Adding augmented reality to laboratory experimentation

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Abstract—This work proposes the use of augmented reality (AR) in laboratory experiments as a way to enrich the user experience in conducting the required procedures as well as reinforcing students' skills in the use of emerging technologies. Three examples of implementing an AR application, running on an Android smartphone, dealing with one haptic device and with two remote operated laboratory experiments are described. The first AR application, allows direct access to a video showing how the haptic device is assembled. The second AR application, ARNsensor, uses a marker to access in real time the data provided by a wireless sensor network used to monitor the laboratory indoor environment. The third application can, not only to access the data from an online experiment, but also to interact with the experiment. In this case, as the experiment involves controlling the level of a water tank, the user can control the water pump through a virtual command provided by the AR application. The three AR applications developed for an android smartphone are fully functional and are available for trial.

Keywords—augmented reality; android application; remote experiments;

I. INTRODUCTION

A few years ago, Augmented Reality (AR) was an expensive technology mainly used by the military and aerospace industry. At present, there are many different types of devices (smartphones, tablets, pc, TVs, head mounted displays, glasses, lenses) that allow distinct AR implementations in multiple areas such as medicine, entertainment, industry and education [1, 2]. So it is considered mandatory to introduce it in every engineering curriculum. In this way, this work supports the interest of reinforcing students' skills in the use of emerging technologies that are already being used in modern industrial environments [3]. In this context a few examples were built in a preliminary project step, all created using AR Marker Based technique and compatible with popular mobiles (Android at the present). The AR applications were developed to be used with existing online experiments and devices available within the Laboratory. Two main objectives were considered, one related to enrich the user involvement in carrying out the experiment and the other to explore and promote the use of AR within the students.

II. AR APPLICATIONS AND EXISTING SYSTEMS

Three existing systems within the Laboratory were selected for the deployment of the AR applications. The developed applications are examples of recognition based AR using markers. The AR applications are developed to be used on a smartphone Android device, making use of its camera and touch screen. The AR applications use the open source ARToolKit that was first presented at SIGGRAPH conference in 1999 [4]. The applications were developed in Unity using the cross-platform ARToolkit SDK for pattern detection and object placement. The scripting is implemented in C# taking advantage of .Net 4.5 framework for web communication and database. The AR applications can be briefly described as follows:

Example 1: The first AR application deals with a haptic device, that offers one degree of freedom (DOF) and provides force feedback. This device is being used in several of the available VR experiments at FEUP. The developed AR application allows access to a video clip where the assembly and disassembly processes of the haptic device can be observed in detail. The video uses the device modelled in SolidWorks®, whose 3D capabilities allow users to visualize the product design. By using AR tools, it is possible to improve the learning process by offering details on equipment under use to demonstrate additional information about that specific device. This helps student establish the connection between the device and its construction and some operating peculiarities. The user, by simply using his/her mobile once pointed to the device marker located on its surface, can access the video stored in an external computer server that the AR app accesses. (Fig. 1). This will contribute to bridge the gap between the real system and the associated knowledge, namely in terms of device design and construction.

Example 2: The AR application was developed to access data stored in a database that is fed by a Wireless Sensor Network that is monitoring the indoor environment of the laboratory. The system uses a sensor gateway that connects through a wireless connection to different sensor nodes. Each sensor node measures distinct environment parameters such as temperature, atmospheric pressure, relative humidity, illuminance and dioxide carbon and volatile organic components. The developed AR application, ARNsensor, uses

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a marker for each sensor node to access the database and present to the user the latest measurements available on that node (Fig. 2). This is an example where AR tools can improve the learning process by offering easy access to smart data, helping to drive students within the concept of smart cities. In fact, the access to environment data, in general terms, can be used to better adjust models by following the tendency of the quantities evolution, to prevent hazardous situations, to feed in a control system based on adaptive control methods, etc. This example simply explores the possibility of using an AR app to get access to a database with environmental data but that concept can be extended to other applications such as the use of machine data for maintenance purposes.

Example 3: The third AR application enables access and control of an online experiment that uses a closed loop circuit of two water tanks [5]. Several level transducers and detectors are used for measuring, monitoring and controlling the water level. The remote experiment is controlled through a computer interface using a JavaScript application embedded on the Moodle platform. The AR application allows the user to book the experiment and to interact with it and so, run the experiment and observe relevant data from sensors. If the experiment is under remote control, the AR application still can retrieve the data from the remote experiment server, but the user is not able to control the experiment.

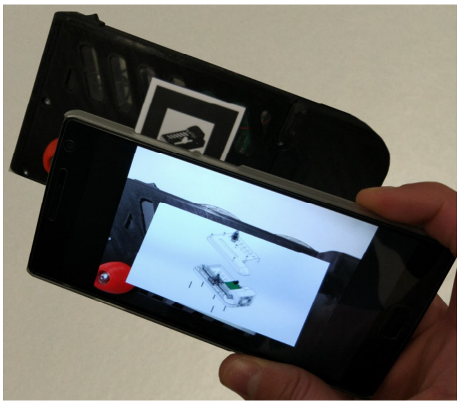

Fig.1. Haptic device with marker and AR app.

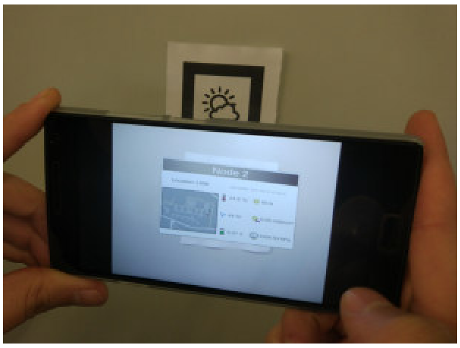

Fig.2. ARNSensor app showing the data from the sensor node marker.

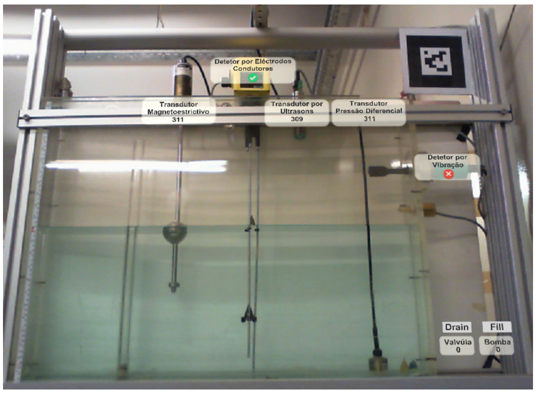

Fig. 3 Overlay of command panel with the online experiment of water tanks.

III. Conclusions

The three implemented AR applications, developed for an android smartphone, are fully functional and are available for trial. The developed applications are examples of recognition based AR using a marker. The markers enable presenting on the smartphone display multiple information such as videos, images and sound related to components, but also to implement an overlay of a command panel to control the experiment. The students' reaction to this type of tools is under assessment.

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