DAEM 5 – 5th International Workshop on Designing Assistive Environments for Manufacturing

Sebastian Büttner[1], Mario Aehnelt[2], Mario Heinz[3], Henrik Mucha[4], Thomas Kosch[5]

Human-Centered Information Systems, Clausthal University of Technology, Clausthal-Zellerfeld, Germany[1]
Fraunhofer Institute for Computer Graphics Research (IGD), Rostock, Germany[2]
Institute Industrial IT (inIT), OWL University of Applied Sciences and Arts, Lemgo, Germany [3]
Fraunhofer Institute of Optronics, System Technologies, and Image Exploitation (IOSB), Karlsruhe, Germany[4]
Telecooperation Lab, TU Darmstadt, Darmstadt, Germany[5]

Executive Summary

After successfully organizing four workshops on "Designing Assistive Environments for Manufacturing" (DAEM) at PETRA 2017–2020, which all created valuable academic discussions, we want to consolidate the exchange and foster the community in this domain. Therefore, we propose a fifth DAEM workshop to be held at PETRA 2022. First experiences of new technologies, such as Augmented Reality or in-situ projection in the manufacturing domain, have been presented at our first workshop in 2017 and the evaluations show the potential that new technologies bring into the domain. Our following workshops in 2018, 2019, and 2020 focused on questions about how these systems affect work in the short and long run. Further, the papers showed the implications of assistive technologies in manufacturing environments. Still, lots of questions are open and new questions arose in the meantime. In our fifth workshop, DAEM 5, we intend to focus on how to improve job satisfaction with new trends in assistive technologies. This includes topics such as enhancing occupational health management as well as integrating voice-user interfaces or meaningful applications of artificial intelligence into the manufacturing workplace.

By proposing this workshop, we are eager to continue the discussion with researchers and professionals from the HCI community. We will take account of the current state of the art in order to provide an incentive for collaboration and to formulate research questions related to the design of assistive environments for manufacturing.

1 Goals

The fundamental change that is happening in manufacturing transforms the practice of

running independent manufacturing units to the implementation of novel and networked cyber-physical systems. The digitalization of industrial production, often referred to as "Industrie 4.0" (GER), "Industrial Internet of Things" (US), or "Industrie du Futur" (FRA), lays the groundwork for more flexible and efficient ways of producing goods. This new approach is often highly complex, putting strains on the operators and supervisors of such systems. Hence, new research questions related to the assistance of humans in the industrial context arise. In the last four years, we organized workshops on "Designing Assistive Environments for Manufacturing" (DAEM) at PETRA 2017, PETRA 2018, PETRA 2019, and PETRA 2020. The first half-day workshop in 2017 with five accepted papers created a first valuable academic exchange and established a cross-organizational community. With twelve accepted papers, the workshop was extended to a full-day workshop in 2018. The second workshop fostered the community that is in regular contact and actively driving the research topic in the form of joint research work, publications, and projects. In 2019, the workshop accepted eleven papers and contributed an additional invited talk held by Prof. Oliver Korn. In 2020, we accepted three papers that consolidated how artificial intelligence and developments in augmented reality lead to an improvement in assembly performance. Due to the pandemic, we had to skip the workshop in 2021. Building on these successful workshops in the years 2017–2020, we seek again to assemble researchers and practitioners from HCI in order to continue pushing the research agenda related to the design of assistive environments for manufacturing and to discuss the latest research results. The workshop will intensify existing collaborations, help to establish new ones, and provide a platform for exchanging ideas relevant to the domain. Of course, we welcome both recurring and new participants for this workshop.

