Design and evaluation of a cooperative supervision system based on supervisory control theory and human centered design

Start date : end of 2017 or start of 2018 (3 years)

Funding : ANR project - HUMANISM (HUman-MAchines CooperatioN for flexIble production SysteMs)

Supervisors :

Co-Phd Supervisor :	Co-Phd Supervisor :
Serge Debernard, Professeur des Universités	Bernard Riera, Professeur des Universités
LAMIH UMR CNRS 8201	CReSTIC, EA 3804
Campus du Mont Houy	UFR Sciences Exactes et Naturelles
Université de Valenciennes et du Hainaut Cambrésis	Université de Reims Champagne-Ardenne
	Moulin de la Housse - BP 1039
59313 Valenciennes Cedex 11	51687 REIMS Cedex 2
Email : serge.debernard@univ-valenciennes.fr	Email : bernard.riera@univ-reims.fr
Web : http://www.univ-valenciennes.fr/LAMIH/	Web : http://crestic.univ-reims.fr/

Registration: Ecole Doctorale Sciences Pour l'Ingénieur Université Lille Nord-de-France

Topic:

The PHD thesis is in line with the problem of Industry 4.0 and the massive use of cyber-physical systems to design intelligent manufacturing systems (IMS) with self-organizing properties allowing greater flexibility of production and better adaptation to hazards. Nevertheless, these approaches do not guarantee an overall optimization of the performance as well as its safety of operation. Moreover, the use of a self-organized command approach can generate behaviors emerging from the operative part leading, for example, to blocking or congestion situations, which could be difficult to understand for a supervisory operator, in particular during slow drifts of settings.

The research to be carried out should therefore consider the Human Operator (HO) at the center of the plant to monitor, understand, decide and pilot by proposing to him advanced supervisory tools which allow him to optimize production on the one hand, and on the other hand, to manage abnormal and unanticipated situations and which constitute a crucial stake for the safety of the HMS. The multiple levels of constraints of the manufacturing process and its dynamic nature involve identifying and combining information in a meaningful way so that the operator retains control of this system.

The approach will be dual by combining supervisory control theory (SCT) approaches and the human centered automation approach and more precisely, Human-Machine Cooperation, with application to the flexible cell of the AIP Valenciennes:

- In the first approach, the control is considered as a black box. The SCT-oriented methods and tools developed by CReSTIC are based on the definition of a filter, checked offline by model checking, to guarantee the safety of the production system, independently of the controller. Therefore, it is possible to formally guarantee the safety of self-organized control systems, whose

behaviors, by definition, are not predictable. In addition, during failures of the IMS, manual or semi-automatic resumption by the HO will be necessary. The filter approach offers interesting possibilities for the design of human-machine cooperation tools, which should be developed. Finally, the filter relies on identification and modeling of the process through the definition of logical constraints. The latter have a strong explanatory power and can a priori allow the development of identification, monitoring and prediction tools providing the HO with pertinent information to guarantee its understanding of the situation and to support its decision making.

- On the contrary, the second approach seeks to modify the current algorithms of self-organized control so as to create points of possible interaction with the supervision operator, these points allowing, on the one hand, this operator to access Information enabling it to understand the situation other than by considering the outputs of this system and on the other hand by giving it the possibility of controlling the operative part with higher-level controls than those acting directly on the physical system. To do this, the Cognitive Work Analysis (CWA) method will be deployed to define the human information needs and the LAMIH human machine cooperation approaches used to define the tools and associated interfaces.

These proposed algorithms and H-M Interfaces will be tested using simulation tools, and implemented on the AIP cell (Figure 1), in order to evaluate them with supervisory operators in the context of swarm intelligent products.

