From integration to augmentation, from interaction to collaborative control - IE/MS frontiers for future work and factories

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When we study the emerging and amazing future of work and future factories, with curiosity and with serious intention to be prepared for them, we realize: Humans must always be in the loop, but differently. There seem to emerge certain role reversals, with interesting and useful transformations. How do we interact with collaborative robots? Can machine learning mean that machines instruct us what to do correctly and safely, just before we are about to make a mistake? And even earlier? What about workers' attention and awareness - which human or machine agents will know to alert us? What about big data and learning engineering? Collaborative intelligence and control with just-in-time and just-if-needed knowledge and skills, exchanged by materials and machines that think together with us? Research and education with skill sharing, pre-skilling, and re-skilling, where knowledge evolves and is mined by cyber agents for us? Economics and rationalization of new, yet unknown technologies? In all these frontiers, IE and MS professionals are already rethinking and reexamining our need and opportunity to transform.

Augmenting collaborative interactions of distributed production and service through e-Work, robotics and cyber-physical systems is becoming increasingly feasible, yet challenging. Now widely desired solutions to overcome obstacles in supply networks, manufacturing, transportation, agriculture, healthcare, security, and more are becoming scientifically and technologically possible. Research and implementation of such cyber-augmented collaboration require understanding of human and organizational augmentation needs for productive, smooth, and effective performance. Such knowledge, which depends on collaborative cyber-physical production and operations, is strengthened by multi-brain models, machine learning, and intelligent control, on the way to achieving the production and service goals. At the heart of cyber- physical augmentation is the Collaborative Control Theory (CCT), guiding the design of interacting, distributed, autonomous agents.

On-going and emerging transformations in the IE/MS roles are described and illustrated in this presentation based on recent studies and surveys. Recently developed cyber-collaborative protocols of best matching, error-and-conflict prevention, and dynamic lines of collaboration to overcome disruptions for resilience by teaming are reviewed to illustrate the transformation we anticipate

in future work and future factories. Open research challenges are also presented on how we can proceed to reexamine and seek successful solutions to the above frontier challenges.