Augmented Reality Integration in Mobile Enterprise Information Systems

[1]Luís Silva, [2]Rodrigo Santos
[1]Department of Informatics, Polytechnic of Viseu, Viseu, Portugal
[2]Research Center in Digital Services, Polytechnic of Viseu, Viseu, Portugal
pv34471@alunos.estgv.ipv.pt, pv24933@alunos.estgv.ipv.pt

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I. Introduction

The increasing digitalization of business processes has driven the adoption of immersive technologies that enable more direct interaction between users and information systems. Among these technologies, Augmented Reality (AR) stands out for its ability to merge virtual elements with the physical environment, providing contextual information in real time and facilitating the execution of complex tasks.

In the business context, the integration of AR solutions into mobile systems represents a significant opportunity to improve operational efficiency, reduce human error, increase mobility, and optimize resource management. The application of this technology in areas such as industry, logistics, and technical support services allows users to access data and instructions directly related to identified objects, fostering a more intuitive and productive experience.

This work aims to design, develop, and evaluate an AR-based mobile solution integrated with enterprise systems (ERP, WMS, and CMMS), using real-time visual object recognition through the mobile device camera, supported by multimodal identification technologies such as QR codes, barcodes, RFID, and NFC. The objective is to improve operational efficiency and significantly reduce human error in industrial and logistics environments.

II. State of the Art / Related Work

The application of Augmented Reality (AR) in enterprise environments has gained increasing relevance due to recent advances in mobile vision systems, object recognition, and real-time data processing. AR has been widely explored in industrial logistics, equipment maintenance, and field service operations, where object-aware interaction with digital information improves task efficiency and reduces operational errors.

Thakkar et al. [2] present a distributed edge computing architecture for intelligent environments, enabling low-latency processing of visual data. Although their work is not exclusively focused on Augmented Reality, it provides a fundamental computational paradigm for deploying object-recognition-based AR systems in real-time industrial scenarios.

Bakale et al. [1] investigate the integration of AR into ERP systems for enhanced business data visualization. Their approach focuses mainly on overlaying static information onto predefined markers, without supporting real-time object recognition or mobile-first offline operation.

Other studies demonstrate the effectiveness of AR combined with computer vision for equipment identification, maintenance guidance, and warehouse navigation. However, most existing solutions rely on continuous cloud connectivity and limited identification methods, restricting their robustness in real operational contexts.

In contrast, the system proposed in this work is based on real-time object recognition using the mobile device camera, supported by a hybrid identification model that integrates visual AR recognition with QR codes, barcodes, RFID, and NFC. Furthermore, the solution adopts an offline-first architecture with local data persistence and synchronized enterprise integration, enabling full operation in both connected and disconnected industrial environments.

III. Architecture

The proposed system follows a modular client–server architecture designed to ensure seamless integration between mobile users and enterprise information systems. The solution is structured into four main layers: the mobile application layer, the data persistence and offline layer, the synchronization middleware layer, and the enterprise backend.

The mobile application was developed using Flutter and deployed on Android devices. It provides the primary interface for users to identify physical objects through multiple identification methods, including Augmented Reality visual interaction, QR codes, barcodes, RFID, and NFC. The application adopts an offline-first approach, relying on a local SQLite database to ensure continuous operation even in environments with limited or no network connectivity.

The local data layer stores all operational entities, including users, equipment, articles, warehouses, movements, states, types, and families, allowing full functionality without immediate backend access. Physical warehouse organization is supported through attributes such as rack, zone, corridor, and shelf positioning.

The middleware layer is implemented using a RESTful API developed with FastAPI. This layer manages authentication,

