An-Najah National University
Faculty of Engineering & Information Technology
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Graduation Project II

Fencing Game

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Disclaimer

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Abstract

This project is mainly built for entertainment purposes. Fencing Game is a project which consists of two identical robots, each of them having a sword and a shield, offering an amusing experience as each robot combines the ability to perform realistic mechanical movement and to sense its surroundings.

The two robots are pinned on a GT2 Belt, tied tightly on a rail system built with two iron poles and a stepper motor on one side and a timing belt pulley on the other side, which allows the robot to stand on a piece of wood and move freely, forward and backwards, on the rail.

Each robot is equipped with its own Arduino and ESP32 to have full wireless control over its movement. The ESP32 can be connected to and controlled from any device with a Wifi.

Each robot also has two stepper motors, one for each arm. The arm with the sword also has a selector switch, along with a valve and a relay, to control a pneumatic piston which represents the arm, this piston allows the robot to perform different attacks with the help of the stepper motor to move it to different angles. The other arm has a stepper motor with a shield attached to it, which allows the robot to defend itself from the attacks.

Each robot has two hit areas, the Head and the Side. Four limit switches were attached on the head, to cover as much area as possible, and two limit switches on the side. When a robot is hit on one of these switches, it will take damage. If its Health drops below zero, it loses and the game is concluded.

The robots can be controlled manually, with player-vs-player mode being accessed by connecting two different Wi-Fi devices, each of which controls one of the robots. Alternatively, Single-player mode allows one robot to be controlled while it plays against a self-playing robot. In AI mode, the two robots can be observed as they compete against each other.

Chapter 1

Introduction

Recently, the popularity of swimming pools and tourist resorts has increased, especially when talking about Palestine, where pools become the first destination entertainment for families. However, maintaining these pools to meet the standards of health, safety and comfort remains a challenging task. There is a clear need to enhance the efficiency of pool maintenance by the adoption of modern technological advancements, which saves efforts and money, since the traditional methods of pool managements often requires a constant human supervision, which is labor intensive and inefficient properly.

1.1 Problem Statement

The main problem lies in the inefficiency of human efforts in monitoring and managing pools system to ensure a high degree of accuracy, effort, and money. This can be achieved using modern technology, which I the aim of our project.

1.2 Objectives

The primary objectives of our project is to build a pool system works automatically by circular testing and sensing for different aspects, which reduces the need for continuous human intervention.
This smart pool will incorporate several features as follow:

1. Automated water filling system to maintain a stable height of water.

2. Heating system which keeps the water temperature in acceptable range.

3. Sterilization system, which automatically add CL and HCL to keep the ph of the water in reasonable range according to global health standards.

4. Lighting system, color for every feature, and it activates continuously if a darkness detected.

5. Cover for the pool, controlled remotely by the owner from an application, which enhance the safety during maintenance periods, and it detects any motion while closing, to save human lives.

1.3 Scope of Work

1. Integrating sensors to take the readings from the pool, water level, temperature, ph, darkness.
2. Developing an automatic system to deal with readings and return them all to standard readings.
3. Testing and validating the system to ensure reliable performance within the safety standards.
4. Creating an application which helps the owner to control the pool functions remotely, and set up the temperature, height, and other factors dynamically.

1.4 Significance

The system of the pool transforms the way pools are managed; by automating the essential maintenance task, it not only enhances the operations efficiency, but also ensures a higher level of health, safety and comfort.
Since Palestine is an occupied country, the swimming pools became the first place for the Palestinian families to have a good entertainment experience.
Additionally, the project demonstrates the effective use of modern technology, with a user-friendly application lets the owner to control everything from his place, with no need for workers or human intervention.

1.5 Organization of the report

The report starts with the introduction, included the problem statement, the objectives of the project, the scope of work, significance.
The second chapter takes the limitations and constraints the forces us during work on the project, also the standards we use and the programs we used in coding and application, finally the earlier coursework.
The next chapter takes the literature review, In that chapter, relevant work and results are included.
Then, the chapter of methodology, which goes deeply on the project, its structure, components used to build it, the electronic hardware components, and talking specifically with details about how the system works.
The fifth chapter includes the results and analysis, then the conclusion and discussion chapter, which give the summary of the project, and the future work that can be done to the project.

