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Augmented Reality Application for the Maintenance of a Flapper Valve of a Fuller-Kynion Type M Pump

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Abstract

The overall purpose of this project is to test the impact and potential benefits of Virtual and Augmented Reality technologies (AR&VR) to improve maintenance operation in industrial equipment. The main function for a Flapper valve of a Fuller-Kinyon type M pump is to prevent that the air generated to convey the bulk material through a conveying pipe flows inside of the material chute through the rotating screw. If this will occur, the material flow will decrease or even stop, causing a reduction of the pump capacity. Thus, it is necessary to maintain calibrated each flapper valve in the plant. This process of maintenance is done once a month, or when necessary, and it needs the pump to be shut down, taking up to four hours to finish the complete process. For this reason, an augmented reality application is being developed, aiming to reduce the consumed time by the maintenance process. Using this application, it is expected to dedicate less time training the new personnel responsible for the maintaining process, displaying tridimensional models, animations, images and text information that would simplify the instructions shown in a printed manual and adding an interactive environment between the users and the information displayed. A mobile device either a tablet or a smartphone is to be used as the hardware that will run the application, allowing the user to take it right to the working area, either in a workshop or directly in field. The information displayed includes CAD models of the pump and its components as well as animations illustrating the instructions to follow in each step of the process. Also, the right tool to use in each step will be indicated following by security warnings when needed. This project was developed according to the collaboration cathedra between CEMEX and ITESM, following the LEAD methodology developed by CEMEX to support the project administration, the general process development was constructed from knowledge and experiences gathered among the different previous AR projects developed at ITESM. This information has been studied and "best practices" has been noted, learned and established to develop and implement AR.

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Keywords: Augmented Reality; Virtual Reality; CAD models; maintenance process; mobile devices

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1. Introduction

Nowadays, the processing industry is highly dependent on the machinery used to meet the desired production. It is well known that this equipment has an effective lifetime depending on the treatment it receives. For this reason, maintenance processes are very important, because if not done effectively they may provoke great losses to the company. Nevertheless, in some cases the maintenance processes require to completely stop an entire production line, so the time consumed becomes a critical factor to minimize. Furthermore, it is common that very few specialists are available in the company, so the maintenance processes could result difficult to schedule and also, the risk of having no expertise available to act in case of an emergency is imminent. Below, it will be explained how an Augmented Reality application can help to solve this issues.

2. Background

Augmented Reality complements the real world by superposing virtual objects in the user's environment, allowing a complete interaction with them in real time [1]. For better understanding the term, Milgram describes a continuum from completely real environment to a virtual pure environment. In the middle of this continuum are Augmented Reality (closer to the real environment ending) and Augmented Virtuality (closer to the virtual environment ending) [2]. Thus, Augmented Reality differs from Virtual Reality in the fact that VR immerses the user in a completely virtual environment [1].

Taking advantage of this technology, AR applications may be created and used in field to facilitate the maintaining processes, aiming to reduce the operating time and the necessity of an expert present during the operation. Simple and complex simulations can be generated from 3D CAD models to be displayed through an application run by a mobile device, either a tablet PC or a smartphone. These simulations contains the information required to complete the maintaining process of an equipment, such as the steps to follow, the right tool for each step and warning notes. Even "best practices" and advices can be shown to the user in order to successfully perform the operation.

The overall purpose of this project is to test the impact and potential benefits of Virtual and Augmented Reality technologies (AR&VR) to improve maintenance operation in industrial equipment, in this case, a flapper valve of a Fuller-Kynion type M pump, provided by Cementos Mexicanos S. A. B. de C. V. The function of a Fuller-Kynion pump is to convey bulk material from a chute to conveying pipes, using first a rotating screw to transport the material to the body of the pump, and then taking the material through conveying pipes using air generated by a pneumatic system. The Flapper valve prevents that the air generated flows inside of the material chute through the rotating screw. If this will occur, the material flow will decrease or even stop, causing a reduction of the pump capacity. Thus, it is necessary to maintain calibrated each flapper valve in the plant. The reason because this maintenance process was selected to be reproduced with the assistance of an AR application is that it needs the pump to be shut down, taking up to four hours to finish the process if the personnel has few experience in it.

