Projet Recherche


# Utilisation des techniques de réalité augmentée et d'interface homme-machine pour la maintenance de systèmes industriels

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# Summary

In the industrial environment, many operators carry out regular maintenance operations in order to prevent a possible breakdown. These machines are often products which are expensive and which are often an indispensable link to the good functioning of the company that owns it.

In order to guard against a possible problem on machines with a high degree of criticality, industrialists call on companies specializing in maintenance to keep equipment in good working order.

There is therefore a considerable cost to be foreseen at the time of the acquisition but also a substantial budget to envisage for the maintenance teams which regularly checks the equipment.

In order to facilitate and make the work of maintenance teams more productive and thus reduce their costs, some industrial companies have decided to trust the technology.

The aim of this research is to present a tool which is able of answering the problems of maintenance and repair of industrial system of any kind; This could range from a simple electrical cabinet, to the repair of off-shore wind turbine through a production line or an aircraft.

All the systems presented above have in common requiring more or less complex maintenance operations; this requires having teams available and sufficiently qualified to respond to various monitoring, maintenance, repairs or replacement of equipment.

During this research paper, we focus on the sector of augmented reality which has benefited in recent years from a notable technological evolution.

Many big groups such as Microsoft with their product in the form of semi-transparent helmet named "Hololens", Google with "Vuzix" or even the company CastAR which plans to launch in 2017 a reality-enhanced 3D board game.

Through research and development, large groups such as those listed above have made possible and still allow the democratization and industrialization of this technology with prices that are increasingly affordable.

Our research therefore focuses on the themes related to the operators.

Several constraints arise when technicians must maintain a system. In particular we find the aspects related to the :

- Security
- Portability
- Help
- Live Support
- Etc.

In order to help them in their approach we will display in superimposed actions ranging from the display of adjustable wrench/ screwdriver with the direction of rotation to the listing of the set of steps to be carried out so that the operator can carry out Maintenance action on said machine.

This technology allows real-time mixing of the real world and the virtual world is an alternative to the paper manuals needed to maintain industrial equipment.

# Introduction

The advent of technologies, whether connected, miniaturized or embedded, has changed the paradigm of society. In these tools that change uses, what about augmented reality? Augmented reality is rooted in a world where the race for progress is increasing noticeably. This technology is in the process of democratization for the public and companies.

In recent years, the field of applied augmented reality has attracted a growing amount of interest, due to its numerous applications like in the field of industry, medical, military, video-play, tourism, urbanism and so many others.

In the framework of this study, we will present a case to establish the usability of augmented reality in the field of industrial maintenance through the following points:

- Prototype and technologies adapted to augmented reality.

This case is about which prototype we will present, why these technological choices and what their potential benefits in industrial maintenance type use.

We will present the characteristics of the prototype set up with Vuforia.

- Project methodology.

This step explains in detail the main elements of our research, the stages of its realization, as well as the experimental approach used to validate our hypotheses.

The mandatory set-ups and tests protocols to be carried out to achieve an optimal result.

- Experimentation and results:

The validation of our work must go through an experimental protocol which will allow us to position ourselves on the reproducibility of the system, it is to provide all the essential details to repeat the experiments described in this article.

It is also necessary to define the project framework correctly to ensure that the validity of our data and the usability of our prototypes are specific to a given system.

- Conclusion and perspectives

This part is used to show the elements of responses and their contribution in the field of augmented reality for industrial maintenance.

- Bibliography

This part contains all the references used in this research work. All the scientific articles and the elements that support our comments and our experiences.

Through this research note, we propose to provide answers to these questions in the light of the latest publications in this field, after having defined what was meant by augmented reality in the context of industrial maintenance.

Keywords:

Augmented reality, IT to the maintenance profile, AR, Experimentation of augmented reality in industrial maintenance, Industrial maintenance of the future.

# State of the Art and Issues

Augmented reality consists of adding virtual elements to a video stream from a camera and displaying them on a PC, a mobile phone, a digital tablet or an interactive terminal, or glasses. These elements - texts or 2D or 3D objects - provide complementary information to the real scene [1]. Formerly, the idea came to fruition in 2009 and is experiencing renewed interest in 2012. The augmented reality becomes a real market thanks to the evolution of devices.

A smartphone is indeed quite powerful and integrates the necessary sensors: camera, GPS, compass, gyroscope.

Industrial maintenance is also a very promising application. An operator can be equipped glasses with an integrated display that adds information to his view to detect errors or guide him in maintenance operations. The same idea can target the public, for example when changing a toner from a printer. This article covers the topics surrounding industrial maintenance. How industrialists can use the services offered by augmented reality in their maintenance operations. To be clear about the maintenance technician, it’s good idea to speak about the role of a maintenance technician for industrial equipment. He develops skills in the fields of mechanics, electricity, hydraulics, pneumatics, and automation. [2]

He's charged:

- to install elements in an assembly and to adapt existing equipment,

- to diagnose the origins of malfunctions on automatic machines (all technologies),

- to carry out corrective but also preventive maintenance work,

- ensure the continuity of service of the production tool.

