Automated Parking Lot

Design Group A:

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PROBLEM DEFINITION

Problem Statement:

- Parking spaces should be efficiently managed to provide a comfortable and convenient experience, but current manual systems often lead to inefficiencies, delays, and discomfort in urban areas, impacting both drivers and facility managers.

PROBLEM DEFINITION

Problem Severity:

Who is Affected?

- **Urban drivers** and **parking managers** face issues from poor environmental conditions (e.g., overheating) and limited guidance in facilities.

How Are They Affected?

- **Drivers:** Spend 17 hours yearly on parking searches, costing $345 in fuel/time (INRIX, 2017).
- **Managers:** Struggle with occupancy monitoring and fee collection.

Impact of Unaddressed Issues

- **Traffic & Pollution:** Idle cars increase emissions (EPA).
- **Operational Costs:** Manual inefficiencies raise costs, needing more staff.
- **Customer Satisfaction:** Declines due to delays in overheated environments.

Additional Concern:

- Lack of ventilation risks overheating for **vehicles and people.**

PROBLEM DEFINITION

Problem Statement:

- Manual parking facilities are poorly ventilated, making them uncomfortably hot, especially in the summer; additionally, identifying available parking spaces is challenging, payment calculations often contain errors, there are oversights in payment collections, and significant time is lost during entry and exit.
- Challenges:
  - Difficulty identifying available parking spaces.
  - Errors in payment calculations.
  - Oversights in payment collections.
  - Significant time lost during entry and exit.