The developed application is intended to be used in both a workshop and directly in field, expecting that less time will be dedicated to train the new personnel responsible for the maintaining process and that possible mistakes or accidents during the process will be prevent.

3. Methodology

The first step to develop an AR application is to analyze the process, identifying the parts and the tools involved in each stage and measure them to create 3D models replicas of each one. Once the 3D models are done, the following step is to apply virtual textures to them. Here are two options, depending to the intention of

the developer the textures could be either similar to the real parts (giving realistic details to the models) or a solid color could be applied to each modeled part (providing a color guide that helps the user to identify each part). After the textures are finished, the next step is to create the animations that will indicate the actions to be performed [3, 4]. An AR library and a graphic library are then used to create the application that later will display the animations in a mobile device, superimposed in real time over the real objects. These steps mentioned may be seen as a cycle, in case of needing to upgrade the application (Fig. 1).

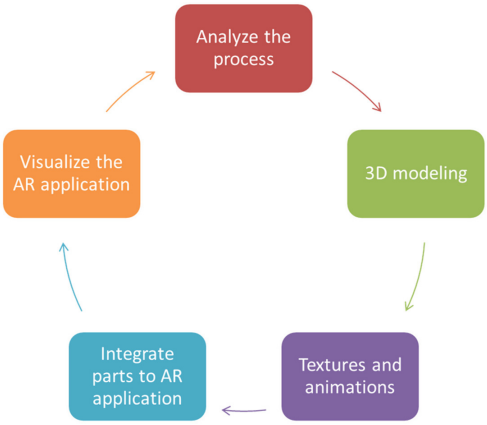

Fig. 1. Methodology for the development of an AR application

3.1. Analysis of the process

After the first visit to the plant, the maintenance process was analyzed and the result was a complex flow diagram (Fig. 2(a)). This was later discussed with personnel of CEMEX and some steps were optimized and a simpler diagram was obtained (Fig. 2(b)).

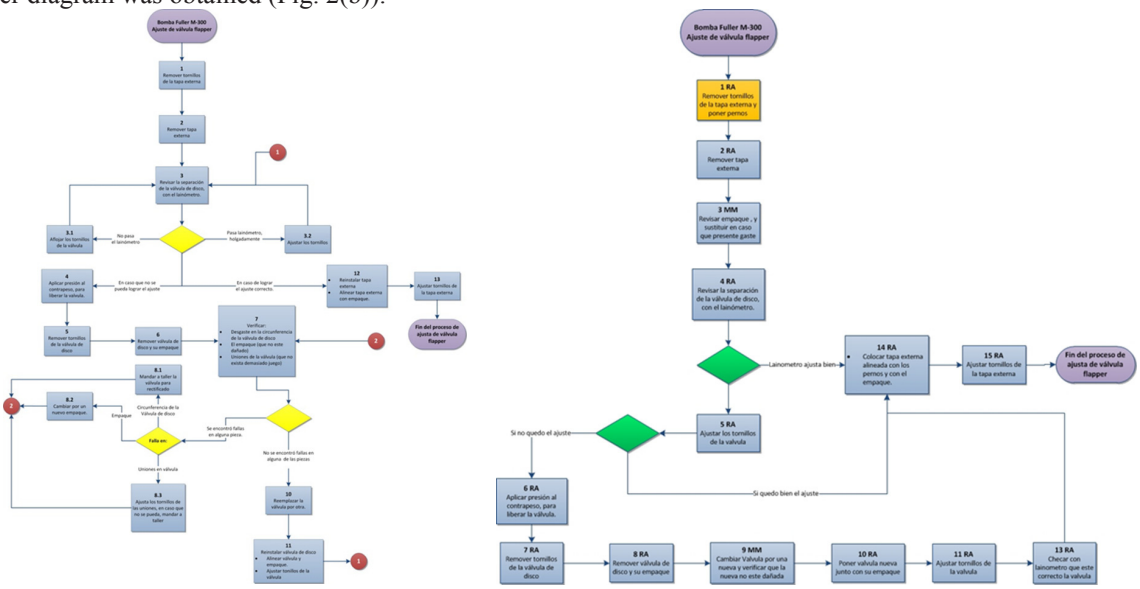

Fig. 2. (a) First process flow diagram obtained; (b) Optimized process flow diagram

