A Context-Aware Technical Information Manager for Presentation in Augmented Reality

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Abstract

Technical information presentation is evolving from static contents presented on paper or via digital publishing to real-time context-aware contents displayed via virtual and augmented reality devices. In this work, we present a Context-Aware Technical Information Management system (CATIM), that dynamically manages (1) what information as well as (2) how information is presented in an augmented reality interface. CATIM acquires context data about activity, operator, and environment, and then based on these data, proposes a dynamic augmented reality output tailored to the current operating context. The system was successfully implemented and preliminarily evaluated in a case study regarding the maintenance of a hydraulic valve.

Keywords: Industrial Augmented Reality, Technical Information Manager, Context-aware information.

Index Terms: Augmented Reality; Context Aware; Visualization.

1 Introduction

The evolution of computer-based user interfaces has seen many innovations over the years especially in augmented reality (AR) devices and applications. Of particular note is the nature or design of information presented; notably both the content presented and the form in which the content takes. We should expect the traditional "one size fits all" design approach to AR interface design (e.g., information content and presentation style) to become replaced by AI-driven active, real-time and context-aware user interfaces that not only customize the information content but how that information is displayed. Such active user interface systems should leverage, for example, deep and longitudinal understanding of specific users, their goals and tasks at the moment, users' past experiences with and implicit preferences in related tasks, as well as environmental and hardware constraints in which they use the interfaces.

In literature, many works quantify the effectiveness of AR for visually presenting technical information and manuals as measured by reduced time and operator error in the fulfillment of procedural task (e.g., [1], [2]). However, by developing practical industrial case studies, some issues arise in managing the presentation of technical information [3]. Therefore, in this work, we explore the utility of a context-aware information manager as applied in an industrial AR setting. Specifically, we present CATIM (Context-Aware Technical Information Manager), a system capable of rendering technical documentation via an active AR interface, dynamically guided by the context. The presented technical information manager is capable of adapting to a number of contextual dimensions and therefore usable in a wide array of operating conditions.

Beyond simply presenting technical information via fixed AR user interface designs, other researchers have looked to increase the utility of AR interfaces by incorporating context-aware features into AR applications. Zhu et al. [4] present an authorable context-aware AR System (ACARS) using a specialized context description of a maintenance procedure, to select a set of information to be provided. However, the context can condition not only the choice of the information content, but also the style of this content, or both. For example, Oh et al. [5] combined context awareness and mobile augmented reality, proposing CAMAR (Context-aware Mobile Augmented Reality), which customizes the content to be preferable to a user according to his/her profile. Many works [6–8] on adaptive AR interfaces propose algorithms to determine optimal text styles (e.g., text color and drawing style, position of labeling), based on the background of the environment. Grubert et al. [9] present a state-of-the-art context-aware AR system that considers the effect of context both on the content and the presentation style.

2 The System

CATIM aims to present the "best" technical assets available for the context to the operator. A functional scheme is depicted in **Errore. L'origine riferimento non è stata trovata.**. *Technical information* can be divided into atomic pieces, conveyable in different ways, that we defined technical assets. Technical assets are usually visual

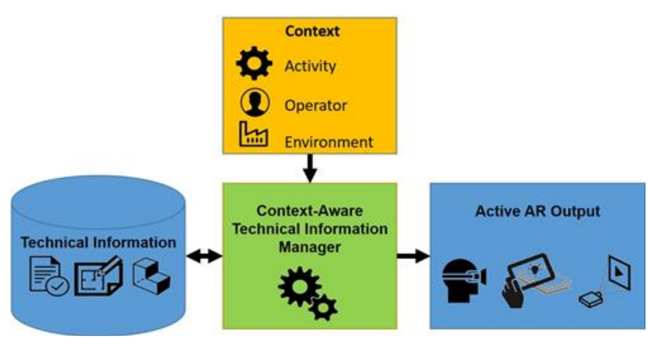

Figure 1: Functional scheme.

