Machine-to-Human Beeping: Unidirectional Communication in Industrial Environments

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ABSTRACT

In this position paper, we want to present and discuss findings regarding unidirectional Machine-to-Human Communication in highly automated environments. These results are part of the research around the cooperative research project MMAssist II with the goal to research and implement modular, reusable assistance systems for employees in production companies. Most of the machines used in this context have limited ways of informing about their status: a unified beeping sound, used for different warnings or errors – and this seems to be highly annoying for operators and service engineers working with those machines. The second problem that arises is related to experienced control (i.e. workers aiming to keep in control of the processes) in this nearly automated environment. We want to tackle both topics by implementing a wearable Assistance Unit with the core functionality to provide machine data remotely to its user. Besides that, we want to add multimodal output options – from auditive signals to vibrational patterns – not only to reduce the levels of stress from to noise and beeping, but to address the problem of experienced control by offering more choices and a higher level of personalization and customizability to the user.

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KEYWORDS

Factory, Automation, Experience, Control, Stress, Wearable, Multimodal Output

INTRODUCTION

In this position paper, we want to describe findings regarding Machine-to-Human Communication in highly automated environments, focusing on the unidirectional transfer of information from machines to their users – ranging from status information and status updates to warnings and error messages. These results are part of the research around the cooperative research project MMAssist II (Assistance Systems in Production in the Context of Man-Machine Cooperation). The goal of this project is to research and implement modular, reusable assistance systems for employees in production companies, and the project partners expect to gain a profound empirical and socio-technical understanding of demands and requirements for assistance systems in this context. Problems identified in this research range from stress due to noise and beeping (most of the machines used in this context have limited ways of informing about their status) to issues regarding experienced control (i.e. workers aiming to keep in control of the processes) in this nearly automated environment.

UNDERSTANDING THE WORKERS

A contextual inquiry [1] consisting of interviews, observations and questionnaires was carried out at the industrial partners' sites, involving various groups of people from future users and decision-makers alike, with 39 participants in total. The analysis aimed at identifying aspects of experience, identifying assistance needs and understanding the industrial partner's application contexts. The results were grouped and summarized using affinity diagrams [2], and the outcome of this process was used in several workshops, where researchers with various backgrounds (e.g., with a background in social sciences and interaction design, etc.) worked together with the project partners to define seven so-called *Assistance Units* (AUs). Following this, conceptual designs were developed for each of those AUs, using flow charts, essential use cases [3] and clickable prototypes to depict the interaction processes based on a user-centered perspective.

SELECTED FINDINGS: WORKING IN (NEARLY) AUTOMATED, BEEPING ENVIRONMENTS

In this paper we want to highlight and focus on one specific aspect revealed in the data: in most of the analyzed use cases, one operator or service engineer has to work with and to maintain several machines on different locations in one production environment. Data from the contextual inquiry highlights that the environmental sound intensity – combined with simple, undifferentiated auditory signals from machines – causes high amounts of stress for operators and service engineers.

This is especially true for Simultaneous Handling of Multiple Machines, due to the fact that employees have to decide which problems – and machines – need to be taken care of first to assure a smooth workflow and to avoid machine downtime. It is important to also address the affected working environment at this point: the operators and service engineers have to work in a nearly fully automated environment. The industrial machines they work with only need human attention only if there is a problem of any kind, ranging from technical issues to tools or material which need to be replaced. Interestingly, most of this machines and facilities still have very limited ways of informing about their status: a unified beeping sound, used for all warning or error signals, supported by visual interfaces attached to the machine. Especially this machines' „undifferentiable beeping" seemed to be highly annoying, as it is mentioned several times in the data. It seems that these facilities were designed and built for a single operator working with a single machine – and therefore there was no need for differentiated warning signals. As automation arises in these environments, every operator has to manage several machines, still with only *one* warning or error signal. In addition to this auditory distraction, rising automation is related to experienced control (i.e. workers aiming to keep in control of the processes). For example, *Wurhofer et al.* point out that it is questionable for operators who is in control of whom, as operators often have to adapt to the automated system, while the system does not adept to the operators [4].

ADDRESSING THESE PROBLEMS

As it was mentioned before, the goal of this project is to research and implement modular, reusable assistance systems for workers in production companies. One of these assistance systems called *AU status indication* will be a wearable system with the core functionality to provide machine data remotely to its user. The displayed data range from real-time status information to warnings and error messages with the option to filter and sort the displayed data, and there are additional functions such as the possibility to snooze reminders or to forward useful information to colleagues and supervisors. To incorporate the before mentioned results from the findings, it was decided to implement multimodal output options into this wearable assistance system. The provided visual data is extended by customizable audio signals, and also the implementation of vibrational patterns is planned, following the assumption that multimodal interfaces can support more flexible, efficient and expressive means of interaction [5], and that the user experience provided by multimodal interfaces is enriched and more complex [6].

EXPECTED RESULTS

These new functions are not only implemented to provide a higher level of customizability for the user and to reduce the perceived subjective feeling of stress by reducing noise and auditory signals, but also to address the problem of experienced control [4]. We want to decrease this problem by offering more choices [5] and a higher level of personalization and customizability [6] in the context

of machine-to-human information, using exemplary multimodal output options for workers, operators and service engineers. The prototype for this assistance system is currently being built and tested and so we cannot provide research results regarding the effects of the system at this time. We really hope that we can reduce stress levels and, at the same time, improve the daily work experience of operators and service engineers with the implementation of these functions and thereby offered options of choice.

CONCLUSION

With this paper and the related project we aim to raise several questions and topics that are similarly addressed by the workshop, especially if we think about the topic of *positively* experiencing automation in industrial environments. For example, how can we design, build or adjust (nearly) automated systems to counteract the perceived notion of losing control while interacting with these environments? How can we provide adequate feedback from ubiquitous automated systems to their users [7]? Which kind of feedback and interaction can or should be provided to enable a more positive and productive interplay between users and automated systems? If we follow the argumentation provided by *Schmidt and Hermann,* we even may ask: how can we team up automated systems, interfaces and users in ways that results in outcomes which provides us with an outcome that is *more* than the sum of their parts [8]? We aim to discuss and reflect on these issues within the workshop and contribute to further discussions around automation experience.

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