3.2. 3D modeling

At the first visit the involved parts and tools were identified and measured (Fig. 3(a)). A second visit was scheduled to corroborate the measurements of the most critical part: the flapper valve assembly. Then, the 3D models were created using CAD software (Fig. 3(b)).

Fig. 3. (a) Measurement of the parts and tools; (b) 3D model

3.3. Textures and animations

Once the 3D models were finished textures were applied to them. In this case the textures chosen were similar to the textures of the real parts. After that, the animations were created (Fig. 4).

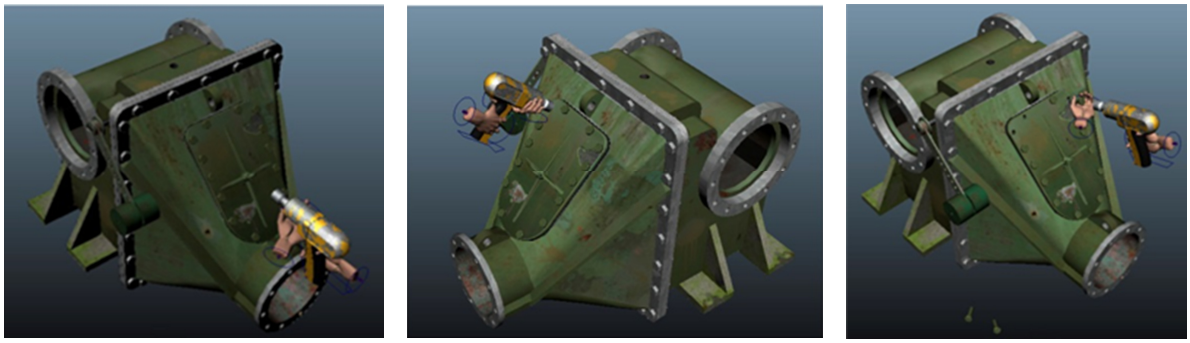

Fig. 4. Some animation screenshots

3.4. Integration of the parts to AR application

Wagner enlists the main tasks for making a functional AR application as follows [5]:

- Initialization of Graphical User Interface (GUI)
- Tracking of the target image

- Estimation of scale and position
- *Renders* creation

The application is programmed using a videogame engine, creating as many scenes as necessary to show all the animations created previously. Each scene includes scripts with the codes that allows the user to interact with the models and that control the position tracking of the reference image, commonly referred as marks. Usually these codes are written in Java, C# or C++ language. At this stage, the warning messages an videos showing advices and "best practices" are added to the display.

For better tracking of the target image, a device with an integrated high definition camera such as tablets and smartphones are recommended.