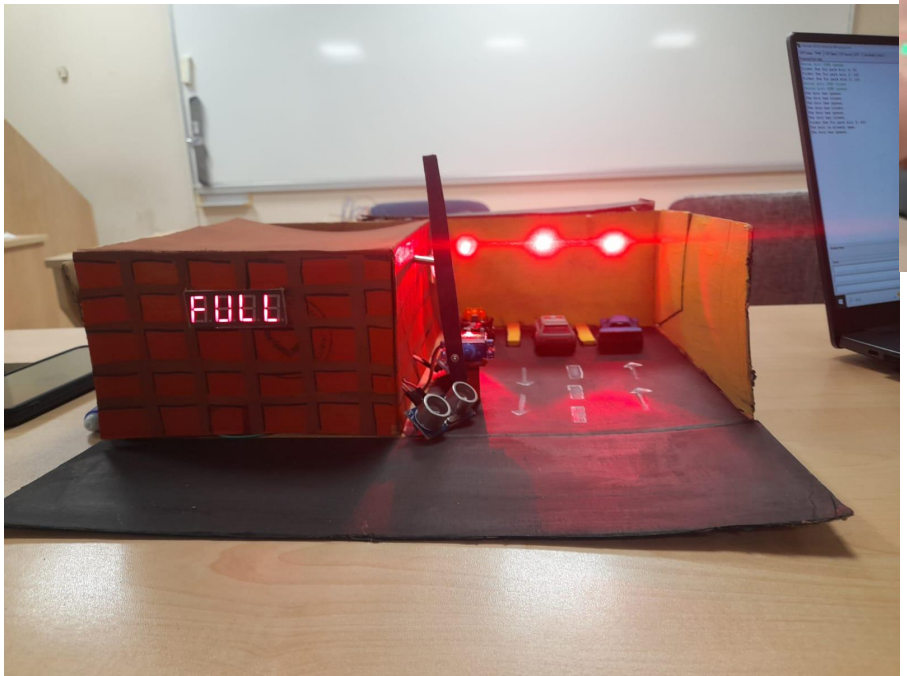
Proposed and implemented design

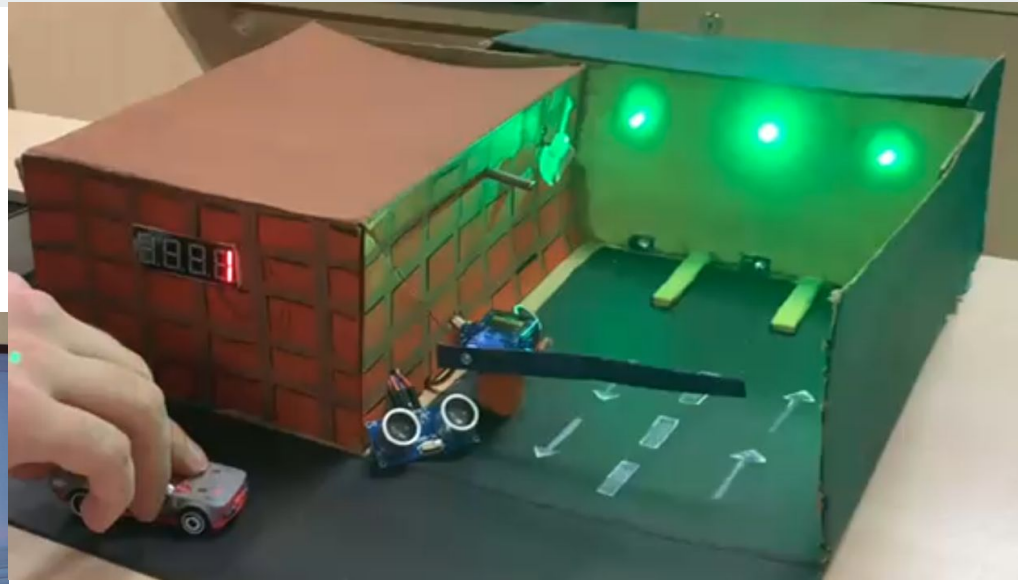
The proposed and implemented designs were closely aligned, with only a few components replaced by more efficient alternatives.

The final implemented design successfully achieved the initially intended functionality while maintaining the core objectives of the original proposal.

We already proposed such a project at the very beginning of the semester. In our opinion, we have completed it successfully.

