Smart Production Systems: Theoretical Foundations, Computational Tools, and Practical Design

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Abstract

Smart Production Systems (SPS) are manufacturing systems capable of self-diagnosing and providing operation managers with an advice concerning optimal continuous improvement projects, with analytically predicted results. In SPS, both manufacturing equipment and decision-making processes are automated. As such, SPS can be viewed as a part of the Industry 4.0 movement.

To be "smart", a production system must be equipped with an Advising Tool (AT) intended to calculate the optimal decision for productivity improvement. The AT developed in this work consists of three units: Information Unit (IU), Analytics Unit (AU), and Optimization Unit (OU). The IU is intended to utilize sensing, computing, and communication devices (e.g., Industry 4.0 technology), in order to monitor system's performance metrics (i.e., throughput, WIP, blockages, starvations, etc.) and machine parameters (i.e., cycle time, MTBF, MTTR, etc.), and communicate this information to AU and OU. Based on this information and the theory of Production Systems Engineering (see our textbook under the same title, Springer 2009), the AU is intended to quantitatively evaluate the "health" of the production system, investigate various "what if" scenarios for potential improvement, and autonomously design a continuous improvement project, along its analytically predicted results. Finally, the OU is intended to develop an optimal way for implementing the above continuous improvement project, using the methods of Artificial Intelligence. The outputs of AU and OU form the advice to the operations manager. In this talk, the theoretical foundations of all three units of AT will be discussed, and an SPS development for an automotive underbody assembly system will be described.

Bio

Semyon M. Meerkov received his MSEE degree from the Polytechnic of Kharkov, Ukraine, in 1962 and Ph.D. in Systems Science from the Institute of Control Sciences, Moscow, Russia, in 1966. He was with the Institute of Control Sciences until 1977. From 1979 to 1984 he was with the Department of Electrical and Computer Engineering, Illinois Institute of Technology, Chicago, IL. Since 1984 he has been a Professor at the Department of Electrical Engineering and Computer Science of the University of Michigan, Ann Arbor, MI. He held visiting positions at UCLA (1978-1979), Stanford (1991), Technion, Israel (1997-1998, 2008, and 2017), Tsinghua, China (2008), and Ben-Gurion University, Israel (2011). He was the Editor-in-Chief of *Mathematical Problems in Engineering*, Department Editor for Manufacturing Systems of *IIE Transactions* and Associate Editor of several other journals. Presently, he is on the Editorial Board of the *International Journal of Production Research* and Associate Editor of *Automation and Remote Control*. He is Foreign Member of the Russian Academy of Sciences and Life Fellow of IEEE. His current research is in Systems and Control (with applications to production systems) and in Mathematical Theory of Rational Behavior (with applications to resilient monitoring and control).