Chapter 15
Human–Machine Interactions:
Evolution, Current Applications, and Future Prospects

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ABSTRACT

Human-Machine Interaction (HMI) studies how a human interacts with a machine, changing the relationship from manual control to intelligent systems. Earlier HMI's were controlled mostly by physical inputs, whereas today's controls depend on GUI, touch, speech (decorated by Natural Language Processing) and gestures to construct a more natural experience. Some more capable systems are voice assistants (Siri and Alexa) these are examples of speech interfaces. The newest technology is the Brain Computer Interface (BCI) where the user is plugged into the machine; BCI technology is also helpful for users with disabilities to directly interact with a machine. Other HMI technology that is noteworthy is haptic interfaces, tangible interfaces and social robots, these types of systems help to foster usability and trustworthiness. HMI technology will continue to evolve in order to create more natural, accessible and intuitive humans and machines interactions.

1. INTRODUCTION

Human-machine interactions (HMI) are the different ways that people talk to and connect with computers. This idea has changed a lot with the advancement of current technology, especially artificial intelligence (AI) (Mourtzis, Angelopoulos, & Panopoulos, 2023). These connections might seem like a lot of different things, from simple mechanical interfaces to complex systems where computers can

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think and reason like humans. Comprehending the various modes of communication between humans and computers is crucial for understanding the application of technology in our daily lives, professional settings, and social contexts. This abstract looks at the main types of HMI (Ribino, 2023) and describes how they have changed over time, usage now, and might happen in the years to come. Accessibility and HMI are increasingly important in the system development process to increase system functionality and meet users' demands and requirements. HMI aids designers, analysts, and users in determining the requirements of a system based on elements such as text style, fonts, layout, graphics, and colour. Usability, on the other hand, verifies whether the system is efficient, effective, safe, useful, simple to learn, simple to remember, simple to use, and simple to evaluate. It also ensures that the system is practical, visible, and provides job satisfaction to the users. Science and engineering have a close relationship with HMI. Humans possess intellectual complexity, but computers are characterized by their simplicity in design. Through comprehension, individuals may create more sophisticated interactive systems. It has potential applications in several disciplines like psychology, sociology, cognitive science, and linguistics (Obrenovic et al., 2024).

The evolution of Human-Machine Interaction (HMI) technologies, significant gaps remain in the design and the following problem statements emerge. Human-Machine Interaction (HMI) has transitioned away from mechanical tools toward multimodal systems such as voice, gesture, and brain-driven interfaces. Many research studies now focus on isolated modality applications focused on graphical user interfaces (GUIs), natural language processing (NLP), gesture control systems, and brain-computer interfaces (BCIs). They have provided valuable contributions separately to HMI in their own right but between modalities, the research as of now is limited. At the same time, adaptive multimodal systems in which the interaction varies based on the user context and the user's preferences is also underrepresented. Besides these, no current research approaches accessibility, personalization, or cultural adaptability, especially for users with disabilities or users needing unique communication modes.

Another cause of concern is that as artificial intelligence (AI) interfaces become more common in support of the interaction experience, trust and transparency continue to be poorly conceptualized and developed. Although perceptions of important considerations of predictability and feedback, not all systems show these attributes. The perceived need for real world integration of future HMI studies and unique and innovative HMIs like BCIs and haptics further highlights the gap. We require more unified and user-cantered HMI frameworks that cover an adaptive, inclusive, and trustworthy integrated user experience.

2. EVOLUTION OF HUMAN-MACHINE INTERFACES

The changes in technology, users and the interactions between humans and computers led to evolution of HMIs over the decades. The following is a categorization of HMIs where the evolution of HMIs can be mapped across different phases that range from simple mechanical systems to complex intelligent systems that utilize aspects of artificial intelligence and immersion shown in Table 1 and Table 2, we can see the growth of human-machine interaction trends for human-machine interfaces.

The first known HMIs date back to early mechanical based systems used to control simple mechanical devices such as levers and pulleys. The coming of electricity brought electromechanical systems in which operators-controlled machines through switches, dials, and simple control panels. It will be helpful to explain that early telephone switchboard consisted of a series of dials and switches, where operators had

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