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Using Smart Glasses to Document Maintenance Processes

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Abstract

Videos are an intuitive and maintainable way to document and transfer knowledge. Smart glasses allow to record videos hands-free from the ego-perspective with little effort. This makes them suitable devices for documenting maintenance procedures in industrial environments. Within the project AmbiWise mobile collaboration systems are developed to make knowledge easier accessible in companies. This paper presents an application that documents knowledge about maintenance processes using videos. A promising proof-of-concept was implemented on Google Glass. It showed the feasibility and the use of the concept and will be evaluated under real conditions in the field within the AmbiWise project.

1 Introduction

This paper presents an application for smart glasses that facilitates the management and exchange of knowledge for maintenance workers. Section 1.1 discusses knowledge management and the challenges that companies are facing today. Section 1.2 introduces the application scenario. Section 1.3 describes the hardware platform that is being used.

1.1 Motivation

Companies are facing difficulties with documenting, managing and sharing knowledge that their employees have acquired. The most important reasons are the following:

- The demographic structure of the developed world leads to an increasing loss of knowledge through retiring employees.
- Globally shared knowledge yields quicker and better solutions to problems, making the company more productive and competitive.
- The increasing flexibility on the job-market shortens the average employment time of employees in one company.

- Better engineered machinery needs less maintenance. The lack of regular practice makes it harder to remember how maintenance tasks are carried out.

Therefore, exchange and conservation of the employees' knowledge is crucial for a company. Techniques for this purpose will be discussed hereafter.

Knowledge is usually transferred by direct teaching-in or by written manuals. Both methods have drawbacks. According to (Wiedenmaier et al. 2003) direct teaching-in is the preferable training method. However, companies are facing difficulties with this method. Experts and beginners work in different shifts, production sites are far away from each other, and employees speak different languages. Hence, experts are not always available for direct teaching-in. Manuals bring challenges as well. Issues are lack of portability, inaccuracy and increasing complexity as illustrated by (Ventura 2000) for technicians of the armed forces. The dynamic production environments of today are constantly optimized through changes on the soft- and hardware side. This leads to outdated documentation since manuals cannot be updated fast enough (Wilson et al. 2012). Moreover, (Novick & Ward 2006) report that users rarely use written manuals when encountering problems. When used after all, (Wiedenmaier et al. 2003) show that written manuals are still slower compared to direct teaching-in. To summarize, new techniques to document and share knowledge are necessary.

Augmented Reality (AR) is a technique finding its way to the industrial domain. It allows displaying information into an employees' vision focus and promises benefits for knowledge transfer. A major disadvantage of AR is the complex content creation and maintenance of the content which requires knowledge in fields like computer vision or wearable computing. As the examples in (Henderson & Feiner 2011) and (Carmigniani et al. 2011) show, current AR-supported maintenance or assembly tasks take place in standardized, static and controlled environments. Given the aim of a solution that can be applied easily and on a broad industrial basis, it was concluded that AR is unsuitable for documentation tasks today.

Video tutorials offer a more intuitive way to transfer knowledge compared to traditional methods. Dynamic media, like video, has a significant advantage over static media, like written manuals, as stated by (Holzinger et al. 2008). Video tutorials are already widely used, mainly for private purposes. A recent study by (BITKOM 2015) states that 37% of the over 14-year-old answered questions of daily life using video tutorials, found on video platforms like YouTube. Documenting and sharing knowledge using videos offers several advantages:

- Knowledge can be documented right on the spot using video and audio. The benefits of multimodal learning can be exploited.
- The creation of video is, compared to the creation of AR instructions, simple.
- Consumer-market-driven computer and mobile technologies offer useful features for the presented scenario. Most devices can record video and have sensors and communication interfaces that allow mobile and context-sensitive interaction.
- Standardized formats (e.g., mp4) are supported by almost any device.

To summarize, using video tutorials together with a profound organizational integration should be a good technique to document maintenance processes and allow a broad fielding in the industrial domain.

1.2 Application Scenario

The described application will be used to document maintenance processes in a global production environment. The aim is to support the documentation and exchange of knowledge of maintenance processes. Therefore, primarily expert knowledge of maintenance processes should be gathered in a knowledge repository. Maintenance procedures should be documented and explained at the point of action with little distraction. The videos should provide instant help for other employees and serve as training material for prospective maintenance personnel.

1.3 Smart Glasses

Section 1.1 motivated to use videos for documentation and exchange of knowledge. Especially, smart glasses are promising devices for the given application scenario. They allow hands-free interaction, so the employee can record simultaneously while carrying out the task. The resulting ego perspective facilitates the application of the knowledge when being consumed (Mura et al. 2014).

Google Glass (Google) was chosen for the development of a proof-of-concept. The Glass consists of a head-mounted display attached to a glasses-like frame. It has a built-in camera and features Wireless LAN and Bluetooth. The main interaction techniques are voice commands and a touchpad. Another smart glass could be used as well and would require minor adjustments of the application.

Google Glass was selected for several reasons. It offers a satisfying camera resolution. Compared to similar devices, it is light and comfortable to wear allowing the user to focus on the task. Its screen is transparent and located above the user’s line of sight making it less distractive. Furthermore, it is based on Android and supported by a large programming community. Nevertheless, possible interactions are limited, like on most other smart glasses. However, it is assumed that the device will primarily be used to record videos, since tablets or smartphones offer more comfortable interactions for video play back.