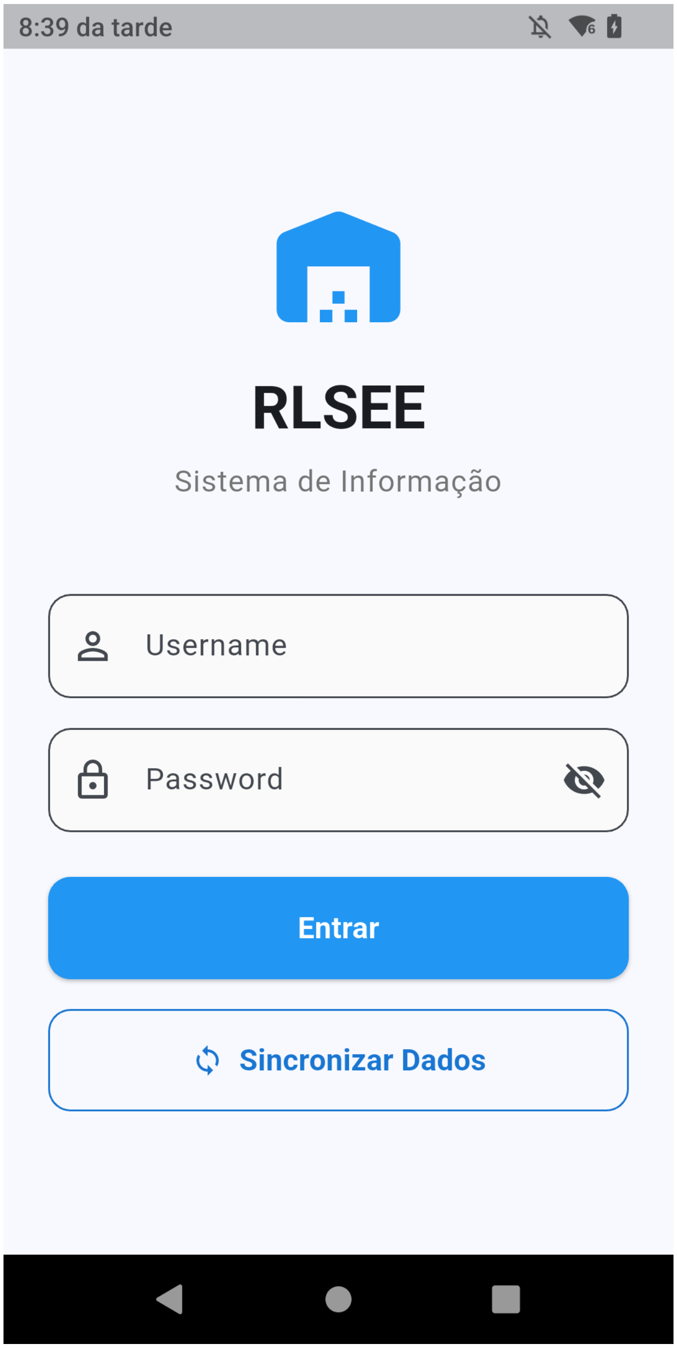

Fig. 1. Mobile application login screen.

data access, and synchronization between the mobile application and the enterprise backend. Communication is based on HTTP and JSON, ensuring interoperability and scalability.

The enterprise backend is supported by a SQL Server database, which simulates ERP, WMS, and CMMS information systems. It stores structured data related to inventory, equipment, user access, maintenance states, and logistical movements. The complete workflow establishes a digital link between physical assets and enterprise records.

IV. Experimental Setup

To validate the proposed architecture, an experimental prototype was implemented using a combination of mobile AR technologies and backend integration services. The goal was to simulate real-world enterprise scenarios, such as inventory inspection, equipment maintenance, and field service guidance.

A. Data Context

The experimental context focuses on operations within a logistics and maintenance environment, where workers interact with physical assets (e.g., machinery, inventory racks, equipment tags) and require contextual digital information for operational tasks. No sensitive data was used; instead, sample ERP-like records were simulated and stored in a structured database for testing purposes.

B. Hardware and Software Specifications

- **Mobile Device:** Samsung Galaxy Android Tablet (Android 15).
- **Development Platform:** Flutter SDK with Dart programming language.
- **Backend:** FastAPI (Python) with REST architecture.
- **Middleware:** Custom synchronization services using HTTP and JSON.
- **Database Systems:** SQL Server (enterprise backend) and SQLite (local mobile storage).

C. Frameworks and Configuration

- **AR Engine:** Mobile-based AR rendering framework.
- **Object Recognition:** Real-time visual recognition of physical objects using the mobile device camera, complemented by QR codes, barcodes, RFID, and NFC.
- **Communication:** RESTful APIs using HTTP and JSON.
- **Spatial Mapping:** Device camera tracking with real-time positioning.

Figure 10 illustrates the interaction flow between the mobile client, AR layer, middleware, and enterprise systems.

V. System Implementation: Scanning, Warehouse and Data Synchronization

This section describes the implementation of the multimodal scanning system, the digital representation of the warehouse environment, and the data synchronization mechanism between the mobile application and the enterprise backend. It also clarifies the operational scope of the mobile application as a read-only consultation tool.

A. Multimodal Scanning System

The proposed solution combines several identification technologies to guarantee strong and flexible recognition of objects in industrial settings. The mobile app is compatible with the following user scanning methods: Augmented Reality (AR) visual object recognition, QR code scanning, barcode scanning, RFID, and NFC. With AR scanning, a physical object can be identified instantly in a video frame captured by the mobile device camera. Consequently, the user may retrieve the

