MOBILE APPLICATION FOR MICROGREENS PRODUCTION MONITORING

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ABSTRACT: Agriculture has been a fundamental pillar for the survival and advancement of society, evolving from primitive methods to highly sophisticated techniques. With the advent of technology, innovations such as urban agriculture have emerged, which enables cultivation in urban areas through hydroponic greenhouses. Thus, this work aims to develop an application for the management of a microgreens production environment instrumented with IoT resources. For the development of the proposed application, a systematic and structured approach was employed. Initially, the project requirements were identified, followed by the design of use cases and the implementation of an API that communicates with a mobile application using the Flutter framework. The result is a functional application that provides access to real-time environmental data visualization about the greenhouse's environmental conditions, including parameters such as temperature, soil moisture, and lighting levels.

Keywords: Urban agriculture, Internet of Things, Greenhouse Technology, App Development.

APLICATIVO MÓVEL PARA MONITORAMENTO DA PRODUÇÃO DE MICROVERDES

Resumo: A agricultura tem sido um pilar fundamental para a sobrevivência e o avanço da sociedade, evoluindo de métodos primitivos para técnicas altamente sofisticadas. Com o advento da tecnologia, surgiram inovações como a agricultura urbana, que possibilita o cultivo em áreas urbanas por meio de estufas hidropônicas. Dessa forma, esse trabalho visa desenvolver um aplicativo para o gerenciamento de um ambiente de produção de microverdes instrumentado com recursos IoT. Para o desenvolvimento da aplicação proposta, uma abordagem sistemática e estruturada foi empregada. Inicialmente, os requisitos do projeto foram identificados, seguidos pelo design de casos de uso e a implementação de uma API que se comunica com uma aplicação móvel usando o framework Flutter. O resultado é um aplicativo funcional que proporciona o acesso a visualização de dados ambientais em tempo real sobre as condições ambientais da estufa, incluindo parâmetros como temperatura, umidade do solo e níveis de iluminação.

Palavras-chave: Agricultura Urbana, Internet das Coisas, Tecnologia de Estufas, Desenvolvimento de Aplicativos.

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1. INTRODUTION

From the dawn of civilization to present-day societies, agriculture has been the backbone of human survival and progress. It holds significant cultural and economic importance in Brazil, supporting rural communities and providing food for a growing population (ARIEIRA, 2017, p.15). As time has passed, farming techniques have evolved from basic methods to advanced cultivation practices.

The advent of technology has stimulated numerous innovations that are reshaping how we grow and consume food. Urban agriculture, a method that involves cultivating food in urban spaces through hydroponic greenhouses, is one such innovation. This practice not only minimizes the food's travel distance from the farm to the consumer but also allows city dwellers to access fresh and healthy produce within constrained urban areas (MACHADO & MACHADO, 2002, p. 18).

Hydroponics is an innovation in urban agriculture, allowing plants to be grown in nutrient-rich aqueous solutions without the need for soil, allowing precise control over plant growth conditions and resulting in more productive and sustainable harvests. Most plant varieties have potential for hydroponic cultivation; however, from an agronomic and economic perspective, the most suitable for this type of cultivation are those of reduced size, such as microgreens (EGÍDIO; LEVY, 2013, p. 109-110). Thus, microgreens stand out due to their efficiency, since they are young plants that are harvested just a few weeks after germination and grown in hydroponic systems.

2. OBJECTIVES

The present study aims to develop a mobile application for monitoring and remotely controlling IoT devices, using a greenhouse already equipped with IoT resources connected to an API as a case study.

