MMI Engineering

INDUSTRIE 4.0:

USABILITY DESIGN FOR THE INDUSTRY OF TOMORROW

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‘INDUSTRY 4.0 ALLOWS US TO MAKE A PARADIGM SHIFT IN THE INTERACTION BETWEEN HUMANS AND TECHNOLOGY: MACHINES WILL ADAPT TO PEOPLE – NOT VICE VERSA.’

Prof. Dr. Wolfgang Wahlster in:
German Academy of Science and Engineering (acatech): Closing report of the Industry 4.0 working group, 2013.

MANAGEMENT SUMMARY

The connection between information technology and traditional industries has been growing stronger with the Internet of Things and Industry 4.0. Machines, products, services and information in various locations are becoming networked to form integrated systems. This in turn facilitates flexible production in real time and has the potential to create new business models and to change many aspects of our daily lives and our work.

As a result of increased networking, machines and products now contain more and more software, and mobile technology is gaining significance in all its forms. The human–machine interfaces (HMIs) used to control and monitor integrated systems are therefore becoming increasingly important.

Usability is becoming a decisive quality criterion for products and capital goods, and it is thus something that differentiates a business from its competitors. Improved usability means that users can operate equipment more efficiently and with more enjoyment, while for manufacturers it offers the potential for greater revenue by increasing the value of the products or by boosting sales as well as allowing savings on support costs.

Excellent usability is the result of interdisciplinary teams who act in line with the principles of a human-centred design process which, as the name suggests, focuses on user needs and preferences. Crucial for optimal usability and a positive user experience are the consideration of different skills and perspectives with respect to the machine, device or product; the early involvement of users; and the continuous evaluation and improvement of repeated processes.[1]

This white paper describes current developments, and it points to the increasing importance of HMIs for devices, machines and products in traditional industries. Furthermore, it demonstrates how the principles of usability design in software development can be applied to the development of applications, products and interactive systems in these industries.

[1] Fraunhofer IAO: Usability and human–machine interfaces in production, 2011.

THE FOURTH INDUSTRIAL REVOLUTION

Industry 4.0 and the Internet of Things

Industry 4.0 is the name of an initiative that forms part of the German government's high-tech strategy. It aims to drive the convergence of information technology and traditional industries such as manufacturing and mechanical engineering. The project includes a new direction of research into manufacturing, services and industrial engineering.

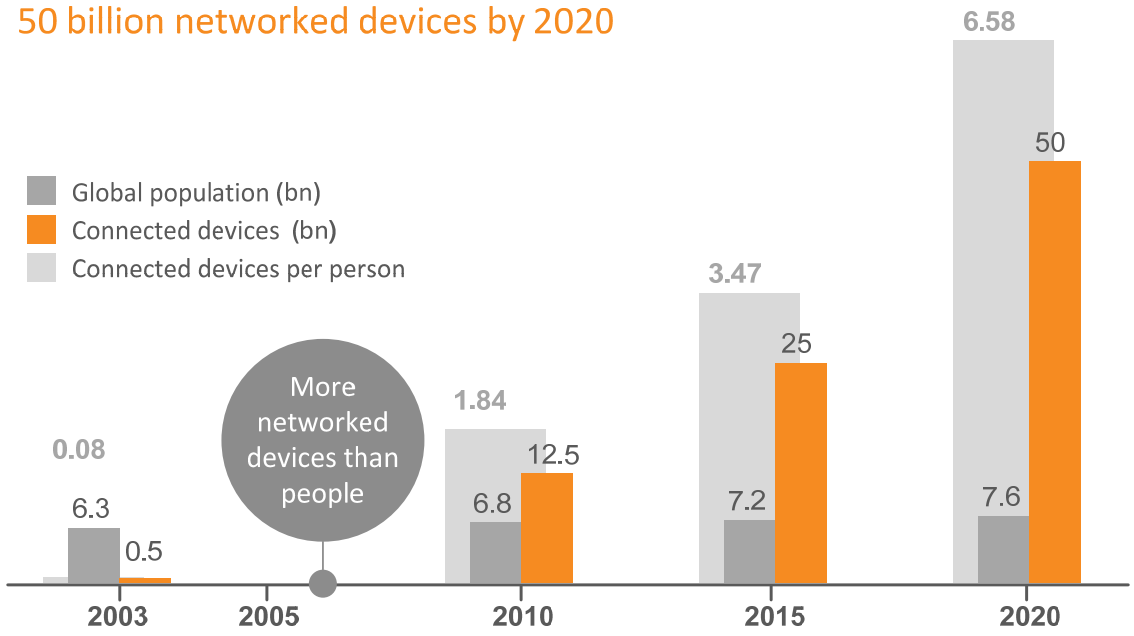
The assumption here is that technical, economic and legal aspects are no longer the only decisive factors that determine how competitive a country is, but also new social structures at the workplace, which help to ensure much greater involvement of employees in the development of innovation processes, for instance.[2]