Chapter 2

Constraints and Earlier Coursework

2.1 Constraints and limitations

1. The main problem was in finding a suitable material to build the pool structure that could withstand the pressure of water inside it.
2. Ensuring of insulation of the connections of pipes and pumps connected with the pool, to prevent leaks and electrical short circuits.
3. The motion sensor did not work accurately, which affect the safety while cover closing operation.
4. Difficulty in getting samples from chemicals used for sterilization.
5. The high cost of chlorine sensor, forced us to leave its use of.

2.2 Standards / Codes

- We developed our code using the Arduino IDE, enabling us to control the hardware via the Arduino platform.
- For communication, we utilized MQTT as our protocol, enabling clients to control the device through a specialized mobile application.
- We created the mobile application using the App Inventor platform that providing the ability for the users to control the system remotely.

2.3 Earlier Coursework

- Microprocessor and Microcontroller courses, we gained a knowledge of how to control the hardware components in our project.

- The critical thinking course, which helps us to search through researches on some issues, in addition of helping in documentation and writing reports skills.
- Wireless and networks courses played a vital role on understanding the communications between nodes, which help us in connecting the application with our system via connecting esp with Arduino.
- Electronics course that provides instruction in various aspects of electronic systems and technologies.
- Self-learning via YouTube Arduino courses, and different researches.

Chapter 3

Literature Review

Integrating advanced technologies to automate and optimize pool maintenance and operation defines smart pools. This review, therefore, aims at unearthing some of the existing research and developments in smart pool systems by emphasising on key technologies, methodologies as well as applications. Through this review, it will form a basis for the project while identifying gaps in current knowledge that are targeted by the smart pool model.

IoT-Based Real-Time Water Quality Monitoring[?]: Researchers have proposed IoT-based devices that would continually monitor the water quality in swimming pools. Systems that automatically check parameters including pH, temperature, turbidity, chlorine residual, and flow are included in this category.
After the sensors have collected their data, it is sent to a cloud server so that a user can access it via an instance web retrieval. In order to maximize pool upkeep, the algorithms can also offer pertinent maintenance chores that correlate to the water quality values.

Chapter 4

Methodology

4.1 System Structure

4.1.1 Pool Body

The pool structure was constructed from fiberglass with dimensions of 70*40. This material was chosen for its ability to withstand water pressure, weight, and the excavation processes carried out in the pool. Additionally, it can endure high temperatures.
A support frame made of iron was designed to hold the pool, as illustrated in the image that describes the model.

Pool.jpeg

Figure 4.1: Pool body design.

4.1.2 Heating part Body

The heating section, consisting of two 220-volt electric heaters, was constructed. Above them, a coiled copper tube was placed through which water flows to be heated. Copper was chosen for its thermal retention and conductivity properties. The heat generated was insulated from the surrounding environment using thermal gypsum and aerated concrete blocks. These components were then placed in a wooden box and connected to the project model.

h0.jpeg

Figure 4.2: Inside heater

h1.jpeg

Figure 4.3: Insulated heater

h2.jpeg

Figure 4.4: Wooden Box

4.1.3 Container Body

A wooden model was constructed to hold the sample container, which is a plastic vessel. The wooden model was designed to accommodate the electronic components required for this process.

ss.jpeg

Figure 4.5: Container Design

4.1.4 Cover Design

The pool cover was constructed using a lid attached to an iron piece with nuts on both ends. One of the nuts was inserted into a long screw to be turned by the movement of the stepper motor. The screw was secured on one end with a cablar and the other end with a bearing.

cover.jpeg

Figure 4.6: Cover Design

4.1.5 Filter Body

The filter was manually constructed by placing a sponge inside a plastic container, which captures impurities from the water as it passes through.

Figure 4.7: Filter Body

4.2 Hardware components

4.2.1 Arduino MEGA

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560[1]. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller.We used it for the large number of inputs/outputs it has that we needed to get this project done. We basically connected most of the components on it like ESP8266 (NodeMCU), all the sensors, the DC motor.This will also include another stepper motor, RGB LEDs, LCD screen, water valves and a water pump.[**?**]

arduino.png

Figure 4.8: Arduino MEGA.

4.2.2 ESP8266 NodeMCU

Based on the ESP8266 Wi-Fi transceiver module and the CH340 USB converter chip, this compact (Open Source) development and prototyping board is ideal for IoT applications.
The Wi-Fi module is compatible with the 802.11 b/g/n standard at 2.4 GHz, has an integrated TCP/IP stack, 19.5 dBm output power, data interface and PCB antenna.

