

Greenhouse

**Name ??**

Relatório Intercalar 1º Semestre

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Trabalho Final de Curso | LEI ou LIG | Data

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Resumo

This project has the objective to automate a a

Abstract

Resumo em inglês.

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## Problem Identification

### What’s hydroponics?

“Hydroponics is the cultivation of plants without using soil”, instead it resides on water, that contains every nutrient, hydration, and oxygen necessary to the herbs and plants to grow and be consumable.

### Why is hydroponics used?

The principal scientific base of hydroponics is that when an herb is planted on the soil, the roots are constantly searching for necessary nutrients and hydration, and with a hydroponics system we can provide those directly to the root, so that the plant/herb doesn´t need to use energy to sustain itself. Instead, the plant/herb, uses that energy towards its own growth, resulting in a faster and better-quality maturation.

In conclusion, the hydroponic system provides a more cost-effective, controlled and stable environment compared to the traditional soil-based agriculture. It results in a more profitable way of herbs cultivation, while providing precise control over their growth and development.

Hydroponics is an extremely viable solution in terms of water conservation and sustainability. In a system like this, water follows a closed-loop circuit, with the only sources of water loss being evaporation and the water consumed by the plants.

### Automatic and manual hydroponic system

On a manual hydroponic system, the farmer must daily monitor the key water parameters like pH, electrical conductivity, and nutrient levels. They then add solutions to water to make the values optimal, creating an ideal environment for the herbs to grow.

This presents a significant challenge, in most of cases, within 6 or 7 hours later, the water values are no longer at their optimal values, so it consumes a lot of time and commitment from the farmer.

The automation of this process is a viable solution, to streamline this daily routine.

If the process is automated, we can continuously monitor the water parameters and fix them every 30 minutes or an hour, resulting in a greater stability in the water conditions. This will result in a quicker and healthier herb development.

### What is the objective?

The principal objective is to automate the control of the water parameters, enabling the monitoring of both historical and real-time data, while simultaneously being able to control all the entire environment.

# Benchmarking

## Alternatives to Hydroponics

The alternative solution to hydroponics is the traditional soil-base agriculture, where the farmer, he plants the herbs on the soil, rather than using a Hydroponic system.

However, this method isn’t as viable as hydroponics, because is susceptible to issues such as pest infestations and predation. Additionally, the quality of the herbs will be directly influenced by the quality of the soil, which, is way harder to control comparing whit the water on the hydroponic system.

In conclusion, there are numerous variables that the farmer does not have full control over.

## The solution/vision

I have a clear and objective vision: develop a set of tools, hardware and software that can fully automate routine tasks, allow manual alignment, collect data for statistical analysis and future optimization.

### Low-cost Microcontrollers and Sensors

#### Microcontrollers and Arduinos

“Arduino is an open-source electronics platform based on easy-to-use hardware and software.”

Arduinos can be programmed, and can read inputs (temperature sensors, pH sensors, etc…), and are also able to provide logic-based output through their ports.

There are various types of Arduinos which each one of the Arduinos are equipped with a different type of microcontroller, for example the Arduino UNO is equipped whit ATmega328P.

Uma imagem com Engenharia eletrónica, Componente de circuito, Componente eletrónico, eletrónica

Descrição gerada automaticamenteThe microcontroller that I chose to use is the ESP32, because it is very cheap, has all the logic and analogic ports that I need, and most importantly it has the capacity of connecting by Wi-Fi to a network.

Uma imagem com eletrónica, Componente eletrónico, Componente de circuito, Componente passivo de circuito

Descrição gerada automaticamenteThe ESP32 is present on the Arduino “Arduino Microcontroller Nano ESP32. Arduino ABX00083” board.

Figure 1 - ESP3266 on the board Arduino Nano

Figure 2 - ESP3266 on the board Arduino Nano

Uma imagem com Engenharia eletrónica, eletrónica, Componente eletrónico, Componente de circuito

Descrição gerada automaticamenteUma imagem com interior

Descrição gerada automaticamenteThere is another Microprocessor that can be eventually use, the ESP8266, which is featured on the “Wi-Fi ESP8266 - CP2102 NodeMCU V3 Lua” board.