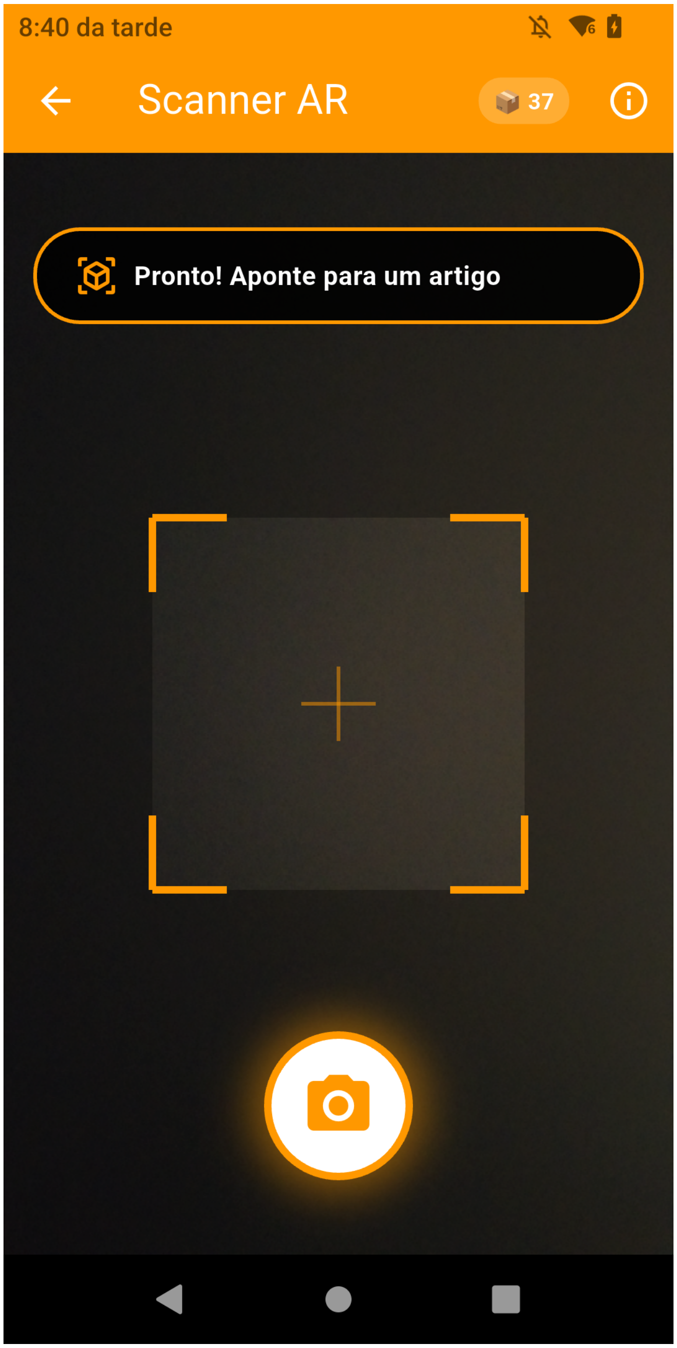

Fig. 2. AR-based object recognition using the mobile camera.

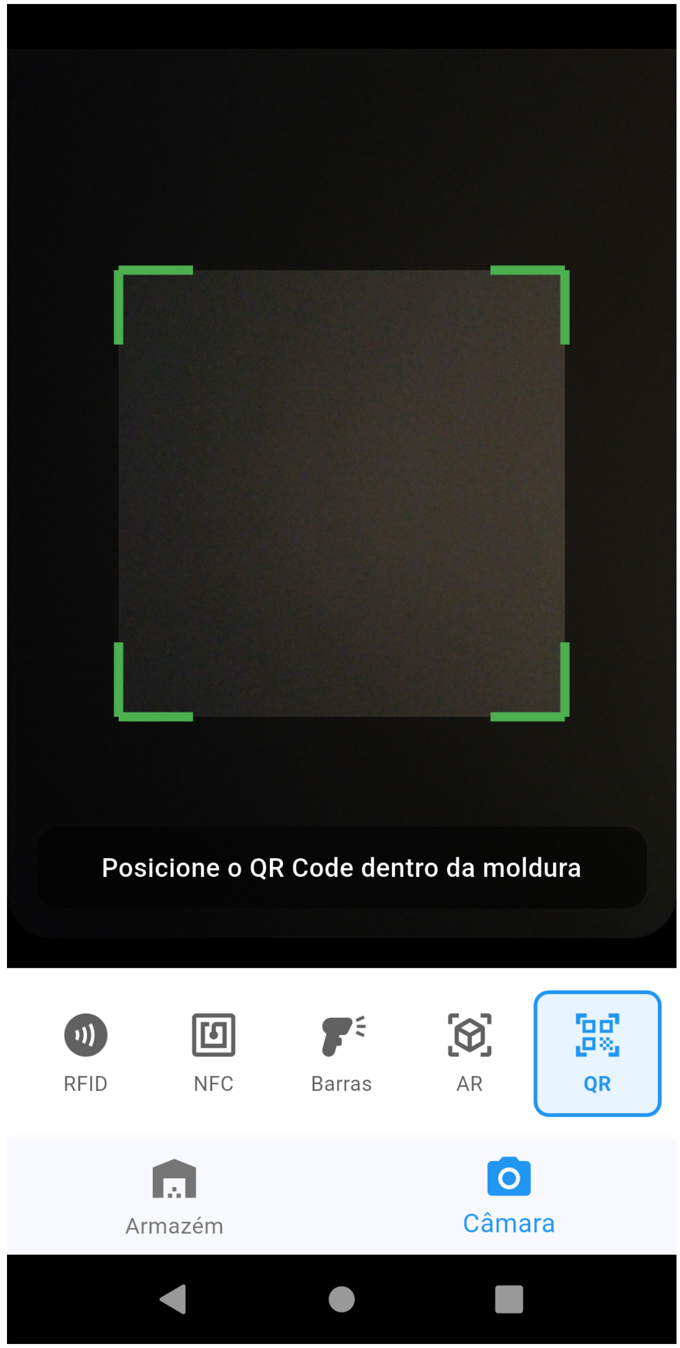

Fig. 3. Barcode and QR-based identification mode in the mobile application.

requested digital information by simply looking at the object. On the other hand, QR codes, barcodes, RFID, and NFC offer alternative identification techniques in adverse environmental conditions, such as low light or partial occlusion.