2 Organizational Details and List of Topics

For PETRA 2022, we envision a full-day workshop. The workshop will be organized in the following way: First, we will begin with a short opening presentation with background on our workshop, followed by a short kick-off activity, where participants get to know each other. Second, we will take account of the state of the art by having workshop participants present their submitted papers to the group and a succeeding discussion for each of the presentations. All papers will be classified according to their topic and presented within about three sessions. Finally, we will conclude the workshop with a wrap-up session in the later afternoon. All participants will be encouraged to have a joint dinner in the evening to continue vivid discussions in a more informal setting. We plan to publish the workshop papers along with the PETRA 2022 proceedings in order to make them accessible to everyone interested in the design of assistive environments for manufacturing. Topics of submissions are encouraged but not limited to covering the following areas of assistive environments for manufacturing:

Concepts

- New interaction concepts for assistive environments
- Combining cognitive and physical assistance at the workplace
- Tools and design techniques
- Transfer of HCI concepts into industrial practice

Industrial Applications of Assistive Technology

- For stationary or mobile assembly tasks
- For monitoring or controlling cyber-physical systems
- Assistance through Human-Robot Collaboration
- Learning and Education
- Assistive systems for special needs

Technologies and Devices

- Augmented Reality and Virtual Reality
- Projection-based interfaces
- Remote and Collaborative Working
- Voice-User Interfaces
- Proxemic Interaction
- Artificial Intelligence
- Mobile and wearable devices
- Industrial Internet of Things (IIoT)
- Haptic Enhancement of Digital Experiences
- Physiological Computing

Methodology

- Usability and user experience of assistive environments in industry
- Prototyping AR and VR
- Evaluation methods
- User and cognitive models

3 Publications Relevant to the Workshop

Aehnelt, M., Bader, S. (2016): *Providing and Adapting Information Assistance for Smart Assembly Stations*. In: Proceedings of the SAI Intelligent Systems Conference (IntelliSys) 2016, London, UK. 21-22 September 2016. IEEE, pp. 314-323, ISBN: 978-1-5090-1121-6

Aehnelt, M., Bader, S. (2015): *From Information Assistance to Cognitive Automation: A Smart Assembly Use Case*. In: Béatrice Duval, van den Herik, Jaap, Stephane Loiseau und Joaquim Filipe (Hg.): Agents and artificial intelligence. 7th international conference, ICAART 2015, Lisbon, Portugal, January 10-12, 2015 : revised selected papers. Cham, Heidelberg: Springer (Lecture Notes in Computer Science, 9494), pp. 207–222.

Aehnelt, M., Bader, S. (2015): *Information Assistance for Smart Assembly Stations*. In: Stephane Loiseau, Joaquim Filipe, Béatrice Duval und van den Herik, Jaap (Hg.): Proceedings of the 7th International Conference on Agents and Artificial Intelligence (ICAART 2015), vol. 2. Lisbon, 10 - 12 January 2015. 2 Volumes. Lisbon, Portugal: SciTePress (2), pp. 143-150. http://dx.doi.org/10.5220/0005216501430150.

Aehnelt, M., Urban, B. (2014): *Follow-Me: Smartwatch Assistance on the Shop Floor*. In: Fiona Fui-Hoon Nah (Hg.): HCI in Business, Bd. 8527: Springer International Publishing (Lecture Notes in Computer Science), pages 279–287. http://dx.doi.org/10.1007/978-3-319-07293-7_27.

Büttner, S., Funk, M., Sand, O. & Röcker, C. (2016). *Using Head-Mounted Displays and In-Situ Projection for Assistive Systems – A Comparison.* In Proceedings of the 8th ACM International Conference on PErvasive Technologies Related to Assistive Environments (PETRA '16).

Büttner, S., Prilla, M., & Röcker, C. (2020, April). *Augmented Reality Training for Industrial Assembly Work-Are Projection-based AR Assistive Systems an Appropriate Tool for Assembly Training?*. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1-12).

Büttner, S., Sand, O. & Röcker, C. (2015). *Extending the Design Space in Industrial Manufacturing Through Mobile Projection.* In Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct (MobileHCI '15). ACM, New York, NY, USA.

Büttner, S., Sand, O., & Röcker, C. (2017, April). *Exploring Design Opportunities for Intelligent Worker Assistance: A New Approach Using Projetion-Based AR and a Novel Hand-Tracking Algorithm.* In *European Conference on Ambient Intelligence* (pp. 33-45). Springer, Cham.