Other countries have also recognised the potential of this development and refer to a 'fourth industrial revolution'. In the United States, for example, General Electric (GE) has predicted additional annual growth of between 1.0 and 1.5 per cent. These are peak values that equal those seen during the Internet revolution.[3]

Driven by the Internet, the real world and virtual worlds are becoming increasingly entwined. It has been estimated that 50 billion devices will be in contact with each other by 2020. The Internet of Things will change the world of work as well as manufacturing. Machinery, equipment and components will communicate in real time. Documentation will be generated for products throughout their entire life cycle, and repairs will be initiated automatically.[4]

The Internet of Things not only makes it possible to customise products to a great extent under the conditions of flexible mass production with the involvement of customers and partners in business and value-creation processes, it also links production with high-quality services to create hybrid offers.[5]

[2] acatech: Closing report of the Industry 4.0 working group, 2013.
[3] GE: Industrial Internet – An outlook for Europe, 2013.
[4] VDMA: Integrated industry – When machines begin to think, 2013.
[5] BMBF, BMWi: High-tech strategy of the German government, 2013.



Fraunhofer IAO: Produktionsarbeit 4.0, 2011

Part of this development are cyber-physical systems (CPSs), which describe the combination of IT and software components with mechanical and electronic parts that communicate using a data network such as the Internet. Examples of CPSs are smart energy grids and manufacturing facilities that can adapt dynamically to changing requirements.[6]

The number of machine-to-machine (M2M) connections around the world has grown by 300 per cent over the last five years and continues to rise.[7]

M2M software platforms used to control and monitor intelligent systems are already gradually replacing networks of isolated computers and direct one-to-one connections. They make it possible to integrate and manage numerous machines and devices, representing the link between the real and virtual world.

The obvious advantages are new methods of remote monitoring by technical staff and early intervention in production processes via a central access point. By collecting, linking and analysing data from machines, predictions can be made about maintenance requirements and possible downtime can be avoided.[8]

[6] Wikipedia: 'cyber physical system', visited in November 2013.
[7] McKinsey: Disruptive technologies, 2013.
[8] Bosch blog: Internet of Things. Article by Alexandra Enderle: From remote to predictive maintenance – How IoT refines a classic M2M concept, 2013.

SMART PRODUCTION

The role of people in intelligent factories

What does this ultimately mean for human labour in manufacturing? One may wonder whether people will be necessary in future if machines are 'intelligent' and can communicate directly with each other. An obvious association here is the image of factories without workers.

Experts assume that Industry 4.0 is not about replacing people with machines, but having people and machines work together. The aim is not rigid mass production as in the past, but flexible automation. Key aspects in this sense are the development of production and business processes for smart factories, and the life cycle of smart products.

With personalised and mobile applications, touch-screen controls and augmented reality, technology involves people and is therefore closer to them than ever before.

Professor Dieter Spath, longstanding director of Fraunhofer IAO, says of this situation: 'If we want to create highly flexible output using fully automated methods of production, it is more than a little complex. Such an approach entails high levels of investment and limited availability. Automation is therefore at its limit in terms of economics. For this reason, we will see separate automated processes that are tailored to a specific area and that people can link together in a flexible way.' More than ever before, people will need to be able to adapt to new situations and tasks, and they will have to respond to change.[9]

In addition to their manpower, qualified employees with many years of experience will be able to contribute greater levels of creativity and flexibility. New technology will relieve them of physically strenuous or repetitive activities and provide a means of obtaining information in real time as well as individual training as needed – and thus new opportunities for personal development.

At the same time, certain features of social media are playing an increasingly important role as a means of participation and collaboration. By adding a comment and video upload function to help users, for instance, it is possible to collect important information for the ongoing development of products and machinery and for their use.

[9] Fraunhofer IAO: Manufacturing in the future – Industry 4.0, 2013.

Key components of Industry 4.0 are mobile and virtual work environments, intelligent assistance systems and straightforward user interfaces that support workers. With personalised and mobile applications, touch-screen controls and augmented reality, technology involves people and is therefore closer to them than ever before.[10]

In the words of Professor Wolfgang Wahlster of the German Research Centre for Artificial Intelligence, 'Industry 4.0 allows us to make a paradigm shift in the interaction between humans and technology: machines will adapt to people – not vice versa.'[11]

[10] ibid.

[11] acatech: Closing report of the Industry 4.0 working group, 2013.

HUMAN–MACHINE INTERFACES

Usability design as a challenge and opportunity

When developing machinery and products, it is important to consider not only the technological possibilities, but also the ways in which people interact with innovations. The perceived benefits must outweigh any risks or concerns. After all, people need to understand and accept a development in order to help shape it.

