CYCLE TIME OPTIMISATION IN SELF-ORGANISING PRODUCTION LINES WITH HUMAN MACHINE COLLABORATION

Titanilla Komenda, Wilfried Sihn

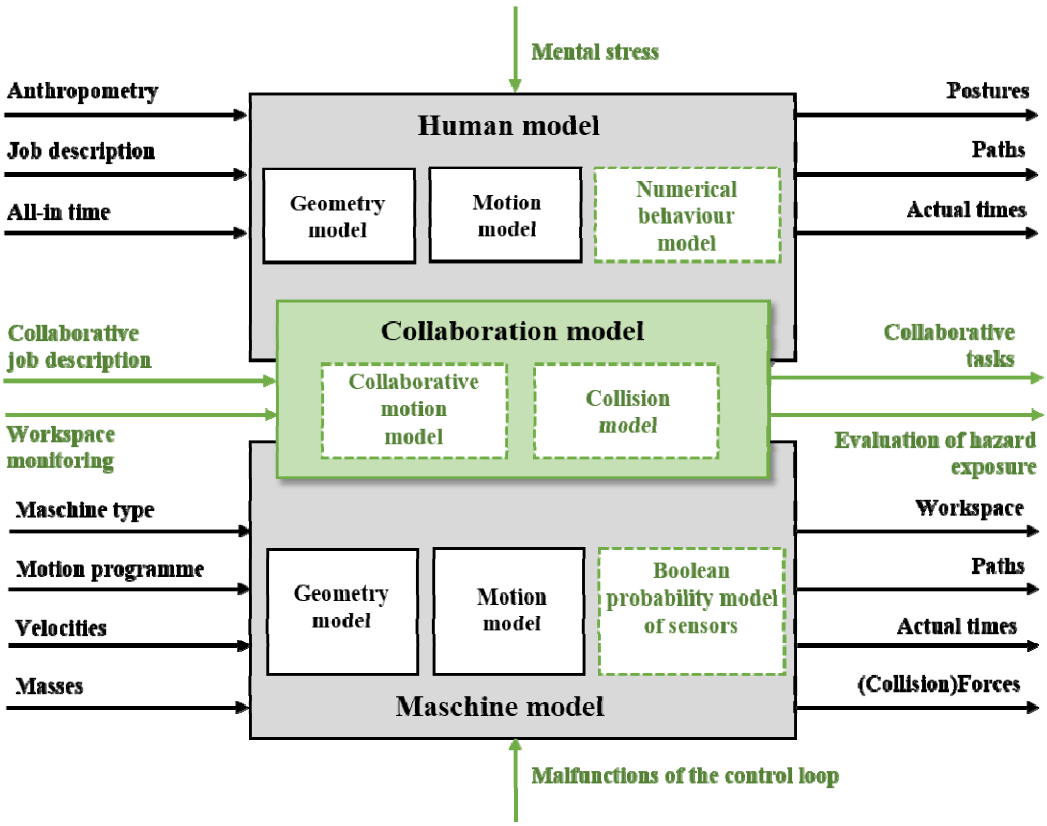
E330 - Institute of Management Science at TU Wien

INTRODUCTION

Human machine collaboration refers to humans directly working together with machines on the same workpiece and in the same workspace. In self-organising production lines, humans and machines determine their location of collaboration based on different parameters individually. Thus, cycle time estimation is not trivial, as it depends on order sequence, availability, distance to other collaboration partners, motion parameters and obstacles on the path [1]. In this sense, there is a need for a simulation model, predicting cycle time for this kind of production lines.

MAIN IDEA AND RESEARCH FIELDS

Even though, digital machine and human models already exist to do feasibility, cycle time and ergonomic analyses, they are not used for a consistent planning process in terms of cycle time estimation of collaborative tasks [2]. State-of-the-art simulation tools consider humans and machines separately when it comes to cycle time estimation [3]. One of the main reasons is the different approach regarding motion modelling [4]. As digital human models are also considered as multi-body systems, the high complexity of human motion modelling leads to a lack of performing tasks on moved objects [5]. Furthermore, models mapping malfunctions of the control system or the psychophysiology of humans are not existent and integrated in such consistent process planning tools [6].



