Right Move
Augmented Reality Project

Project in Computer and Informatics Engineering

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Group 1

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Abstract

Our Project in Computer Engineering and Informatics has as its main objective to develop an application that makes use of Augmented Reality and helps the user to carry out a sequence of instructions related to the assembly of Legos. The user will have several boxes available. Each box is identified with a QR Code and will contain a type of piece, with different colors and sizes available. The user's purpose is to carry out a given assembly and the application will guide him in order to track both the collection of parts (verifying shape, size, and color) and the position where they were subsequently placed. For this we will use the 'Google Glasses Enterprise Edition 2', kindly provided by Huf Portuguesa, which has been supporting us in the development of this project.

Resumo

O nosso Projeto em Engenharia de Computadores e Informática tem como principal objetivo desenvolver uma aplicação que faça uso da Realidade Aumentada e auxilie o utilizador a realizar uma sequência de instruções relacionadas com a montagem de Legos. O utilizador terá disponíveis várias caixas. Cada caixa é indentificada com um QR Code e conterá um tipo de peça, estando disponíveis diversas cores e tamanhos. A finalidade do utilizador é realizar uma dada montagem e a aplicação irá orientá-lo de modo a rastrear tanto a recolha das peças(verificando forma, tamanho e cor), como a posição onde estas foram posteriormente colocadas. Para isso utilizaremos os 'Google Glasses Enterprise Edition 2', gentilmente cedidos pela Huf Portuguesa, que nos tem vindo a apoiar no desenvolvimento deste projeto.

Contents

Glossary

API Application Programming Interface

AR Augmented Reality

GMS Google Mobile Services

GpS Google play Services

HTTP Hypertext Transport or Transfer Protocol

IL Immersive Learning

MR Mixed Reality

SDK Software Development Kit

SOAP System Object Access Protocol

UI User Interface

UX User Experience

VR Virtual Reality

XR EXtended Reality

Chapter 1

Introduction

1.1 Motivation

With the evolution of the industry 4.0, every day new technologies extend our reality, with AR, VR, and MR. This XR mechanisms allow us to optimize production on many levels:

- Immersive Learning;
- AR-based guidance in product assembly and repair;

Our motivation is to develop a solution for any user that wants to do assembly work, like an operator. Using LEGO we will recreate an environment that helps the untrained personnel better perform their tasks and recognize their errors without supervision. Augmented Reality is getting better by the day and is increasingly being more and more used in applications and this project will help us understand better the potential of XR-based technologies. While we are developing the application, although it is aimed at the assembly of legos, we have in mind possible future applications at an industrial level, which could have an impact on the efficiency of manual assembly processes.

1.2 Goals

The main goal for this project is to aid a user with the intent to perform a manual task with no prior experience, using a EXtended Reality-based guidance.

In an early stage, for example, there will be two boxes, both with different pieces, different colors, and shapes, our goal will be to notify the user from which box he should take the piece first piece after the application will verify if the piece that we took is the correct one using the color as reference.

In the Second phase, after the user takes a piece he should place it on a green board, where the construction takes place, the application will validate if the piece was set in the correct position.

In the Third phase, the objective is to adapt the validation of the steps described previously. The application in this phase will be able to validate the correct position but also orientation, making sure that the construction has no defects. Finally, the last phase is to optimize the interface developed, in order to finalize the product and be ready to use in any construction desired.

Finally, the application will repeat this process until the user takes all pieces correctly in order.

With our application, firstly , we intend to reduce the time of assembly of a client trying to assemble a LEGO construction. Secondly, in the future we expect that it will be able to be used in an Industrial scenario, to reduce time and errors made by inexperienced workers.

1.3 Dashboard/website

We have developed a website where all the work done so far is displayed in detail, as well as the planning of the entire project. In it, it is possible to consult the WorkPlan in a Gantt Chart, as well as the current objectives of the Project that we intend to fulfill. In addition to all this, there are also some possible use cases of the application that we are starting to develop and the implementation made so far.

This website will be updated depending on the development of the project, with the future goal of using it to analyze data collected with the application. That is, as users make use of the app to collect data such as the number of correct movements, graphically exposing the data obtained on the Dashboard in order to be able to draw some conclusions. In a training system, for example, where a user repeatedly performs a given movement, it is useful to know, on average, how long after using the application the trained movement began to be performed without any error.

