CoRoSect: Implementation of a smart AR interface

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1 Abstract

The integration and utilization of real time data and autonomous technologies has been increasing with the advancements of such technologies and the demand for them. How can these technologies be integrated into the workflow in a clear and safe manner? The goal of this research project is to build an AR interface that relays real time data of a fully automated insect farm, ranging from the various components present on it, such as an AGV and a robot arm, to showing their actions in an integrated format. This is to help raise situational awareness and productivity of employees working on the farm. Finally, this approach was designed to also be demonstrated to younger generations of students, to inspire them to pursue a degree in the field of computer science.

2 Introduction

This project aims to develop an efficient and helpful Augmented Reality Interface that helps to increase productivity and situational awareness in a fully automated environment. It does so by giving visual cues in real time and providing contextual information about the processes on the farm. Prior research by Huuskonen and Oksanen (Huuskonen & Oksanen, 2019) show that HUD's (Head-Up Displays) in agricultural farming with autonomous devices have enhanced productivity. To do that, 2D panels were developed that display real time information about the status of autonomous components of the farm like an AGV and a robot arm as well as information about crates and upcoming events on the farm. Furthermore, 3D models for the robot arm and the AGV were developed to give an overview of the robot and their next planned steps to help understand the environment around a person and prevent people from putting themselves into the danger zones of the machinery. Object recognition is used to pinpoint the object in a real setting. A concept of such monitoring methods is shown by Chacon-Quesada and Demiris (Chacon-Quesada & Demiris, 2020), where 3D digital twins, as well as simple 3D objects and object recognition, are used in an AR environment to observe a multi-robot environment designed to help impaired people in wheelchairs to achieve daily tasks. All this information will be displayed on AR glasses that gather the information untethered from a server. Moreover, Lin, Wang, Liu, Pan P.-N. and Pan H.-R. (Lin, Wang, Liu, Pan, & Pan, 2019) show

that the employment of AR technologies can indeed stimulate and motivate learners to study using e-Learning techniques and depending on the quality of the interface, develop an interest in the field they are confronted with and potentially even the field of developing such systems themselves.

Additionally, it is also important to know that two separate packages were developed, one that is executed on the Meta Quest glasses, and another that is run with the help of Android AR Core on a phone. This division was mainly to observe the effects of object recognition, since the development during the first and second phase were only compatible with the Android ARCore package and couldn't be carried out on the Meta glasses.

Based on our problem statement, there are several research questions to be answered:

- Does our interface help employees of the farm understand their surroundings better?
- How could the AR application increase the efficiency of the processes at the insect farm?
- Can our interface increase safety on the farm?
- Are students excited about AR development after seeing the AR Interface?
- What are the most efficient approaches for the accurate representation of the sensor data along with the data received from other project teams?

3 Methods

3.1 Software

The software that the interface got developed with is Unity and a couple of objects were designed in Blender. For object recognition AR Core is used. To connect to the server a webhook in C# was developed from scratch that communicates with http requests. Since we show real time data from other groups, it is necessary to have a stable connection with the server that they send their data to.

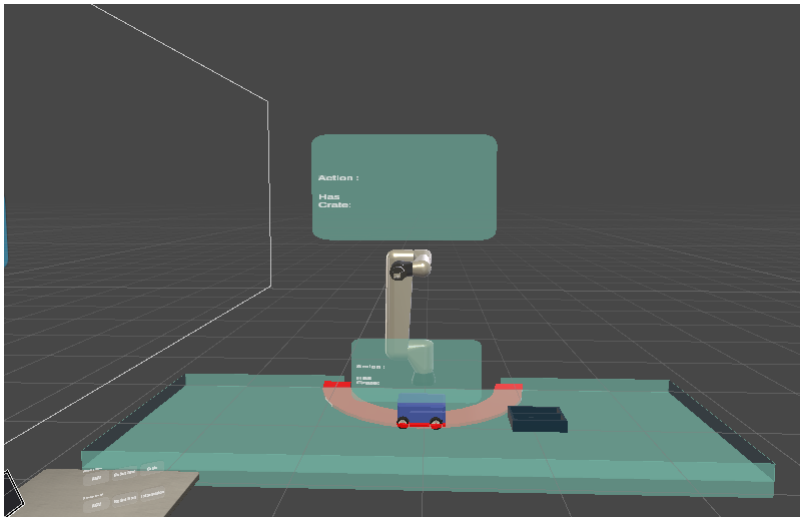


Figure 1: 3D Model of the Insect Farm

3.2 Hardware

There were a lot of Virtual glasses available on the market, but one of them stood out because of its camera quality, the software adaptability and their connectivity, so the interface is developed and tested on the Meta Quest Pro.

