

INSTITUT FÜR  
MANAGEMENTWISSENSCHAFTEN  
Human Centered Cyber Physical  
Production and Assembly Systems

# Concept Presentation for the 25<sup>th</sup> TÖK

Task Allocation between Humans and Collaborative Robots in Assembly  
24.05.2019; Graz

Christina Schmidbauer, MSc

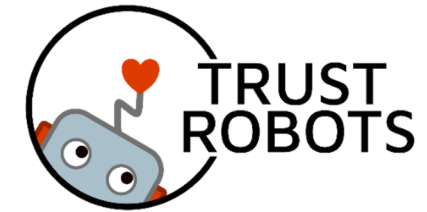
Doctoral College *TrustRobots*

Research area *Human Centered Cyber Physical Production and Assembly Systems*

TU Wien – Institute for Management Science

**TU Wien:**

Technology for People



**Doctoral College TrustRobots:**

How should/can/will our life with robots look like in the future?



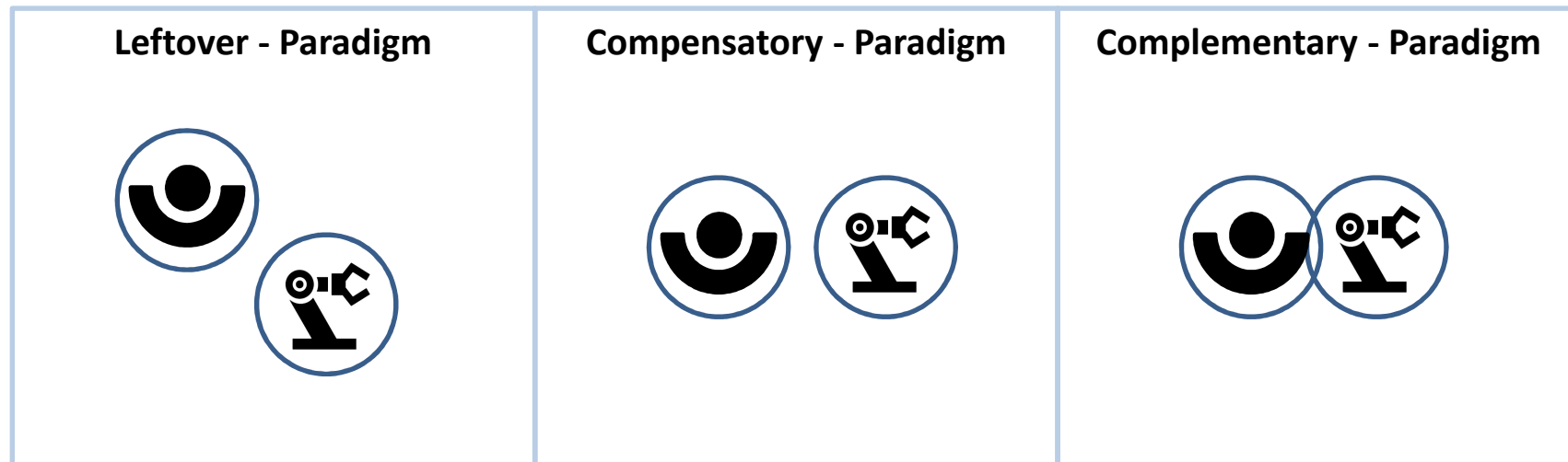
Pepper, Living Lab, Library, TU Wien



Panda, Living Lab, Library, TU Wien

## State of Research:

- 3 Paradigms:



### Leftover-Paradigm

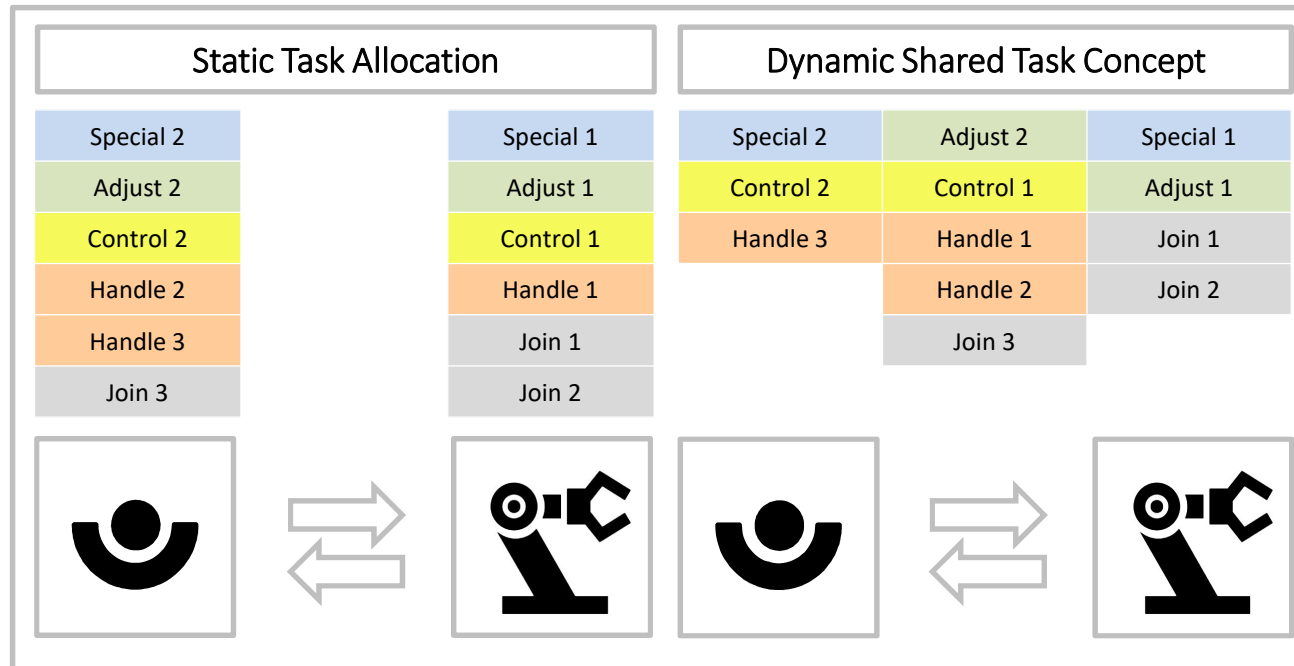
- (1) Bainbridge L., 1982. Ironies of Automation. IFAC Analysis, Design and Evaluation of Man-Machine Systems, Vol. 15, Issue 6 September, pp. 129-135.
- (2) Challenger R., Clegg C. W. & Shepherd C., 2013. Function Allocation in complex systems: reframing an old problem. Ergonomics, Vol. 56, No. 7, pp. 1051-1069.
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### Compensatory-Paradigm

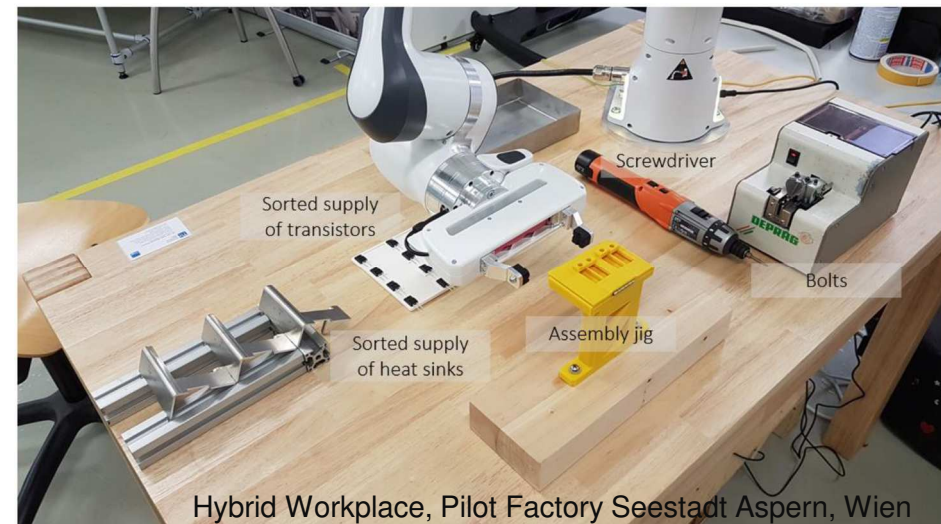
- (1) Fitts P., 1951. Human engineering for an effective air navigation and traffic control system. National Research Council, Washington, DC.
- (2) Dekker S. W. A. & Woods D. D., 2002. MABA-MABA or Abracadabra? Progress on human-automation coordination. Cognition, Technology & Work, 4(4), pp. 240-244.
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- (4) de Winter J. C. F. & Dodou D., 2014. Why the Fitts list has persisted throughout the history of function allocation. Cogn Tech Work, 16:1-11.
- (5) Ranz F., Hummel V. & Sihm W., 2017. Capability-based task allocation in human-robot collaboration. 7<sup>th</sup> Conference on Learning Factories, CLF 2017, Procedia Manufacturing 9, 182-189.
- (6) Michalos G., Spiliotopoulos J., Makris S. & Chryssolouris G., 2018. A method for planning human robot shared tasks. CIRP Journal of Manufacturing Science and Technology 22, 76-90

