Web–Based Human Machine Interaction in Manufacturing

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INTRODUCTION

The quality of HMI in automation is an important issue in manufacturing. This special form of interaction occurs when the combination of human abilities and machine features are necessary in order to perform the tasks in manufacturing. Balint (1995) has identified three categories of such human-machine systems:

1. Machines might do the job without human involvement, but the feasibility is questionable. For example, weld seams in car assembly are made mostly autonomously by robots, but in many cases, humans have to guide the robot to the weld point, because the robot is not able to locate the point correctly, which is a relatively easy task for a human.
2. Humans might do the job without machines, but the efficiency/reliability is questionable. This is the case in almost all cases of automation (e.g., the varnishing of cars).
3. HMI is necessary (no purely machine- or human-based execution is possible), although robots today are widely in use; in many cases, they cannot substitute humans completely, because the possible conflicts that can occur are so diverse that a robot alone cannot manage them.

The term HMI is used widely for the interaction of a human and a somewhat artificial, automated facility, which is true in many situations, including HCI. In this article, we speak of HMI in industrial settings. We term the machine especially for industrial facilities for producing a certain (physical) output; in this case, the term man-machine interaction also is used synonymously for HMI. We define HMI as the relation between a human operator and one or more machines via an interface for embracing the functions of machine handling, programming, simulation, maintenance, diagnosis, and initialization.

BACKGROUND

The interface between humans and machines generally influences the quality of HMI, especially in the third category of the previously presented human-machine systems. The design of the interface between humans and the machines has evolved dramatically in recent decades (Nagamachi, 1992). The first step was mechanically controlled machines. With the rise of numerical control, the interaction between human and machines changed. In the second step, the operator no longer has an exact knowledge about how the machine is programmed and cannot influence the processes in the machine. The third step is computerized machines, where the operator can influence and program a wide array of parameters in the machine. In this step, computerized HMI becomes a central aspect in manufacturing on the shop floor.

The advances of computerized techniques for enriching the interface allow a human-centered modification of HMIs. This enables an effective use of the skills and abilities of the operators of machines and the features of the machines themselves. Such a human-centered design of manufacturing technologies should obey the following steps (Stahre, 1995):

1. Consider existing skills of the user.
2. Facilitate the maximizing of operator choice and control.
3. Integrate the planning, execution, and monitoring components.
4. Design to maximize the operator's knowledge.
5. Encourage social communications and interaction.

RISE OF WEB-BASED HMI

The usage of interoperable, adaptive, and standardized information technologies on the shop floor is essential to solve the problems in human-centered manufacturing, in which the previously mentioned fulfill the criteria. Due to restrictions in the capability of computers and their associated technologies in the 1980s and 1990s, the computer interfaces were built upon those technological limits and were not oriented to an optimized effectiveness of the human machine interaction on the shop floor. In addition, HMI has been machine-specific up until now and bounded on the implementation by the facility vendor. The diffusion of Internet technologies within automation and new trends in automation technologies provide the necessary infrastructure (Blecker, 2003). The following trends are essential:

1. **Mobilization of Computers:** For example, Web pads enable the mobilization of all interactions between humans and machines as well as between humans on the shop floor.
2. **Embedded Computing:** Every machine may have an integrated full-featured computer that stores data, which provide a front end; it autonomously can sense and respond to the environment (by blinking, e-mail messages, software calls, etc.) and offers services for machine maintenance and control. Embedded computers in machines and facilities on the shop floor induce the development of intelligent systems in every machine. Here, intelligence means that the system can set a wide array of autonomous (clearly predefined) actions on the occurrence of certain events.
3. **Standardization of Networks:** (Industrial) Ethernet replaces common field busses and proprietary networking. It is also compatible with wireless networks, which enable wireless communication on the shop floor.

Consequently, Internet technologies have become ubiquitously available on the shop floor. The data and computation services will be portably accessible from many, if not most, locations on the shop floor. Internet technologies also trigger a standardization of the screen design and content distribution. This leads to a major change in the traditional HMI, especially for blue-collar workers. In fact, the interaction between workers and machines approximates the common screen handling of the office world. Therefore, we state that the human machine interaction is converging into a Web-Based Human Machine Interaction.

Web-based HMI is an advanced and extended form of computerized HMI characterized by the logical separation of the computer unit from the machine itself. Internet technologies integrate the human as well as the machine within a corporate network. They make the entirely Web-based information infrastructure and all of the interaction partners connected to it available for the employees as well as the information systems on the shop floor. By using Web-based interfaces for user input, screens can be implemented or modified rapidly. Cost savings are realized, since any device (mobile or fixed) that can support a browser becomes a personal computer. The enhancements due to the use of Web-based HMI in manufacturing can be summarized in the following groups:

1. An ergonomic visualization in many variants (colored, high resolution screens and standardized visualization technologies enable an appealing and effective representation of data from the shop floor and data, for example, from the ERP-System).
2. Hardware and software advancements enable more efficient input- and data-manipulation processes.
3. The contents and screen designs are easily updatable und changeable.
4. The visualization is not bounded to the computer in the machine but connects via the Internet, which enables the delocalization of the interaction in various scenarios.

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