The aim is to maintain and manage a company's machine fleet, regardless of its sector of activity. From modern automated systems, the student will be able to carry out a diagnostic or repair a property. To participate in the installation, the improvement or modification of an asset in the fields such as mechanics, electricity, hydraulics and pneumatics.

In the context of curative-type maintenance, the augmented reality can be integrated to helping the operator, to making maintenance operations more reliable and guaranteeing the effectiveness of the maintenance operation. The different applications of augmented reality lead to the following reflection: how to integrate augmented reality technologies into a system helping the maintenance operator.

The 3D/2D elements integration allowing, in the context of we use an artificial screen projected on the glass, to display aids to the operator would answer the problematic of help to the maintenance operator. The various applications studied in the state of the art confirm the technical feasibility. The state of the art makes mention of the algorithms allowing the detection of an object in a scene from a video stream, the detection is therefore made using an objects database, or even a Machine learning algorithm, this part will not be developed in this article and concerns an area still being studied in research laboratories and therefore cannot be subject to reliable industrial deployment to assist maintenance operators.

# Prototype and technologies adapted to augmented reality

How can we help a maintenance operator using augmented reality?

To answer this question, we will first address the technology used for our experience and how it can answer the problem through two imaginable and credible solutions.

In this paragraph, we review about Vuforia.

Vuforia is an augmented reality platform that enables Image Targets to precisely position a 3D model on a predefined medium (an image or an object).[3]

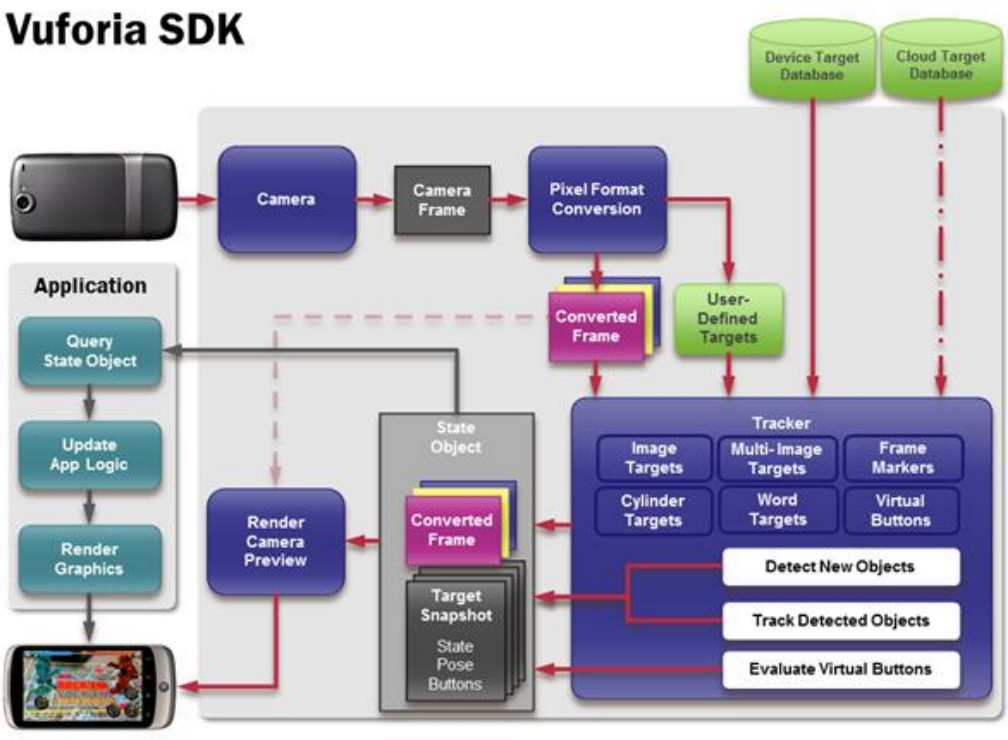
Image Targets represent images that the Vuforia SDK can detect and track. Unlike traditional fiducial markers, data matrix codes and QR codes, Image Targets do not need special black and white regions or codes to be recognized. The SDK detects and tracks the features that are naturally found in the image itself by comparing these natural features against a known target resource database. Once the Image Target is detected, the SDK will track the image as long as it is at least partially in the camera's field of view.[4]

Vuforia also allows to display augmented reality models using 3D support with the Object Recognition system.

Object Targets are a digital representation of the features and geometry of a physical object. They are distinct from image based target types, such as Image Target. [5]

Our two solutions will therefore deal with the recognition of a 2D support placed on the machine designed to improve the activity of a maintenance operator as part of its functions and on 3D recognition, thus to indicate to the system the machine or the sub-machine concerned for displaying useful information in augmented reality.

The tests and protocols demonstrated in this paper will also focus on the usability of the first and second solutions to determine which system is most effective in integrating augmented reality into industrial maintenance.



# Experimentation and protocol

The criteria for the success of the experiment are based on the assessment of the functional capacity of the system, that is to say, the provision of assistance to the industrial maintenance operator in an established and enlightened environment, and An environment established as dark:

An illuminated environment corresponds to a lighting of 820lm (lumen) in a room of 20m ².