Photo of the final product

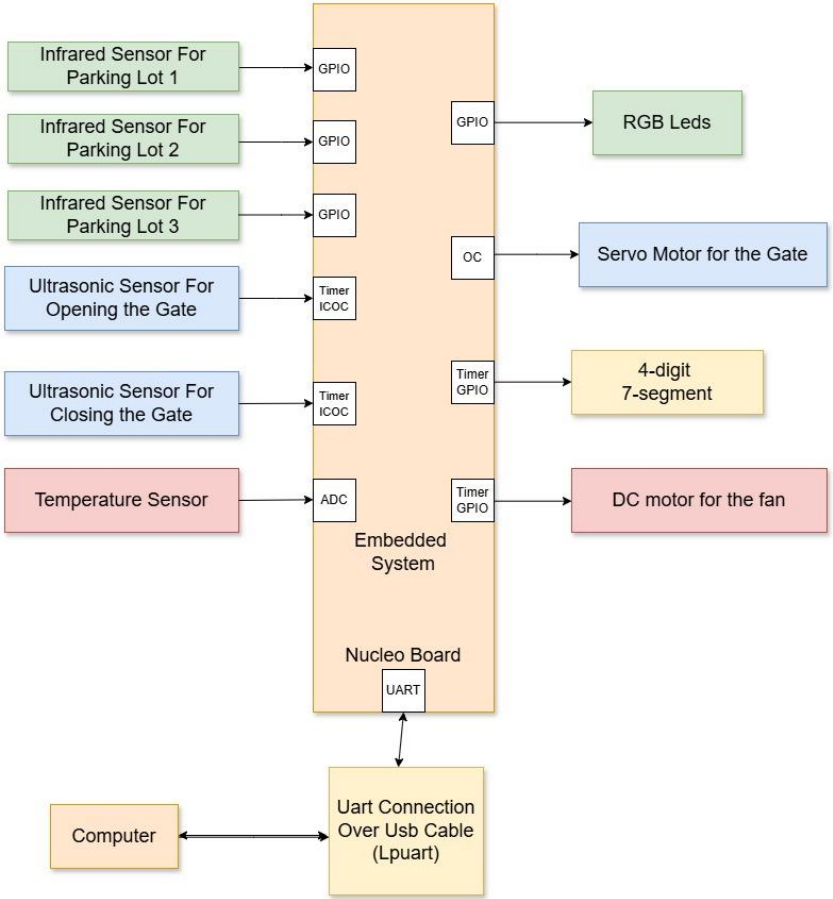




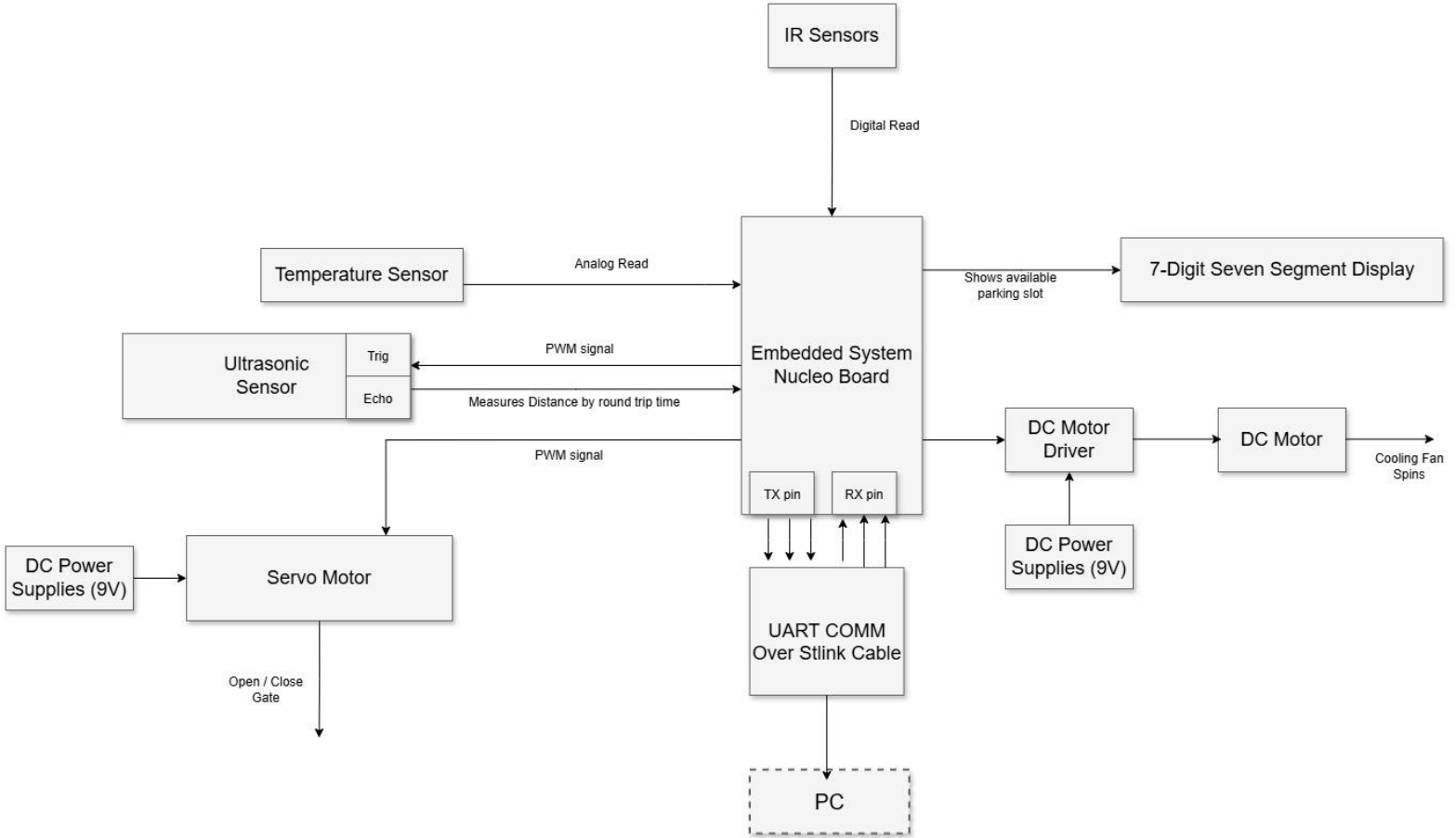
Changes from Conceptual Design proposal

Proposed	Modified	Reason
Ultrasonic sensor for detecting the presence of vehicles/cars in the parking lot	Infrared sensor is used for detection of the cars in the lot.	We also added same functionality using an IR sensor. Also ultrasonic sensors were more expensive and consumes more power.
Using 4 different 7-segment LEDs as output	4-digit 7-segment as a single component used for output	It has more compact design and it is visually more compelling.
DC-motor for gate opening	Servo-motor for gate opening	It is quite difficult to provide precision with a dc-motor, servo motor is much more successful in angular rotations (more accurate) and power-efficient