If we apply our experience of a knowledge-based society and the influence of the Internet and wireless technology, there is reason to be optimistic: around the world, some 1.1 billion people already use smartphones and tablet PCs. The sustained level of enthusiasm shows that these devices are more than just another way to go online and browse the Internet. Automated functions and apps for every conceivable routine have already changed our lives and the way we perform our work.[12]

The importance of straightforward controls and user interfaces in this development becomes evident if one considers the success of personal digital assistants (PDAs) such as the Palm™ handheld and mobile digital assistants (MDAs) compared to the later development of the Apple iPhone™. When redeveloping a highly usable touch-screen design for the iPhone® and iPad®, Apple integrated an almost sensual element into the operation of its mobile devices, transforming the interface into an emotional link between the device and the user. It is safe to assume that ease of handling has been a significant contributing factor to the overall success of smartphones.

Good usability has the potential to boost customer loyalty, to increase brand value, and thus to generate better prices in the long term.

Such developments are progressing at a rapid pace. From functioning voice recognition on the Apple iPhone® and gesture navigation, which first became popular in gaming applications, to innovations such as Google Glass™, new forms of use and control are constantly being developed.

Given the number of new devices, their ease of use and the possibilities they create, employees have higher expectations concerning the technical equipment provided at work and the tools available to them. They expect technology and tools that support their jobs in the best possible way. This development, which has become known in the

[12] McKinsey: Disruptive technologies, 2013.

media as consumerisation, leads to greater demands in terms of usability across the board. Poor usability and performance are simply no longer acceptable for many users.

Currently, however, things are quite different in practice. Given the speed at which such expectations and demands are increasing, manufacturers are reporting new problems: users who are unable to cope, faulty software, frequent updates, and problems with quality and image can impact the economic success of companies and brands.

In this sense, the interface between user and machine (HMI) and its ease of operation should be of strategic importance. As an operating element used to control and monitor machines and equipment and as a feature of product quality, the interface represents an important and sometimes decisive opportunity to stand out against the competition.[13]

Usability is already a standard category in the product tests carried out by industrial and consumer magazines, and it is increasingly gaining in importance. A product that is easy to use is also easier to demonstrate and can sell better; it is also brought back less frequently and reduces the cost of user support. Good usability has the potential to boost customer loyalty, to increase brand value, and thus to generate better prices in the long term.

In addition to customer satisfaction, quality improvement and a better corporate image, potential savings play a major role for customers. For example, the people at operation terminals can be identified quickly using radio-frequency identification (RFID) so that workflows are not interrupted by constant logging in and out.[14]

[13] Fraunhofer IAO: Usability and human–machine interfaces in production, 2011.
[14] VDMA News, July 2011.

GESTALTUNGSKRITERIEN

Was ist gute Usability?

DESIGN CRITERIA

What is good usability?

Effectiveness, efficiency and satisfaction are the criteria used to measure usability. In simple terms, it is not only important that users complete their objectives, but also how quickly and elegantly these goals can be achieved.[15] Good usability is always oriented towards the user. In addition to the simple realisation of functions, it considers the context of the application as well as user habits, including psychological aspects.

This does not only refer to software. There is a great need to adapt complex interactive systems as well as products so that they meet people's needs. It is important to consider the usability of technology as a whole. The software interface represents only part of the user experience.[16]

The term 'user interface' is internationally defined as 'all the components of an interactive system that provide the information and controls needed by users to carry out a certain task at work using the interactive system'.[17]

Usability standards are not directives. They apply to any platform and serve only to prevent predictable problems faced by users.

DIN EN ISO 9241 (Ergonomics of human–computer interaction) is a collection of norms that define guidelines for the user interfaces of interactive systems. The standard describes requirements with respect to software, hardware and work environments, and it also outlines the criteria of usability and the principles of dialogue design, among other things.

In addition, there are numerous other standards that define usability for specific fields of application. DIN EN ISO 20282, for example, is the standard used to measure how easy it is to operate everyday items such as coffee machines, ticket machines and

[15] VDMA News: July 2011.
[16] UX Magazine: How to design for the gut, 2013.
[17] Wikipedia: 'user interface', visited in November 2013.

cameras. It includes test methods to quantify usability criteria with the goal of being able to prove usability.[18]

Examples of usability standards for specific fields of application are:

- DIN EN ISO 9355: Ergonomic requirements for the design of displays and control actuators;
- DIN EN ISO 11064: Ergonomic design of control centres;
- DIN EN ISO 14915: Software ergonomics for multimedia user interfaces.

In contrast to traditional technical standards such as DIN 7985 for the Phillips pan head machine screw or the simple DIN A4 for paper, there are no rigid instructions in usability standards. This is because they do not aim to produce standardised products where every button must look the same, for instance. Instead, they consist of recommendations that need to be assessed in context.