2 Concept

The scenario as given by section 1.2 leads to the following requirements:

- The application is integrated with the AmbiWise system, realizing the knowledge repository.
- The application allows gathering context information to be allocated as metadata to the recorded videos (e.g. identifying the user and a machine).
- The application allows retrieving videos using context information.
- All functions are reachable by voice commands to ensure hands-free operation.

The employee has to identify himself at the beginning. Depending on his rights he can record and consume videos as an expert or only consume videos as a student. When documenting a task the machine needs to be specified first. This is realized by an integrated scanning application to recognize optical codes (e.g. QR-codes) as illustrated by figure 1.

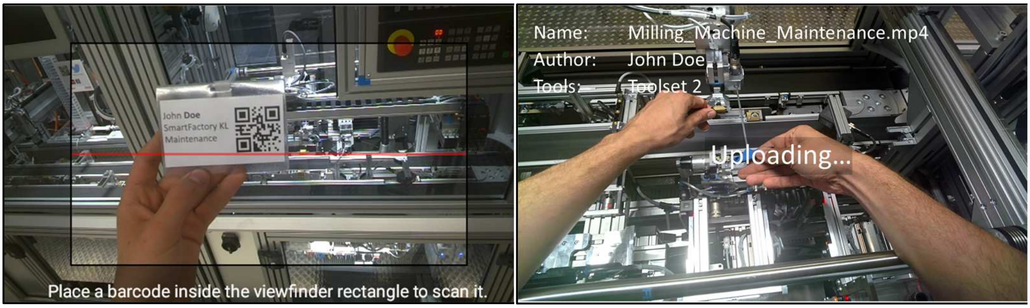

Figure 1: Scanning an optical code for identifying user (left), Uploading the video (right)

Thereby the already available optical codes on the machines can be reused. Afterwards the employee starts the recording and conducts the maintenance task. Once it is completed he stops the recording and the video is automatically uploaded to the AmbiWise backend. The editing (e.g. cutting, adding annotations, etc.) and the release process is realized via the AmbiWise system involving 3rd party software before being available for all users.

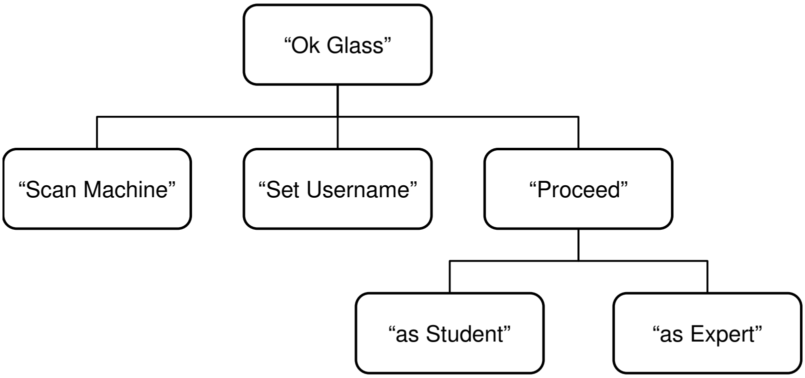

Figure 2: Structure of the application

The resulting structure is illustrated in figure 2. Every interaction starts with the voice trigger "Ok Glass" that activates Glass so that it listens to commands. The user can traverse the menu hierarchy using voice commands or the touchpad to select options in a textual menu.

3 Conclusion and Outlook

The paper described an application for Google Glass. This application demonstrated the feasibility of using smart glasses for recording and playing instructional videos within the context of an organization. In the following sections our experiences are discussed and extensions to the application are proposed.

3.1 Discussion

The prototypic application showed that smart glasses are appropriate devices for knowledge conservation. Nevertheless, technical and organizational challenges are described hereafter.

The current generation of smart glasses has limitations that inhibit their large scale introduction. One drawback is battery power. The batteries of current devices cannot power the device for a whole shift. Processing power is limited as well. New and more capable devices should render these drawbacks obsolete. Current smart glasses have limited possibilities of interaction. This can be critical if a specific video has to be found out of a big number of available video files. Moreover, the advantage of a small screen during recording can at the same time be a disadvantage when consuming the video.

Another issue concerns the organizational integration into the company. Several aspects like the release process or privacy issues have to be considered. New agreements and workflows have to be established to make sure that recorded videos are technically correct, comply with safety standards and do not harm the privacy rights of the employee. Such procedures need close collaboration of all involved stakeholders to allow a broad and successful fielding.

3.2 Further Work

An inherent tradeoff is to implement complex functionality while embracing the unique interaction capabilities of smart glasses and keep the interactions simple. Detecting contextual factors automatically can for example be used to annotate the video with metadata and to filter the available videos. The current speech commands could be enhanced by speech recognition to extract the language of verbal descriptions. Image recognition could be used to detect machines and tools used in the video. Furthermore, the application could be enriched with more interactivity. Possible ideas are gesture-based control of playback, allowing to add comments or to extend the video. The sensors of Google Glass, for example location or tilt could be used for this purpose.

The application will be evaluated together with the other modules of the AmbiWise system in a site of a German manufacturer of automotive parts. There the benefit of using videos for knowledge transfer and documentation will be evaluated compared to traditional methods. Furthermore, the developed application will be compared to other devices used for recording.

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