Work process and task-based design of intelligent assistance systems in German textile industry

M Löhrer[1], N Ziesen[2], A Altepost[1], M Saggiomo [1] and Y S Gloy[1]

[1]Institut für Textiltechnik der RWTH Aachen University (ITA), Aachen, Germany
[2]Institute for Sociology of RWTH Aachen University (IfS), Aachen, Germany

mario.löhrer@ita.rwth-aachen.de

Abstract. The mid-sized embossed German textile industry must face social challenges e.g. demographic change or technical changing processes. Interaction with intelligent systems (on machines) and increasing automation changes processes, working structures and employees' tasks on all levels. Work contents are getting more complex, resulting in the necessity for diversified and enhanced competencies. Mobile devices like tablets or smartphones are increasingly finding their way into the workplace. Employees who grew up with new forms of media have certain advantages regarding the usage of modern technologies compared to older employees. Therefore, it is necessary to design new systems which help to adapt the competencies of both younger and older employees to new automated production processes in the digital work environment. The key to successful integration of technical assistance systems is user-orientated design and development that includes concepts for competency development under consideration of, e.g., ethical and legal aspects.

1. Introduction

In a context of globalized textile production with companies in low-wage countries featuring lower production costs than German enterprises [1], modern production machines in connection with digital technologies will be the prospective competitive basis of German textile industry. Mostly small and medium-sized enterprises (SMEs), they have to be enabled to profit, for example, from links of physical objects and virtual entities ("industry 4.0") in a suitable way. The digitalization of value-added processes and the necessity for employees to interact with intelligent systems connected to modern production systems create new tasks, work structures and processes with increasing complexity. Simultaneous to these demands, German textile manufacturers face a social challenge due to a staff structure characterized by heterogeneity and aging. One way to address this challenge is to provide assistance systems as a technical tool to support employees in different situations and operations, especially in improving their knowledge in a way adapted to their individual needs [2, 3].

2. Interdisciplinary research group SozioTex

In favour to let the implementation of such systems lead to work-integrated, socio-technical equipment and work systems and thus also to provide vocational and academic education along with new challenges, the integration of different perspectives has to be considered as crucial. To ensure the

consideration of both, the innovation in techniques and the social point of view, the interdisciplinary research group SozioTex comprising engineers, sociologists, and educational scientists was established. SozioTex aims at installing an assistance system for weaving operators which supports employees with different levels of qualification in successfully working in an "industry 4.0" setting. For this purpose, the team takes on the task of analyzing and evaluating the effects of increasing diversity as well as the increasing usage of highly complex "industry 4.0"-technology in the textile industry. So especially the ever-changing interaction of employees, machinery, control systems and work organization systems can be considered in an integrated, holistic manner.

3. Methodical approach

In general, the methodology of SozioTex (figure 1) can be described as an interdisciplinary, participative approach to the described task. The experts from different areas of expertise meet regularly and evaluate continuously their work with respect to the findings and preconditions of the other disciplines. Participation of stakeholders is embedded in the crucial steps of system development. First, a catalogue of requirements for assistance systems was framed by the research group [4]. It was generated by a wide range of empirical methods of social science, such as literature review, surveys, guided interviews, group discussions and observations in weaving mills, workshops and feedback by experts from the companies as well as industrial and scientific advisors.

