AR concept tool to help operators in their work in industrial environment

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Abstract. The outcome of this paper is to present an example of implementation of an AR system within a production chain. The device aims to increase technician's security and productivity while accomplishing maintenance work on production chains.

Keywords: Augmented Reality,

1 Introduction

In an industrial context, a hand-free support tool to guide through the maintenance process would be a good asset to modernize the actual workflow of a company. In fact, an AR tool could give the information that the operators need quickly and then reduce the waste of time during the operations and simplify the operator's work. This tool could also guide the operators in their actions and movements to reduce the risk of injuries.

Nowadays, the operators have to search the information they need to proceed their tasks in some technical books (physical or numeric) which is really time consuming. During their tasks, the operators use a wide range of tool that lead to over-encumbrance and safety-risks.

We will present you a concept tool to guide the operators in their tasks with the AR technology reducing the time taken to fulfill tasks and ensure the operator's safety.

The two solutions we achieved, display specific 3D models when a marker is detected by an image treatment software. One of the solution have a back-office that enables an engineer to signal issues on a specific machine.

2 Augmented Reality

Augmented Reality (AR) is a domain of new technologies that consists in overlapping computer rendered objects (3D models) with real images to mix reality with virtuality. AR can be used in multiple domains, for instance a well known utilization of AR is the mobile game called Pokemon GO in which the Pokemons are coming to life thanks to AR. Nowadays, AR tends to be more and more used in professional and industrial environments thanks to better technologies, for instance AR can be used in architecture to foresee what a construction-site will be like.

2.1 AR General approach and principles

In most cases, AR applications uses 3 components. The first component is the input, it is usually a camera that acquires images to send them to the second component in charge of overlapping the 3d object on the current images to finally render them on the third component which is a display screen.

2.2 Inputs

A camera is used to capture images in real time which will be sent to the analysis component, such as a computer, that will process them.

2.3 Analysis

The component in charge of treatment tries to identify a special marker to spot where the 3D objects has to be positioned on the image, then the image will be overlapped with the object in real time. The flux of the combined images will be then sent to the output component.

2.4 Outputs

The output get the new images from the analysis component to render them for the user to see.

3 Related Work

3.1 Augmented Reality needle ablation guidance tool for Irreversible Electroporation in the pancreas

Timur et al. [8] present an AR concept tool to provide needle ablation guidance to ease the treatment of tumor. The tool use a HoloLens platform, using the SDK Windows, pair of mixed reality smart-glasses, to track the needle and other object and add some holograms on it (needle trajectory, ultrasound hologram,...). Some IR markers are set on the different tools used by the user and tracked by an IR camera to place the different tools in a referential, this camera use the OptiTrack Motive, and then send the data to a middle-ware to create the scene in an absolute referential by using an algorithm which changes the right-handed system of OptiTrack Motive into a left-handed system for Unity3D, and add the holograms on it by using Unity3D to finally send the result to the glasses by WiFI using the TCP protocol. The system was tested on an abdominal surgical simulator, with silicone organs. The disadvantage to this method is to use an external objects (the IR camera), forcing the user to keep the objects in the camera's field of view to track the scene. This method was due to the lack of API on the glasses.

3.2 Augmented Reality for Construction Tasks: Doorlock Assembly

Dirk et al. [2] show the use of augmented reality as part of the training of technicians in an assembly line. They use the mounting of a lock on a car door, a headset with glasses, a camera, and a microphone. The glasses are used to display 3D models and instructions in different formats, the camera can calibrate the model with the target positioned on the door, and finally the headphone system can receive instructions and the microphone can send instructions. The camera sends the image of the target to a server which identifies the image to be displayed as well as the display direction. Unfortunately, the symmetric nature of the ids makes some combinations not unique in case of rotations.