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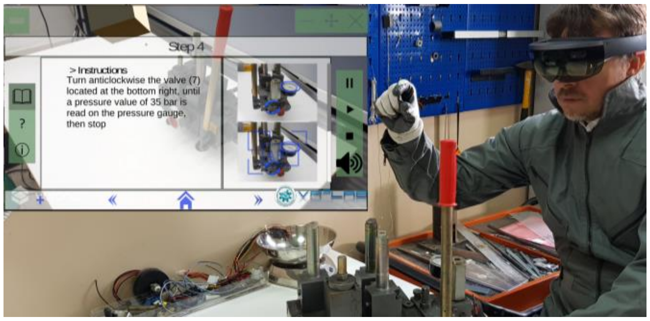

Figure 2: Example of AR output for novice operators.

cues such as 3D CAD models, video, text, images, icons, graphs, and so on. Furthermore, other assets could be used, such as auditory, haptic and olfactory cues in order to provide a multisensorial approach to technical documentation presentation. The technical assets can be static but also associated to dynamic information. The same technical information can be mapped with different assets that share the same content but with different media and interface presentation style (e.g., short text, long text, animated text, video, audio). Thus, the choice of the optimal technical asset for the same technical information is paramount.

We assume that the context in which to perform the task described by technical information, can be known. For example, the system could infer the *activity* to be performed by automatically using state sensing, IoT or by user selection. CATIM could know the *operator* technical, physical and cognitive skills, as well as interface preferences by, for example, user profiling and wearable sensors. And lastly, the system could sense the *environment* using sensor suites and computer vision to identify available tools, lighting condition, available AR devices, and so forth.

Using our proposed approach, upon operator initiation of a task procedure, CATIM browses the technical information database to find the technical assets which best match the context and presents them to the operator via an AR user interface. The information search is based on the context description rather than having the user selecting the information needed. The operator can be continuously profiled by the acquired data (e.g., number of presentations of the same asset and task time for a repetitive procedure) and the presentation can be dynamically adapted to an operator's learning curve.

Technical information is mapped onto a database of technical assets using an ontology for technical information. The context is then dynamically mapped onto a context vector also using a context ontology to describe the application domain. This vector contains data about the activity, the operator, and the environment. A real time reasoner, using recommender system technology, according to the context vector, selects and presents the best technical assets using an *active AR interface* to the user. CATIM implementation uses a Java http back-end and a front-end mobile application implemented with Unity 3D for the interactive AR experience.

3 Preliminary Evaluation

For a preliminary evaluation, we used CATIM for the maintenance of a hydraulic elevator valve.

For the context, we chose a technical single instruction (*activity*). For the operator, we consider the single attribute of *user experience* (values: novice and expert user). For the *environment*, we consider three attributes: (i) object trackability for situated visualization (values: trackable or not trackable), (ii) noisiness (values: noisy and acceptable), and, (iii) AR device (values: HoloLens and android mobile device).

The Active AR output application, running on the AR device, displays the technical assets according to a context-dependent layout. Figure 2 shows the AR output suggested for novice operators who receive more detailed information. Expert operators will receive less detailed information with many advantages as: less occlusion of the real world, that is particularly crucial for the HoloLens due to the limited field of view; avoiding of annoying information; less cognitive effort.

We tested the effectiveness of the proposed CATIM verifying its interactivity by measuring the turnaround time. We recorded turnaround time seven times for three different android mobile device and a MS HoloLens. For all the devices, the turnaround times were lower than 1 second, thus suggesting that CATIM can support highly-interactive user experiences.

Although we used a reduced context dataset for this work, the system is able to maintain interactive processing speeds with larger datasets. The properties of the recommendation system allow it to be scalable, eventually dividing the ontologies into knowledge subsets, while the visualization engine does not depend in any way on the system size. For this purpose, a valuable feature of the system would be the possibility of automatically populating the ontology with a set of technical manuals, by taking them from large datasets (e.g. IFixit), often written in authoring-oriented standards, like oManual, DITA or DocBooks.

The final objective of the ongoing research would lead to the development of the following two parts: (i) an optimized active AR user interface, not bounded by any fixed layout, capable of interpreting user properties and environment constraints, and, (ii) an automatic recognition of technical documentation needed in a certain context. As to the dynamic AR interface, the current implementation is bounded to a limited set of fixed layouts even if they are populated dynamically. Future work will include also dynamic arrangement of assets in the interface layout.

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