Chapter 2

State of the Art

2.1 Introduction

From the beginning of the development of the project until the present moment, the Project has undergone several changes, since the beginning, where we did not have any type of information about the material that would later be made available to us, we started the research in order to explore which tools have been used to develop projects where AR is used in industrial environments. This research was then divided into 2 moments, an initial one in which we did not know what materials we would have available, and a second in which we began to be accompanied by members of Huf who gave us a more precise idea of where we should start and the objectives to be fulfilled taking into account our project.

In this first phase of the research, we consulted several articles, papers, and we also attended the International Conference on Graphics and Interaction – ICGI'2022. Given all this research, we found quite relevant articles that brought us up to date with what is needed in the current industry, the fact that innovation and the production of new products is something recurrent, makes updating operator training something extremely necessary (as explained in the article [SAP22]), we confirmed this same need when we visited the Huf factory. In order to obtain more immediate results, submitting people to training that uses resources such as AR is a strategy that is widely adopted today, since immersive teaching has better results when compared to traditional teaching methods (as exposed in the article [CRURCC22]). Given the research done, we learned what Augmented reality really is and what tools allow us to work with it.

2.2 AR Environment

Augmented reality (AR) is the integration of digital information with the user's environment in real-time. Unlike virtual reality (VR), which creates a totally artificial environment, AR users experience a real-world environment with generated perceptual information overlaid on top of it.

To create the AR environment, we will use 'Google Glasses', which represent a significant advance in Google's development of augmented reality, a technology that many people believe could be a major shift in computing like the smartphone and PC before it. Augmented reality superimposes computer-generated images over the real world, unlike virtual reality, which completely immerses the viewer in an artificial world or "metaverse".

All of this becomes advantageous for the evolution of the current world when applied to time-consuming processes in order to optimize them, for several tools are used (as explained in the article [DPN+22]) such as Unity3D (this being one of the most frequently used in the analyzed papers), the Vuforia, among others now explained.

2.2.1 Unity

Unity is a cross-platform game engine developed by Unity Technologies, first announced and released in June 2005 at Apple Worldwide Developers Conference as a Mac OS X game engine. The engine has since been gradually extended to support a variety of desktop (as the Project descript in [MZV17]), mobile (such as the article [SC20]), console, and virtual reality platforms (for example the descript in [MMS+19]). It is particularly popular for iOS and Android mobile game development is considered easy to use for beginner developers and is popular for indie game development.

2.2.2 Vuforia Engine

Like Unity, first of all, we try to use Vuforia Engine in the development of AR environments in our project. Vuforia Engine is a software development kit (SDK) for creating Augmented Reality apps. With the SDK, you add advanced computer vision functionality to your application, allowing it to recognize images, objects, and spaces with intuitive options to configure your app to interact with the user.

Although we had clear examples that this is a good tool when we attended the lectures at the International Conference on Graphics and Interaction – ICGI'2022, we concluded that it would not be feasible to use it with the material that was provided to us by what we started to explore other aspects more compatible with what was made available to us.

2.3 3D Environment

A 3D environment can be taken as a computer-controlled digital environment. It is created with the illusion of depth and can be done for outdoor and indoor locations, the viewer can get visually specific sensations. The 3D-modeled environment can be a unique atmosphere with realistic objects, vehicles, or furniture. These realistic items are modeled for the non-fictional environment setting ([HH20]). However, the world of fiction is broad, and the 3D-modeled fictional environment consists of non-realistic items. This modeling is widely used in science fiction movies and games.

2.4 Movement Detection

The user will have an application that will tell him how to make the constructions in LEGO and using a QR Code the application will lead the user on what step to do next, (using a camera), the application will see if the user is doing the correct movement setting up the construction. Whether based on QR Codes, color markers, or other algorithms, tracking of the user's movements will be carried out so that we can understand whether he is performing the intended movement or not, for this, there must be a system that detects movements performed by the user and estimate the desired movements (something similar to what is described in [HQT+21]).

2.5 User Visualization

2.5.1 Google Glasses

Google Glasses were designed to be lightweight and are equipped with a camera and sensors, that help in reading QR codes and detecting what the user is seeing. Transforming the data into something helpful for the user. It also comes with a small screen in the top right corner where the user can see the output intended. These glasses need to use a google library. with multiple functions to manage all the devices available by the glasses.

Although the use of AR glasses is more frequent (as for example in the project described in [MZV17]), google glasses have the advantage that, even accompanying the user, they do not provide a fully immersive environment that makes the user feel abstract from reality in the present moment. Therefore, it is a more suitable tool for projects where the objective is to perform a task in real time and not simulate an immersive environment.