It also has a micro USB connector and reset button. Programmable with Arduino IDE, it includes interpreters for processing commands for languages such as LUA. And in our project we used it to connect the project to the App Inventor application that we have created.[**?**]

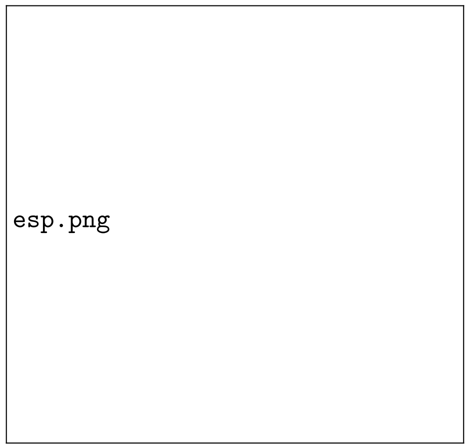

Figure 4.9: ESP8266 NodeMCU

4.2.3 Computer Power Supply

ISO-450 ATX Computer Power Supply 350W, 5V 32A, 12V 16A. Also we needed to yse an external power supply 24-volt for water valves which will explain later.

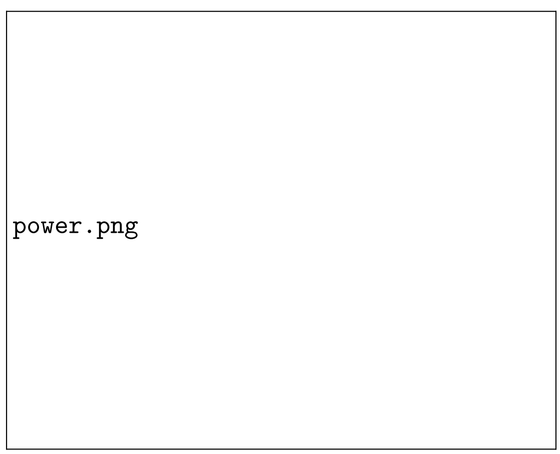

Figure 4.10: Power Supply

4.2.4 Water Pump

High Pressure DC 12V 3.7A Water Pump. We used it to pump water forcefully from place to place. It used to pump water from pool to heater also otherwise, also from container to pool also to empty the pool.

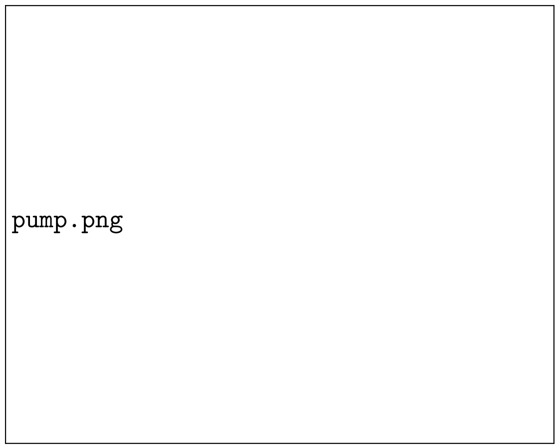

Figure 4.11: Water Pump

4.2.5 Water Valve

GEMS SENSORS and CONTROLS P/N- A2017-S174 / 24VDC / 7.4W. Valves are used to control water flow in pipes. They can allow water to flow in one direction only (check valves), control the flow rate (control valves), or completely stop water flow (shut-off valves).Three valves are used for one for filling and two for control the direction of water in container.

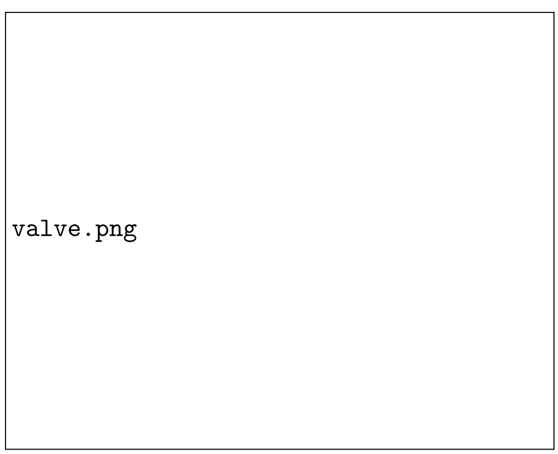

Figure 4.12: Water Vlave

4.2.6 Water Flow Sensor

1/2 Inch Water Flow Sensor.When the water flows through the rotor, rotor rolls and the speed of it changes with a different rate of flow. The hall-effect sensor outputs the corresponding pulse signal. In this project, it was used to calculate how many liters of water are being introduced into the pool.