3.3 Interaction en Réalité Augmentée Spatiale pour le Dessin Physique

Laviole, [4] presents a new applications of AR focused on physical drawing, such as pencil drawings or paintings, using interactive projection. The AR takes internal and external parameters of a camera / projector pair to allow accurate projection on sheets of paper. In addition, it allows the detection of touch on sheets and the position of the hand above them thanks to a depth camera (ToF camera). He use ARToolKitPlus library that can be used to calculate camera position and orientation relative to physical markers in real time. He use also Microsoft's SDK for Kinect. The tool has been experimented with 13 drawers where the results shows that they are not disturbed by the tool and mostly satisfied. The main limitations are the resolution of the projection and the shadows created by the users.

3.4 Une implémentation de la réalité augmentée pour le patrimoine

Emmanuel et al. [3] present the steps and choices made to propose a realistic and smooth augmented reality system focused to the museum visit. They make a realistic depiction of virtual objects using an IBR technique (Image Based Rendering) that rely on a set of two-dimensional images of a scene to generate a three-dimensional model and then render some novel views of this scene. It is associated with the simulation of visual aberrations related to the camera such as light blur. The device takes the form of a 32 inch screen in portrait format orient-able around two axes. The camera used to capture the actual scene is a high-definition industrial camera (Prosilica GE1910C), equipped with a wide-angle optics offering a 95° field of view. The device was tested in the abbey church of Cluny but applicable only on static positions.

3.5 Contribution of augmented reality to the maintenance of network equipment

Michel Cordonnier and Augustin [5] identify the new technical solutions capable of bringing in the short and medium term most value to the technicians in terms of performance and safety. This study presents three complementary prototype tools which take advantage of augmented reality to perform maintenance of network equipment in a more effective way and with an increased safety. Their solutions can work with just a smartphone (with its APN, its other sensors and its screen) or with fully featured AR glasses. A field test program was conducted with the selected innovative companies with the aim of experimenting prototypes of the new tools.

3.6 A wearable augmented reality system using positioning infrastructures and a pedometer

Tenmoku et al. [7] implement one example of Augmented Reality (AR) using glasses as a display support. The solution crafted multiple devices to realize their project, they use a camera mounted on the glasses to record what the user is looking at, a computer retrieves the information recorded by the camera and add the AR 3D models on the live feed. Then, the images are sent back to the user's glasses as recommendations. The solution has been tested in a school, to help students to find their way inside the school using these glasses, by placing antenna near signs to guide students wearing AR glasses. Thanks to the AR glasses, the student were able to see reality augmented objects, but however the device isn't convenient since the equipment is not really practical to wear. The principal limitation of the prototype is that the user must know in advance where are the "components of positioning infrastructureötherwise the annotations cannot be triggered on screen if the user doesn't look at the correct object.

3.7 An augmented Reality Interface to Contextual Information

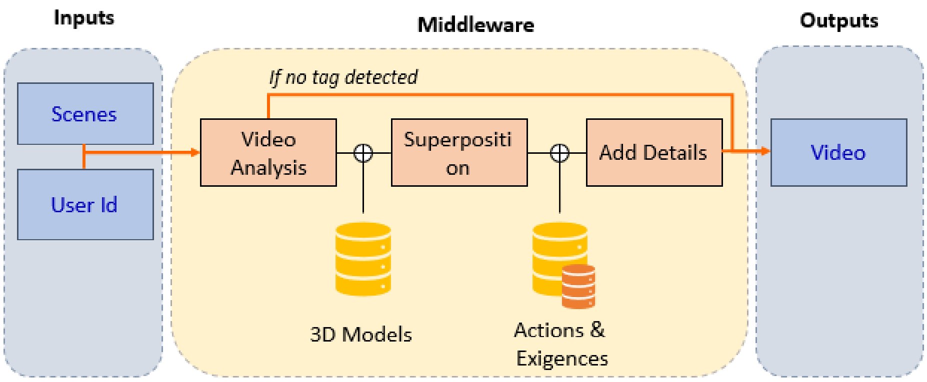
Antti et al. [1] tried to create an AR glasses that are able to understand what information the wearer would need at a given time without the user giving any kind of signal which mean the device must be able to get a grasp of the context like people and objects in the user's vicinity to trigger queries and search on useful information. These glasses would collect information on the user's behavior by collecting data on the user's gaze, visual focus of attention and using implicit measurements about the user's interactions with his vicinity. The data collected by a camera mounted on the glasses are sent to a remote database using HTTP. The datas are then stored on a database and compared to another database called ÏR database"that contains annotations for people and objects. Each annotations have an associated context, if the context of the annotation matches the context that the user of the device is currently in, the annotation gets displayed on the AR device of the wearer.

