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Using Handheld Devices to Support Augmented Reality-based Maintenance and Assembly Tasks

A. Sanna[*], F. Manuri[*], F. Lamberti[*], *Senior Member, IEEE*, G. Paravati[*], *Member, IEEE*, P. Pezzolla[§]
[*]*Dipartimento di Automatica e Informatica, Politecnico di Torino, I-10129 Torino, Italy*
[§]*FIDIA S.p.A., I-10099, San Mauro Torinese, Torino, Italy*

***Abstract*-- This paper studies the opportunities coming from the use of consumer devices like smartphones and tablets to perform maintenance and assembly procedures with Augmented Reality (AR). Pros and cons are evaluated by comparing completion times and errors made while executing a maintenance procedure with an AR-based tool and paper-based instructions.**

I. Introduction

Although Augmented Reality (AR) technologies can be dated back to 1960s, the concept of AR was formalized only in 1994, when a graphic representation of the reality-virtuality continuum was introduced [1]. Generally speaking, AR refers to applications able to offer users a set of computer-generated hints, which are overlapped and/or aligned with the real world to "augment" it. These hints, which are often called assets, can be: 3D static objects, computer generated animations, videos, text labels and sounds.

AR applications have witnessed a widespread diffusion in tourism, advertisement, shopping, social networks and, more in general, in geo-localization scenarios [2][3]. Maintenance, repair and assembly have been identified as possible fields where AR could play an important role [4][5], although large-scale solutions are still unavailable. This is partially due to the fact that special purpose hardware is often required in these contexts. Nonetheless, new and intriguing opportunities are offered by continuous advancements in mobile technologies and recent projects showed how consumer electronics might represent a valuable tool for implementing AR applications.

Mobile devices support an AR paradigm named Handheld Augmented Reality (HAR), in which costly hardware for see-through visualization (like Head Mounted Displays) is replaced by the screen of a common smartphone or tablet. The use of mobile devices in the context considered in this paper is not totally new. For instance, an AR application for handheld devices to support the overall lifecycle of facility management is presented in [6]. Mobile devices and AR applications are exploited to train technicians in [7] and [8]. AR technology is exploited to replace paper-based instructions in the car market, showing its great potential when used with mobile devices [9].

It is worth observing that up to 4% of ownership costs of a car are due to maintenance and repair [10]. Other impressive figures come from the aeronautic domain (where maintenance costs are estimated to grow up to $54 billions in 2015 [11]) and, more in general, from considering the costs related to the entire lifecycle of any given product. Figures above provide a clear evidence of the impact that AR applications running on personal consumer devices might have, both from the economic and the social point of view.

This work aims to explore the usefulness of these solutions, by outlining their possible advantages and drawbacks.

This work is funded by the EASE-R[3] project: Integrated framework for a cost-effective and ease of Repair, Renovation and Re-use of machine tools within modern factory, FP7, FoF.NMP.2013-8, Grant agreement no: 608771.

II. Handheld AR Maintenance Application

Several studies related to the impact of AR in maintenance, repair and assembly tasks are known in the literature [12]. However, they are mainly focused on measuring performances of skilled technicians while executing complex procedures with specialized hardware. This work is aimed to gather both objective and subjective indications on the use of mobile AR-based maintenance tools by people that cannot be considered "experts" of the domain. To this aim, a specific procedure for the maintenance of a netbook has been considered. An AR-based application has been designed and deployed on a tablet using a commercial SDK. User interface is shown in Figure 1.

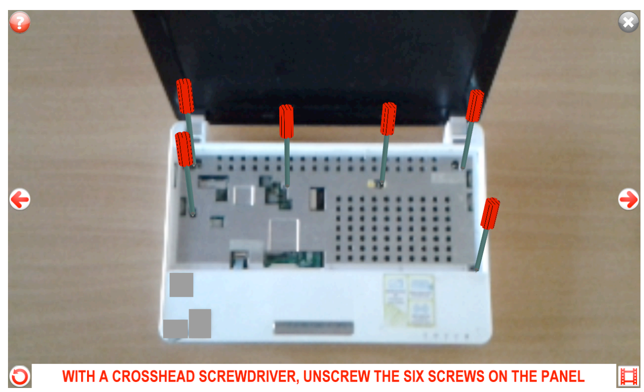

Fig. 1 A screenshot of the user interface of the AR-based application.

Left and right arrows allow the user to move backward and forward through the steps of the procedure, which has been implemented as a set of strictly-sequential states. Each step is activated when a well-defined configuration of the object to be repaired is found in the scene framed by the device's camera. The application starts to track the object once recognized with the aim of aligning the AR assets. The tracking can be either implemented "by images" or "by CAD models". In the first case, the AR application is trained by a set of photos of the real object and local feature descriptors are exploited to describe a matching with the actual view of the scene. The latter method uses a CAD model of the object to be tracked and looks for its specific geometry in the scene. The tracking by CAD models is independent of environmental conditions (e.g., illumination and shadows) and pictorial attributes (e.g., textures and materials). However, this approach requires that CAD models representing all the configurations of the object to be tracked are available. The icon on the lower left corner