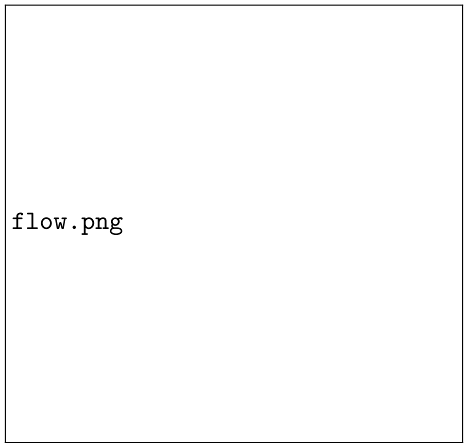

Figure 4.13: Water flow sensor

4.2.7 DS18B20 Temperature Sensor

Waterproof DS18B20-Compatible Temperature Sensor is a digital thermo probe or sensor that employs DALLAS DS18B20 used to measure water temperature inside a container.

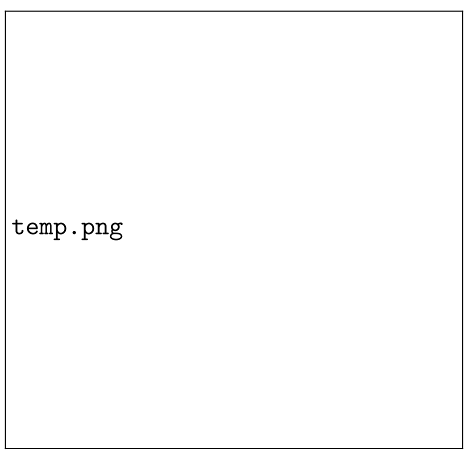

Figure 4.14: Temerature sensor

4.2.8 pH Sensor

Plastic pH Electrode BNC connector is the high accuracy pH probe.It was used to measure the pH level in the water of the container.

`ph.png`

Figure 4.15: pH Sensor

4.2.9 Ultrasonic sensor

Ultrasonic Sensor that measures the distance to an object using ultrasonic sound waves. In this project we used two ultrasonic sensors to measure the height of the pool and the water level in the container.

`ultra.png`

Figure 4.16: Ultrasonic Sensor

4.2.10 PIR Motion Sensor

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. In this project was used to detect if there is a motion inside a pool while pool's cover was closing. If the sensor detect a motion then cover will open .

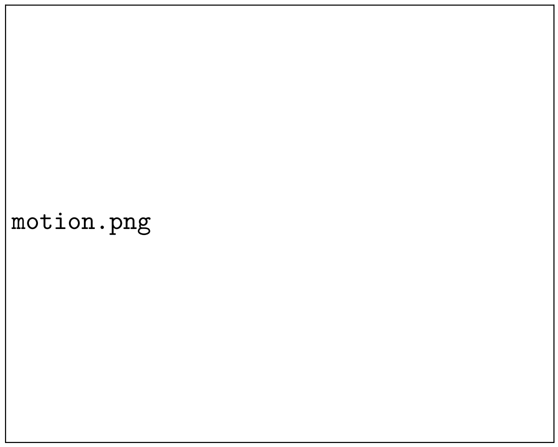

Figure 4.17: Motion Sensor

4.2.11 LDR Sensor

An LDR, or photoresistor, is a passive electronic component that modifications its electrical resistance due to varying light intensity. In the presence of light, LDR's resistance lessens; when hidden from light, its resistance intensifies. By harnessing their light-sensitive properties. It was used to sense the absence of sunlight, which triggers the pool lights to turn on permanently.