Further, the SozioTex Team assessed the work process and details of task performing which led to the definition of critical work tasks requiring assistance. By taking into consideration the results of the further studies, concepts for the overall assistance system with its subcomponents and a qualification concept have been developed. At the end of the development phases, concept decisions were made, which are then followed by further development and implementation steps. The aim of the system construction is the implementation and evaluation of experimental prototypes. From the synthesis of these prototypes, a complete assistance system is developed. During the phase of system implementation, the assistance system is realized in a real-world condition lab, the textile learning factory in Aachen, Germany where it will be validated in user studies.
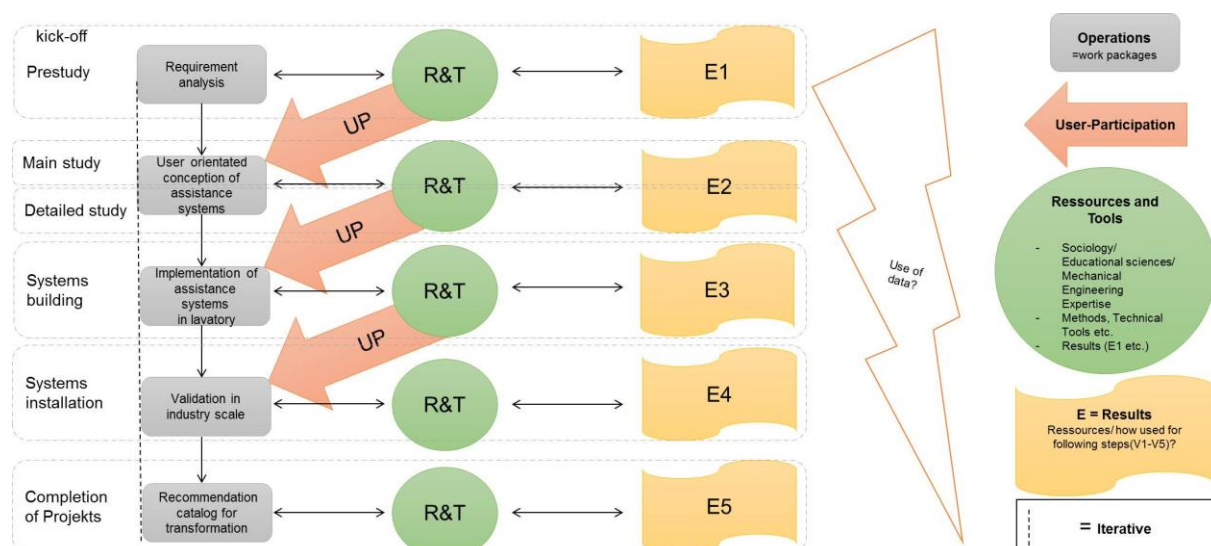

Figure 1. Methodical approach for designing sociotechnical systems exemplary on assistance systems.

A recommendation catalog for the design and implementation of assistance systems with the example of textile production will be drafted as project completion for the transfer of the project results. Furthermore, the implemented assistance system will be used in the textile learning factory for transfer activities such as workshops or training courses, beyond the course of the project.

4. System architecture

In order to support the future design of user oriented systems, a catalogue of requirements for assistance systems was developed, including technical, organizational/company-specific, individual-related and legal requirements. The assessment of task performing provided concrete tasks needing assistance so that the functionality of the assistance system could be specified. Based on these criteria, the SozioTex team developed the following system architecture (figure 2).
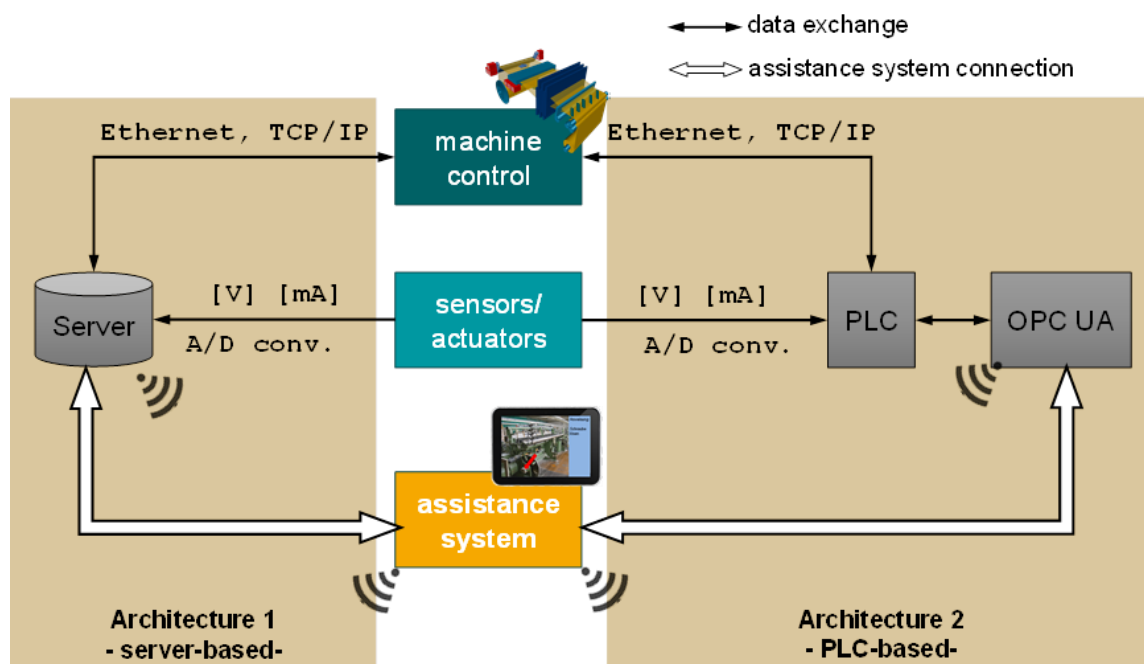
Figure 2. System architecture for assistance system.