Figure 3- ESP8266 on the board Wi-Fi ESP8266 - CP2102 NodeMCU V3 Lua

Figure 4 - ESP8266 on the board Wi-Fi ESP8266 - CP2102 NodeMCU V3 Lua

Table 1 - ESP32 vs ESP8266

|  |  |  |
| --- | --- | --- |
|  | ESP32 | ESP8266 |
| Microcontroller Type | Dual-Core microcontroller | Single-Core microcontroller |
| Processing Power | Dual-core architecture is more capable of more complex tasks | Has a single-core microcontroller it has a lot less processing power, but is capable of making simple tasks |
| Analog Inputs | 8 analogic ports | Single analogic port |
| Wi-fi Capabilities | Has robust Wi-Fi capabilities, supporting both traditional 2.4GHz Wi-fi and Bluetooth | Has Wi-Fi capabilities but has a lot of limitations as range |
| Bluetooth | Features built-in Bluetooth capabilities | Does not have built in Bluetooth |
| GPIO Pins | 14 analogic pins | 14 analogic pins |
| Price | expensive | Cheap |

The decision of using microcontrollers was made because they are cheap, they can handle all the complexity that the sending and collecting data requires, being also able to work whit a really low power supply.

Microcontrollers are accessible and straightforward to program. Abundant online resources and information are readily available to assist in finding answers to questions and accessing relevant information.

#### Sensors and Actuators

To gather data, it is essential to employ critical sensors to ensure the feasibility of this automation.

1. An electrical conductivity sensor that will determine how many particles and nutrients the water has.
2. A pH sensor is essential because certain herbs require a specific pH level in their water environment. This ensures they thrive in their preferred conditions, leading to faster growth and higher-quality produce.
3. A water temperature sensor has a lot of importance for calibrating the pH and electrical conductivity sensors, as well as monitoring whether the herbs are in the optimal water temperature environment.

To make actions according to the data we recovery I need to use equipment too:

1. Peristaltic pumps so that we can drop a certain dosage of solutions into the water.
2. Relays so that we can trigger (by the microcontroller) every type of electrical outlet.

#### Joining the microcontrollers and the sensors creating the modules

The primary solution involves having multiple locations/tanks, where each location can accommodate the microcontrollers preferred by the user. These microcontrollers can range from having a single sensor/output per microcontroller to a single microcontroller with all the sensors and outputs (with no sensor repetition). This ensures that output management and reading are adaptable and accessible for any greenhouse environment and layout. Additionally, the system can support an unlimited number of locations, making the solution highly scalable.

With this setup, the placement of sensors on each microcontroller and their configuration must be designed in a way that even non-technical users can easily accomplish it.

Uma imagem com texto, diagrama, Esquema, Desenho técnico

Descrição gerada automaticamenteThe combination of a microcontroller and sensors is referred to as a module.

Figure 5 – Module Example

### Event decision taking services.

The decision-making process will not occur on the microcontrollers themselves but on a .Net Core web application hosted on theAzure Web Services cloud. Here are the reasons for this approach:

1. The microcontrollers don’t have has much processing power.
2. With decision-making taking place within the web application, altering the values used for these decisions becomes remarkably easier.
3. It’s easier to control If all the microcontrollers are online, and if they are making correct readings.
4. Its easier to save all the collected data on a database.

### Data storage

//todo

## Market Analysis

### Key companies on the market:

1. Priva:

Priva is a principal global Provider of automation solutions for controlled agriculture environments. Their automation systems encompass environmental control, irrigation, and fertigation, creating a comprehensive solution for hydroponic greenhouses.