3.5. Visualization of the AR application

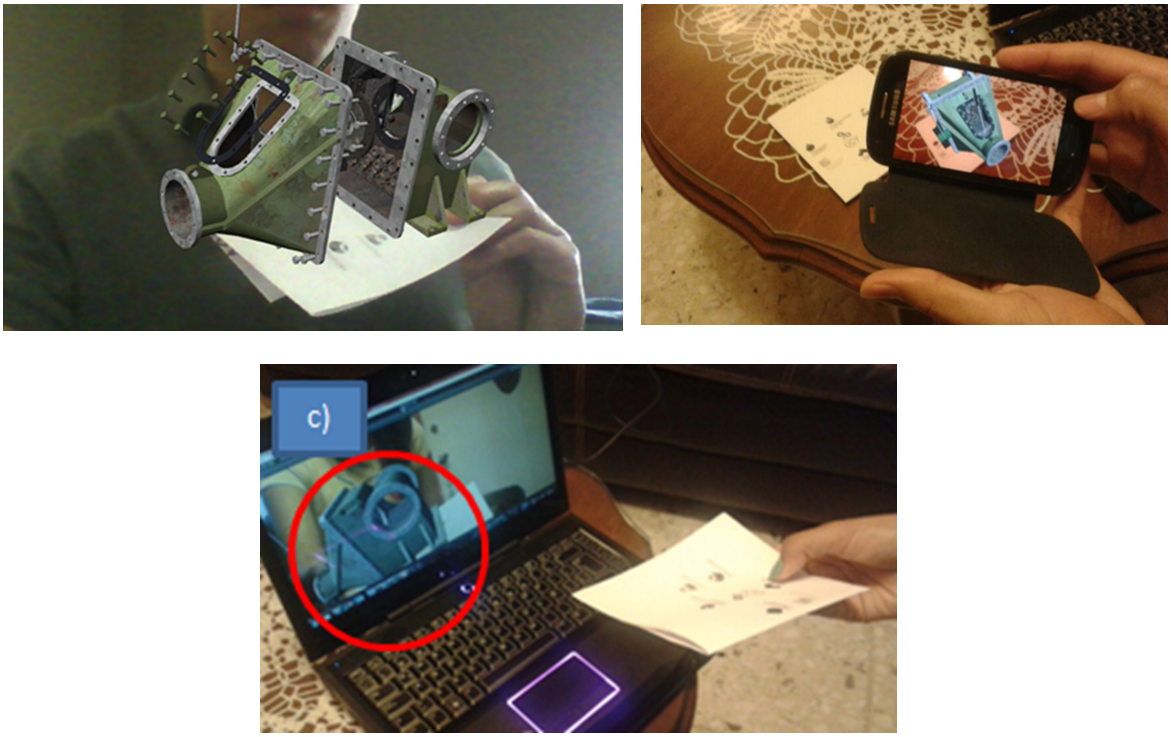

Fig. 5. Fuller pump animation displayed over mark (a) AR application tested on mobile device (b) and portable PC (c)

4. Future work

During the modeling stage of the project a new idea emerged. The 3D models that were created for the application could be used to print some prototypes using the Fortus 400 rapid prototyping printer that is available at ITESM campus Monterrey.

The main purpose is to create training workshops where technicians could practice and learn to use the pieces created in the 3D printer. With these prototypes, individual work stations will be made for the new generation of technicians in CEMEX in order to practice the different maintenance procedures to follow in the Fuller Kynion type M pump.

A similar approach was taken in a previous project in collaboration with Aeromexico, one of the main airline companies in México. An Augmented Reality application was created to assist the maintenance procedures of a CFM 567b engine bleed air system, following that, some of the components were printed in 3D to begin the training sessions with the technicians.

Fig. 6. Comparison between printed (a) and functional (b) pieces of a CFM 567b engine bleed air system

5. Conclusions

Augmented Reality has demonstrated that it can be a guidance tool for technicians during maintenance and training courses. It reduces working time and significantly decreases the probability of making mistakes by clearly displaying the knowledge needed to complete a task (information and animations).

Also, the advantages of Augmented Reality technology can be exploited in different applications for other areas apart from manufacturing industry, such as medicine, construction, arts, or entertainment industry. It is worth noting the potential capacity of this technology to serve as a key tool in education and other areas where knowledge transfer is necessary to successfully complete critical tasks.

AR can bring great results when well applied, but there is still a lot of work to make this technology a part of our everyday living. Mobile devices may be the key to achieve this goal. They have started to take big part of the hardware that surround us and every year better, cheaper and lighter devices are produces. The opportunity of using them to improve manufacturing, education and other areas is latent and it should be approached in all possible ways.

Acknowledgements

The team that was in charge of the development of the application explained in this paper wants to thank the personnel of CEMEX for viewing in Augmented Reality the future of the training and maintaining programs,

giving the chance to apply the AR technology in one of the most important processes in the plant. Their expertise, knowledge and support were vital in order to create the AR application.

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