ldr.png

Figure 4.18: LDR Sensor

4.2.12 NEMA 17 Stepper Motor

There is a wide spread popularity of the NEMA17 stepper motor because of its small size as well as its great torque output, which makes it to be used in many places. It needs 200 steps to complete a revolution and these steps have an accurate angle of 1.8 degrees per step. Its coils can take a maximum current rating of 3.5 A each and one can also apply voltage inputs that range from 3 to 12 volts. It was used for the process of opening and closing the cover. By turning it, the screw connected to the nut that holds the cover is moved. Thus, when it rotates 360 degrees, the nut moves, allowing the cover to open and close by reversing its direction of rotation.

stepper.png

Figure 4.19: Stepper Motor

4.2.13 SG37BL-A DC Brushless Gear Motor

A 12 volt DC Motor is used when both a high starting torque and good speed regulation is needed. In this project we used two DC motors to move the nut to release HCl and chlorine from the syringe during the disinfection process.

dcc.png

Figure 4.20: DC Motor

4.2.14 L298N Motor Drive Controller Board Module Dual H-Bridge

The H-bridge configuration is usually utilized to reverse the polarity /direction of the motor but sometimes it's also possible to use it for 'braking' the motor i.e. when its terminals are connected together, the motor abruptly stops.

Hbridge.png

Figure 4.21: H-bridge

4.2.15 Micro Limit Switch

Micro Limit switches are a simple but effective solution to stop an axis on a machine from travelling out of limits. We used two limit switch to stop the stepper motor from rotating when the cover reaches its maximum limit, either when opening or closing.

limit.png

Figure 4.22: Limit Switch

4.2.16 RGB LED

An RGB LED is an LED module that can produce almost any color using these three primary additive colors: Red, Green and Blue. It was used in the pool lighting system, In each system activation, a different color is turned on.

led.png

Figure 4.23: RGB LED

4.2.17 Relays

Relay is a device which is electrically controlled to initiate and end electrical connections, or activate and deactivate operation of other appliances within the same or different electrical network. We used active low relays to turn on/off the heater, water pumps, valves and change the color of RGB LED.

relay.png

Figure 4.24: Relay

4.2.18 Intercom Wires

We used them for wiring and connecting different components together.

inter.png

Figure 4.25: Intercom Wire

4.2.19 Arduino Wires

To be able to connect the components to the Arduino.

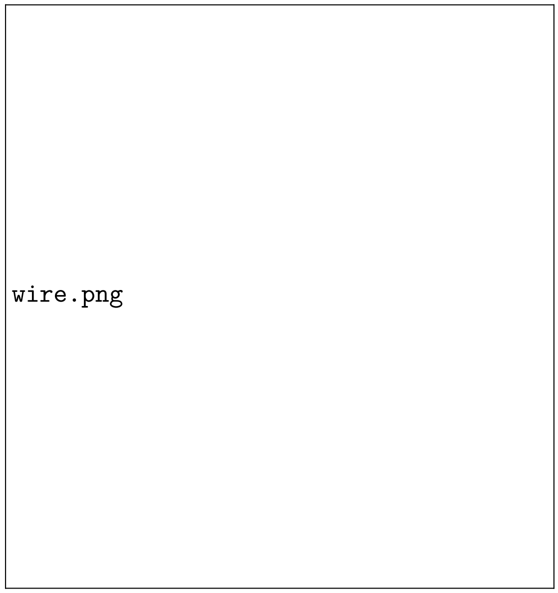

Figure 4.26: Arduino Wires

4.2.20 4.7K ohm resistor

It is connected to the 1DS18B20 Temperature Sensor.

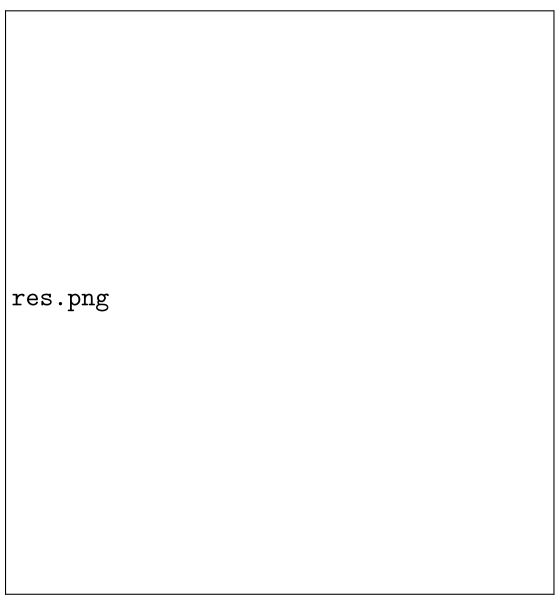

Figure 4.27: 4.7K Ohm

4.2.21 20x4 LCD screen

Being a popular alphanumeric display type, a 20x4 LCD screen can showcase up to 20 characters arranged into 4 columns. Widely used in electronic projects and devices, computing can display data/message via alphanumeric characters in devices such as thermometers, clocks, and interfaces. It displays the readings from both the temperature sensor and the water level sensor, which represent the ultrasonic reading. Additionally, the pH sensor reading and the flow sensor reading, which indicates how many liters of water have entered the pool.

