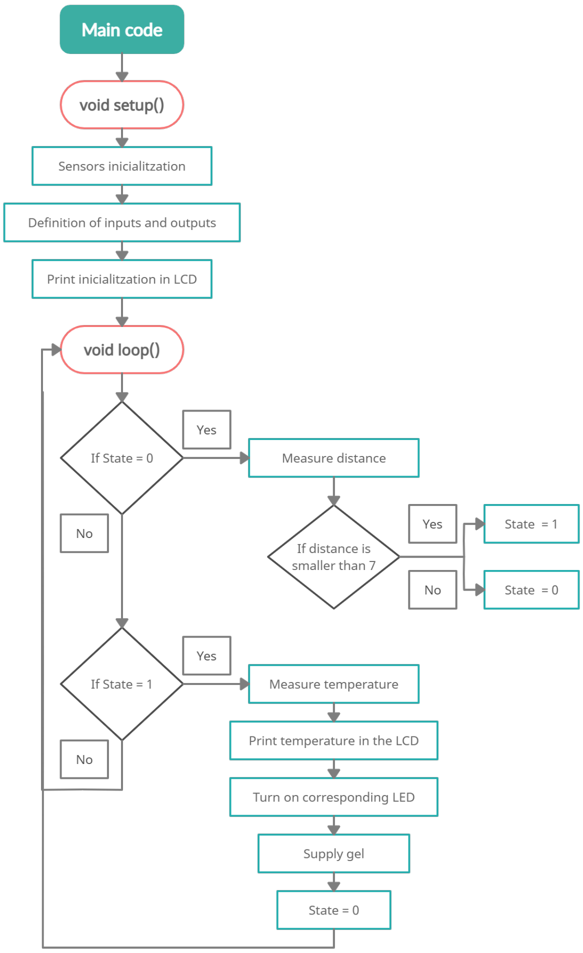


Figura 7: Software workflow.

The full code of the device can be found in Annex I: Main code.

4 Prototyping

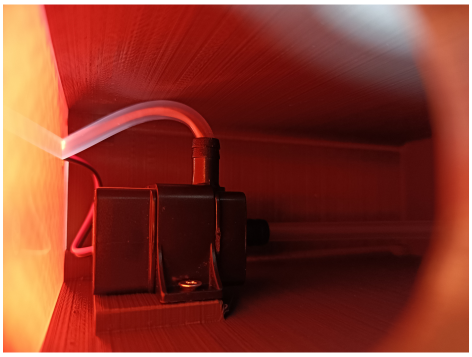
In this section, the development of the prototype will be developed, which is the process to make real the virtual design produced.

To perform the prototyping of the device, the six described SolidWorks pieces have been 3D printed in the University with cost for the student of 0€. The electronic components have been bought in AliExpress and to screw pieces, screws of M3x8, M3x10 and M3x12 have been used. The total cost of the components has been 39.19€.

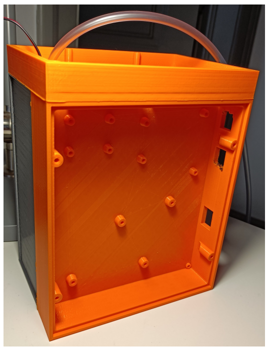
The assembly of all the different parts was a challenging but interesting step, because as it was the first time that the parts were printed, it was possible to identify some problems regarding the design, as well as that, for example, components sizes were not exactly the same as the ones from the designs extracted from GrabCAD. Besides of that, while we were working with plastic, it was possible to do small modifications and new holes using heat in order to avoid the need of additional printings to conduct the proof of concept. By the after actualization of the piece design, these problems will be solved for future printings.

The installation of the electronic components was also challenging, because although the space for the electronic parts was well calculated in order to reduce space and material, the space predicted for the electric wires was small. This difficult a bit in the connections of all the components, and the result was a bit messy. At the end, while all the parts are closed, the result is good, but more space would have been useful for providing a more comfortable component installation. Finally, the switch button did not arrived on time, so an experimental one was used by having two cables in the switch hole. When these two cables were connected, the battery circuit was closed and the system started.