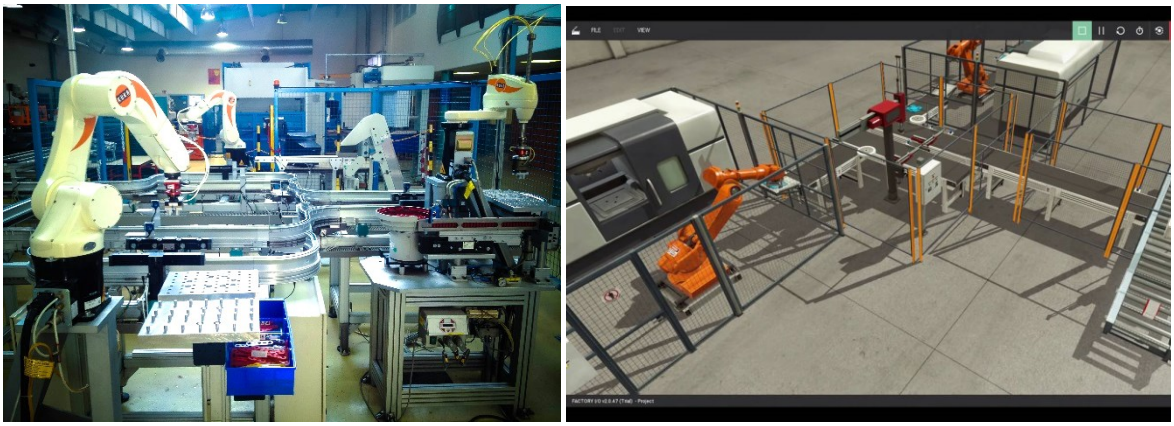

Figure 1: Inter-university Workshop of Production (AIP PRIMECA) of the University of Valenciennes and Factory IO a 3D factory Simulation Software

The PHD student will be located on Valenciennes University but several trips are to be expected to Reims University.

Funding:

PhD thesis will be financed during 3 years (ANR funding).

Skills / Candidate profile:

Candidates must have a strong background in Automation and Industrial Computing, especially in discrete events systems, and be fluent in English. Experiences regarding Human Factors will be appreciated.

Candidature:
The candidature file must be composed by:

- One page CV
- Application letter in English revealing the motivation

- Two last years' Master or Engineering school transcripts and class ranking if possible
- Recommendation letter from professors concerned by the PhD thesis topic
- Any documents deemed useful by the candidate

Contact**:** Serge Debernard, Professeur des Universités, Email : serge.debernard@univ-valenciennes.fr

Applications must be sent before end of november 2017 to: serge.debernard@univ-valenciennes.fr.

References:

Chauvin C., Rauffet P., Tréhin M., Berruet P., Lassalle J. (2015) Using Cognitive Work Analysis to design smart-grid interface, Human Factors and Ergonomics Society, October 14-16, Groningen, The Netherlands.

MARANGÉ P., DEBERNARD S., GELLOT F., PACAUX-LEMOINE M., PHILIPPOT A., POULAIN T., RIERA B., PÉTIN J. (2014). Approach to detection and explanation of control by a robust filter. Journal Européen des Systèmes Automatisés JESA, vol. 48, n° 4-5-6, pp. 339-372.

DEBERNARD S., RIERA B., POULAIN T. (2014). The Common Work Space for the Support of Supervision and Human–Machine Cooperation. In P. Millot (Ed.), Designing Human-Machine Cooperation Systems, ISTE-Wiley, London, pp. 285-342, ISBN 9781848216853.

Ramadge, P.J., & Wonham, W.M. (1987). Supervisory control of a class of discrete event processes. SIAM J Control Optim., 25(1), 206 -230.

Riera B. Philippot A., Coupat R., Gellot F., Annebicque D. A non-intrusive method to make safe existing PLC Program. 9th IFAC Symposium on Fault Detection, Supervision and Safety for Technical Processes (SAFEPROCESS'15), Paris, France.

Zaytoon J., B. Riera (2017) Synthesis and implementation of logic controllers – A review, Annual Reviews in Control, http://dx.doi.org/10.1016/j.arcontrol.2017.03.004