The team designed prototypical applications (apps) which assist the operator of a weaving machine. These design variations were rated following economic criteria to identify a concept which will guide the conceptual systems design. To allow the transfer of findings to other industrial sectors, the team classified tasks needing support by an assistance system. Next results will be a technical realization of the chosen prototype and the examination of organizational implications.

5. Training concept

The development of a learning tool and the related teaching-learning situations in the technical work requires an analysis and description of organizational and person-centered occurrence as well as professional action situations. Within the framework of written surveys and work process analyzes, the necessary data are collected and analyzed in exemplary weaving mills [5, 6]. The qualification level in the examined weaving mills is at a high level, as almost all employees have completed vocational training in a textile profession. Through the tablet app as an assistance system, the individual work steps of the work process could be illustrated in detail and the work-in time, for example when new machine types were set up. According to the surveyed companies, further training and further

education are very important for competitiveness [5], so that the assistance system should support lifelong learning as well. Furthermore, there will be implemented self-learning elements for apprenticeships machine operators or production mechanics, whose experience and knowledge are still on a lower level. From the results of the work process analysis teaching-learning modules for the work-integrated further education are developed.

Didactic goal of the teach-learning module is the promotion of reflexive acting competencies concerning operation processes. Therefore, the focus of the learning situation will be on reflexive learning, especially on experience based learning. This stands out for an awareness of an action and the resulting reflection [7]. That's the reason why the production system of a weaving machine and the related production chain of a concrete process is the starting point to be able to offer theoretical knowledge as a reflection basis throughout the learning tool. Through appropriate work assignments from the learner's field of action, concrete goals are given as a point of reference for reflexive action. The reflections on the subject of the weaving machine and the superior textile process chain in the company will be promoted first. Furthermore the reflection concerning social processes, e.g. the interaction with colleagues in up- and downstream processes, will also been promoted. The learning tool provides step-by-step instructions through the work process as well as background materials for the increasing of knowledge. If the experience of the employees increases, they can skip individual explanations and action instructions, or the entire assistance function. Further, the assistance system will provide feedback to employees and information, e.g. in form of a result feedback, for the assessment and optimization of the own work results. [6]

6. Conclusion

To conclude, the adoption of such "industry 4.0" solutions in the textile industry and its effects on employees are assessed in cooperation with partners in industry and research and along with key user tests of demonstrator models. Furthermore, the compatibility of enterprises to processes is tested and recommended actions are deduced from best practice examples. To sum up, our contribution therefore shows an integrated interdisciplinary and participative approach to the conception of intelligent assistance systems in German textile production which aims at integrating both, critical economical-technical as well as social issues of "industry 4.0".

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