In the following figures it can be seen the evolution of the process of assembly of the device:



(a)

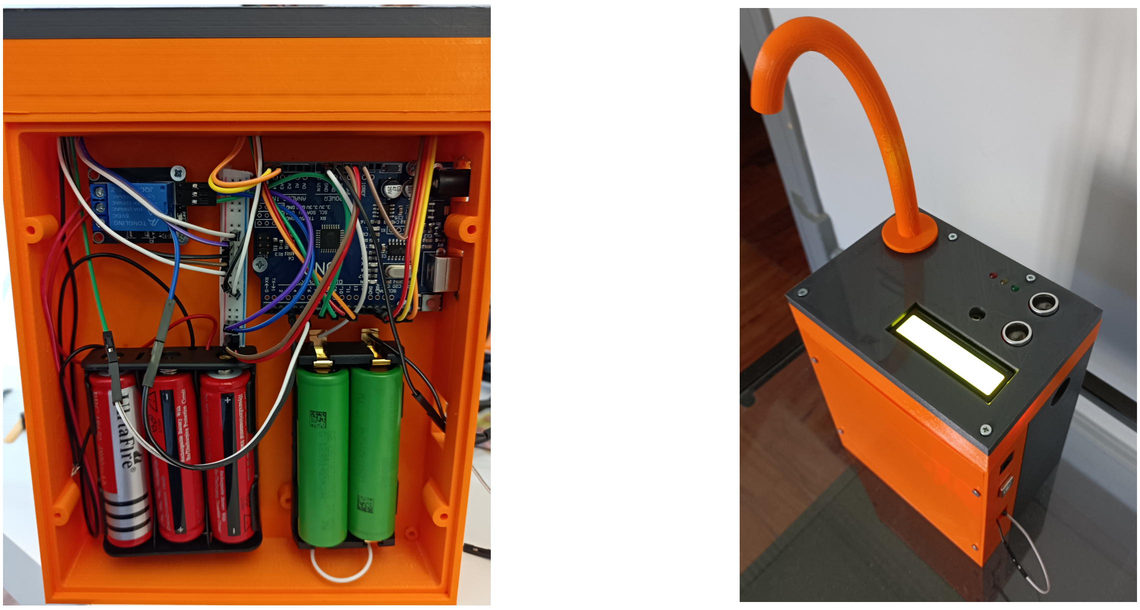


(b)

Figura 8: Installation of the pump (a), assembly of the principal structural components (b).

(a) (b)

Figura 9: Piece 5 components bottom view (a), top view (b).



(a) (b)

Figura 10: Piece 2 and components (a), final result of the assembly.

With all the components installed correctly, modifications where upload at the SolidWorks assembly model, with the objective to make the pieces perfect for all the elements in the device, and do not have the technical problems that I have had during the assembly of it.

During the testing, it was also seen that the original code proposed in section 3 was not working as expected regarding the read of temperature, because at the minimum that the instruction of reading temperature with the sensor was given, it read the it of whatever was in range of detection, not necessary the wrist of the user. For this reason, a new state variable was introduced and a while loop to keep reading the temperature while the detected one was not between 33 °C and 43 °C. Then the system was not activating the pump if temperature was not correctly read. Besides of this, during all the process, the LCD screen kept informing about the state of the station.

The proof of concept was conducted using water instead of hydro-alcoholic gel, because it is free and similar to the gel. The main problem seen was regarding the pump. It had not enough power to pump the water from the tank to the dispenser. By the other way, if the column of water was already passed the pump, it worked perfectly. This means that possibly the pump might have problems to make the vacuum to pump the water. The system was also tested with another 5V pump and worked perfectly, but as the design was done for the original 12V pump, it was not possible to install the one that worked well.

Another important issue was regarding the gel tank. Although it seems to be fully waterproof, after some hours after filling had some looses, not very significant but left some water drops on the assembly table.

5 Improvements and Conclusions

During the prototyping process, we have been able to evaluate the performance of the hand sanitizer station. We have detected some features that should be corrected in order to have a better device. The first obvious thing to be improved is the water pumping, because it has not much sense to have a sanitizer station that can't supply hydro-alcoholic get. After seeing that the 5V pump worked perfectly, it would be necessary to change the pump support design to make it available for this new pump. By the other way, the battery case would not be necessary to be changed, since we can change the battery connection from series to parallel.

The second important improvement that must be done is in order to solve the problem of leaks of the gel tank. For the printing, the width of the piece was reduced to save materials, but maybe by keeping the original thickness of 5mm the piece would be waterproof. Maybe another possible solution is to keep the smaller thickness but increase the printing density.

Finally, the last improvement should be the improvement of the calibration and optimization of the temperature sensor and time of supply of hydro-alcoholic gel. Since my resources to do the temperature calibration were small, I think that it is not very well calibrated and would require an optimization.

In conclusion, the design of this hand sanitizer station have been a complete success. The main objectives has been achieved, although we have had some minor problems with some of the electronic components and few small design errors. This project has allowed me to learn a lot in CAD design and also to make me remember the magic world of Arduino and the excitement of doing engineering projects. In terms of the device, with the corrections will be completely functional and ready to be produced in mass if it was necessary.