lcd.png

Figure 4.28: LCD Screen

4.2.22 I2C LCD Driver

I2C LCD Display Adapter is specially designed o drive LCD Display using only 2 data pin. This module uses the I2C serial bus to communicate with microcontroller like arduino. Normally it requires minimum 6 data pins to use a lcd display. It creates a problem when multiple sensor and is module is using with arduino at the same time. Because Arduino has limitation of I/O pins. This I2C LCD Display driver will helps to reduce the uses of pin of your arduino and makes the project more easier. You can use this module with other I2C supported device on the same line and at the same time. Check the tutorial from Tutorial Section to learn how to use this driver module with Arduino.

driver.png

Figure 4.29: I2C LCD Driver

4.2.23 Power adapter from 220v to 12v

It was used to supply electricity to the RGB LED.

adap.png

Figure 4.30: Power Adapter

4.3 Mobile Application

The system connected with an application that enable remote controlling by the owner of the pool, the application has 4 interfaces as follow:

4.3.1 Start page

startPage.jpeg

Figure 4.31: Start page of application

The page includes 3 buttons implies to other pages, control, status, and set up.

4.3.2 Control page

controlPage.jpeg

Figure 4.32: Control page of application

This page contains all control buttons, since the owner click the button, the process of this button starts. the processes are:

1. Open cover.
2. Close cover.
3. Start the system (filling, heating, sterilization, filtration,...etc).
4. Empty the pool
5. Stop the system (stop all processes).

4.3.3 Set up page

`setup.jpeg`

Figure 4.33: Set up page of application

This page helps the owner to specify some system factors according to his need and the usage of the pool,

- water temperature: the owner can choose the temperature of the water in the pool, so the heating process stop when reaches this temp, if he doesn't specify, it will be 26 as default temp.
- Sterilization cycle: specify the time between the sterilization processes, in default 5 minutes
- Water height: the owner can specify the height of water in the pool he needs, this help when a child want to swim for example, he can choose a low height.

- Heater: the owner has a choice to turn on the heating system or not, for example in summer, the water already hot, so maybe no need for turn on the heating system.

4.3.4 Status page

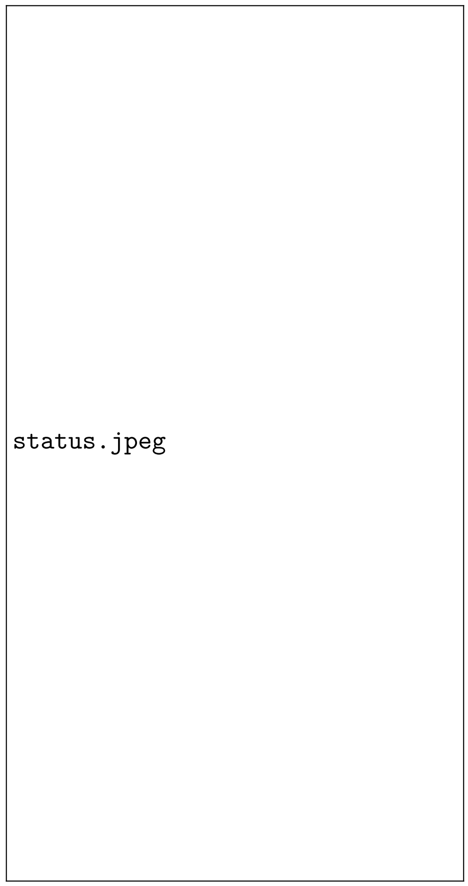

Figure 4.34: Status page of application

By this page, the owner can get a feedback about pool processing, by get the values of the current water level in the pool, the temperature, the ph and the water flow. In addition of checking for active processes and operation at the time he need, by clicking on update.

