Intelligent Technical Systems OstWestfalenLippe

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Summary: The Leading-Edge Cluster Intelligent Technical Systems OstWestfalenLippe (it's OWL) focusses on the innovation leap from mechatronics to systems with inherent intelligence. The intention is to show the way from the first steps of the foundation to the implementation of technological methods into the cluster companies. The development of intelligent technical systems which can optimize their behaviour by themselves to become more flexible, robust and user-friendly is one of the key aspects of the cluster. Therefore intelligent technical systems are explained as distinct from conventional mechatronic systems. Based on this the technological evolution and its drivers for future systems are explained. This leads to a technological concept which has been chosen as basis for the leading-edge clusters technology platform and future cyber-physical systems. The development and implementation into the cluster within specific projects conclude this paper and give a short outlook of future technical systems.

Keywords: Mechatronics, Methodology, Conceptual Design, Artificial Intelligence.

1. Introduction

Within the framework of the Leading-Edge Cluster by the Federal Ministry of Research (BMBF) 173 partners from Ostwestfalen-Lippe – 127 companies, 16 universities and research institutions as well as 30 business-related organizations - joined the cluster it's OWL (Intelligent Technical Systems OstWestfalenLippe). Figure 1 illustrates the partners and their roles.

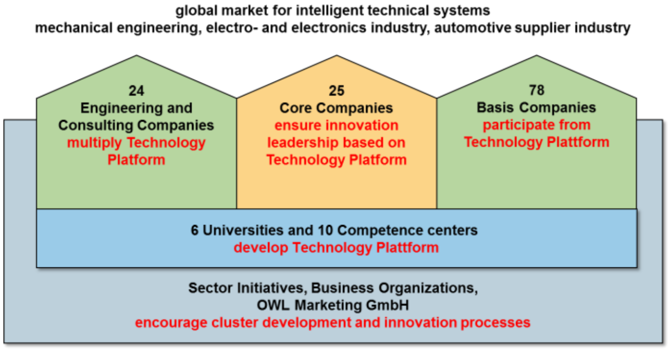

Figure 1. Partners of the Cluster and their roles.

The cluster formation began in 2001 and was prepared by the industry networks and OWL Maschinenbau and InnoZent OWL as well as the initiative "Innovation and Knowledge". OWL Maschinenbau e.V. combines the strengths of 180 companies and organizations to enhance the performance of the medium-sized companies by new technologies to create a pacemaker in the industry. The network InnoZent OWL e.V. (80 partners) focusses questions about the future of IT and system integration and the development of innovative solutions. With the campaign "Innovation and Knowledge", coordinated by the OWL Marketing GmbH, these activities have been intensified since 2008. The aim of the innovation initiative is to take advantage of the success potentials of Intelligent Technical Systems and to develop the region into one of the most powerful technology locations in Europe.

Within the framework of the cluster the partners have their sights on the innovation leap from mechatronics to systems with inherent intelligence. Within a close alliance of business and science in 47 projects product and production innovations are getting developed. The spectrum ranges from intelligent sensors, drives and automation components to machines, white goods and vehicles up to networked systems such as production facilities, smart grids and cash management systems, wherefore the term cyber physical systems stands. The projects are based on a mutual technology platform as the overall core of the cluster's innovation leap. Smaller and medium-sized enterprises are participating from the developed cutting edge technologies via this technology platform and resulting transfer projects [1].

2. Intelligent Technical Systems

The technical systems of tomorrow will be based on the close interaction of mechanics, electric / electronics, control engineering, software technology and new materials and will exceed mechatronics by an inherent intelligence. Information technology and also non-technical disciplines, such as cognitive science, neurobiology and linguistics, are developing a variety of methods, technologies and procedures that integrate sensory, actuatory and cognitive functions into technical systems previously known only in biological systems. We call such systems Intelligent Technical Systems, see figure 2.

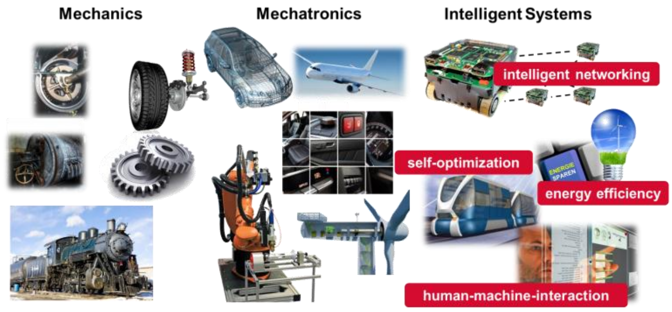

Figure 2. From mechatronics to intelligent systems.

Four key features characterize such systems:

Adaptive: They interact with the environment and adapt to this autonomously. In this manner, they can evolve during the runtime inside the framework set by the designer and ensure their existence in the long term.