### Complementary-Paradigm

- (1) Bradshaw J. M., Feltovich P. & Johnson M., 2011. Human-Agent Interaction. [Online] Available at: <https://www.researchgate.net/publication/267819585>.
- (2) Jordan N., 1963. Allocation of functions between man and machines in automated systems. Journal of Applied Psychology, 47(3), pp. 161-165.
- (3) Lagu A. & Landry S., 2011. Roadmap for the Next Generation of Dynamic Function Allocation Theories and Strategies. Human Factors and Ergonomics in Manufacturing & Service Industries 21 (1) 14-28.
- (4) Goodman T., Miller M. & Rusnock., 2015. Incorporating Automation: Using Modeling and Simulation to enable task re-allocation. Proceedings of the 2015 Winter Simulation Conference. 2388-2399.
- (5) Nikolakis N., Kousi N., Michaelos G. & Makris S., 2018. Dynamic Scheduling of shared human-robot manufacturing operations. 51<sup>st</sup> CIRP Conference on Manufacturing Systems. Procedia CIRP.



- Design
- Implementation
- Evaluation



How to design a method  
in order to dynamically allocate tasks during assembly,  
between a human and a collaborative robot  
in regard to an increase in productivity and  
improving human working conditions.

Through the dynamic sharing of tasks in assembly...

**I. the productivity** is increased

(compared to manual or fully automated processes, especially with regard to small order sizes)

**II. the adaptability** of the process is increased

(concerning e.g., small order sizes)

**III. the skill set** of the worker is increased

(caused by the job enrichment, which comes along with the dynamic approach, including the situation awareness and willingness to learn)

**IV. the workers job satisfaction** for his/her work is increased

(caused by the job enrichment, which comes along with the dynamic approach. The arising complexity could also cause a mental overstrain of the human worker)

Stage	What to do?	How to do that?
Problem Definition & Scoping	<ul style="list-style-type: none"> <li>Theory of static task allocation methods</li> <li>Theory of dynamic task allocation</li> <li>Classification of tasks</li> </ul>	<ul style="list-style-type: none"> <li>Literature research</li> <li>Bachelorthesis "Current applications in practice"</li> <li>Hands-on in industrial project "Dynamic Shared Tasks"</li> </ul>
Design & Development	<ul style="list-style-type: none"> <li>Identify decision criteria to identify which tasks are shareable</li> <li>Identify decision criteria to allocate tasks dynamically in practice</li> <li>Define methodology for dynamic task allocation</li> </ul>	<ul style="list-style-type: none"> <li>Project „Dynamic Shared Tasks“</li> <li>Literature supported further development of methodology</li> </ul>
Demonstration & Evaluation	<ul style="list-style-type: none"> <li>Demonstration of concept of methodology on effects on process stability and human factors</li> <li>Evaluation and adaption of methodology</li> </ul>	<ul style="list-style-type: none"> <li>Experiment on "Process stability/system awareness"</li> <li>Experiment on "effects on human factors"</li> </ul>

Current Status: finished  
ongoing  
open

- (1) Agnew, A., Forrester, P., Hassard, J. & Procter, S., 1997. Deskillung und Reskilling within the labour process: The case of computer integrated manufacturing. *Int. J. Production Economics* 52, pp. 317-324.
- (2) Ansari, F., Selim, E. & Sihm, W., 2018. Rethinking Human-Machine Learning in Industry 4.0: How does the Paradigm Shift Treat the Role of Human Learning?. *Procedia Manufacturing* 23 (2018), 8th Conference on Learning Factories 2018 - Advances Engineering Education & Training for Manufacturing Innovation, pp. 117-122.
- (3) Bainbridge, L., 1982. Ironies of Automation. *IFAC Analysis, Design and Evaluation of Man-Machine Systems*, Vol. 15, Issue 6 September, pp. 129-135.
- (4) Bauer, W. et al., 2016. Lightweight robots in manual assembly - best to start simply!, Stuttgart: Fraunhofer Institute for Industrial Engineering IAO.
- (5) Beumelburg K., 2005. Fähigkeitsorientierte Montageablaufplanung in der direkten Mensch-Roboter-Kooperation. Approved Dissertation, Institut für Industrielle Fertigung und Fabrikbetrieb (IFF), University of Stuttgart.
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- (7) Britzke, B., 2010. MTM in einer globalisierten Wirtschaft. Arbeitsprozesse systematisch gestalten und optimieren.. 1. Hrsg. München: mi-Wirtschaftsbuch, FinanzBuch Verlag GmbH.
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- (17) Michalos, G., Spiliotopoulos, J., Makris, S. & Chryssolouris, G., 2018. A method for planning human robot shared tasks. *CIRP Journal of Manufacturing Science and Technology* 22, pp. 76-90.
- (18) Nikolakis N., Kousi N., Michaelos G. & Makris S., 2018. Dynamic Scheduling of shared human-robot manufacturing operations. 51<sup>st</sup> CIRP Conference on Manufacturing Systems. *Procedia CIRP*.
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