System-level Block Diagram

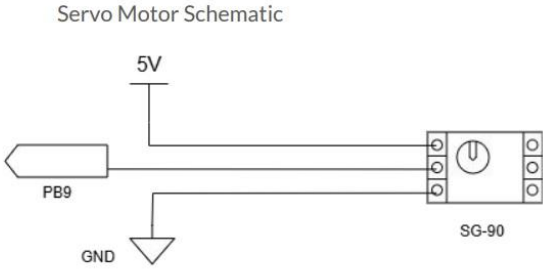


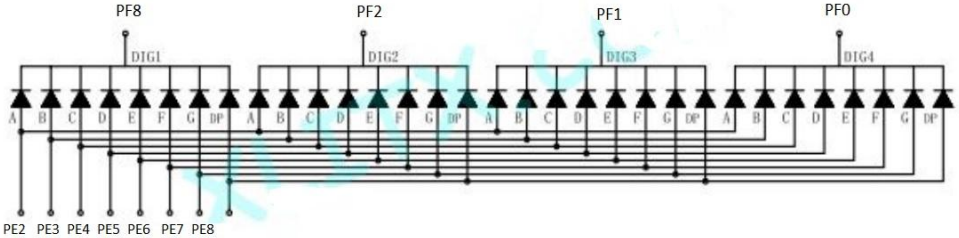
Functional Block Diagram



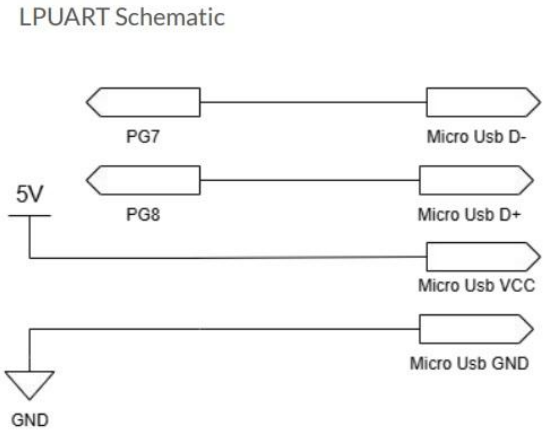
Pin connections are clearly shown in schematic diagrams

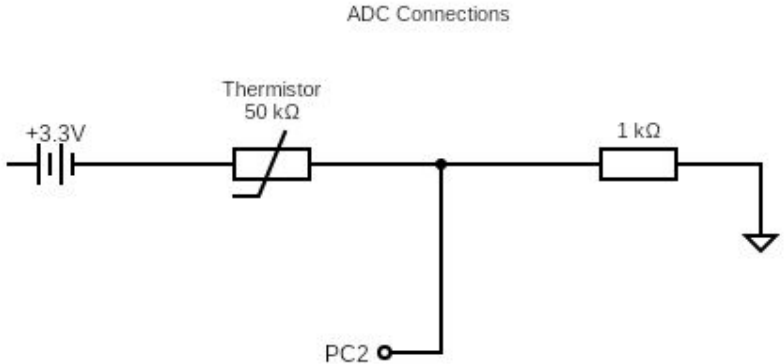
Schematic diagrams



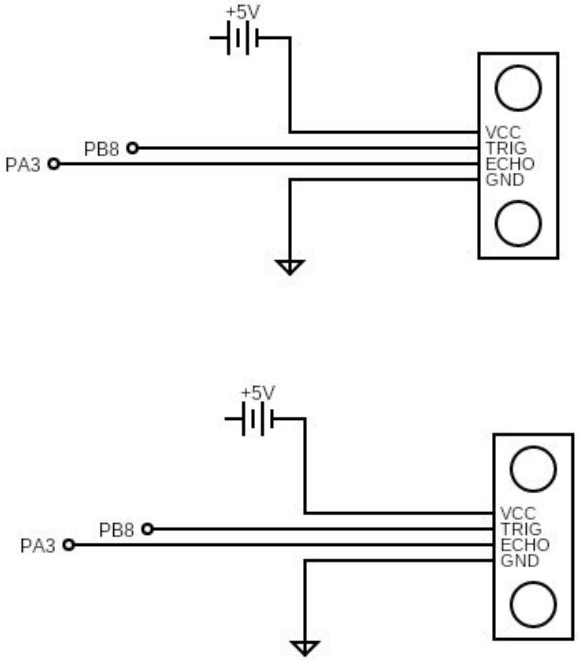


4-digit seven segment schematic [7]

