

> Innovation potential of human-machine interaction

acatech IMPULSE – Executive Summary



Humans and machines link up

The focus of human-machine interaction (HMI) is shifting to the human user. Learning machines increasingly adapt to the individual abilities and needs of their users instead of requiring them to adhere to a rigid control scheme. The interaction with machines approximates the interaction with other persons. The gap between man and machine is narrowing, sometimes closing altogether. Futuristic though this scenario may appear, it is already a reality in several areas of our lives. Hearing implants, wearable sensors or collaborative robots – all these are examples of a trend that is just beginning and that will gain momentum and importance in the next few years.

Many experts see a strong transformative power in the current technological developments, a power likely to affect all areas of human life. This particularly includes developments in the field of artificial intelligence as well as innovative concepts and applications of human-machine interaction. The advent of smartphones and tablets is followed by that of the app-principle, the intuitive operation of complex applications – whether for hospital purposes, while driving or in production.

This study aims at raising awareness for these developments, revealing their potential for innovation and outlining a positive target scenario of successful human-machine interaction. Realising this vision not only requires a high level of sensitivity with regard to the social implications of the technologies discussed in this paper. It is further up to science and business to provide for adequate testing areas and experimental spaces in order to take advantage of the chances offered by HMI.

Technological trends and challenges

Experts have described the current progress in HMI-technologies as exponential, even explosive. The key drivers are technological advances in the fields of sensors and actuators, as well as in the area of data transmission, the processing of information and Intelligent Systems/AI.

In order to flexibly adapt their behaviour to users and their environment, interactive machines require sensor data from which to extract relevant information. This includes data from cameras and microphones, from position, motion and acceleration sensors as well as information generated via radar, laser and ultrasound. The multimodality of human communication (combining language, eye contact, gestures and physical contact to convey meaning) and the principles and dynamics of human conversations constitute a particular challenge for technology advances in this field. The progress machines have been and still are making in this field depends on the combination of data from multiple sources in real-time.

Intelligent Systems are capable of integrating the functions of perception, control and learning into a closed, self-reinforcing loop. By interacting with their environment and their users, these systems can evolve of their own accord. They can, for instance, learn and improve by autonomously processing images, language or sensor data and linking them with existing knowledge. This ability will become a regular feature both of machines in the real world and software agents – so-called softbots – in digital space. Machine Learning has already revolutionised many applications of language processing as well as of image and object recognition and will become even more important in the future.

An important trend in robotics is the adaptive force and movement control. The traditional strengths of robots, i.e. power, precision and repeatability are thus complemented by the ability to grasp and handle objects with unknown properties. This requires special equipment such as flexible drives or highly sensitive angle, position and torque sensors. Their development is of particular importance in service robots, which are employed in environments much less structured than the factories classical industrial robots are used in (e.g. the household).

Market potentials

The technological developments described above are already in high demand in many fields of application. According to forecasts the global market volume of HMI-technologies is to grow

at considerable, often double-digit rates. Experts predict that this will result in significant shifts of existing value chains and industry boundaries. With regard to a relative weakness of German products in terms of usability and user experience, some also see a potential threat for the German economy.

The health sector is one of these expanding markets, currently contributing with more than ten percent to Germany's gross value added. The importance of mobile health, particularly for digital applications and products, is reflected in a current German market volume of 6.5 billion euros and annual prognostics of double-digit growth rates. In addition, the German health system is regularly credited for an enormous savings potential that could be realised by digitisation and innovative HMI-applications (e.g. electronic health records). So-called wearables are likewise considered to have a significant market potential. So far mainly known as lifestyle products (e.g. fitness bracelets), they offer the perspective of more intricate functionalities with high diagnostic and therapeutic benefits.

As regards the mobility sector, the development and gradual automatization of vehicles is currently the main trend. German companies are technology leaders and lead providers in the field of assisted driving. Taken together with the high growth rates predicted for the next 15 years, this implies particularly good opportunities for the German economy. The transformation of the German manufacturing sector towards Industrie 4.0 can create an added value of 270 billion euros by 2025. HMI-technologies and applications will play a central role in this transformation. The digitization of production comes with an increased use of robots, the world market volume of which will consequently be more than doubled in the next decade. The greatest potential for value creation of robotics is expected in the automotive industry – once again, good news for the Germany industry.

Social, ethical and legal implications

A positive development of human-machine interaction can by no means be taken for granted; rather, it is a process society must actively shape and control. Despite the current high demand for

many products, certain HMI-technologies also give rise to concerns and anxieties.

Public acceptance of these applications cannot be forced, but needs favourable conditions to grow and strengthen. Positive or even inspiring user experiences are important to this process. Consequently, we should not underestimate the role of products from the entertainment and lifestyle sectors for the acceptance and spreading of these technologies, since they frequently constitute the first contact with new applications. Involving users early in the design and development of such products helps to make the applications user friendly and to increase their adaptation.

Hence, the choice approach is that of "integrated research", which takes ethical, social and legal implications into account in addition to the scientific, technical and economic aspects. This is all the more important because, while new HMI technologies can prevent many accidents, injuries and deaths in all fields of application discussed here, it is also likely that some people may come to harm as a consequence of these technologies. Especially the design of autonomous systems capable of responding flexibly to unforeseen situations will require clarity in questions of conduct standards or the solution of ethical dilemmas. These requirements already have to be met in the design of current assistance and expert systems.

In addition to legal and liability aspects, HMI-technologies also give rise to issues of data security and data protection, since the technologies are frequently based on the collection and analysis of personal data. There is no doubt that this allows for the creation of many useful offers and innovative business models. They will, however, only be successful if the collection, transfer and use of this data is subject to socially agreed upon boundaries.

In this context, many experts call for the development of so-called privacy-by-design solutions – particularly by German developers, who could thus turn the strict German data protection standards into a competitive advantage and ensure that the potentials of HMI can be fully used.

The technologies we have described give rise to expectations of better workplace ergonomics and increased productivity; on the other hand, people fear a loss of control over their work processes or of their job.

In work environments it is therefore essential to tailor the use of HMI to the diversity, skills and needs of the employees. This requires the close cooperation of management and employee representatives when introducing HMI solutions.

Conclusion

Our analysis of the demands for HMI, the underlying technologies and the ethical, legal and social implications shows that Germany is in a good starting position to successfully participate in the global developments in the field of HMI-technologies. This however requires a better synergy of the skills and expertise present in Germany. More experimental spaces are needed to accelerate the conversion of research results into successful innovations.

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