Evaluation of Smart Glasses for Documentation in Manufacturing

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Abstract

Devices from the consumer sector are increasingly pushing into industrial production to realize applications to support workers. Especially, smart glasses are currently in the focus and discussed regarding their application scenarios and potential benefits. Nevertheless, most of the available applications are considered to be concept studies or demonstrators that often lack empirical evaluation of their use in industrial settings. Hence, data is missing to provide insights into benefits and drawbacks of smart glasses as well as on the user acceptance. This paper presents first evaluation results of an application used to document knowledge about assembly and maintenance processes using video recording with smart glasses. It has been evaluated by maintenance and production workers both under laboratory as well as under real conditions within multiple work contexts.

1 Introduction

The advancing automatization of production, which is promoted by the ideas of Industry 4.0, will not lead to deserted factories. Although automation systems are becoming more intelligent, the human is still the most flexible entity and a prerequisite for flexible production. Technologies introduced in the consumer sector are increasingly applied in production environments to assist workers within increasingly complex environments. Smart glasses, for instance from Google, raised much attention. Especially, car manufacturers evaluated these devices for various applications (VW 2015; AUDI 2015; BMW Group 2014). Other prototypes, as presented by (S. Rauh et al. 2015), use Google Glasses to improve the calibration of a testing bay in automobile production. It replaced a paper-based process by providing work instructions and allowed documenting their execution. The

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application focusses on providing instructions and helps to remember the sequence of steps to be performed. General findings regarding the hardware are presented, yet lacking an evaluation of benefits and drawbacks compared to an existing process. A similar application that realizes a checklist in the automotive domain was evaluated by (Stocker et al. 2016). The evaluation compared interaction modalities (touch, speech, and gestures) by measuring the time to reach certain functions. A qualitative evaluation yielded negative comments regarding usability and comfort of use. The findings imply dissatisfaction with smart glasses in general and in particular with the device used.

2 System

The application, as introduced by (Quint & Loch 2015), utilizes Google Glasses to document knowledge on maintenance and assembly tasks. It is embedded into a knowledge management system developed within the project AmbiWise. The smart glass application gathers context information by identifying the user and the current machine based on QR-codes or barcodes. The user can either record videos or retrieve videos from a repository. The videos are uploaded to the AmbiWise backend and allocated to the respective machine. Editing can be done by third party video editing software. All functions of the application can be reached by the touchpad or voice commands to allow hands-free operation.

3 Evaluation

The evaluation targeted the usability of the application and the device, as well as the quality of the recorded videos. The evaluation consisted of two phases, (1) an initial workshop for an introduction to Smart Glasses and their handling, with a first tryout session (in a controlled setting, outside the production context), and (2) an on-site evaluation testing the application in the real environment. To assess usability aspects and the quality of the videos, a questionnaire was applied to gather users' individual assessments of these attributes. It contained 6-point Likert scales (ranging from 1 = very good to 6 = not sufficient and, when applicable, from 1 = very low to 6 = very high), and was filled in by the participants right after the use of the application. The quality of the recorded videos was evaluated based on watching them on the target devices for playback (i.e. a PC or tablet). Each question could also be commented. Finally, obstacles for a practical adoption and further ideas for the smart glass applications were gathered.

The evaluation was performed in two companies. In the first company, the system was used to document standardized tasks within assembly processes in the automotive sector. Experienced assembly workers used the system to document selected tasks. 14 persons participated in phase 1, ten of them being involved in production, three in logistics and six in qualification and training. The sample also included work council members. Four assembly workers participated in phase 2 and documented tasks at 29 work stations. In the second company, the system was used to document maintenance tasks. Eight persons participated in phase 1, five of them involved in the maintenance division and three in other divisions, including work council members. Phase 2 is being currently under evaluation.

4 Preliminary Results

Phase 1: Although workers with diverse job profiles participated in phase 1, their results are similar. Using smart glasses instead of their usual recording device (mostly tablets) yielded significantly better results in both companies. This was true with regard to the following aspects: weight of the device (in particular with regard to longer periods of use); wearing comfort (excluding weight); applicability in hard to reach locations; and potential adverse effects of device handling on the work task. Improvements compared to the existing recording solution were identified for the storage of the device in phases where it is not being used, and regarding the potential of distraction from health and safety risks. Results were ambiguous with regard to training efforts. Workers in both companies criticized the lack of visibility of the recorded area with the smart glass, since it records slightly above the user's field of view. Regarding the quality of the results, workers from the first company see some improvements in the perceptibility of details and colors and the picture quality under varying lighting conditions, and significant improvements regarding sound quality at varying locations as well as regarding the image stability. Workers of the second company see – if at all – only minor improvements for these four factors.

Phase 2: This phase is currently under evaluation in the second company, hence the following results are restricted to the first company. The smart glass was evaluated at a total of 29 work stations. The differences to the evaluation in a controlled setting are reported in the following. Wearing comfort, the potential for distraction from health and safety risks and image quality under varying lighting conditions were rated similar to the controlled setting. Better results were reported with regard to the visibility of the area that is being recorded, the applicability in hard to reach locations, efforts needed for training, the quality of sound at different locations and image stability. Worse results were reported with regard to the weight of the device, the storage of the device in phases where it is not being used and the perceptibility of details and colors. However, for each single usability and quality aspect – including those that were reported worse in the testing at workstations – the smart glass outperforms the results of the previously used recording devices.

5 Discussion and Outlook

The evaluation benefits from the testing at a wide variety of work stations, under real working conditions and by real workers. However, the fact that only a small number of workers participated might overemphasize the aspect of ease of learning to operate the device and the application. Some slightly negatively appraised aspects of usability and quality in the controlled environment turned out less significant in practice. Differences in the results between the quality evaluation of the two companies are potentially grounded in the characteristics of the tasks in the second company that are typically of a more delicate nature. The use of work gloves was problematic with regard to the operation of the device but could be eliminated through special gloves that both serve the safety as well as the devices operation or by voice operation if the surrounding sound allows for this.

Through the two-phased process including all stakeholders on a voluntary basis and the establishment of organizational agreements lead to a high acceptance and few comments regarding potential barriers (intended or unintended recording of co-workers without their consent, protection of data & industrial secrets). Furthermore, the hardware restrictions seem to have little impact on the results since all questions related to the quality of the results yielded good marks. These good results, for instance compared to (Stocker et al. 2016), could be explained by the focus on a different use case (documentation instead of assistance) that does not require much interaction. Hardware specific drawbacks (e.g. low battery capacity) have less impact, since the device is only used temporarily. A conclusion is that applications need to be tailored to the characteristics of smart glasses. Applications that require extensive interaction should be avoided due to the limited interaction modalities. Furthermore, a temporary use helps to relieve typical complaints of long-term usage. The presented video recording application is, according to the authors, an application that fits to the device characteristics and was thus evaluated positively.

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