POLITECNICO DI TORINO

Dipartimento di Automatica e Informatica

PhD in Computer and Control Engineering

XXIX cycle

Advisor

Prof. Andrea Sanna

Visualization and human-machine interaction

PhD Candidate:

Federico Manuri

1. Introduction / Context

Visualization comprehends any technique for creating images, diagrams or animations to communicate a message; it has applications in many different fields of use which all share common problems, such as information representation or visual quality.

Moreover, one of the most relevant visualization topic is the problem of interacting with the visualized information; this issue is common to many different contexts, such as Augmented Reality.

Augmented Reality (AR) is a well-known technology that allow the users to “experience” the real world enriched by a set of overlapping computer-generated contents and eventually other sensory inputs.

In the last years AR applications have become very popular, due to the diffusion of low-cost mobile devices such as smartphones and tablets. However, some applications domains just started to take advantage from this technology: maintenance, repair, and assembly have been considered as strategic fields for the application of the AR technology from the 1990s, but often only specialists using ad hoc hardware were involved in limited experimental tests.

Nowadays, AR-based maintenance and repair procedures are available also for end-users on consumer electronics devices and they offer many challenges and research opportunities.

2. Goal / Objectives

The main goal of the proposed work is to research interaction solutions that could improve the effectiveness and the usability of AR-based applications, focusing on the field of maintenance.

The intuitiveness and the robustness of the interface are the two main problems addressed by this research.

3. Method

In a preliminary phase of the research, user requirements have been collected and uses cases defined. The use cases consist of maintenance procedures to be performed by a technician at the customer location.

One of the main issue of previous solutions is related to the system reconfigurability: AR maintenance applications are usually designed to support a set of procedures that consist of a fixed number of well known steps, defined by a state diagram.

A dynamic reconfiguration of the state diagram to deal with unexpected situations is usually a very complex task that is hard to be performed at runtime.

The problem was addressed developing a flexible framework to allow experts at the headquarters to dynamically reconfigure/modify AR procedures to be implemented by technicians on site [1][2].

The architecture of the proposed framework is illustrated in Figure 1. The framework has been developed by implementing an agile methodology. Specifically, four basic steps have been identified: user requirements collection and analysis, design, implementation and testing.

The client side is represented by a mobile AR application that is designed for being used by the on site technician with an Android tablet. Figure 2 shows a screenshot of the client application.

Figure 2: AR application

The (remote) control station consists of a Java-based desktop application that allows the operator sitting at the headquarters to define maintenance procedures and to provide tele-assistance to the on site technician, with the possibility to update the client procedure to address unexpected situations that may come up during the maintenance procedure.

During the development of the prototype, small group of users tested the prototype to provide feedback and to suggest improvements. These tests were useful to point out bugs to fix and to get feedback and ideas from the users to further improve the proposed solution.

After a test session with a small group of technician, another problem arose: the need for a touch-free interface to address the problem of hands-free operations.

To solve this issue, the AR application was adapted to be used with head-mounted AR systems and a speech recognition interface was designed and developed on a desktop system: it works as the server side of the speech recognition solution, receiving voice commands from a Bluetooth microphone and returning the recognized commands to the AR application running on the wearable device.

At last, the final version of the prototype was tested with a larger group of users in order to better assess the proposed solution.

4.Results

During the design and development of the proposed framework different issues have been encountered and addressed.

Some drawbacks related to the speech recognition interface include response time, recognition of errors and cognitive load. These problems were addressed designing a system that could automatically generate a graphic user interface made up by icons that evoke in the user the word needed to activate a specific functionality. The intuitiveness of the interface was studied by analyzing the results obtained through trained users with both objective and subjective measurements [3].

Another problem related to the speech recognition interface is its robustness in noisy environment. This issue was addressed proposing three different ‘one switch interfaces triggered by vocal commands and comparing them to a traditional multiword interface [4].

Overall, all the issues encountered in this research have been addressed and solutions have been proposed to overcome them.

5.Conclusions

Even though the framework is primarily focused on the maintenance context, it explores and assesses problems and limitations that are shared by every AR application and proposes solutions that could be applied in different application domains.

Further developments could be aimed at improving the intuitiveness and the robustness of the proposed interfaces or exploring different hands-free interaction devices.

6.References

1. Lamberti F., Manuri F., Sanna A., Paravati G., Pezzolla P., Montuschi P. (2014) Challenges, opportunities and future trends of emerging techniques for Augmented Reality-based maintenance. In: IEEE TRANSACTIONS ON EMERGING TOPICS IN COMPUTING, vol. 2:4, pp. 411-421. - ISSN 2168-6750
2. Sanna A.; Manuri F.; Lamberti F.; Paravati G.; Pezzolla P. (2015) Using handheld devices to support Augmented Reality-based maintenance and assembly tasks. In: 32nd IEEE International Conference on Consumer Electronics (ICCE2015), Las Vegas, NV, January 9-12, 2015. pp. 178-179
3. Lamberti, Fabrizio; Manuri, Federico; Paravati, Gianluca; Piumatti, Giovanni; Sanna, Andrea. Using semantics to automatically generate speech interfaces for wearable virtual and augmented reality applications. In: IEEE TRANSACTIONS ON HUMAN-MACHINE SYSTEMS. - ISSN 2168-2291
4. Manuri, Federico; Sanna, Andrea; Lamberti, Fabrizio; Paravati, Gianluca. Vocal One Switch (VOS) selection interfaces for Virtual and Augmented Reality hands-free tasks. In: Proc. Smart Tools and Apps in computer Graphics (STAG2016), Genova, Italy, October 3-4, 2016. pp. 1-8

Figure 1: proposed framework