B. Digital Representation of the Warehouse Environment

The warehouse ecosystem is a digital simulation based on structured enterprise data that depicts the physical asset organization and the logistics operations. Every warehouse unit is distinctly recognized and linked to a physical location defined through attributes such as rack number, zone, corridor, and shelf. This structured portrayal makes it possible for the mobile application to deliver accurate contextual information about the physical location of inventory and equipment. Operators can quickly find materials, check stock availability, and recognize equipment status directly in the warehouse environment.

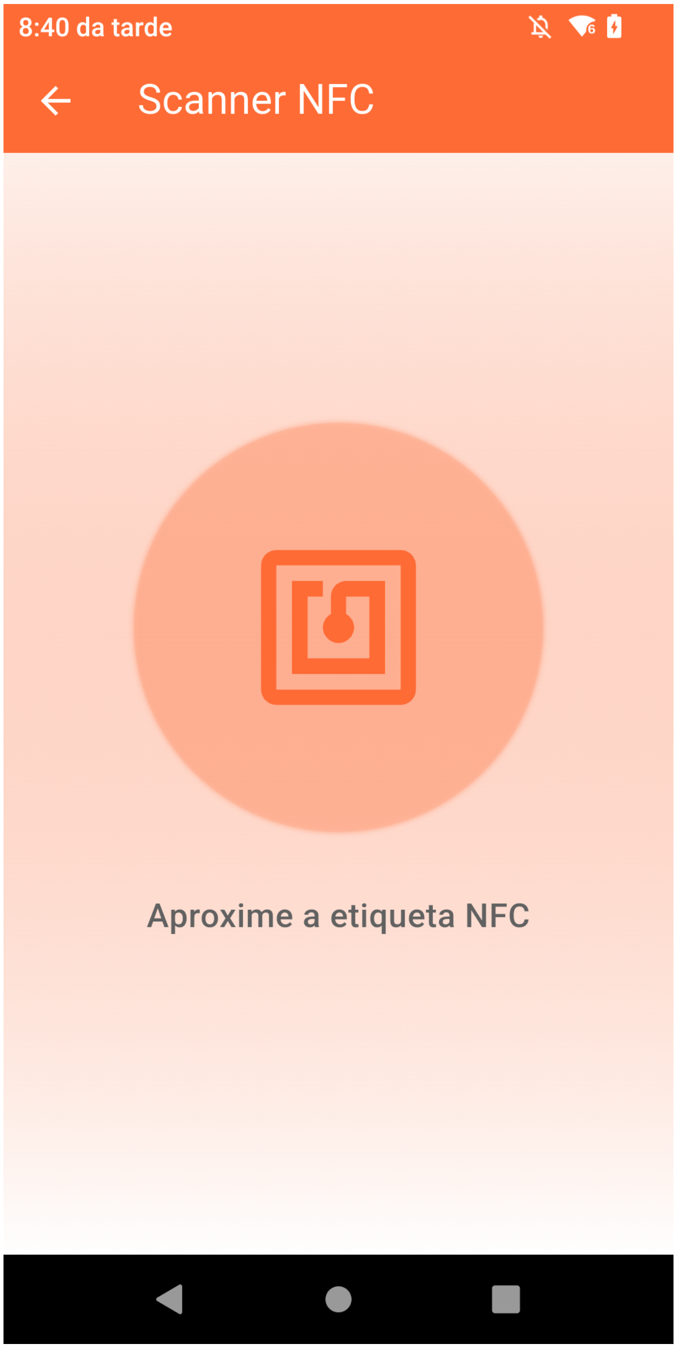

Fig. 4. NFC tag reading for equipment identification.