3. METHODOLOGICAL PROCEDURES

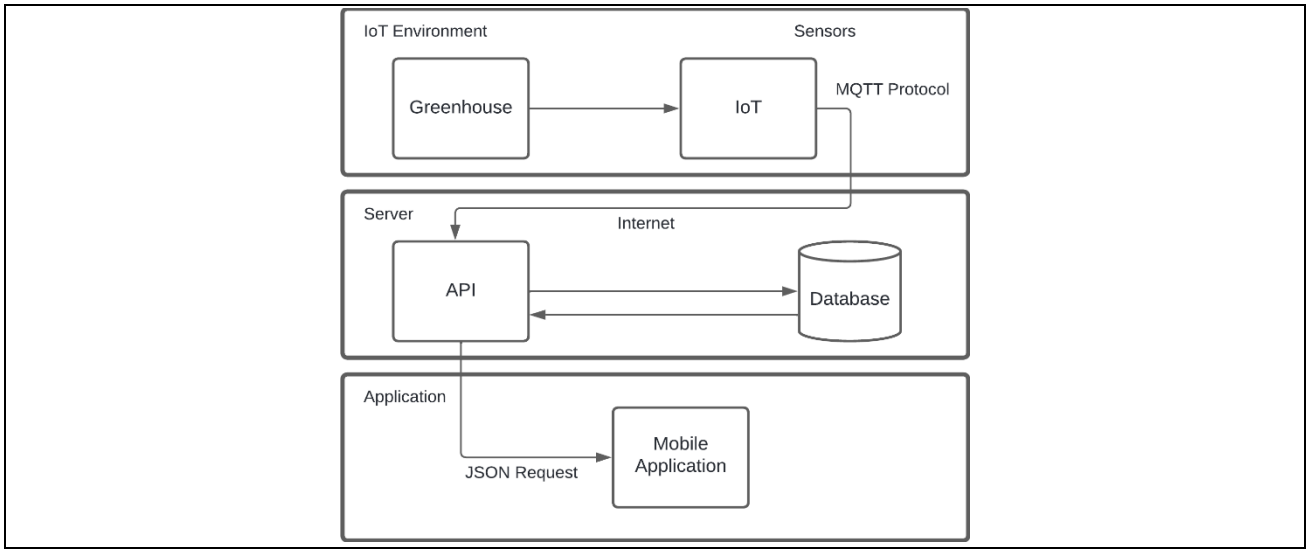
This project adopts a systematic and structured approach to develop a mobile application for remotely monitoring and controlling an IoT-enabled greenhouse. The methodology is descriptive, focusing on the design, implementation, and testing of the application. Unit and integration tests were employed as part of the development process to ensure the functionality and reliability of the system. These tests covered various modules, including Home, Navigation, Settings, General, and Profile, verifying key aspects such as counter increments, navigation flow, conditional rendering, system integration, and state validation.

White box testing was performed during the development of the greenhouse application to verify the correct operation of internal functions. According to the practices recommended by Myers, Badgett and Thomas (2011), these tests are essential to identify and correct logical errors in the code, ensuring the robustness and reliability of the system.

4. RESULTS AND DISCUSSIONS

Development began with detailed requirements gathering and use case design to map out the application's functionalities. A pre-existing API developed by Franz (2023) on the AgDataBox platform was customized to meet the specific needs of this project. Modifications included the addition of new endpoints, data formatting to suit the application's requirements, and updates to ensure compliance with the MQTT communication protocol.

Figure 1 – Architecture Diagram of the IoT Greenhouse Monitoring and Control System



Source: Own Elaboration (2024)