Büttner, S., Mucha, H., Funk, M., Kosch, T., Aehnelt, M., Robert, S., & Röcker, C. (2017, June). *The design space of augmented and virtual reality applications for assistive environments in manufacturing: a visual approach.* In Proceedings of the 10th International Conference on PErvasive Technologies Related to Assistive Environments (pp. 433-440). ACM.

Funk, M., Bächler, A., Bächler, L., Korn, O., Krieger, C., Heidenreich, T. & Schmidt, A. (2015). *Comparing projected in-situ feedback at the manual assembly workplace with impaired workers.* Proceedings of the 8th ACM International Conference on Pervasive Technologies Related to Assistive Environments

Funk, M., Mayer, S. & Schmidt, A. (2015) *Using In-Situ Projection to Support Cognitively Impaired Workers at the Workplace.* Proceedings of the 17th international ACM SIGACCESS conference on Computers & Accessibility.

Funk, M., Shirazi, A.-S., Mayer, S., Lischke, L. & Schmidt, A. (2015) *Pick from here!: an interactive mobile cart using in-situ projection for order picking.* Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing. ACM

Heinz, M., Büttner, S., & Röcker, C. (2019, June). *Exploring training modes for industrial augmented reality learning.* In Proceedings of the 12th ACM International Conference on PErvasive Technologies Related to Assistive Environments (pp. 398-401).

Hoffmann, C., Büttner, S., Prilla, M., & Wundram, K. (2020, September). *Impact of augmented reality guidance for car repairs on novice users of AR: a field experiment on familiar and unfamiliar tasks.* In Proceedings of the Conference on Mensch und Computer (pp. 279-289).

Knierim, P., Kosch, T., Groschopp, J., & Schmidt, A. (2020, April). Opportunities and Challenges of Text Input in Portable Virtual Reality. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems* (pp. 1-8).

Korn, O., Funk, M. & Schmidt, A. (2015). *Assistive Systems for the Workplace: Towards Context-Aware Assistance.* Assistive Technologies for Physical and Cognitive Disabilities 121-133.

Korn, O., Funk, M., Abele, S., Hörz, T. & Schmidt, A. (2014). *Context-aware assistive systems at the workplace: analyzing the effects of projection and gamification.* Proceedings of the 7th International Conference on PErvasive Technologies Related to Assistive Environments. ACM

Kosch, T., Kettner, R., Funk, M., & Schmidt, A. (2016, October). *Comparing tactile, auditory, and visual assembly error-feedback for workers with cognitive impairments*. In Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility (pp. 53-60). ACM.

Kosch, T., Abdelrahman, Y., Funk, M., & Schmidt, A. (2017, September). *One size does not fit all: challenges of providing interactive worker assistance in industrial settings*. In Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers (pp. 1006-1011). ACM.

Kosch, T., Funk, M., Schmidt, A., & Chuang, L. L. (2018). *Identifying Cognitive Assistance with Mobile Electroencephalography: A Case Study with In-Situ Projections for Manual Assembly.* Proceedings of the ACM on Human-Computer Interaction, 2(EICS), 11.

Kosch, T., Wennrich, K., Topp, D., Muntzinger, M., & Schmidt, A. (2019, June). *The Digital Cooking Coach: Using Visual and Auditory In-Situ Instructions to Assist Cognitively Impaired during Cooking*. In Proceedings of the 12th ACM International Conference on Pervasive Technologies Related to Assistive Environments, New York, NY, USA, 2019, p. 156–163.

Murauer, N., Müller, F., Günther, S., Schön, D., Pflanz, N., & Funk, M. (2018, June). An Analysis of Language Impact on Augmented Reality Order Picking Training. In *Proceedings of the 11th PErvasive Technologies Related to Assistive Environments Conference* (pp. 351-357). ACM.

Mucha, H., Büttner, S., Röcker, C. (2016). *Application Areas for Human-Centered Assistive Systems*. In: Human-Computer Interaction – Perspectives on Industry 4.0. Workshop at i-KNOW 2016 Graz, Austria, Oct 2016.