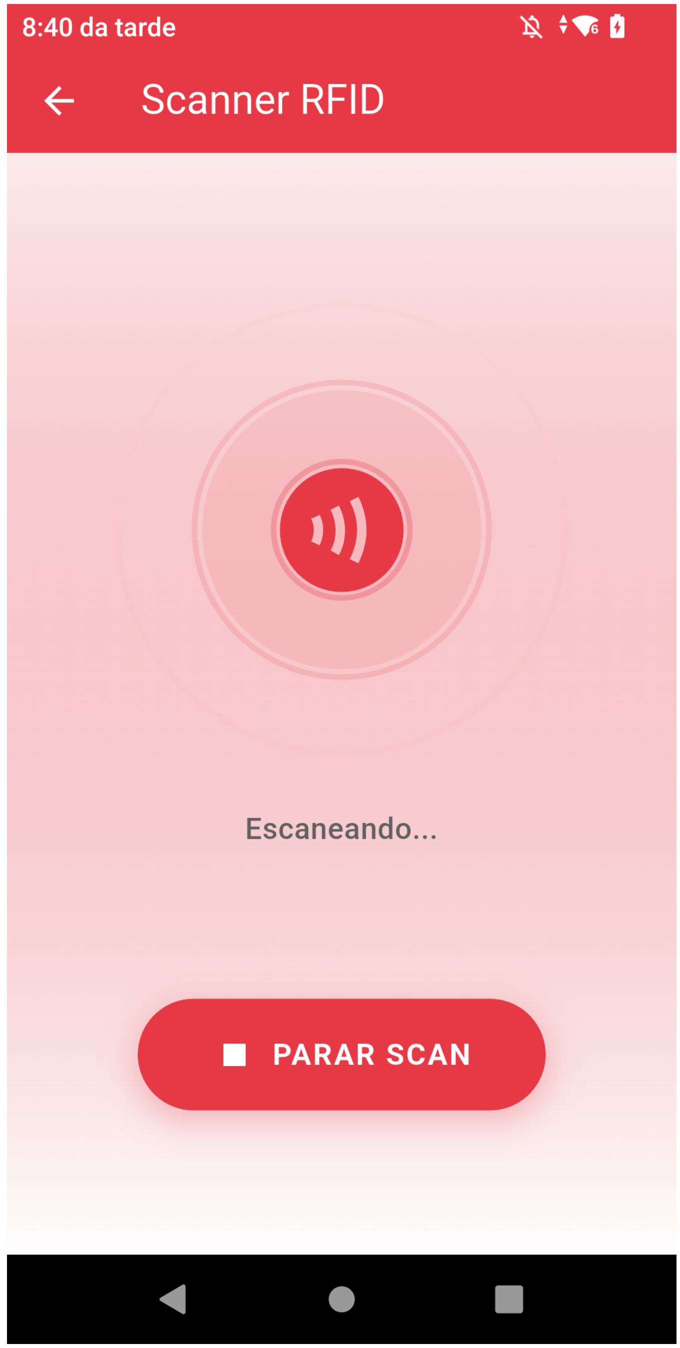

Fig. 5. RFID-based object identification using the mobile device.

C. Data Synchronization and Offline Operation

The application is structured in such a way that it prioritizes offline usage and is supported by a local SQLite database. To ensure seamless operations, all enterprise data such as users, articles, warehouses, equipment, movements, states, types, and families are kept locally on the device.

Data synchronization is performed between the mobile client and the enterprise backend through a RESTful middleware developed with FastAPI, which connects to a SQL Server enterprise backend. Synchronization can be executed either fully or partially, allowing the selection of data to be updated according to operational requirements. Updated records are exchanged via JSON over HTTP and stored locally.

The system is designed so that it can function without a network connection. In offline mode, the application maintains full access to previously synchronized enterprise data with almost instantaneous response times. When a network connection is available, the system allows data to be resynchronized, ensuring that the mobile device and enterprise backend remain consistent.

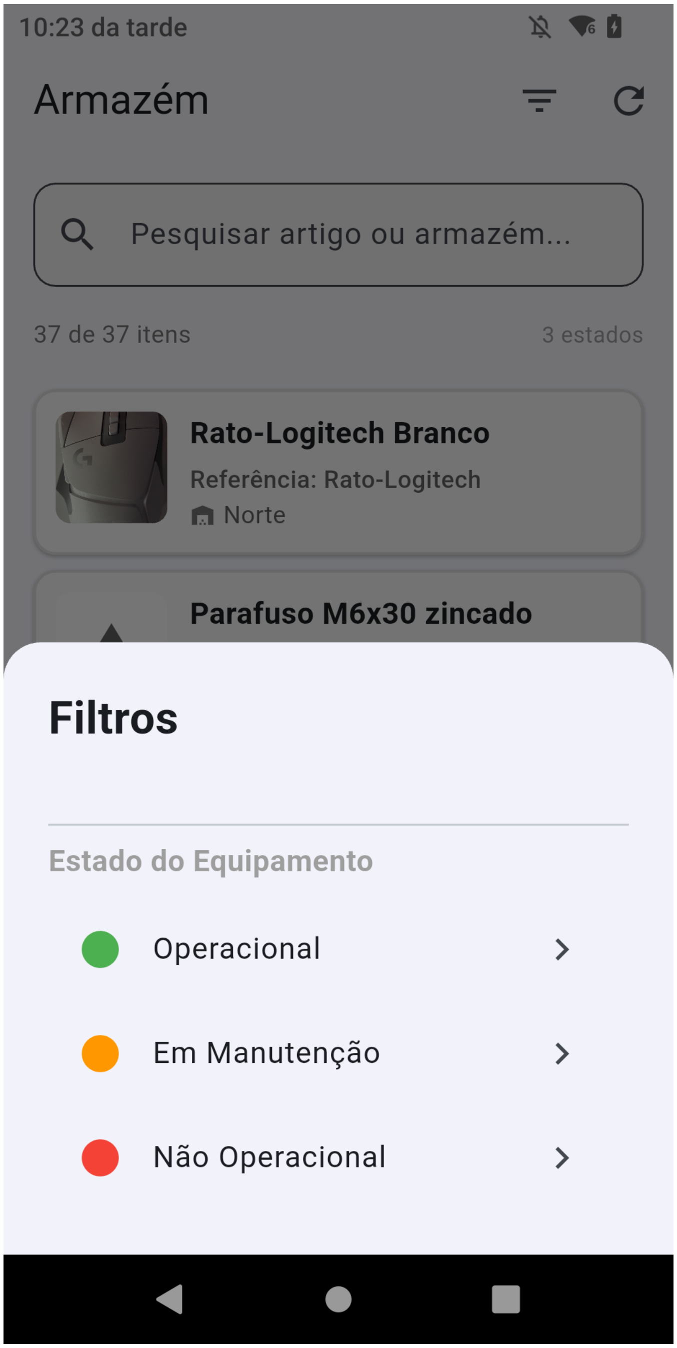

Fig. 6. Filter and search options applied after object identification.