Picture 1: Extended model parameters for human machine systems

RESEARCH ACTIVITIES AND RELEVANCE

In this sense, influencing factors of cycle time in collaborative tasks are analyzed [7]. A simulation model is developed, considering not only motion models but also a logical model of the control system including malfunctions as well as a psychophysiological model of collaborative partners. Based on an analysis and classification of collaborative tasks, requirements for modelling human machine collaboration are defined. The collaborative system is then modelled as a simulation-ready hybrid model [8], which is optimised by a multi-criteria optimisation considering production requirements and constraints. Even though, design parameters for collaborative tasks are often in conflict with cycle time and productivity, there is an optimal set of collaborative parameters meeting this trade-off. Based on multi-criteria optimisation an optimal set of physical, psychophysiological and operational costs can be determined for each step of production. The application of the model is shown on different use-cases.

ACKNOWLEDGEMENT

This project was initially funded by the Federal Ministry for Transport, Innovation and Technology (bmvit). Experiments validating the simulation model were performed in the TU Wien Industry 4.0 Pilot Factory, located in the Aspern Technology Center of the Vienna Business Agency. The Pilot Factory is partly funded by the Federal Ministry for Transport, Innovation and Technology (bmvit), the Vienna University of Technology (TU Wien) and participating companies.

REFERENCES

[1] Cherubini, A., Passama, R., Crosnier, A., Lasnier, A. und Fraisse, P. 2016, ‘Collaborative manufacturing with physical human-robot interaction’, Robotics and Computer-Integrated Manufacturing, Band 40, Ausgabe August 2016, S. 1-13.

[2] Leidholdt, W. 2014, ‘Die Simulation von Mensch-Roboter-Kollaboration – unabdingbar für die Prozessgestaltung’, in Produktion und Arbeitswelt 4.0. Aktuelle Konzepte für die Praxis: TBI2014 – 15. Tage des Betriebs- und Systemingenieurs, E. Müller (Hrsg.), Wissenschaftliche Schriftenreihe des Instituts für Betriebswissenschaften und Fabriksysteme, Chemnitz, S. 109-115.

[3] Komenda, T., Malisa, V. und Leidholdt, W. 2016, ‘Modellierung von Arbeit an bewegten Objekten. Digitale Menschmodelle für Mensch-Maschine-Kollaboration’, atp edition. Automatisierungstechnische Praxis, Band 2016, Ausgabe 12, München, S. 34-43.

[4] Komenda, T. und Leidholdt, W. 2016, ‘ema – a Software Tool for Planning Human-Machine-Collaboration’, SNE Simulation Notes Europe, Band 26, Ausgabe 1, Wien, S. 27-32.

[5] Komenda, T. und Breitenecker, F. 2016b, ‘Modellierung von Arbeit an bewegten Objekten in kollaborativen Betriebsformen’, in Proceedings of the 23rd Symposium Simulationstechnik (ASIM 2016), T. Wiedemann (Hrsg.), ARGESIM, Dresden, S. 17-23.

[6] Komenda, T. und Breitenecker, F. 2016a, ‘Nonlinearity in Collaborative Applications incorporating Humans and Machines: Identification and Modelling’, in Proceedings of the Vienna Young Scientists Symposium (VSS), B. Ullmann (Hrsg.), Book-of-Abstracts.com, Wien, S. 94-95.

[7] Komenda, T. 2016, ‘Systematic Analysis of Collaborative Human-Machine-Scenarios: Task Execution on Moved Objects’, in Proceedings of the 14th Industrial Simulation Conference (ISC’14), N. Vasiliu (Hrsg.), EUROSIS-ETI, Bucharest, S. 47-49.

[8] Deatcu, C. und Pawletta, T. 2009, ‘Towards Dynamic Structure Hybrid DEVS for Scientific and Technical Computing Environments’, SNE Simulation Notes Europe, Band 19, Ausgabe 3-4, S. 75-78.