4.4 How the system works?

Since the Arduino mega and esp8266 connected to the power, and the application is now opened and the WIFI network is the one for the Esp, the system starts, and all components are stopped, waiting for the user to choose what process he need, the processes are as follow:

4.4.1 Cover closing and opening

Open Cover

OpenCover.png

Figure 4.35: Cover opening Flow chart

When the user selects open cover option from the application, the cover start opening, by rotating the stepper motor which carries a screw attached to the cover, in a clockwise direction, it keeps rotating till the pool is fully opened by pressed the limit switch by the cover, or the user stops the operation from the application.

Close Cover

CloseCover.png

Figure 4.36: Cover Closing Flow chart

When the user selects close cover option from the application, the cover start closing, by rotating the stepper motor which carries a screw attached to the cover, in a counter clockwise direction, it keeps rotating till the pool is fully closed, or the user stops the operation from the application.
While the cover is closing, there is a motion detecting sensor which attached to the beginning of the cover, this motion detects if there is a motion under the water, which means there is a person. to save his life from suffocation, the cover stopped and start opening to let the person leave the pool.

4.4.2 Start the system (Heating, Sterilization, Filling)

When the user selects start the system option from the application, the processes of heating, sterilization, filling and light system starts.

4.4.3 Taking Sample

Figure 4.37: Taking Sample Flow chart

There is a sample of water token from the pool repeatedly, the time between the samples determined by the user from the application, if it didn't determine, it token every 5 minutes.

- Firstly, a valve connected with the pool opened to let the water to pass from the pool to the sample container.

- There is an ultrasonic checked for the height of water, when it reached a previous measured height, which means that 1 liter of water is taken, so the sample is ready now.

- The temperature sensor and PH sensor placed on the container reads the temperature and the PH of the water.

- If the temperature is less than 26 c or the temperature specified by the user from the application, and the user activates the heating system from the application, the heating system will start, the process of heating will be explained on heating section.

- If the PH of the water is higher than 7.6, the sterilization system will be activated, the process of sterilization will be explained in sterilization section.

- After finishing sterilization (if needed), the sample returned to the pool by a pump, until it become empty.

4.4.4 Heating

`heating2.drawio.png`

Figure 4.38: Heating Flow chart

If the temperature read is less than 26°C or the specified temperature by the user, the heating system will be activated. The heater will turn on, and a pump will start working by passing the water from the pool to the copper pipes. The water gains heat from the hot pipes and then returns to the pool.
The process continues until the temperature sample reads the required temperature.

4.4.5 Sterilization

sterilization.drawio.png

Figure 4.39: Sterilization Flow chart

If the PH read is higher than 7.6, which is the standard PH level set by the World Health Organization for swimming pool water, the sterilization process starts.
The system works calculate how much HCL must dropped in the sample.

- PH1 = PH standard =7.6.
- PH2 = PH read from PH sensor.
- Delta PH = PH2 – PH1

- PH = -log [H+2 / H+1]
- [H+] = antilog (PH)
- Since HCL is strong acid, so the HCL concentration = H+ concentration
- [HCL]= antilog (PH) molŁ
- By applying the following function

  M1 * V1 = M2 * V2

  Where M1= the concentrate of HCL that will be added

  V1 is the volume needed from HCL to balance the PH

  M2 is HCL concentrate calculated above

  V2 is the volume of water in the pool

  V2 = height (from ultrasonic) * 40 (width) * 70 (length)

- So, the system now knows the volume needed to add from HCL to balance the PH of the water.
- The dc motor for the HCL starts rotating, for every rotation it drops 3 drops, it continues rotating until the needed volume finished.
- For CL, because we are not able to have the cl sensor, the system adds some drops in every sterilization process, adding CL didn't affect the PH.
- After finishing the process of adding HCL and CL the mixer on the container will turn on, to mix the materials, then the water returned to the pool by the pump.

****All equations and calculations were provided to us by a chemistry professor at PTUK University, who explained the ratios, equations, and materials needed to achieve an accurate sterilization process.**

4.4.6 Filling The pool

filling2.drawio.png

Figure 4.40: Filling pool Flow chart

While the system is processing, ultrasonic sensor keeps reading the water level in the pool.
If the water height become less than a height determined by the user from application, the valve responsible of filling the pool will open, and fill the pool.
The water entered the pool through a water flow sensor, which calculates how many liters entered the pool, to help the owner in payments for the Municipal.