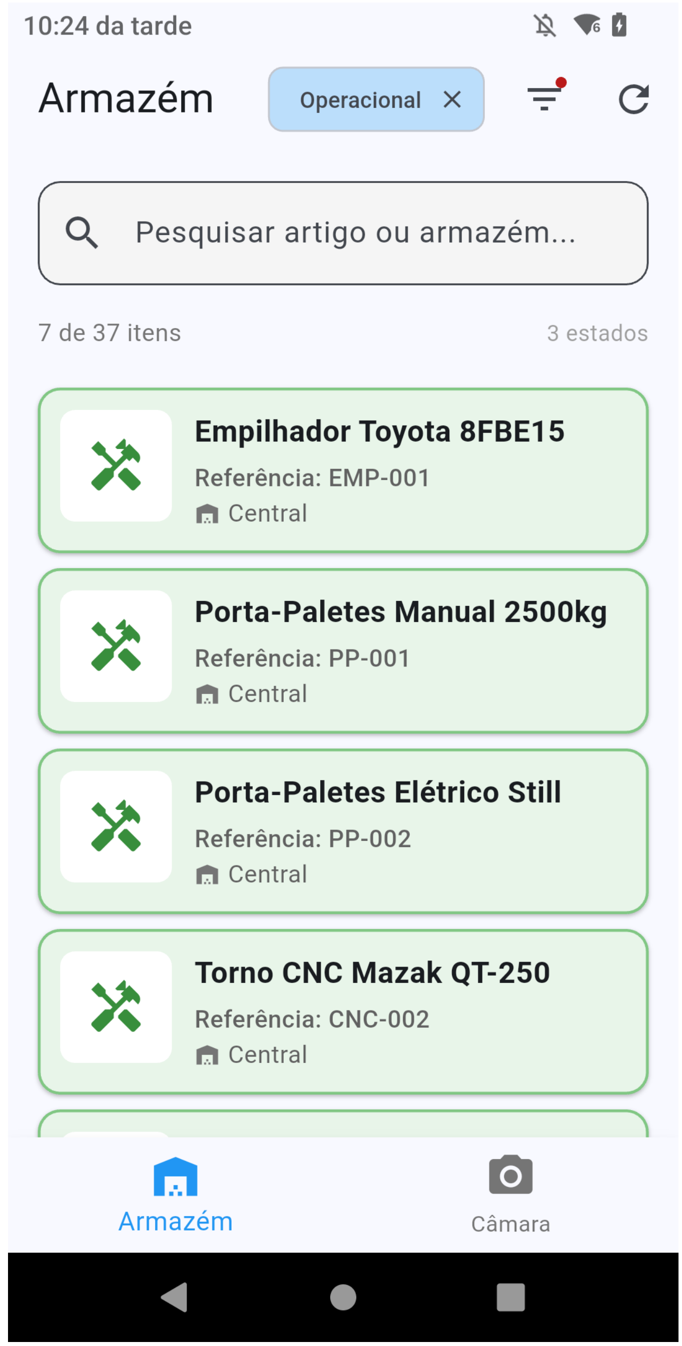

Fig. 7. Overview of the warehouse environment and storage areas.

D. Operational Scope of the Mobile Application

The mobile application is a tool that was deliberately created for consultation only and is read-only by nature. It enables operators to see and check enterprise information in real time through Augmented Reality and multimodal scanning.

Any data modification activities such as inventory updates, movement registration, equipment maintenance records, and user management are performed exclusively by the enterprise backend systems. This decision improves data integrity, security, and consistency, while at the same time keeping the mobile application architecture less complex.

VI. Results and Analysis

The proposed prototype was evaluated using simulated enterprise scenarios, including equipment inspection, inventory tracking, and warehouse navigation. The tests demonstrated that the mobile AR system provides fast and reliable access to contextual enterprise information.

System latency was evaluated by measuring the time between object identification and data visualization. The average

Fig. 8. Home screen of the application with access to warehouse functions.