“Our sensors provide real-time data on crucial environmental factors, plant health, and resource usage, enabling you to monitor and adjust your greenhouse conditions proactively. By harnessing the power of IoT and sensor networks, we aim to revolutionize the way you grow crops. Discover the possibilities of our cutting-edge sensor technology in optimizing your greenhouse performance.” (<https://www.priva.com/horticulture/solutions/greenhouse-sensors>)

“When growing in substrate, you can accurately measure both the exact quantity and the EC value of the drain water by the Priva drain sensor. In combination with the Priva Groscale (weighing scale), the water dose is set automatically in line with the growing conditions, the condition of the plant, and the condition of the substrate. This is done based on the plant's requirements.” (<https://www.priva.com/horticulture/solutions/greenhouse-sensors/water-sensors> ) Priva about their pH and electrical conductivity sensors.

1. Growlink:

Growlink is a leading company in agricultural technology, specializing in control and automation solutions for indoor farming, hydroponics, and greenhouse cultivation. Their product range includes environmental controllers, irrigation systems, and nutrient delivery systems, all customizable to suit specific crop needs. With a strong focus on IoT, their systems allow remote monitoring and control via smartphones and computers. Growlink prioritizes energy efficiency to reduce costs and environmental impact. Their user-friendly interfaces cater to a wide range of users, and they offer support and training services. Ongoing innovations may include AI and machine learning for enhanced crop management.

(https://www.growlink.ag/)

1. Pro System Aqua:

Sellers of electrical conductivity and pH controllers modules, having 4 principal products:

Uma imagem com azul, máquina

Descrição gerada automaticamente com confiança média

Figure 6 - ProSystem Aqua hydroponic system

“The ProSystem Aqua hydroponic system is the automatic nutrient controller. This automatic fertigation system is ideal for all types of crops, especially hydroponics, and is adaptable to water tanks for both large and small volumes.

It can apply different varieties of fertilizers and nutrients together and, at the same time, regulate the water tank's pH.

The control of pH and nutrient dosing is fully automated through continuous conductivity control, ensuring a solution with the desired values for the customer.

This system comes with a complete installation kit, including:

- Nutrient controller

- pH probe

- EC probe

- pH probe holder

- EC connection cable

- pH calibration solutions pH7 and pH4

- Suction and discharge tubes

- Injectors

- Mounting blocks and screws

- User instructions

- PPR manifold”

(https://cognoscitiva.pt/)

Uma imagem com texto, diagrama, captura de ecrã, design

Descrição gerada automaticamente

Figure 7 - Hydroponic System by Computer

“The Computer Hydroponic Controller controls and regulates the parameters of a water tank for irrigation and activates irrigation according to the programmed schedule. The programming and user information are transmitted through a panel that includes 5 keys, an alphanumeric display with 2x16 characters, and 15 LED indicators.

The equipment can be remotely controlled by a computer with an RS-485 connection.

The system manages:

- The amount of water in the irrigation tank

- Water conductivity appropriate to the contained fertilizer

- pH

- Temperature

- The dosage of fertilizers should be proportional to the water quantity.

- Activation and deactivation of irrigation

Hydroponic cultivation is primarily recommended when suitable land with essential agricultural skills for proper plant growth is not available. Hydroponics is always a type of soilless agricultural cultivation, but not all soilless crops use the mineral solutions required for hydroponic cultivation.

”

(https://cognoscitiva.pt/)

The company also sells the controllers individually.

The market prices are available on <https://www.prosystemaqua.com/treatment-of-water/manuales/detail-price-2022-tel-34652427766.pdf> (23/10/2023).

The solution presented on this report has the same features has the solutions on the market, but is cheaper to make:

* Use of low-cost sensors.
* Low-cost microcontrollers, that run on low power.
* Option to select only the sensors and features needed.
* The solutions on the market use a probe to detect the water level, this solution uses a distance sensor.

Whit this the solution proposed on this report can be produce cheaper.

### Market Trends

1. Integration of AI systems:

The integration off AI and machine learning, as data analysis is a trend in the area off the greenhouses, they can analyse data to optimize resource use and predict ideal conditions for plant growth.

1. Sustainability focus:

Automation solutions increasingly focus on sustainability, with features such as energy-efficient systems, reduced water consumption, and the use of renewable energy sources.

