Knowledge and Expertise Sharing – Designing an AR-mediated Cyber-Physical Production System for Industrial Set-up Processes

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Abstract

Cyber-physical production systems (CPPS) are receiving a lot of attention in the context of the fourth industrial revolution. The present elaboration is rather based on the question of what support such systems can provide for the exchange and appropriation of knowledge-intensive human practices in industrial surroundings. This paper presents the method and conceptual foundations of an Augmented Reality (AR) and sensor technology based CPPS for manual set-up processes on production machines. In the present context, both the recording of physical movements and the representation of local knowledge are potentially relevant. The basis is formed by design implications identified in the course of an extensive ethnographic study through the implementation of which a new methodological approach to the capture and transfer of (technical) knowledge embedded in embodied actions could be realized.

Keywords: Augmented Reality, Cyber-Physical Production Systems, Design Case Study, Human-Computer Interaction, Industrial Set-Up, Knowledge and Expertise Sharing

Introduction

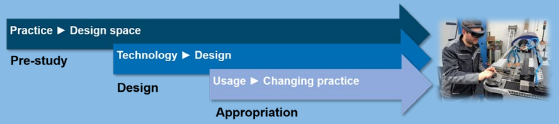
- Impact of customized products (Janssen & Möller, 2011):
  - increasing number of product variations
  - production of low batch sizes
  - increasing proportion of manuel set-up operations
- digital solutions (e.g., in the form of AR-based data glasses) combined with sensory input to reduce complexity and set-up time (Bhattacharya & Winer, 2019)

➢ *Challenge*: efficient handling of the knowledge-intensive (set-up) processes

➢ *Objective*: archiving and processing of knowledge embedded in embodied actions to support machine setters

Methodology

- Conduct a design case study (Wulf et al., 2011) to explore a user-centered design approach of a CPPS tool



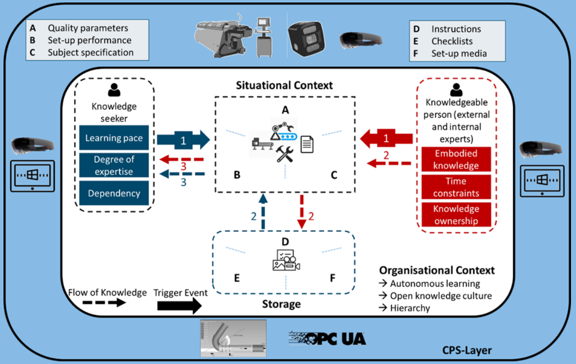
- Ethnographic approach
  - shadowing sessions and video recording with "Think Aloud" principle to collect in-situ data on work practices and social interactions
  - in-depth interviews (Hermanowicz, 2002) with 24 process-related employees from 4 different SMEs
  - thematic analysis (Braun & Clarke, 2012) and triangulation (Bryman, 2008) of the data

Participant	I	E	S	Role	Company	Education (u/s)	Job tenure
P1	x			Foreman	A	Graduated (u)	> 10 years
P2	x			Designer	A	Master school (s)	> 10 years
P3	x			Foreman	A	Master school (s)	> 10 years
P4	x			Production Engineer	A	Graduated(u)	> 10 years
P5	x	x		Machine setter	A	Master school (s)	< 10 years
P6	x	x		Machine setter	A	Master school (s)	< 10 years
P7	x	x	x	Machine setter	A	Apprenticeship (s)	> 10 years
P8	x	x	x	Machine setter	B	Apprenticeship (s)	< 10 years
P9	x	x		Machine setter	B	Apprenticeship (s)	< 10 years
P10	x	x		Machine setter	B	Apprenticeship (u)	< 10 years
P11	x	x	x	Machine setter / Foreman	B	Apprenticeship (u)	< 10 years
P12	x			Process Owner	B	Apprenticeship (s)	< 10 years
P13	x			Foreman	B	Master school (s)	> 10 years
P14	x			Technical salesman	B	Gratuated (s)	> 10 years
P15	x			Technical salesman	B	Master school (s)	> 10 years
P16	x			Construction Engineer	B	Gratuated (s)	> 10 years
P17	x			Technical salesman	B	Gratuated (s)	> 10 years
P18	x			Production Engineer	B	Gratuated (s)	> 10 years
P19	x			Quality Engineer	B	Gratuated (s)	< 10 years
P20	x	x		Foreman	B	Apprenticeship (s)	> 10 years
P21	x	x		Machine setter	C	Apprenticeship (s)	< 10 years
P22	x	x		Foreman	C	Master school (s)	> 10 years
P23	x	x		Machine setter	D	Apprenticeship (s)	< 10 years
P24	x			Production Engineer	D	Gratuated (s)	> 10 years

I: Interviews, E: Eye-Tracking, S: Shadowing. Education (u/s): Education (unspecialized/specialized)

Results

- Design implications
  1) timely and error-minimized provision of process-relevant information
  2) appropriate visualization of auditory as well as image and video-based content from a first-person perspective
  3) Monitoring of the working area as well as reduction of uncertainties through sensor technology
- Knowledge transfer model embedded in a CPS infrastructure



- CPPS tool: "Expert to Go"
  - AR data glasses Microsoft „HoloLens"
  - Basic functions
    - Writing Mode
    - Reading Mode
  - Context-specific and step-by-step visualization of set-up instructions including internal and external sensor data

Discussion & Conclusion

- Knowledge transfer of supposedly irrelevant, self-evident and banal as well as consciously withheld knowledge
- Suitability of the system for inexperienced machine setters or machine setters to be trained
- Striving for continuous optimization with regard to the constructive, ergonomic and technological design of data glasses for the benefit of user acceptance

References

- Bhattacharya, B., Winer, E.H.: Augmented reality via expert demonstration authoring (AREDA). Computers in Industry 105, pp. 61-79 (2019)
- Janssen, S., Möller, K: Erfolgreiche Steuerung von Innovationsprozessen und -projekten – Ergebnisse einer empirischen Studie. Zeitschrift für Controlling & Management 55(2), pp. 97-104 (2011).
- Wulf, V., Rohde, M., Pipek, V., Stevens, G.: Engaging with practices: Design case studies as a research framework in CSCW, Proceedings of CSCW '11, pp. 505-512 (2011).
- Hermanowicz, J.C.: The Great Interview: 25 Strategies for Studying People in Bed. QUALITATIVE SOCIOLOGY, vol. 25, no. 4, pp. 479–499 (2002).
- Braun, V., Clarke, V.: Thematic analysis. In: Cooper, H., Camic, P.M., Long, D.L., Panter, A.T., Rindskopf, D., Sher, K.J. (eds.) APA HANDBOOK OF RESEARCH METHODS IN PSYCHOLOGY, vol. 2., pp. 57–71, American Psychological Associa-tion, Washington DC (2012).
- Bryman, A.: Social Research Methods. Oxford University Press, New York (2008).

Acknowledgement

Research project "Cyberrüsten 4.0", funded by EFRE-0800263