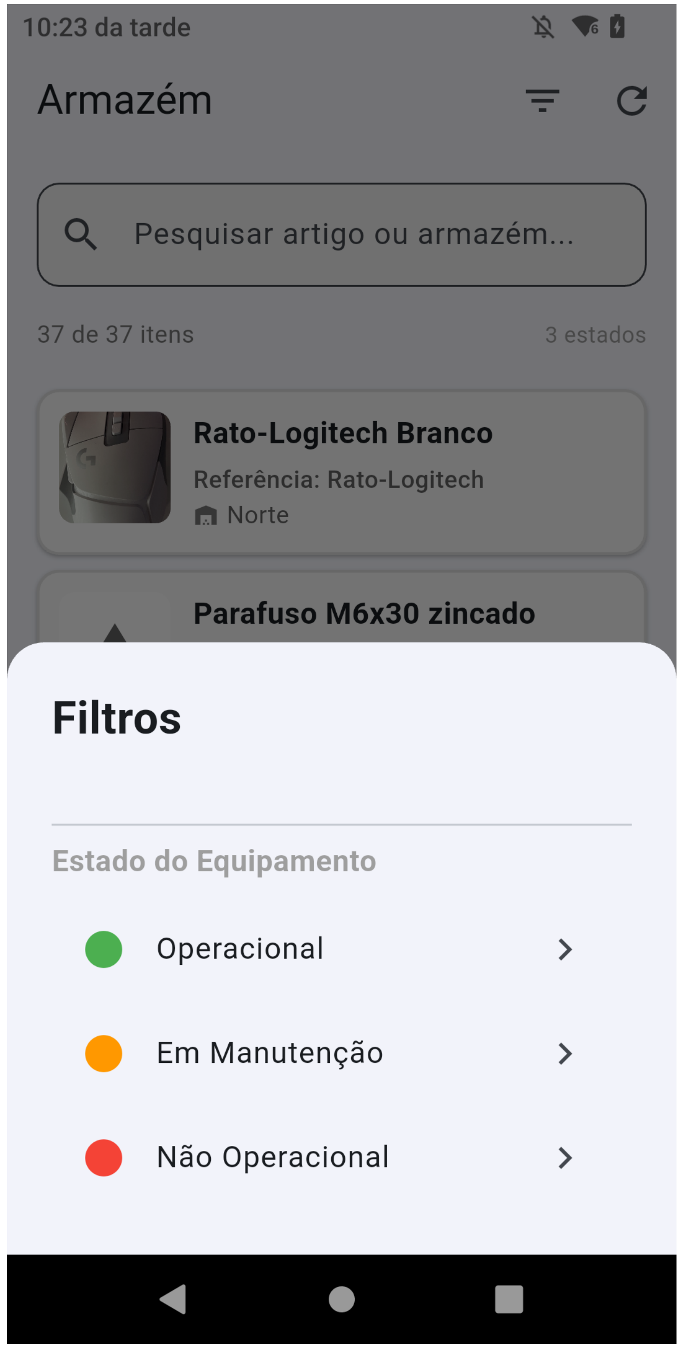

Fig. 9. Filtering and navigation within warehouse locations.

response time ranged between 250 ms and 600 ms under normal network conditions, ensuring a smooth user experience. Offline access resulted in near-instantaneous responses due to local SQLite access.

User evaluations revealed a clear improvement in task execution speed, reduction of manual data lookup, and reduction of identification errors. Operators highlighted the intuitive nature of visual interaction and the usefulness of contextual information directly in the work environment.

Environmental limitations were also observed, particularly under low-light conditions, which affected camera-based visual identification. However, alternative code-based identification (QR, NFC, RFID) remained unaffected, reinforcing the robustness of the multimodal approach.

Compared with related solutions such as [1], which rely primarily on static visualization, the proposed system demonstrates a fully integrated, dynamic, and mobile-oriented enterprise AR solution.

Fig. 10. Synchronization and access to updated enterprise data on the mobile client.