Robust: They may operate in a dynamic environment flexibly and autonomously even in situations that are unexpected or not foreseen by the developer. Uncertainties or the lack of information can be handled, at least to a certain degree.

Anticipative: On basis of empirical knowledge, these systems anticipate future impact and possible states. In this manner, dangers can be identified early and appropriate strategies to resolve the problem can be selected and executed. objectives can be achieved faster.

User-friendly: They adapt to user-specific behavior and interact sensibly with the user. Nevertheless, its behavior is comprehensible for the user all the time [1]. The route to such systems is determined by three general trends in technology:

1. **Miniaturization of the electronics**: This development allows multi-faceted advantages that combine the parallelization of information processing by multi core processors, an increase of storage capacity and a reduction of energy needs. This allows the suitable hardware for intelligent technical systems to be developed [3].
2. **Software technology as driver of innovations**: Software penetrates more and more modern engineering products and enables new functions. At the same time, however the complexity of such systems rises rapidly, especially those of embedded software [4]. Modern, model-based methods, notations and tools of software technology enable us to control the complexity better and nevertheless create software of the necessary high quality [5].
3. **Networking of information systems**: The "Internet of Things", "Ubiquitous Computing", "Pervasive Computing" or " Ambient Intelligence" are current research areas, that deal with electronic, mostly wireless, networking of information processing systems. Their aim is the consistent and omnipresent penetration of the physical every-day life by the virtual world. The term "Cyber-Physical Systems" stands for this kind of coordination, on which basis, especially in industrial applications, not only new intelligent products and production systems will be created, but also novel forms of intelligent services. [6].

Primarily - but not exclusively - the way of information processing is implementing the change from mechatronical to intelligent technical Systems. Mechatronic Systems provide a reactive and rigid coupling between sensors and actuators whereas intelligent technical systems are capable of modifying this specifically. Reactive action sequences are not replaced completely, as most existential system mechanisms must take place for reasons of safety reactive and reflexive (figure 3).

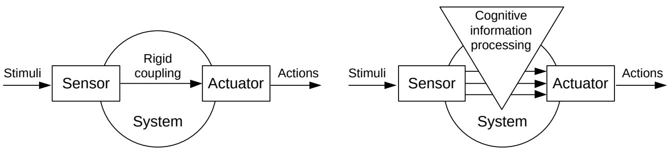

Figure 3. Comparison of a cognitive and a non-cognitive system [7].

The three-layer model known from cognitive science for behavior control illustrates this abstract view on the information processing of intelligent systems (figure 4). Thus, the cognitive data processing enables a flexible and intelligent adaption of the system's behavior to changing internal and external conditions. The cognitive data processing does not substitute the reactive control, it extends it. The process of adaption always goes along with the phenomenon of learning. Learning means to gather and perceive information, to draw conclusions concerning the system's conditions and to process the so gained knowledge. Afterwards, this knowledge can be used to change the system's behavior, e.g. by varying control parameters. At different levels of behavior control, different forms of learning take place.

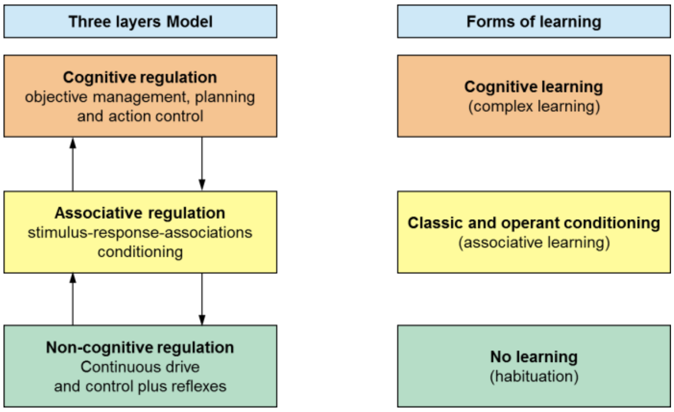

Figure 4. Three layer model of behavior control [7],[8].

2.1. Technological concept

Hence, the technological concept of the cluster structures an intelligent technical system as shown in figure 5 in the four units: basic system, sensory, actuatory and information processing. Information processing intervenes via communication system between sensory, by which the necessary information are perceived, and actuatory that performs, partly in cooperation with the basic system, the actual system action. The basic system normally is a mechanical structure.

