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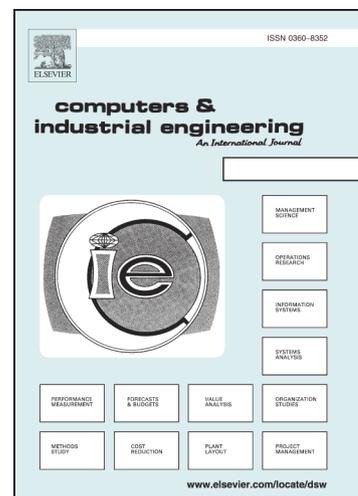
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## Designing Intelligent Manufacturing Systems through Human-Machine Cooperation Principles: A Human-Centered Approach

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### Abstract

Since the start of industrialization, machine capabilities have increased in such a way that human control of processes has evolved from simple (with mechanization) to cognitive (with computerization), and even emotional (with semi/full automation). The processes have also evolved from simple to complicated, and now complex systems. This is notably the case with Intelligent Manufacturing Systems in which processes have become so autonomous that humans are unaware of the processes running, while they may need to intervene to update the manufacturing plan or modify the process configuration if a machine breaks down, or to assist process-intelligent entities when they find themselves in a deadlock. This paper highlights the lack of attention paid to the correct integration of humans in Intelligent Manufacturing Systems and provides solutions based on Human-Machine Cooperation principles to retain humans in the process control loop with different levels of involvement identified by the levels of automation. The aim of these principles is to propose a human-centered approach to design and evaluate systems, processes, and their interactions with humans. Herein, these principles are detailed and applied to Intelligent Manufacturing Systems using Artificial Self-Organizing systems (ASO) as an example. An assistance system was designed to support cooperation between ASO and human operators. Experiments were conducted to evaluate the system and its utility in improving the performance of Human-Machine Systems, as well as its acceptability with regard to human factors. The results presented highlight the advantages of the approach.

Keywords: Techno-Centered Design, Human-Machine Cooperation, Human-Centered Design, Levels Of Automation, Intelligent Manufacturing Systems.

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