Experiencing Automation in the Factory and Automotive Domain: Differences, Similarities, and Challenges

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ABSTRACT

Based on our previous research in the automotive domain and in the factory, we discuss how users experience automation in these two contexts. We point out contextual characteristics of each domain and exemplify how *workload*, *knowledge*, *involvement* and *control* are experienced in relation to increasing automation in each domain. Finally, we formulate overall challenges of automation from an experiential perspective, showing directions of future HCI research.

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User experience; automation; smart factory; automotive

INTRODUCTION

Automation is growing in importance and changing the way we handle and experience technology. Two very prominent application domains of automation are factories and vehicles. Buzz words like Industry 4.0, smart factories or "factories of the future" indicate that digitalization and automation is increasingly relevant in industrial settings. In a similar manner, automated vehicles and autonomous driving have been discussed intensively in academia, industry, and public over the last decade. Within our research, we did a range of studies in both contexts (e.g., [2], [6]).

In our studies in the factory, we put emphasis on the humans' side of automation and focused on workers' experiences in increasingly automated and digitalized shop floors. We have identified four topics that are of particular importance with regard to the daily work experience in increasingly automated factories [6]: *workload*, *knowledge*, *involvement*, and *control*. In the automotive domain, we conducted several studies with respect to automated vehicles (e.g., [2]). Similar to the factory context, workload, knowledge, involvement, and control were crucial for users.

By providing examples of how automation is experienced with regard to workload, knowledge, involvement, and control, we point out differences and commonalities of users' experiences in the two domains. Referring to the lists below, the automotive and the factory domain are rather heterogenous contexts. Therefore, reflecting on experiences of automation in the two domains and then deducing overall challenges of automation for HCI from an experiential perspective provides a comprehensive view on the interaction with automated systems.

Characteristics of the factory context

- Work, professional life
- Meanings: from getting money to establishing identity
- Aims of automation: increase productivity and efficiency, less strain for workers
- Duties and work procedures often imposed top down (by authorities)
- Strict and inflexible working procedures
- Challenging, restricted research context: limited time, undisclosed processes or artifacts

Characteristics of the automotive context

- Leisure and work (e.g. commuting)
- Meanings: from transport to symbol of identification
- Aims of automation: reduction of accidents, fluent traffic, less effort for drivers
- Drivers' enjoyment as important design goal
- Challenging to conduct studies: driving safety must be guaranteed, ethical issues

In general, safety is important in both contexts; it has to be guaranteed when working with automated machines in the factory as well as when driving an autonomous vehicle.

EXPERIENCING AUTOMATION

In the following, we will reflect on four topics [6] assumed to be crucial for users' experiences.

Workload

The concept of cognitive or mental workload describes the load users experience when interacting with a technology [5]. In our factory studies we define workload as the perceived cognitive effort required when interacting with a technology to solve a task. This includes subjective and objective workload as well as time pressure.

With increasing automation in factories, workload appears on two extremes: on the one hand, workload may be low as workers' main task is to supervise processes and passively observe the machines' activities, which eventually may cause boredom. On the other hand, (highly qualified) workers are needed to solve errors and problems as fast as possible; this puts a lot of pressure on workers and may lead to high cognitive load and excessive overstrain.

Regarding workload and automated driving, the Society of Automotive Engineers (SAE) identifies five levels of automation ranging from no automation to driverless vehicles. For example, on level 3 (the driver can do whatever he/she wants until it is requested to take over control), in so-called hand-over situations, drivers may be overstrained, for example, because they are not used to such situations and therefore have to deal with high cognitive effort to take over control and resolve a potential dangerous situation.

Knowledge

Knowledge can be distinguished between declarative knowledge (i.e., knowledge about facts, principles, or goals) and procedural knowledge and skills (i.e., cognitive, psychomotor or physical skills) [1]. In our research, we operationalize knowledge as comprising the user's qualification, expertise, as well as access to knowledge.

In comparison to "traditional" factory work, knowledge structures have changed. When working in automated factories, knowledge is mostly needed in case of errors and unexpected incidents. Further, increasing connectedness of systems and enhanced complexity makes it harder to have sufficient knowledge and act as an expert. Overall, selective and very specific knowledge is needed in automated factories.

Knowledge in automated cars is related to the level of automation; the higher the level of automation, the less knowledge is required by the driver during routine driving tasks. However, in case of complex situations, where the driver should be able to hand over tasks, a higher level of automation may be linked to less training and thus lead to more difficulties for the driver. Estimating speed and keeping driving skills may be exemplary aspects related to knowledge and automated cars. Another factor here is de-skilling, dealing with a lack of experience and knowledge of the driver on how to resolve dangerous situations (as the system takes over tasks).

Involvement

Involvement and participation occur either directly or indirectly [3]. We define involvement as the user's integration in decision processes in the form of responsibilities and means of participation.

With regard to automated factories, we found that workers often did not feel involved in processes and developments. For example, workers were not informed about new technological developments or managerial decisions were taken without asking for their expertise/advice. Having the feeling of not being actively involved in processes led to fears and uncertainties.

In contrast to traditional driving, autonomous driving comes along with a change of decision processes and the question who is in charge of (critical) decisions. Involving drivers in decisions like e.g., deciding which route the autonomous car takes may reflect involvement. Contrary, providing no chance to intervene in overall decisions like route taking or driving speed may lead to a feeling of being overruled by the system.

Control

Common definitions about control and autonomy (e.g., [4]) describe a certain degree of freedom of choice. Transferred to the automation context we define control as workers' perceived influence on the system's actions.

In contrast to non-automated processes in factory and in the car, increasing automation is often associated with a perceived loss of control by the users. Regarding control in the factory, working with automated systems often provided workers with the feeling of having no influence on the system's actions. Instead of controlling the system, workers often had to adapt to the system, i.e., subordinate their activities to the systems' actions.

Autonomous cars may be also associated with humans' feeling a loss of control. Driving a car is often perceived as a means of freedom. To reduce accidents and traffic jams, automated vehicles will probably drive accordingly to the logics of algorithms in the background; routing and re-routing will be determined by these algorithms rather than by individual choices.

DISCUSSION – OVERALL CHALLENGES OF AUTOMATION FROM AN EXPERIENTAL PERSPECTIVE

With our work, we intend to trigger discussions between involved stakeholders and point out challenges for HCI in the domain of automated systems. Based on the comparison of contexts with regard to the four topics described above, overall questions which could be addressed by HCI research arose. These questions can be considered as future challenges and research topics of automation from an experiential (HCI) perspective.

Challenge 1 – Boredom: How to counterfight boredom and inactive times if the autonomous systems takes over tasks? How could "meaningful in-between activities" be integrated?

Challenge 2 – Overstrain: How can overstrain be reduced in cases where the human has to intervene, for example, in case of errors or breakdowns?

Challenge 3: Access to knowledge: How can necessary and specific knowledge be provided dynamically, i.e., in the situation when it's needed?

Challenge 4: Preserving knowledge and training skills: How can knowledge and skills be preserved although the system takes over humans' tasks?

Challenge 5: Integration in decision processes: How to provide humans with a feeling of involvement and participation instead of feeling overruled by the system's decisions?

Challenge 6: Preserving control: How to provide users of autonomous systems with a feeling of control?

With regard to the workshop, we hope to elicit fruitful discussions about how HCI can face these challenges and how further challenges of automation could look like.

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