A dark environment corresponds to lighting of 100lm (lumen) in a room of 20m ². A situation without light (0 lumen) is not evaluated in this experiment, the technological limits do not allow us to test this situation.

We evaluate the speed of processing as well as the processing efficiency (display of the 2D / 3D elements).

In this test will use Vuforia with the game engine Unity.

Unity 3D is a 3D engine. It is a software for creating 2D or 3D video games. It is a software that resembles 3D modeling software like Blender, so there is a partgraphic and programming part to create its projects.

Projects can be exported to be played on PC, Mac, Linux, PS Vita, PlayStation 4, Xbox One, iPhone, iPad, Android, etc.[6]

The augmented reality platform Vuforia supports the widest range of devices, operating systems and tools. The platform is supported by the largest augmented reality ecosystem in the world with more than 200,000 registered developers on the Vuforia community, 25,000 applications created and more than 225 million application installations worldwide. [7]

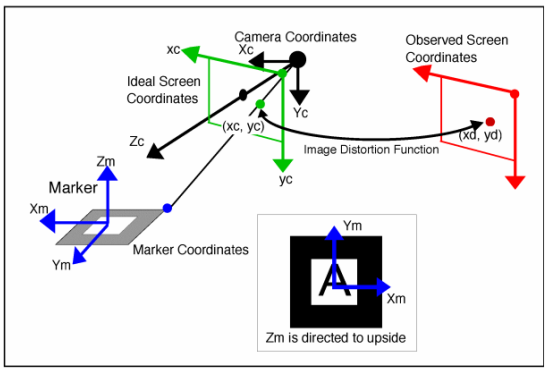
For the acquisition system number 1, based on image detection, 3D industrial maintenance objects have been modeled, these work tools for the operators will be displayed dynamically when the detection system detects an image at the place of job. A distinctive image must therefore be present around a screw hole, a screw with a screwdriver must be displayed on the detected image in order to guide the maintenance operator.

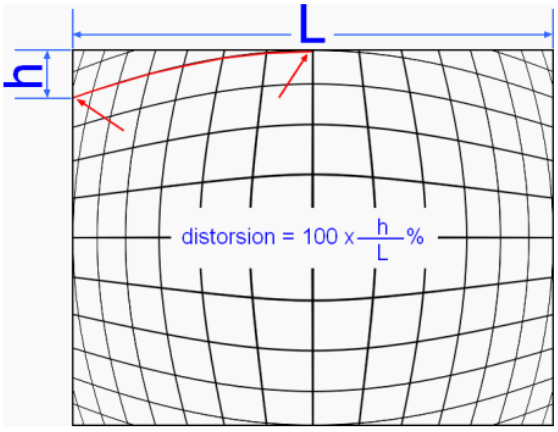
For the system of acquisition number 2, we use the system vuforia with the detection of 3D object in space, the system will be able to detect the part intended for the maintenance and position of the artifacts illustrating the protocol carried out Some action (arrow, number, instrument to use to carry out the operation) we use a coffee cup as part of this test. We can therefore envisage the detection of an engine block in the context of a car maintenance, for example.

The acquisition protocol breaks down as follows [8]:


The Vuforia system ensures the management of image distortion, in fact the problem is due to the image acquisition that is done through the lens.

[9]




The distortion phenomenon is managed by Vuforia. The algorithm transforms each point of the image captured by the camera thanks to the formulas below:

$$d^2 = (x_1 - x_0)^2 + (y_1 - y_0)^2$$
$$p = 1 - f \cdot d^2$$

$$x' = p(x_1 - x_0) + x_0$$
$$y' = p(y_1 - y_0) + y_0$$

$(x_0, y_0)$ : *Origine de la distorsion*
$(x_1, y_1)$ : *Point de l'image que l'on cherche à corriger*
$(x', y')$ : *Point après correction*

Following the experimentation of the test, we observe a higher computation time in the framework of the detection number 2, detection of 3D object. The detection 1 is faster with images which makes it possible to have a more compact embedded system for image detection, in the context of setting up a system with spectacles.

# Conclusion

In order to produce much more with much less, the factories of tomorrow will increasingly be equipped with robotic assembling chains. Humans may yield to the profile of the machine.

It becomes clear that tomorrow's plants, which will be more intelligent, more connected and more digital, will have to provide their maintenance team with digital tools in order to reduce the time and therefore the cost of this activity which is necessary for the proper functioning of all Businesses dependent on robotic chains.

The augmented reality is an IT solution that will take an increasingly important place in the management of a company, and in particular in the maintenance operations since our study deals with this subject.

In conclusion, according to our comparative criteria, we have demonstrated that the augmented reality algorithms used by Vuforia perform advantages when using two-dimensional reference models only when using complex three-dimensional references.

The ability to detect elements present on the scene is a direct result of the number of hook points on each model. Indeed, a three-dimensional reference model offers more possibilities of attachment points than its two-dimensional counterpart. Certainly. However, the computing time required for the detection of a 3D support is such that, ergonomically, such a system is not maintainable for use in real conditions.

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