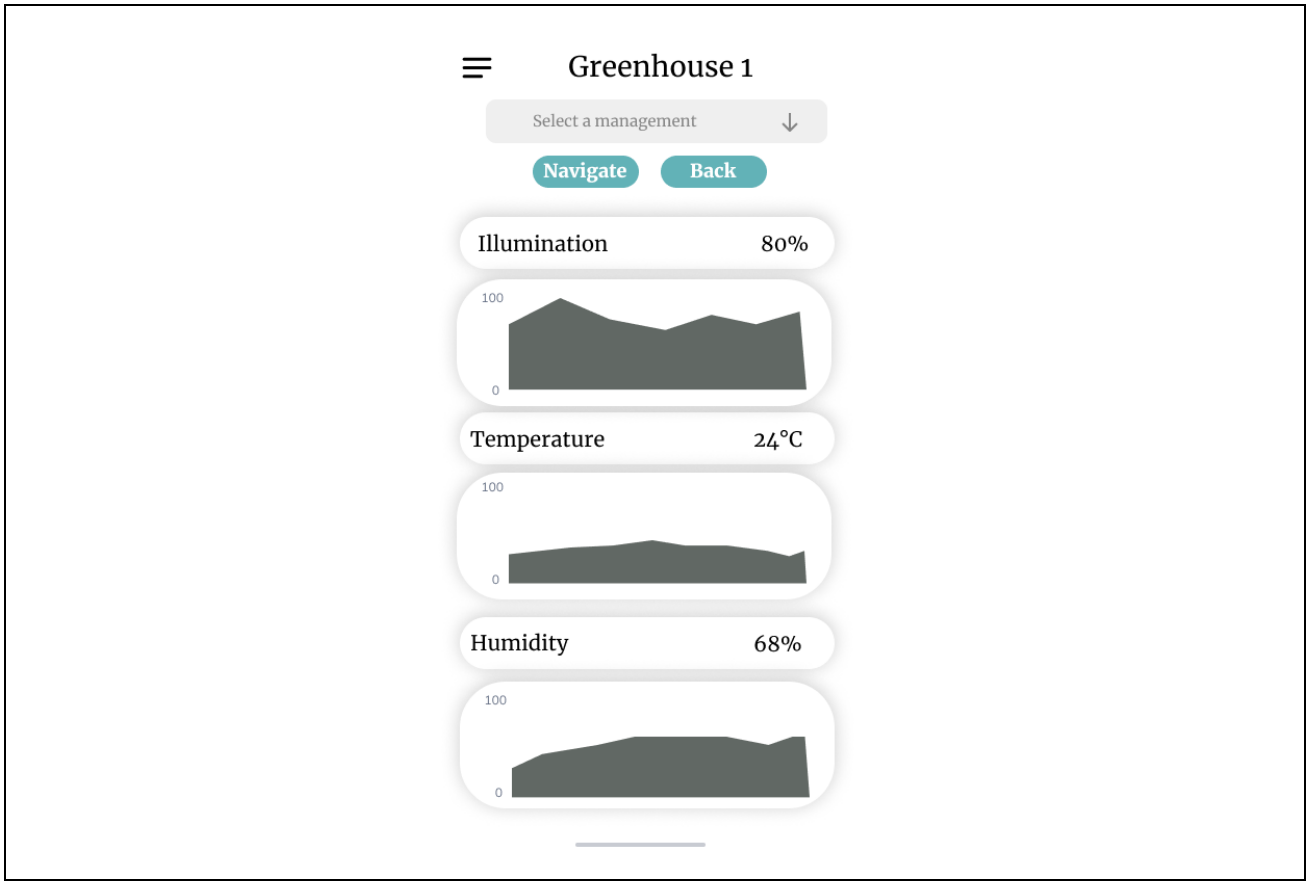
UI prototyping was done using Figma, allowing for preliminary visualization and user interaction. Coding was done in Visual Studio Code using Flutter, addressing both backend and frontend aspects.

The system provides a user interface that allows real-time visualization of data including ambient temperature, soil moisture and lighting. Additionally, the app provides remote control of systems such as irrigation and lighting, ensuring that desired environmental conditions are maintained.

During the implementation phase, critical environmental parameters for microgreen cultivation were defined, such as the temperature range between 15°C and 25°C, as suggested by Sánchez and Berghage (2024), who highlight these limits as ideal for healthy plant growth. Users have the possibility to directly adjust these parameters, allowing precise control of the growing environment and ensuring that conditions remain within the recommended limits to optimize productivity.

The application allows users to add, remove and manage IoT devices, automating the initial setup and ongoing maintenance of connected devices. Among the implemented features are the sending of alerts and notifications in response to critical events, such as adverse weather conditions or device failures. The system also includes historical visualization of collected data, which allows the generation of customized reports based on this data.

Figure 2 – Greenhouse Monitoring Dashboard Screen Prototype



Source: Own Elaboration (2024)

All unit and integration tests ran successfully with no failures identified. Test coverage reached 85%, including runtime checks, condition tests, loop tests, execution and boundary value coverage, as well as execution and data flow coverage.

Table 1 - Status of tests performed

Test	Module	Result	Failure details
Counter Increment Test	Home	Success	N/A
Navigation Test	Navigation	Success	N/A
Conditional Rendering Test	Configuration	Success	N/A
Full Integration Testing	General	Success	N/A
State Validation Test	Profile	Success	N/A

Source: Own Elaboration based on authors' data (2024)

5. FINAL CONSIDERATIONS

The development of a mobile application for monitoring and controlling IoT greenhouses outside microgreens cultivation has proven to be an interesting solution for the automated management of controlled agricultural environments. The integration of IoT devices and the implementation of essential functionalities, such as real-time visualization of environmental data and remote control of systems, allows users to adjust growing conditions efficiently.

The project represents a breakthrough in the application of IoT technologies in agriculture, providing a useful tool for monitoring and controlling greenhouses, with the potential to improve productivity and efficiency in the cultivation of microgreens.

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