The water flow sensor working concept depends on pulses calculations, the sensor has a fan inside it, when the water flow, the fan spin, then a pulses recorded in the code. The volume of water calculated using this equation:

Volume in L = 2.663 * pulse / 1000

The pulse increases as the speed of water flow increases.[**?**]

4.4.7 Light system

The pool provides a lighting system that displays a specific color for each operation. Additionally, there is an LDR (light-dependent resistor) sensor that senses darkness, and when darkness is detected, it continuously lights the pool with white light.

4.4.8 Filtration system

To keep the water clean from impurities, there is a filter connected to the pipe that pass the water from the pool to the heating system, this filter filters the water entered the heating system, so it saves the pipes from closing as a result of accumulation of impurities.
In addition, the heating operation is the most operation that takes a water from the pool in a circular process, so the percentage of water that will be filtered and clean is about 70-80% of pool water.

4.4.9 Empty The Pool

When the user selects empty the pool option from the application, the pump of empty will turn on, and all other processes will stop, because no need for heating or sterilization for the water, the empty will stop when the height of water reaches 5.

4.5 Hardware connections

Heating

heatcon2.png

Figure 4.41: Heating connections

Sterilization

stercon.png

Figure 4.42: Sterilization connections

Pool Filling

fillcon.png

Figure 4.43: Pool Filling connections

Cover open and close

covercon.png

Figure 4.44: Close and open cover connections

Other features (Pool empty, Light system, LCD display)

othercon.png

Figure 4.45: Other connections

Chapter 5

Results and Discussion

Arduino based Smart Pool Model Working - With Arduino and Sensors, the smart pool model was able to show how pool automation works using various other systems. In the water filling system, the stability of the water level was kept well because the ultrasonic sensor reliably triggered the water pump to operate so that the error of the water level with 2 cm above and below target height did not exceed ±2 cm, which demonstrated high accuracy and reliability. Water volume: A water flow sensor, which allows the amount of water going into the pool in ml to be monitored, is essential for water savings and effective water management. During the full testing, this system regularly maintained a high water level on its own, reducing the amount of work required to maintain a pool greatly.

Heating system ensured excellent regulation of the temperature but for that it was dependent on the accuracy of water temperature reading provided by DS18B20 to adjust heating element according to value (set/reading). The water temperature was maintained within ±1°C of the target range showing very good control and responding to changes in input temperature. This automatic temperature control allows for increased user convenience and energy savings.

The sterilization system was also precise at the chemical balance of your pool; pH sensor sensed accurately hydrochloric acid while they used them. The pH value were kept in the right ranges below or equal 7.6 to guarantee water quality without overdosing.
The lights came on exactly when they were supposed to, since the LDR sensor accurately measured the ambient light and turned on the pool lights reliably in low-light conditions.

It was supported by a user-friendly mobile application for monitoring and controlling from distance, providing real-time data viewing and adjustment as required. This feature helped the user experience by adding remote access to downplay physical interaction. The experience of the firefighter interface demonstrated a great level of satisfaction in terms of usability and functionality.

Bringing these systems together to form an integrated smart pool setup has shown how practical and successful it is to employ Arduino and sensors to automate pool tasks. This project shone a light on how smart technology can greatly improve the ease of use safety and the way we maintain pools by making the process more efficient. But they pointed out hurdles like getting sensors right adjusting for nature and making it bigger can be tough.

Chapter 6

Conclusion and Future work

6.1 Conclusion

The smart pool model, using Arduino and various sensors, demonstrated the potential of using this solution to automating pool maintenance and operation. The adaptive systems worked with each other for managing the water conditions, which provided more convenience, safety, and efficiency promptly. The telemetry provided by various sensors and the Internet of Things were the technical aspects collected during our study. The project elaborated the advantages of digital technology to the application of everyday life and laid the groundwork for bettering and inventing new systems for pool automation.

6.2 Future work

- Adding a drowning rescue system.
- Installing additional and advanced sensors, including those for checking water quality and chlorine levels.
- Using more effective methods to detect the presence of an object or movement inside the pool while the cover is closed, such as placing a camera and using digital image processing techniques, ensuring the camera's safety from water.
- Implementing energy-efficient components and optimizing system algorithms could reduce energy consumption and enhance sustainability.

Bibliography