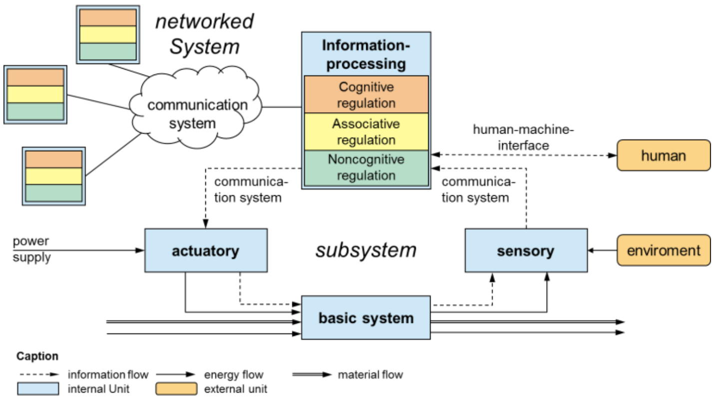

Figure 5. Technological concept – from intelligent subsystems to networked, cyber-physical systems.

Within the information processing, the cognitive regulation is the most challenging part. The basic cognitive functions, that are realized by a cognitive regulation are for example: Perceiving and recognizing, encoding, or using of language. Their implementation can vary substantially though. The implementation of "using language" may be fulfilled by the ability of distinguishing between "yes" and "no". To assess the "intelligence" of a technical system, the following three characteristics for cognitive systems and thus for intelligent technical systems can be found [9]:

1. Active embedding into the environment and the ability to exchange information with it.
2. Flexible and environment-adaptive action control via internal representation of the system-relevant information about the environment.
3. Ability of learning and anticipating of the integrated information processing.

We call such an elementary configuration of the four units a subsystem. Examples of subsystems are drives, automation components and intelligent energy storage. Systems like a vehicle or a machine tool are usually made of several subsystems, which are considered as an interacting compound.

Another key point of the technological concept is that intelligent technical systems, which are often geographically distributed, communicate and cooperate. The functionality of the resulting networked system only reveals itself through the interaction of the individual systems. Neither the network nor the role of the individual systems is static, but can change both in terms of the (also dynamically changeable) required overall functionality. The networking is progressively global in dimension. Thereby approaches in terms of cyber-physical systems are integrated, which in the past were considered completely separately, such as cloud computing on the one and embedded systems on the other side. Networked systems will not be controlled by only one global control unit; moreover a good behavior can be achieved by local strategies. The challenge is the development of mechanisms for the interaction of the individual systems.

The proposed innovation leap in the leading-edge cluster from mechatronics to systems with inherent intelligence is based on this technology concept.

3. Implementation

Within the Leading-Edge Cluster three types of projects will be realised. **Innovation projects** are designed to address concrete questions within the core partners companies. They serve the achievement of strategic goals of the technological (e.g. resource efficiency, usability, reliability) and performance level (e.g. project-specific recruits, widespread impact of the project results in the company) of the cluster. **Cross-sectional projects** provide a common technological platform that enables companies to enter the business with intelligent technical systems within the next few years. Furthermore, the technology platform is the key lever to involve companies that do not participate in concrete innovation projects in the technological development. They are scientifically driven and designed to be widely utilizable. Five topics have been identified during the development of the cluster:

Self-optimization: Self-optimization means, the endogenous adjustment of the objectives of a system to changing influences and the resulting, goal-compliant, autonomous adaptation of the system behavior. The reliability of such technical systems increases considerably, because they are more robust against run-time errors.

Human-machine-interaction: The growing complexity of intelligent systems sets intense requirements on natural and intuitive handling for the user as well as flexible configuration for the developer. For this purpose the project human-machine interaction provides consistent, well-structured and supportive human-machine interfaces that improve the usability of technical systems.

Intelligent networking: Intelligent technical systems consist of a variety of closely interconnected, complex subsystems. The cross-linking is increasingly of a global dimension. A good global optimum is the result of local, decentralized strategies of the subsystems.

Energy efficiency: Energy efficiency is a measure for the utilization of applied energy. High energy efficiency of intelligent technical systems requires the detection and utilization of electrical and thermal energy savings in design phase and subsequently during operation.

Systems engineering: The overall functionality of intelligent technical systems only reveals itself through the interaction of the subsystems, which is strongly characterized by mechatronics. The resulting system complexity and their development require an integrative system thinking of the involved experts. Systems engineering meets this challenge.

The **Sustainability projects** at last shall contribute long-term sustainability beyond the promotional period of the programme. Within these projects smaller and medium-sized enterprises shall be enabled to develop intelligent technical systems themselves. Intelligent Technical Systems adapt to their environment and the requirements of their users. They provide utility in households, in production, on the streets; they go easy on resources, are intuitively operable and reliable. **Examples** are a tumble dryer that adapts in seconds to changing electricity prices and nevertheless gives a premium drying result thanks to self-optimization; a production machine, which can be easily operated by the workman even for the most difficult tasks and that knows when it is time for their maintenance; a large-scale laundry that automatically washes, dries, irons and folds each piece of laundry with the best quality and minimum use of water, electricity and detergent

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