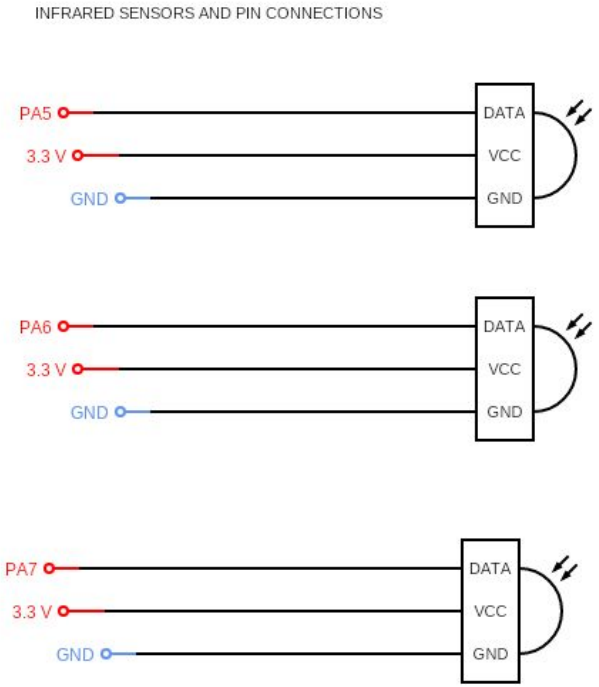




Schematic diagrams



Ultrasonic Distance Sensor Connections



Infrared Sensor Connections

Pseudocode

PARKING SLOT LOGIC :

```
while TRUE do

for lot = 1 to numLots do

        if isLotOccupied(lot) then

                lightupRGB(lot, ”red”)

            startTiming(getNewlyOccupiedLot())
        else

                lightupRGB(lot, ”green”)

                stopTiming(getNewlyOccupiedLot())
                isParkingSpaceAvailable ← true

        end if

end for
```

FAN LOGIC :

```
while TRUE do

currentTemp ← readTemperatureSensor()

if currentTemp > threshold then
        if NOT isFanMotorRunning then
                activateFanMotor();
                isFanMotorRunning ← true
        endif
endif

else
        if isFanMotorRunning then
                stopFanMotor()
                isFanMotorRunning ← false
        end if
```

GATE LOGIC :

```
while TRUE do

if isVehicleAtEntrance() then
        if isParkingSpaceAvailable then
                openGate()

        else
                displayMessage(”FULL”)
        end if
end if

if  isVehicleLeaving() then
        totalFee ← calculateParkingFee(getVacatedLot())
        displayFee(totalFee)
        sendFeeToAttendant(totalFee)
        openGate()

while TRUE do

if receiveOpenGateCommand() from userUart  then
        openGate()
end if
if receiveCloseGateCommand() from userUart then
        closeGate()
end if
end while
```

Components that used in PI

Components: STM32 Nucleo-144 board, Sc90 Servo motor, Infrared Sensor, HC-SR04 Ultrasonic distance sensor, DC Motor, three LEDs, 1K Ohm resistors, 7-Segment Display 4-Digit, Breadboard, Jumper Cables, fan, 9V-battery

- **The input devices and sensor(s) :**

- Ultrasonic Sensor : Detecting vehicles at doorways

- Infrared Sensor : Detecting occupied slots in the parking area

- **Temperature Sensor :** Ambient temperature measurement and fan operation

- **Output devices and actors :**

- 7-Segment Display : It shows the available space in the parking lot (number) and also writes full if the parking lot is full.

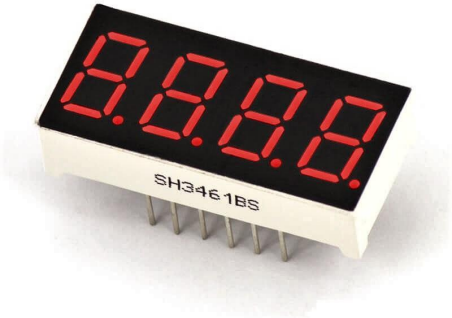
- DC motor and Fan : If the temperature is high, the motor fan operates and cools the environment.

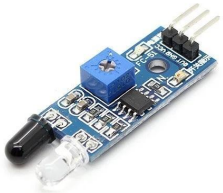
- RGB Leds : The LEDs on the parking spaces are red if they are full and green if they are empty.

- Servo Motor (Gate) : Allows the door to be opened and closed

- **Communication devices :** We do not use any communication device. We communicate with the computer via lpuart communication with the board's own USB cable.