6 Annex I: Main code

```
#include <Adafruit_MLX90614.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>


#define echoPin 5 // attach pin D2 Arduino to pin Echo of HC-SR04
#define trigPin 3 //attach pin D3 Arduino to pin Trig of HC-SR04
#define GreenLed 8
#define YellowLed 10
#define RedLed 9
#define Relay 7

LiquidCrystal_I2C lcd(0x27,20,4); // set lcd A4 SDA - A5 SLC
Adafruit_MLX90614 mlx = Adafruit_MLX90614(); // set temperature sensor SLC SDA

// defines variables
int State; // variable defining the state of the action
int Temp; // variable for temperature measurement
long duration; // variable for the duration of sound wave travel
int distance; // variable for the distance measurement
float temperaturaObjeto; // variable for temperature

void setup() {

  pinMode(trigPin, OUTPUT);// Sets the trigPin as an OUTPUT
  pinMode(echoPin, INPUT); // Sets the echoPin as an INPUT
  pinMode(GreenLed, OUTPUT);
  pinMode(YellowLed, OUTPUT);
  pinMode(RedLed, OUTPUT);
  pinMode(Relay, OUTPUT);
  // Serial Communication is starting with 9600 of baudrate speed
  Serial.begin(9600);
  mlx.begin();             // Temperature sensor
  lcd.init();              // initialize the lcd
  lcd.init();
  lcd.clear();
  lcd.backlight();
  State = 0; // rest state as initial
  Temp = 0;  // temp  control as 0 initial
}
```

```
void loop() {
  Serial.print(distance);
  if (State == 0) { // if there is no hand detected:
    lcd.setCursor(1,0);
    lcd.print("Station ready");
    lcd.setCursor(1,1);
    lcd.print("Waiting user");
    // Clears the trigPin condition
    digitalWrite(trigPin, LOW);
    delayMicroseconds(2);
    // Sets the trigPin HIGH (ACTIVE) for 10 microseconds
    digitalWrite(trigPin, HIGH);
    delayMicroseconds(10);
    digitalWrite(trigPin, LOW);
    // Reads the echoPin, returns the sound wave travel time in microseconds
    duration = pulseIn(echoPin, HIGH);
    // Calculating the distance
    distance = duration * 0.034 / 2;
    // Speed of sound wave divided by 2 (go and back)

    if (distance < 7 && distance > 1){
      State = 1;
      lcd.clear();
      lcd.setCursor(1,0);
      lcd.print("Hand Detected");
    }

  }
  if (State == 1) { // if hand has been detected:
    lcd.clear();
    lcd.setCursor(1,0);
    lcd.print("Hand detected");
    lcd.setCursor(1,1);
    lcd.print("Measure temp...");
    while (Temp == 0) {
      temperaturaObjeto= mlx.readObjectTempC()+7;
      if (temperaturaObjeto>34 && temperaturaObjeto<45){
        Temp = 1;
      }
      else{
        Temp = 0;
      }
    }
```

```
if (temperaturaObjeto<37.0){
  digitalWrite(GreenLed,HIGH);
  Serial.print("greeen");
} else if (temperaturaObjeto<38){
  digitalWrite(YellowLed,HIGH);
} else {
  digitalWrite(RedLed,HIGH);
}

// Print temperature in the LCD
lcd.clear();
lcd.setCursor(1,0);
lcd.print("BODY TEMPERATURE");
lcd.setCursor(1,1);
lcd.print(temperaturaObjeto);
lcd.setCursor(4,1);
lcd.print((char)223);
lcd.setCursor(5,1);
lcd.print("C");
delay(1000);

// Give the advise of the gel supply
lcd.clear();
lcd.setCursor(1,0);
lcd.print("SUPPLYING GEL");
lcd.setCursor(1,1);
lcd.print("IN");
lcd.setCursor(4,1);
lcd.print("3");
lcd.setCursor(6,1);
lcd.print("SECONDS");
delay(1000);
lcd.setCursor(4,1);
lcd.print("2");
delay(1000);
lcd.setCursor(4,1);
lcd.print("1");
delay(1500);

digitalWrite(Relay, HIGH); // Close relay to activate the pump
delay(500); // During 1 sec give gel
digitalWrite(Relay, LOW); // Open relay to close the pump
```

```
    State = 0; // turn state to rest
    Temp = 0;  // turn temp to original
    lcd.clear(); // clean the LCD
    digitalWrite(GreenLed,LOW);
    digitalWrite(YellowLed,LOW);
    digitalWrite(RedLed,LOW);
  }
}
```