1. Modular systems:

Many automation solutions are designed to be modular and scalable, allowing growers to expand or adapt their systems to changing needs and greenhouse sizes.

The proposed solution fits all this trends:

An AI model can be developed to analyse the relational database, providing insights into the quality and growth time of herbs based on the available data. Furthermore, it can recommend optimal pH levels, electrical conductivity, and water temperature to cultivate high-quality herbs.

From a sustainability perspective, automation significantly reduces the need for controller solutions in the hydroponic system, such as pH and electrical conductivity adjusters. This, in turn, makes the system far more sustainable by reducing water usage and minimizing waste from these solutions.

The scalability of the solution is highly adaptable, contingent on the Wi-Fi range. This can be extended using "LoRa" or by installing additional access points. Moreover, it can support as many microcontrollers as required by the system, and if there's a need for enhanced processing power, upgrading the Azure cloud service suffices.

# Viability and Maintenance

## Environment limitations

Every hydroponic farm has limitations that can ruin a complete farm:

1. Natural disasters, since every hydroponic farm is inside a greenhouse, whit a stronger natural cause, and as result all the farm can suffer considerable damage.
2. Pests can destroy a complete farm of herbs.
3. Bacteria present in the water used to feed the herbs can lead to their demise and damage.

## Sensor limitations and maintenance

One of the possible limitations is the fact that if the sensors output false values, the consequence might be to impair or eventually destroy part of the farm.

To achieve that, I need to implement a functionality to periodically calibrate all the sensors.

The sensor can also be broken and whit that needs to be substituted.

## Microcontrollers limitations

These microcontrollers are not water-resistant, and in a greenhouse environment, they will be exposed to high humidity and water, which can eventually lead to a lot of damage to them, but the situation can be resolved by putting de final prototype on a waterproof box (IP65), also protecting the microcontroller from falls and all the surrounding environments.

The microcontrollers require a 3.3-volt power supply. They can be powered by either connecting them in close proximity to an electrical outlet through a transformer connected to a USB cable linked to the Arduino or by utilizing a breadboard power supply, which is powered by a 9-volt battery and transformed down to 3.3 volts, and with that the development of a way for the microcontrollers read the life of the battery, so that the farm doesn’t takes the risk of damage by the microcontroller runs out of power.

The solution is designed in such a way that a Wi-Fi connection is absolutely essential for the system to function, which can be a limitation, as there is always a possibility that the greenhouse may not have Wi-Fi connectivity. For further enhancement this entire system can potentially be modified in the future to operate via LoRa technology, which offers significantly greater range compared to Wi-Fi.

LoRa and Wi-Fi are two distinct wireless communication technologies. Wi-Fi is well-suited for high-speed, short-range connections within buildings, while LoRa excels at long-range, low-power communication in outdoor and remote environments. Unlike Wi-Fi, which requires substantial power, LoRa devices have exceptional energy efficiency. Additionally, Wi-Fi provides faster data transfer, making it ideal for internet access, while LoRa specializes in transmitting small packets of data over extended distances. Each technology serves unique purposes, with Wi-Fi for local connectivity and LoRa for wide-area, low-power applications.

# Solução Proposta

Identificação, justificada detalhadamente, da tecnologia a utilizar no desenvolvimento do TFC e fundamentação das principais opções na construção da solução. Como forma de validar os critérios de avaliação de abrangência, o relatório deverá indicar disciplinas e áreas científicas do curso que serão aplicadas na solução proposta. Esta indicação deve ser revista e ajustada nos relatórios seguintes sempre que se justifique

Diagrama

# Calendário

Plano de trabalho e cronograma proposto para o remanescente do TFC, em formato Gantt. O planeamento deve, dentro do possível, apresentar orientação a gestão de projecto.

O plano a apresentar deverá focar-se no trabalho a desenvolver na fase seguinte do projecto, apresentando em detalhe as tarefas a realizar nesse período. Em complemento, deve apresentar estimativas de alto-nível para o trabalho posterior, perspectivando características dos entregáveis da avaliação final em termos que permitam, em avaliações posteriores, aferir se os objectivos agora enumerados foram cumpridos no desenvolvimento do TFC

Complementarmente, deve-se incluir neste capítulo indicações do progresso do trabalho, onde se refira tarefas realizadas, dificuldades mais marcantes e alterações que tenham sido introduzidas ao plano e objectivos iniciais.