3.3 Components of the interface

3.3.1 Event Panels and HUD

The event panel at the right bottom of the screen shows what actions and events are executed next, such as "AGV1 drives to Location A" or "RobotArm1 loads AGV3". That gives a better overview of the processes on the farm and helps the user understand where his action could have the biggest impact.

3.3.2 3D models

Image recognition is used to find objects in a room. When they are detected the 3D model is attached to them. The robot arm 3D model shows how the arm will move and there is a circle around the real arm to mark a zone where the Robot arm will hit an employee when they move. It also has a

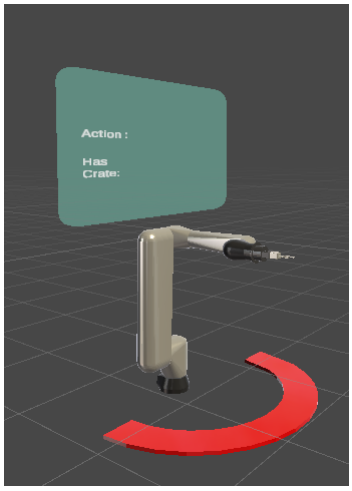


Figure 2: 3D Model of the Robot Arm

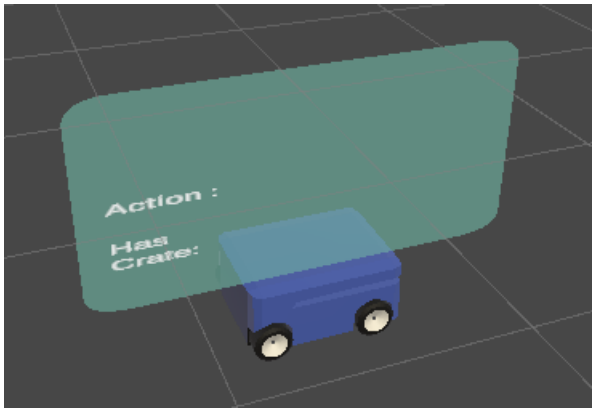


Figure 3: 3D Model of the AGV

modular panel attached to it to show the status of the robot arm, such as if it is receiving new movements at the moment or if it is loading. Since ROS, a software package most commonly used for communication and processing of robot-generated data, does not run on the Meta Quest Pro, the forward kinematic script had to be rewritten. The AGV model is attached to the AGV and will show the next move and the direction it is going next. There is also a modular panel attached to it that shows the status of the AGV and the end location of the AGV is highlighted in the room.

4 Experiments

Keeping in mind the target audience of the project, a non technical survey was created to gather insight on how comfortable the interface was to use and navigate, its productivity and how excited the students were about AR development. First the participants got a brief introduction about the insect farm project, because not all of them were familiar with it. Then they put on the glasses and explored the interface by themselves. While one of our goals was to inspire students to pursue a stem degree, the answer to this question is outside the scope of a one semester university project, since it requires long term observation of the career path of students. Instead we settled for

an easier question, whether or not students are excited about the possible applications of AR after trying the glasses. Another restraint of our survey was that in the end of the collaborative project, planned functionalities of other project components were not ready to be integrated and thus the AR Interface was effectively rendered obsolete. That means that there was no information to be displayed other than the 3D models of the farm and an explanation by the researchers about what the interface would be able to show once the farm was connected and running. None of the question were mandatory to answer. 6 out of the 17 participants were not studying a computer science related field. Ideally there would have been more students with a different background than computer science, but it was not possible to organize more students from other faculties, given the waiting times for other project components to finish.

4.1 Hardware Productivity and Ease of Use

To ascertain our research questions, a survey was created that contained questions about situational awareness on the farm and excitement about AR development. The questions were as follows:

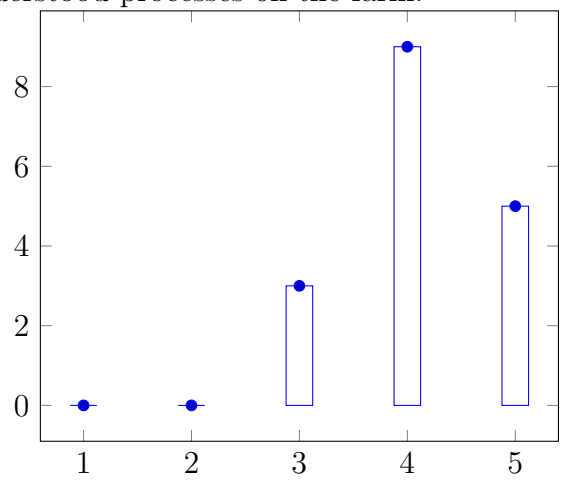
- How well were you able to understand the processes on the farm with the glasses?
- In which regard did you understand the processes on the farm better?
- Did you identify any potential hazard zones?
- Are you able to identify upfront where your help is needed on the farm?
- How excited are you about the potential that AR applications have

