Chapter 15

Should I Try Turning It Off and On Again?

Outlining HCI Challenges for Cyber-Physical Production Systems

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ABSTRACT

The flexible production and process designs of complex and automated manufacturing systems – called Cyber-Physical Production Systems (CPPS) – lead to enormous challenges for the machine operator with regard to understanding their "behavior" and therefore their technical controllability. One way to face these challenges is to foster the operator's appropriation of highly complex hardware-centered ICT-systems. Based on the historical development of CPPS and a short excursion into a study about the appropriation of 3D printers, the authors will adapt the concept of sociable technologies, as hardware-centered appropriation infrastructures, to CPPS.

1. INTRODUCTION

Globalization and the resulting larger markets, better purchase conditions and cheaper production possibilities could offer a lot of potential to industrial companies, but it is often accompanied by a number of challenges too. A global market means global competitors. For long-term survival on international markets, industrial companies need to adapt their products to market trends at even shorter intervals

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and market positions must be kept or even expanded with new, technologically more advanced products offering higher quality at competitive prices. Companies find themselves in an area of conflict between customer-driven cost pressure, quality demands and features expected of the products as well as services that customers request; customers who, if left dissatisfied, might otherwise shift to other companies offering similar products. The steadily increasing demand for individual and customized manufacturing products is leading to an increased number of product variations, which generally means higher set-up times. This in turn leads to lower quantities and the result is higher costs per piece compared to traditional mass production.

Complex manufacturing systems offer a solution to these expectations and challenges. Modern manufacturing processes of shaping or cutting, separating or joining operations consist of a large variety of process parameters and resources needed to complete a product. Various mechanical functions of a machine and a range of ICT tools are brought together in the manufacturing process, resulting in a wide range of machine states and dependent process parameters. In the light of this complexity, the implicit pressure exerted by customers through their demands for increased variety, smaller batch sizes and more product complexity makes the monitoring and control of fully-automated manufacturing machines increasingly confusing and opaque. The rise of complexity with problems of operating such systems could also be found in other application fields like crisis management (Comes et al., 2011).

Despite of a more flexible production and process design, these complex and automated manufacturing systems still present enormous challenges for the machine operator with regard to their availability and technical controllability (Munir et al., 2013). A particular challenge is presented by the intra- and inter-organizational gathering and analyzing of relevant factors of the machine with regard to the real-time-based complex production processes. This is especially critical if errors or incidents within the highly complex automated production process occur as the machine operator is often not fully aware of a hardware-related machine failure (Ludwig et al., 2014). The capability of the production machines to report internal and external critical situations systematically and to present the production process to the machine operators is often limited; thus machine operators are often hindered in appropriating the complex production process. In other words: If an error in the machine – which is usually automated – occurs, the machine operator does not always know why it fails nor how to fix it, because the state of the machine depends on too many parameters both inside, but also outside the machine itself (Ludwig et al., 2015). This has become especially critical since modern complex production systems often operate within an entire value-added chain; so, if an error occurs within a previous company, it can have fatal consequences within one's own systems.

Within this paper, we outline current challenges in the field of Human-Computer-Interaction (HCI) and Computer-Supported Cooperative Work (CSCW) that deal with the question of how machine operators could be supported in appropriating the modern complex production machines known as cyber-physical production systems (CPPS). Based on a historical perspective on the development of CPPS (section 2), we will provide an excursion into a study, in which we empirically examined the appropriation of 3D printers as modern and complex machines in the field of additive production (section 3). Based on this study, we will outline design challenges for the appropriation of CPPS in the field of industrial production (section 4).