Nowak, A., Knierim, P., Romanowski, A., Schmidt, A., & Kosch, T. (2020, April). What does the Oscilloscope Say?: Comparing the Efficiency of In-Situ Visualisations during Circuit Analysis. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems* (pp. 1-7).

Paelke, V., Röcker, C., Koch, N., Flatt, H. & Büttner, S. (2015). *User interfaces for cyber-physical systems*. In at-Automatisierungstechnik, Volume 63, Issue 10, pages 833-843.

Sand, O., Büttner, S., Paelke, V. & Röcker, C. (2016). *smARt.Assembly: Projection-Based Augmented Reality for Supporting Assembly Workers.* In Proceedings of the 18th International Conference on Human-Computer Interaction (HCII '16). Springer, Heidelberg, Germany.

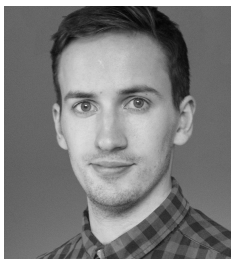
4 Workshop Organizers

Sebastian Büttner

Sebastian Büttner studied Business Administration with Computer Science at Darmstadt University of Technology (Germany), with stays at KTH Royal Institute of Technology and Mobile Life VINN Centre in Stockholm (Sweden) and at Tongji University in Shanghai (China). He finished his studies in 2010 and worked in industry and academia for several years. Since 2015, he has been a research assistant at the HCI Lab at OWL University of Applied Sciences and Arts in Lemgo, Germany. In addition, Sebastian joined the group "Human-Centered Information Systems" at Clausthal University of Technology (Germany) in 2018 as a PhD student. His research interest lies in the application of Augmented Reality technologies – more specifically, in-situ projections – in an industrial context.

Mario Aehnelt

Mario Aehnelt studied computer science and psychology at the University of Rostock. Since 2002 he is a member of the scientific staff at Fraunhofer IGD. There his research is focused on the seamless interlinking of knowledge, learning and work processes at the workplace. He holds a PhD in Computer Science from the University of Rostock. His main research topic is the design of assistance technologies for the manufacturing workplace based on visual computing and cognitive automation. Mario organizes and moderates annual scientific and industrial workshops, e.g. the ACM International Workshop on Sensor-based Activity Recognition and Interaction (http://iwoar.org) or the Go-Visual science meets business workshop in Berlin (http://igd-r.de/govisual).



Mario Heinz

Mario Heinz is currently working as a research assistant at the HCI Lab at OWL University of Applied Sciences and Arts in Lemgo, Germany. He holds a bachelor degree in computer science and a master degree in cognitive and movement science from Bielefeld university. His research is focused on interaction devices and feedback technologies for assistive systems in industrial contexts.

Henrik Mucha

Henrik Mucha currently works as a researcher at the Fraunhofer Institute of Optronics, System Technologies, and Image Exploitation (IOSB), Karlsruhe, Germany. Henrik holds degrees in Industrial Design (Dipl.-Des., University Duisburg Essen) and Usability Engineering (M.Sc., Rhine-Waal University of Applied Sciences). Henrik focuses on design approaches such as participatory design and their evolution in face of new technological developments such as AI. His current work is concerned with usability, user experience, and interaction design for decision support systems in expert domains.

Thomas Kosch

Thomas Kosch studied Software Engineering at the University of Stuttgart in Germany with a focus on signal processing algorithm design, analysis of physiological sensory data, and implementation of context-aware computing systems. He was a PhD student at the Ludwig-Maximilian University of Munich under the supervision of Albrecht Schmidt and is currently a postdoctoral researcher in the Telecooperation Lab at the Technical University of Darmstadt. His research primarily encompasses the analysis and interpretation of physiological sensory data to explore its use in adaptive computer environments, influence on self-awareness through understandable visualizations, and the creation of new methods to objectively quantify cognitive states. He is generally interested in physiological sensing in combination with recent advancements in artificial intelligence to understand the individual's cognition during interaction. His research was successfully evaluated in practical real-world environments with several industrial research partners.