3.8 Augmented reality application to support remote maintenance as a service in the Robotics industry

Mourtzisa et al. [6] described the importance of maintenance of production chain's robots and other machinery. The paper proposes an Innovative System that enables tele-maintenance device through Augmented Reality, the proposed device would help reducing the cost of maintenance. When a problem occur on the production chain, the technicians explain the problem by writing a malfunction report using a tablet or a computer, the report is then stored in a remote database. The engineers uses the database in order to find the solution of the failure and create a step by step tutorial to fix the problem. The tutorial would use 3D objects that will be used to describe the parts to change and the different steps. They uses a "world grid"that is a matrix of 3D space coordinates. Using sensors, they are able to locate the position of the technicians on the world grid. In order to display the 3D images on the user field of view, the team uses a Matrix that contains the coordinates of the actual field of view of the user on the world grid named T. The matrix T is then multiplied by the position of the user in order to calculate where to display the AR objects and how to display them. The Matrix is calculated using To display the AR objects in the vicinity of the user, they multiplied the coordinates of the position of the user in the world grid by the translation and the rotation of the position matrix of the object to display in AR. Thanks to the previous algorithms, the system is able to translate images into 3D scenes that can be directly viewed by the technician in real time through his AR goggles. The System knows when to display 3D images when the system detects "frame markers". Those frame markers are used to give four points that will highlight the corners of a flat screen floating in the air, the system then calculates a transformation matrix that will be used to set the borders of the image to display at a specific position in the world grid. The principal drawback of that method is that it uses a wired connection through the glasses and the computer, which mean the user isn't really free in its movements when carrying glasses, it would be better to implement a wireless connection using other means between the glasses and the computer.

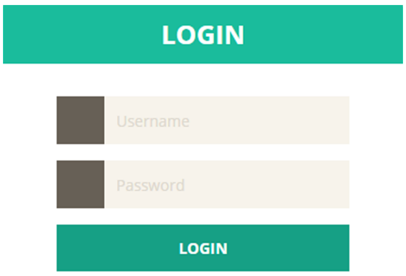
4 Approach

First of all, the user must authenticate with his username and password to get the right to use the app. This will enable us to secure the app and to give the correct information to the correct user.
The user will shoot the scene with his smart-phone enabling the app to send the scene and the user identity to the analysis component (Middleware).
The Middleware will analyze the scene to identify some marker and if it can find one it add a 3D model and some information depending of the user identity on the scene and return the result to the smart-phone which render the new scene on its screen.

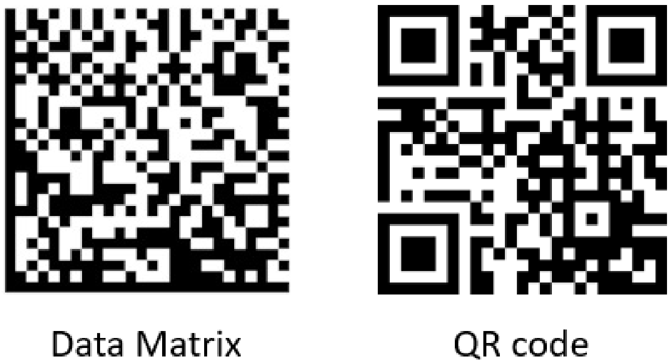


4.1 User Authentication and Machine Identification

To identify an user the app will just ask him his username and password by a login form and check if this user exists in the user database. If the user exists and he gives the correct password then he get a token to use the app, in other case he will stay on the login form until he can authenticate.



The machine will be identified by some tags stick on them, each tag are stored in a database with the attributed machine, this will enable the analysis component to choose what 3D model to add on the scene.