Chapter 3

System Requirements

3.1 Requirements Elicitation

Initially not having any kind of information about the type of material that would be made available to us, we carried out multiple searches, consulting multiple papers and scientific articles related to applications of AR to the industry in an industry 4.0 environment.

We kept recording all the research we did in excel files where we highlighted the key points of each article consulted, such as the architecture used, programming languages, Software Packages, devices, evaluation and success of the article, etc. ...

By recording all this information relating to various projects within our area of interest in tables, we were able to highlight the most relevant points of each one and extract some useful information for the further development of our project. Of all the articles and projects studied, we highlight 2 below:

Title	Goals	Devices	Software Packages
Augmented Reality Application to Develop a Learning Tool for Students: Transforming Cellphones into Flashcards[SC20]	Making learning with flashcards more efficient and intuitive	Iphones Android Mobile Devices	Unity3D
Augmented reality application to support remote maintenance as a service in the Robotics industry[MZV17]	Allows a non-specialized technician to repair an assembly line machine with the help of an expert and AR 3d models.	Smartphones/Tablets AR googles	Unity 3D

We decided to highlight these two articles from all the ones we read since they are the same, given that taking into account the material that was made available to us and the most recently defined objectives, they are those that are most similar to what we want to develop. On the one hand, we aim to develop an application that optimizes learning and the time that a given user takes to complete an assembly task. On the other hand, we would like this project to evolve in order to be implemented in an industrial environment, and after consulting the article [MZV17] we realized that this type of technology is already being adopted by the industry and that it may one day be possible to complete our objective.

3.2 Actors

Common users who have the hobby to assemble LEGO, or companies that manufacture them, will act as actors in the developed project. On one hand, customers who, with the objective of assembling a construction, optimize their time to the maximum, using the application to carry out the assembly as efficiently as possible by following the instructions provided by the app. On the other hand, there are companies that manufacture this type of product that will be able to use the application in order to improve the customer experience, providing step-by-step instructions to the application so that they can be followed later by the user. This entire process can be applied to different situations in industrial settings, for example, on a factory floor, where much of the work is done manually, this application would bring added value as it would help operators to carry out their tasks in a more monitored way and to automate all their movements and steps to be carried out more quickly. It is a very versatile application that can evolve and be adapted to various scenarios where someone has to be instructed step by step to carry out a given task, thus having a wide range of possible actors.

3.3 Use Cases

- **LEGO assembly** The system correctly guides the user through the assembly of the LEGO pieces. In case of a user's error, the system alerts for the misplacement of the piece. Once the user finishes the assembly, the system informs the task has been successfully completed.
- **Task management - creation** The admin user inserts the necessary Data to create a new guide. The system validates the Data and saves it.
- **Task management - deletion** The admin user chooses a guide to delete, and the system eliminates it from the pool of available tasks/guides.
- **Statistic Data** The system stores statistic data associated with its usage, e.g. .

3.4 Non-functional Requirements

- **Usability:** The UX/UI presented must be intuitive and of easy comprehension.

  Priority: High
- **Efficiency:** The recognition of the Lego piece must be done in real-time.

  Priority: High
- **Availability:** The recognition and recovery of the QR codes and their information must be done in an adequate time frame.

  Priority: High
- **Security:** The dashboard as well as the API must be secure and robust.

  Priority: Medium
- **Recoverability:** In the event of crashing (software or hardware) must be easily recoverable and deployable.

  Priority: High
- **Maintainability:** The system must be constructed with its potential future grown in mind.

  Priority: Low

3.5 Functional Requirements

- The System must tell the user in what box the next piece should be taken off.
- The System must tell the user the location and direction of the piece.
- The System must recognize if the piece is well placed and notify the user.

Chapter 4

System Architecture

4.1 Google Glass Enterprise Edition 2

Glass Android OS - Glass EE2

Glass EE2 runs on Android Oreo 8.1. It doesn't include Google Mobile Services or Google play Services, which impacts the choice of google APIs, as it needs an application developed in Android Studio and Android SDK 8.1 (API level 27).

4.2 Right Move Google Glass application (API)

The System's API works as a connector between all of the application entities and components to its presentation and Data storage.

In this case, Right Move's API is a Java SOAP Web Server, which means that the request to the API is an HTTP POST request with an XML request body. This provides an important advantage when in comparison to regular REST APIs: It defines its own security and it is highly secure.

As mentioned, it has to be developed in Android Studio and use Android SDK. The application will handle the information gathered by Google Glass, and using this SDK will be able to explore its features with no limitations. This application will also implement ksoap2.

The ksoap2 provides a lightweight and efficient SOAP client library which makes the connection between the frontend client and the API possible.