Although consistency is a principle of design, the primary consideration should be to make sure that software provides users with sensible support that helps them to complete their tasks and does not impede their work. Usability standards are not directives. They apply to any platform and serve only to prevent predictable problems faced by users.

The following example illustrates the application of a directive from DIN EN ISO 9241-110 (Dialogue principles) with the specific context of a form.

The directive on suitability for the task states that 'an interactive system is suitable for the task if it helps users to complete their task, which is to say that functionality and dialogue are based on the characteristics of the task rather than on the technology used to complete the task.' The directive includes recommendations such as pre-populating a field if certain details (e.g. a date) are typical at a certain point on the form and allowing users to edit this if necessary.[19]

In addition to usability standards that focus on dialogue design, information displays and user guidance as well as codes of practice for accessibility, Web design and internationalisation, the guidelines of well-known software manufacturers such as Microsoft, Apple and Google can be used for orientation.[20]

[18] DIN Deutsches Institut für Normung e. V., 2013.
[19] Fit for usability blog: Usability off the shelf? Norms and standards. Thomas Geis, 2005.
[20] VDMA News: July 2011.

METHODS AND MORE

Where does good usability come from?

Experience shows that good usability design is not created in the mind of a single person with a special set of skills, but in interdisciplinary teams that act in line with the principles of a human-centred design process (DIN EN ISO 9241-210) and focus on the user.[21]

Engineers and software developers have the task of developing good technical solutions using established engineering practices while meeting agreed deadlines. As a rule, they are not usually trained to manage the design of the application to be developed, and this means they place the focus elsewhere in their work.

However, functional and user-friendly applications should be planned, realised and tested from a range of perspectives. In addition to software developers, industry specialists and marketing managers, those involved could include usability experts from a different professional background, such as psychology or interaction design. The usability experts should be just as familiar with analytical methods such as card sorting, AB testing, focus group interviews, field tests and usability heuristics as with design tools such as personas, storyboards, wireframing and rapid prototyping. It is essential that they already have practical experience in using these tools that they can bring to the design process. After all, the development of interactive applications always entails functional, strategic and economic requirements that must be kept under review and adjusted throughout the entire project.

Usability is not something that can be forced into an application or product retrospectively through testing. It has to be planned from the outset.

In addition to technical knowledge and proficiency in the relevant methods, usability experts require good communication skills, a large amount of curiosity, a willingness to experiment and the ability to ask critical questions about requirements.[22]

After all, sometimes it does not matter whether all the desired functions are realised. In certain cases, it is more important to reduce complexity, and this may mean dispensing with a number of features and gadgets. This applies to the design of control rooms and the cockpit of cars and aircraft, for instance. Drivers and pilots must not be

[21] Fraunhofer IAO: Usability and human–machine interfaces in production, 2011.
[22] Userfocus: Bright ideas for UX managers, 2013.

distracted from their primary tasks, but at the same time it is necessary to display an amount of up-to-date and meaningful information.

On the other hand, innovations that aim to create a brand-new user experience – such as the change from keyboard input to voice recognition, gesture navigation or the use of augmented reality – only emerge on the basis of technology screening and systematic user observations with an openness to creativity and new design concepts.

The human-centred design process does not dictate how a team should work together. It can be applied both to agile development (e.g. the scrum approach) and to a style similar to the waterfall model process. The only crucial factor is that the concept of interaction can be analysed independently of the functional requirements in iterative cycles.

If usability is considered as a quality criterion, it is natural to test this aspect at the end of the development process in a similar way to other quality criteria (e.g. the avoidance of functional faults). However, if problems are not discovered until the final application or system is evaluated, it is usually too late.

Good usability is the result of a strategic approach and a holistic product development process. There is a lot of truth in this simple observation: Usability is not something that can be forced into an application or product retrospectively through testing. It has to be planned from the outset.[23]

[23] Hendrik Meth and Felix Kahrau: Recommendation of usability processes and roles for SME software producers and users, University of Mannheim, 2011.

CONCLUSION

Industry 4.0 is more than the Internet of Things and the linking of machines to cyber-physical systems. The challenge is to develop new business models and services, and therefore also new production processes that aim to make efficient use of the potential that exists from humans and machines working together and to capitalise fully on this partnership.

Work tasks, processes and environments are becoming more flexible. In order to make this a positive economic development, there is a need to integrate future technologies intelligently into operational organisation. This will change the interfaces between humans and machines as well as the interfaces between humans and systems.

Usability design for the industry of tomorrow requires manufacturers to make a strategic decision today and to understand usability as an important criterion of product quality. They need to promote interdisciplinary collaboration and make sure that the user is always at the centre of the development process.

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