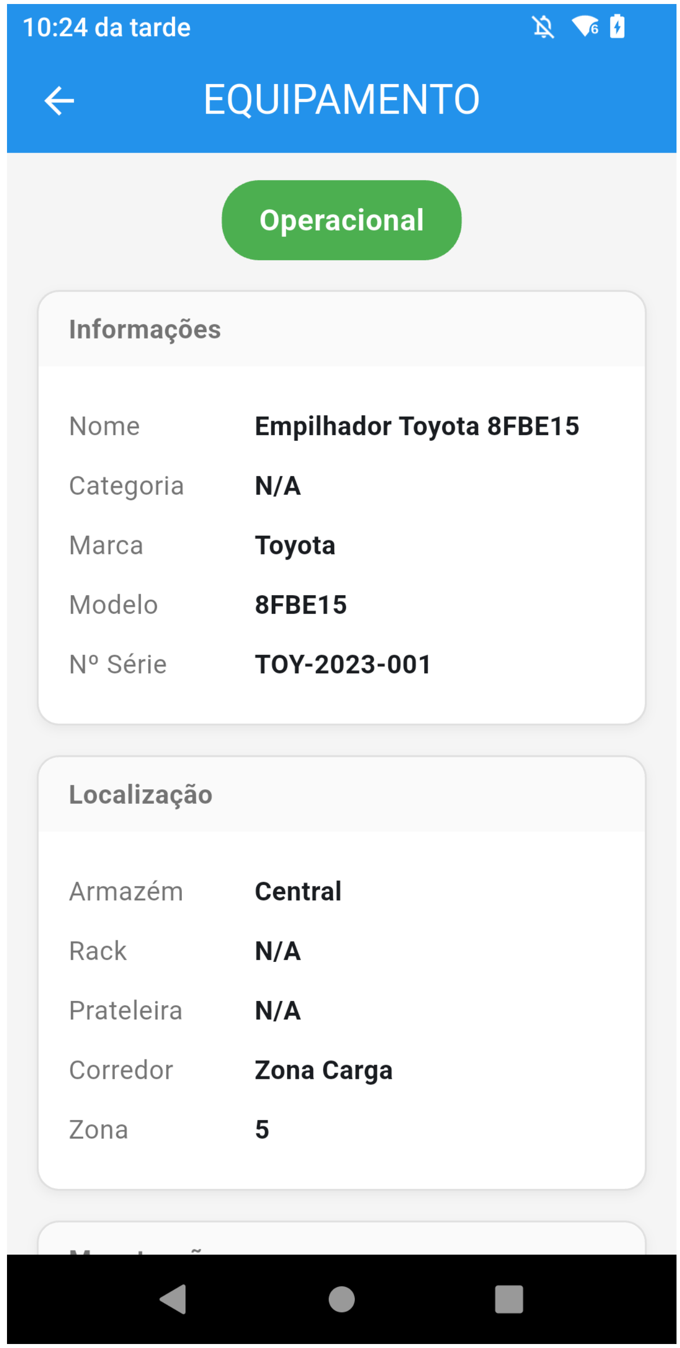

Fig. 11. Detail view of enterprise information related to a selected item.

VII. Conclusions and Future Work

This work proposed and implemented a mobile Augmented Reality system integrated with enterprise information systems, with the aim of enhancing operational workflows in industrial and logistics environments. By combining object recognition, spatial computing, and real-time data synchronization, the solution allows workers to access contextual information directly in the field, improving task efficiency and reducing error rates.

The prototype developed successfully demonstrated the feasibility of using AR in conjunction with ERP/WMS/CMMS systems through a modular architecture composed of a mobile AR client, middleware layer and backend services. The results confirmed performance adequacy, usability gains, and potential for broader application across different enterprise sectors.

A. Future Work

Future developments may focus on the following aspects:

- Improvement of the Augmented Reality module to increase object recognition accuracy, tracking stability, and

Fig. 12. Additional contextual data associated with the identified object.

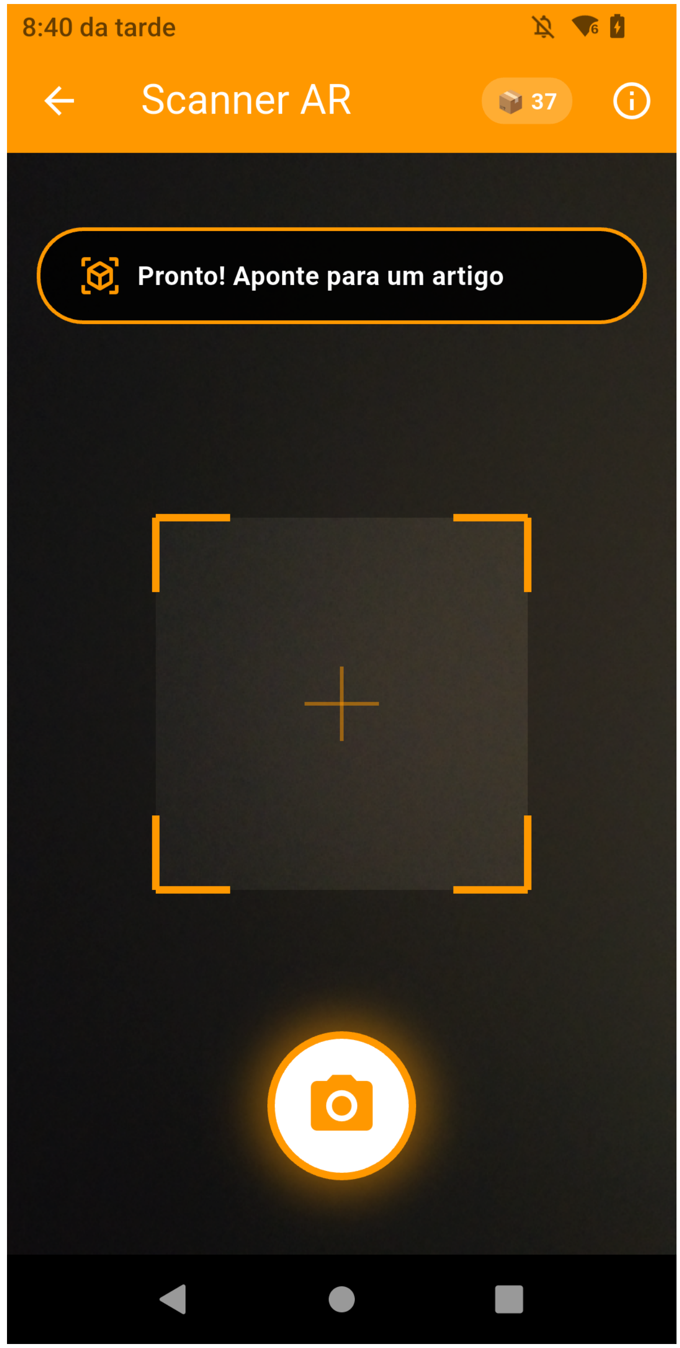

Fig. 13. Augmented Reality overlay showing detailed object information.

robustness under challenging lighting and environmental conditions.

- Integration of artificial intelligence techniques for automated object classification and predictive maintenance based on historical operational data.
- Expansion of multi-user collaborative AR scenarios to support team-based industrial operations.
- Deployment and validation of the proposed solution in real enterprise environments with direct connection to production ERP, WMS, and CMMS systems.

Acknowledgements

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