4.3 DataBase

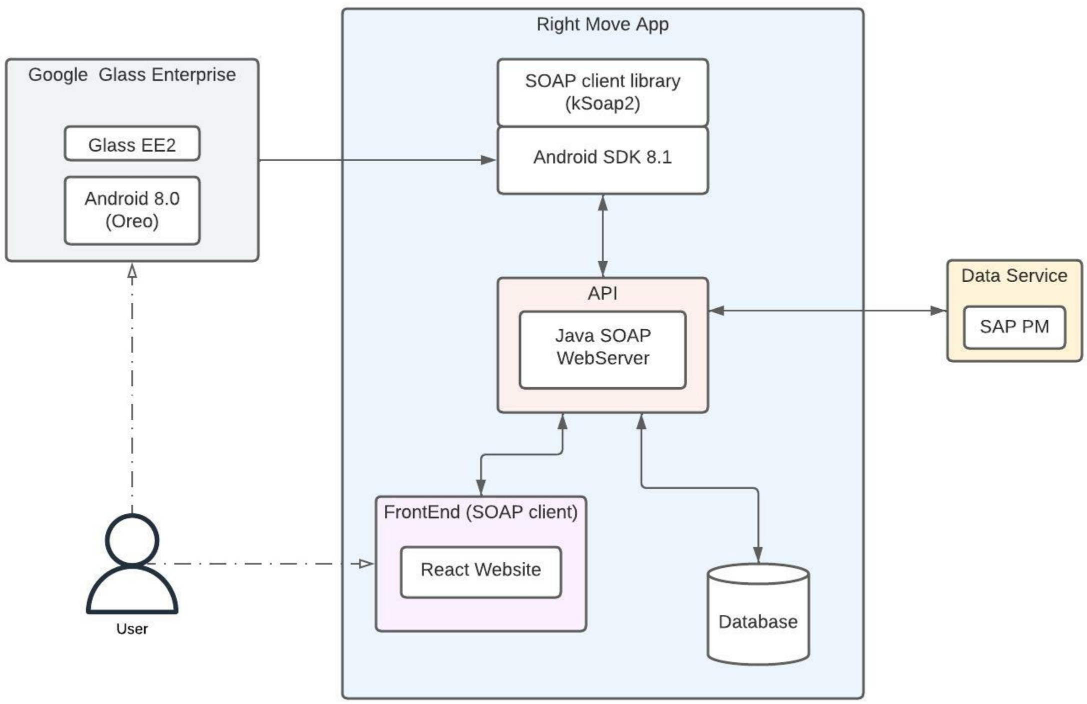
The System requires internal data storage, where will be stored tasks (that are accessed by the user through the QR codes and can be added or removed by the admin), and statistical Data (e.g. Task completion duration, number of wrong steps made by the user, etc).

Initially, this structure is planned to be developed in SQLite, once it's the most consistent with Android Studio and Android SDK. There might be, however, the need to implement a non-relational database or a time series database instead. This topic can only be fully developed as the API is worked upon, and if it's considered needed for the application's optimal functioning.

4.4 Data Persistence

Ideally, there is no data storage, in terms of what's captured directly with Google Glass (camera footage, voice recognition, etc). All the Data that is used to do piece recognition (references and other details) are provided by an already existing Data Service, HUF's SAP PM (SAP Plant Maintenance, which is a module of SAP Enterprise Core Component for industrial companies. SAP PM typically displays important tasks).

There might be, however, the necessity of filtering this information, with a Native Service from the System's API.



Chapter 5

Conclusion

Since our project is an exploratory project, we can conclude that most of the work done so far has been essentially researching work and requirements gathering. Initially, the fact that we had no direct contact with Huf, or the material made it difficult to start the project.

Therefore, from the moment we contacted the company and it exposed its ideas to us, explaining that for the beginning of everything the ideal thing would be to start with a relatively simple project, the initial research changed direction and was resumed but this time not focus attention on the research of AR applications in Industry but rather on the sense of researching which technologies, libraries and eyewear-compatible tools kindly provided by Huf.

The meetings with the company, as well as the visit to the factory, were essential for a good understanding of the future application cases of the Case Project the same is well implemented in its simplest way (relative to the assembly of legos).

We then realized that taking into account the versatility of the application that we are developing will have a wide range of future use cases, both in terms of training in the industry and in other scenarios of different training.

At this moment we already have more concrete objectives and more objective guidelines that we intend to comply with, so we conclude that we are ready to start developing the application as we carried out research and analysis long enough to find out what currently exists in the explored area.

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