# Bibliografia

[DEISI21] DEISI, Regulamento de Trabalho Final de Curso, Set. 2021.

[TaWe20] Tanenbaum,A. e Wetherall,D., *Computer Networks*, 6ª Edição, Prentice Hall, 2020.

[ULHT21] Universidade Lusófona de Humanidades e Tecnologia, [www.ulusofona.pt](http://www.ulusofona.pt), acedido em Out. 2021.

# Anexo 1 – Questionário

# Anexo 2 – Recomendações para escrita de um relatório

**Este anexo exemplificativo deverá ser removido antes de submeter o seu relatório**. A escrita do relatório deve seguir o presente template, sugerindo-se não mudar nada em termos de formatação (fontes, espaçamentos, tamanhos, etc). Antes de entregar o relatório, exercite a sua capacidade de auto-crítica, lendo-o e verificando se está adequadamente redigido. Consulte os videos tutoriais com dicas sobre [Como fazer um relatório de TFC em Word](https://educast.fccn.pt/vod/clips/245cjb4nn6/streaming.html?locale=en) e [Trabalho colaborativo com MS Word](https://educast.fccn.pt/vod/clips/key0dbo5c/html5.html?locale=en).

São dadas de seguida algumas explicações sumárias. Na Tabela 1 exemplifica-se uma tabela e a forma como esta deve ser referenciada. Como poderá ver, se passar com o rato por cima da palavra “Tabela 1”, neste parágrafo, aparece o hiperlink. Tal é possível se for incluída uma referência da forma que se explica a seguir. As tabelas devem ser apresentadas sempre depois de referenciadas. A legenda da tabela deve ser inserida através da opção do menu *References\Insert caption* (no menu em cima do MS Word), sempre no topo da tabela. A referência a uma tabela insere-se através do comando *References*\*cross-reference*, sendo a sua numeração automática.

Tabela 1 – Tipos de Selectores existentes.

|  |  |
| --- | --- |
| **Tipo** | h1, p |
| **Universal** | \* |
| **Classe** | .class1 |
| **ID** | #element |
| **Atributo** | [target=\_blank] |
| **Pseudo-classe** | div:hover |
| **Pseudo-elemento** | p::first-letter |

O processo de carregamento de uma página HTML está representado na Figura 1 para exemplificar como se deve inserir uma legenda a uma figura assim como uma referência a esta mesma. Para inserir uma Figura, seleccione *References\Insert Caption* e indique que quer inserir uma Figura. A figura deve sempre aparecer depois de ser referida no texto. Para inserir uma referência a uma figura, utilizar *References\Cross-reference*. O índice e listas de tabelas e figuras (mas páginas iii a v) actualizam-se automaticamente se inseridas desta forma. Para actualizar basta selecionar todo o texto e premir F9.



Figura 1 – Processo de carregamento de uma página HTML.

Explica-se de seguida a inserção de referências bibliográficas. Qualquer texto ou ideia que venha de uma referencia bibliográfica deve ser indicada com uma referência. Por exemplo, podemos referir que este trabalho se enquadra dentro do regulamento do Trabalho Final de Curso [DEISI21]. O hyperlink aponta para a referencia bibliográfica inserida relativa ao regulamento de TFC. Para sua criação deve:

1. escrever o texto que pretende na bibliografia
2. usar uma numeração adequada [], de forma a que respeite a ordem de aparecimento da referencia no texto.
3. selecionar a referencia inserida com o rato (por exemplo [2]) e escolher em Insert\Bookmark, criando um nome associado à referencia.

Depois, no texto onde pretender pode inserir a referencia através de Insert\Cross-reference.

# Glossário

LEI Licenciatura em Engenharia Informática

LIG Licenciatura em Informática de Gestão

TFC Trabalho Final de Curso