4.2 Object detection

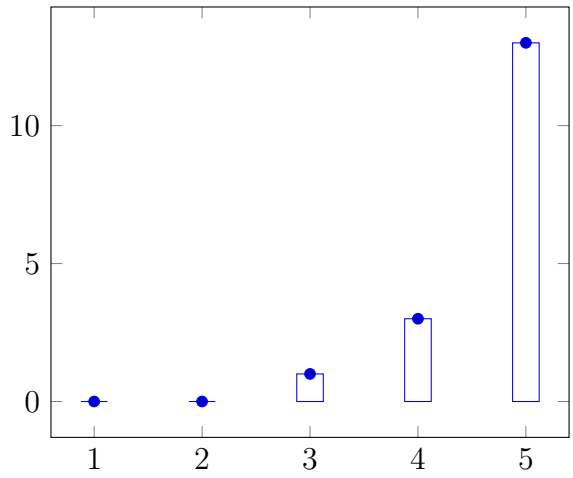
In order to determine the most effective image reference for object detection, there were several experiments conducted. The dependence of image recognition efficiency on the size and the contrast of an image and the distance from the camera was analyzed.

4.3 Situational awareness

There were 17 answers recorded for question 1. Participants could rate on a scale of one to five, where one is not at all and five is very well how well they understood processes on the farm.



For question two, two people claimed that they understood the processes on the farm after one of the team members explained it to them. Another two people claimed that they understood potential hazard zones and three more people referenced that they understood the movement of the AGV. Another 6 people said that they understood where things were located on the farm and and that the design was intuitive. For question 3, 58,8% of the people claimed that they could identify potential hazard zones and the rest said no. There was no option to stay undecided. 64,7% of the participants could identify upfront where help was needed on the farm and the rest couldn't. There was also no option to stay undecided. For the 5th question a one on the scale implies that the participants were not excited about future AR applications and a five implies that they were very excited.



5 Discussion

Despite the promising result of the survey, a lot of the participants did not understand the model without a former introduction to it or a proper explanation. This can partly be explained by the fact that some of the students were no computer science students who were familiar with the project. Other students were mostly confused because the 3D model was not showing any processes or information on the farm and could not be manipulated. That is due to the fact that the connections with the other groups could not be achieved by the end of the project due to incomplete components from those groups. Although our group was ready to receive data, other groups were not able to provide it. This defeated the sense of the interface, whose sole purpose to explain processes on the farm and increase situational awareness. On the other hand, participants were able to identify hazard zones with a high level of confidence. It is assumed that this likely would have worked even better if the farm would have carried out processes, as the interface would then have displayed actual useful information. Without any moving processes, only the hazard zone around the robot arm was visible. An explanation for the high approval rate for the question if participants were able to figure out where help was needed on the farm, even though there were no processes carried out, is that participants were asking for clarification on this question during the presentation of the interface. This might have influenced their answer in a positive way. In general the participants were very excited about AR applications after seeing the interface. In particular the participants who do

not study a computer science related field were excited and described it as "Cool" and "futuristic". This is an anecdotal quote since there was no data collected on it.

The main challenge for object detection that was faced during the project is system incompatibility. For the glasses, the implementation of image/object detection was not possible due to a lack of relevant packages. As for the Android application, only image detection and tracking were available. ARKit plugin offers object detection that uses object reference instead of image reference, however, an .arobject file is required as a reference. This file can be generated by iOS applications only such as 'Scanning and detecting 3D objects'. Scanning iOS applications in turn require iOS development mode that can be activated with a MacBook only. This resulted in the incomplete implementation of Object detection functionalities.

6 Conclusion

In conclusion, one can say that the interface showed promising test results considering that it could not be tested to its full potential. Participants were able to understand the farm better and were able to identify potentially dangerous zones. It seems like participants were also able to find out where their help on the farm is needed, although they might have been biased by prior instructions. That is why there is an urgent need for more research, to be carried out with the interface being fully functional. Moreover, the interface made the participants excited about the topic. While this can't demonstrate that this project inspires students to pursue a stem degree, it is a good indicator that it can excite them and maybe light a spark in them for the passion to study computer science in the future. From a technical standpoint, this project demonstrated the strong direct correlation between the complexity of the technologies and the difficulties with integration and compatibility of the involved systems and modules. This peculiarity has to be taken into account for future development.

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