Components that used in PI





Cost analysis

Name	Unit Price (TL)	Amount	Total Price (TL)	Source
NUCLEO-L552ZE-Q	1331.14	1	1331.14	Borrowed
Ultrasonic Sensor HC-SR04	50	2	100	Purchased
DS18B20 Temperature Sensor	44.93	1	44.93	Borrowed
Breadboard	32.93	1	32.93	Borrowed
Jumper Wires	39.63	1	39.63	Purchased
9 V Battery Lithium Ion	65	1	65	Purchased
SG90 Servo Motor	70	1	70	Purchased
L298N Motor Driver	70	1	70	Purchased
7 segment display 4 digit	35	1	35	Purchased
1 k Ohm Resistors (set of 10)	10	1	10	Borrowed
3 V DC Motor	12	1	12	Purchased
Infrared Sensor (IR detector)	35	3	105	Purchased
Total Component Cost :			**1916 TL**	

Integration Task Allocation

PIs	Components	Name of Student	Which Task
GPIO	4-digit 7-segment LED	Nurullah Uçan	Displaying the lowest available parking spot (1, 2, or 3) based on occupancy, or "FULL" on a 7-segment LED if all spots are occupied.
GPIO -Timer	Infrared sensor, parking lot model	Enes Yıldız	Building the mock-up of the model. Measuring the fee of the cars, based on the duration time.
GPIO - Interrupt	4-digit 7-segment LED	Baver Bengin Beştaş	Timer interrupts initialized.
IC- OC	Ultrasonic Sensor HC-SR04, Motor, Led pins	Yiğit Sarıoğlu	Detecting object distance and opening and closing the door using ultrasonic sensors
Timer Interrupts - ADC	Temperature Sensor, DC motor, Motor Driver, Fan	Enes Furkan Arslan	Measure temperature with ADC conversion. Utilize timer interrupts to avoid continuous conversion. Use motor driver and DC motor for ventilation system.
OC - UART	Servo Motor, Micro USB for Communication	Deniz Ulaş Poyraz	Sending data from the computer to the board for controlling servo behaviour, sending servo state to the computer from the board. Send ticket fees to the computer from the board.

Self Evaluation of Integration Requirements

Requirements	Achieved?	Explain
Prototype looks like an ES	Yes	No electronic visible
Full-interrupt driven	Yes	No busy wait, everything is written with interrupts
Complex GPIO Component	Yes	4-digit seven segment display
“Meaningful” UI	Yes	UART strings are: “Ticket fee for park slot 2: 100” “The door is already open.” “The door has opened.”
Floating Point Operations	No	
Power efficient code	Yes	No continuous communication no continuous ADC conversion interrupts and timer interrupts are utilized Low power uart communication used
Bonus Action	No	

INTEGRATION TASK: How we produce the final product

- Integration tasks meet all functionality. It has the features required for a smart automated parking lot.

- We had some problems in our team work. One of our friends left the school due to health problems. Another friend failed at the PI demo (ADC) . We have worked intensively with the remaining team members and friends who joined us in the last week in a short period of time. We quickly integrated our tasks by re-dividing personal tasks among our colleagues.

- We faced many difficulties during the implementation. First of all, since we did not pay attention to our pin selections, sometimes we had problems using common pins. Also, when combining different member's codes, there were malfunctions in the code operation, we fixed those. We also had difficulties connecting the circuit during the integration phase. Finally we managed to make a prototype of a real embedded system.

References

[1] Alexander G Dean, Embedded Systems Fundamentals with Arm Cortex-M based Microcontrollers: A Practical Approach Nucleo-F091RC, 2021
[2] Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C, EMan
[3] RM0438 Reference manual STM32L552xx and STM32L562xx advanced Arm®-based 32-bit MCUs
[4] UM2581 User manual STM32L5 Nucleo-144 board (MB1361)
[5] STM32L552x Datasheet
[6] For prices -> direnç.net , robotistan.com ,robolink.com
[7] http://www.xlitx.com/datasheet/5461AS.pdf
[8] https://dlnmh9ip6v2uc.cloudfront.net/datasheets/Sensors/Temp/DS18B20.pdf
[9] Bogazici University Faculty of Engineering CMPE 443 Course PS: 7, 8, 9, 10, 11 for coding.

Note : The sources used in the code section are also shared here.