4.2 Analysis

Scene Analysis

The first task of the analysis component is to detect a tag on the scene and get its position and its angle to give them of the next step, the overlapping.

Overlap 3D Model & Comments

Once the position and the angle of the tag is known, the overlap process will reproduce the scene stored in the database. This scene contains the detected tag with the 3D model, both are positioned in a 3D plan. With the scene the app know where the 3D model should be positioned and place it at the right place.

4.3 Visualization

Once all the previous steps are done, the scene is sent back to the user's display device. The operator can now see on his device the new scene with the 3D model and the comments associate to the task.

5 Experimental Results

Our group used multiple libraries to recognize real markers in the environment. We experimented two solutions, one using the JavaScript library called 'AR.js', and the second one using the C# library called "Vuforia Unity3D". Our group implemented both solutions in order to compare them and keep the best one. Our criteria for the best library would be, time of execution, maintainability, reactivity/latency and portability. Both implementations will be executed on a smartphone or a computer. The application will also be connected to a database that will contain 3D models links. thanks to these links, the application will be able to fetch the correct 3D Model corresponding to the marker.

To recognize real markers in the environment, a device for recording visual images in the form of video signals, like a smartphone, will record a scene. The application installed on the device will recognize if a marker (QR code or Data-Matrix) is present on the scene, if it is the case, the application will trigger the processing of the 3D model exactly where the marker is on the scene. The server will serve as a 3D object models storage which will be requested by the application depending on the context. The 3D models will come with a description of the actions and the requirements to be executed by the technician. The 3D models will be sent to the application when ever it request them.

5.1 Experiment with tag

In order to test the reading, and tracking, we decided to use two types of marker.

A QR code is formed of black squares on a white square. The distribution of these points represent a message. A QR code can store up to 7,089 numeric characters.

A Data Matrix is formed just like the QR code. It is composed of black squares on a white square. But it can store up to 2,335 numeric characters.

During our experiments we were able to compare the effectiveness of these two tags. The QR code is more efficient than the Data Matrix, in fact as we can see it above the QR code has patterns which allow a better stability of the display.

5.2 Experiment with AR.js

For the first prototype, we use AR.js, a JavaScript library based on the A-Frame framework. This framework allows to render 3D elements (or images, text...)

in the space only with browser technologies. They can be overlapped with the camera images to create the AR effect. The AR.js library use also JSARToolKit to detect markers and place it in the space. To allow engineer to give some information to technicians (what engine have issue and information about it) we have created a simple dashboard in PHP/JavaScript.

6 Conclusion

The realized work. one paragraph including the obtained results.

6.1 Experiment with Vuforia

Our first prototype was made using a laptop, the AR framework "Vuforia" and the 3D engine Ünity". With this prototype we achieved to display a 3D model (.obj extension) over a marker and a datamatrix. The system is correctly tracking the movements of the marker and can follow it almost perfectly. Our solution is available on PC (Windows) as well as on Android and works well on both platforms.

The main drawbacks of our solution is that we couldn't implement the middleware between the database that contains the 3d models and the device that would be used by the end-user. As a consequence, the entirety of our solution is on the same device, for instance when the prototype is deployed under Android, the database will be compiled with the core of the application resulting on everything being hosted on the client's device.

An other difference between what we wanted to do and what was actually done is that, since the middleware doesn't exist, it is impossible to display custom text on the screen. Only pre-defined 3D Objects can be shown on the end-user device.

We would like to implement the middleware with all its functionnalities for the next step of this project.

6.2 Experiment with AR.JS

Our second prototype was made using AR.JS and A-FRAME. Thanks to the versatility of the JavaScript language, we were able to host our second solution on a hand-made website that is hosted on a private server. Thanks to that, we don't need to export the application, it can be directly accessed throught a web-browser on any kind of device. With this solution, we implemented an user interface that we use to choose which 3D model to display to the user. For ease of use, we implemented a back-office that simulate the detection of a problem on the machines. The back-office would be accessible uniquely by the an operator that would select the types of engineer,

The future work. one paragraph discussing the extension of this work.

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