Workshop (Special Track):

Shaping Techno-Organizational Processes: Energy – Information – Autonomy

Friyday, June 16th, 2017, 9 h. – 12.30h.

Within the realm of technological sciences and engineering, the main topic of the SPT-Conference seems to be a little bit confusing: How is it possible to connect a linguistic category like grammar with technology? Nevertheless, there is a close connection between a programming language, which is able to control technological processes on the one side, and its formal grammar (like Chomsky Grammars) which expresses the inner, mathematical structure on the other side. The same holds for the inner structure of natural languages, music pieces, drama and tales, rooms in architecture etc., and also for the control of processes. If this kind of modeling is adequate, it could be possible to describe technological and organizational processes in technology by the formal means of grammars, i.e. analytically. The formal structure of such grammars determines the formal structure of programs, and by this, the programming of algorithms, which are structuring and controlling the techno-organizational processes.

The topic of the conference has suggested a reflection whether this approach could be fruitfully applied to some basic areas of acatech: energy systems of the future, Industry 4.0, Smart Services and autonomous Systems. All these fields share the fact, that the mentioned processes are highly complex and vulnerable. Here, the interaction between man and technical system plays an important role. Moreover, these interfaces can be frequently found at nodes of critical paths. In other words: The comprehension, the modeling, the shaping and control of such processes could be usefully supported by the structuring effect of a theoretical description “in terms of grammars”.

The half-day workshop will cover its topic in three steps: First of all, a raw sketch of a possible common structure of generalized structures with techno-organizational processes should be developed. In three contributions, the idea of such kind of structures shall be applied to different field that are of particular interest to acatech, namely,(1) the German energy transition and its implementation, (2) the complexity of systems like smart grids and industry 4.0 and (3) the question about the future possibilities of autonomous technologies. At the end, a round table discussion will try to focus the results and to formulate open questions that should be tackled by researchers in technological sciences as well as in the humanities.

Programme of the Workshop

Friday, June 16th 2017, 9.00h – 9.10h	▪ Prof. Dr. Eberhard Umbach, Karlsruhe Institute of Technology, Member of the Executive Board of acatech: *Welcome Address*
Time incl. Discussion	▪ Introductory Lecture:
9.10h- 9.50h	– Klaus Kornwachs (University of Ulm, Member of acatech): *The Grammar of Techno-Organizational Processes*
	▪ Special Contributions
9.50h – 10.30h	– Eberhard Umbach, Karlsruhe Institute of Technology, Member of the Executive Board of acatech: *People and Things – The German "Energiewende" – do we do the right things and do we do them right?*
10.30h – 10.50h	▪ Coffee Break
10.50h – 11.30h	– Klaus Mainzer, Technical University of Munich, Member of acatec: *People and Things –Complexity 4.0 and Artificial Intelligence*
11.30h – 12.10h	– Otthein Herzog, University of Bremen, Member of acatech: *People and Things – How far Autonomy may go? Autonomous Multi-Agent Systems, controlling Logistics and Production*
12.10h – 12.30h	▪ Roundtable Discussion with all speakers. Moderation: NN

Abstracts and CVs

PEOPLE AND THINGS: THE GRAMMAR OF TECHNO-ORGANIZATIONAL PROCESSES

Klaus Kornwachs

How is it possible to connect a linguistic category like grammar with technology? Nevertheless, there is a close connection between a programming language, which is able to control technological processes on the one side, and its formal grammar (like Chomsky Grammars) which expresses the inner, mathematical structure on the other side. The same holds for the inner structure of natural languages, music pieces, drama and tales, rooms in architecture etc., and for the control of processes, too. If this kind of modeling is adequate, it could be possible to describe technological and organizational processes in technology by the formal means of grammars, i.e. analytically. The formal structure of such grammars determines the formal structure of programs, and by this, the programming of algorithms, which are structuring and controlling the techno-organizational processes.

Within this introductory lecture, (A) the concept of a formal grammar is briefly sketched. It is well known in Computer Science that there are morphisms between grammar and the concept of automaton. This concept has been used to describe different kind of machines and processes. (B) A generalized techno-organizational process like the control of material flow, the structure of a value chain [1] or manufacturing can be described in terms of system theory [3]. (C) Transforming this description into the shape of a formal grammar, it can be easily seen, what the advantages of the formal description of such kind of techno-organizational processes can be [2]. (D) Moreover, the limitations of this formalization become visible [5], and these are the limitations of structuring and controlling such processes by (even learning) algorithms [4]. These are also the limitations of Industry 4.0.

References:

[1]. **Jung, H.H., Kraft, P.:** *Digital vernetzt. Transformation der Wertschöpfung*. Hanser, München 2017

[2]. **Kornwachs, K.:** *Strukturen technologischen Wissens. Analytische Studien zu einer Wissenschaftstheorie der Technik*. Edition Sigma, Berlin 2012

[3]. **Kornwachs, K.:** System Surfaces – there is never just only one Structure. In: B. O. Küppers, U Hahn, S. Artmann (ed.): *Evolution of Semantic Systems*. Vol 1. G. Frege Center for Structural Science, Springer, Berlin Heidelberg 2013, S. 31-66

[4]. **Kornwachs, K.: W. Coy:** Zur gesellschaftlichen Integration Intelligenter Objekte. In: Herzog, O.; Schildhauer, Th. (Hrsg.): *Intelligente Objekte. Technische Gestaltung – Wirtschaftliche Verwertung – Gesellschaftliche Wirkung*. Acatech diskutiert. Springer Heidelberg u. a. 2009, S. 125-138

[5]. **Kornwachs. K.:** Vom Widerspruch in der Maschine: Die Parapraxie. In: *Berichte der Fakultät für Mathematik, Naturwissenschaften und Informatik*, BTU Cottbus, PT-02/2009, Cottbus 2009

Klaus Kornwachs, former Chair for Philosophy of Technology at Brandenburg Technical University of Cottbus (1992-2011), since 1990 Honorary Professor for Philosophy at University of Ulm, studied Physics, Mathematics and Philosophy. He was Senior Research Fellow at the Fraunhofer-Institute for Industrial Engineering, Stuttgart (1979-1992), and Guest Professor at Technical Universities in Budapest, Vienna, and Dalian (China). Since 2004 Prof. Kornwachs is a Full Member of the National Academy for Science and Engineering (acatech), since 2013 he is Honorary Professor at Intelligent Urbanization Co-Creation Center at Tongji-University, Shanghai. He won 1991 the Alcatel-SEL-Research Award for Communication Technologies.

Research interests: Analytical Philosophy, Philosophy of Pure and Applied Sciences, General System Theory, Theoretical Philosophy, and Ethics. Numerous publications; for more see: www.kornwachs.de (in German).

PEOPLE AND THINGS: THE GERMAN "ENERGIEWENDE" – DO WE DO THE RIGHT THINGS AND DO WE DO THEM RIGHT?

Eberhard Umbach

The German "Energiewende" is an extraordinary challenge, in particular if we compare the extremely ambitious goals with the present real development and if we consider the required huge future steps. A particular challenge is the interlinking involvement of the various stakeholders with focus on the hardly predictable behavior of the people. These must be prepared to accept a much more responsible role in the future energy system. Scientific scenarios, technological assessments, and economic estimates, as well as political declarations of intent are certainly required to sketch possible pathways, to decide on directions of development, and to shape the political framework and regulations. However, the unknown factor nowadays is the willingness of the people, the media and hence the politicians to follow a long term strategy that cannot be fixed in detail and may require not only frequent readjustments but also significant offerings by the citizens. The technological and economic challenges of the future energy system will be sketched and related to the increasing responsibility of the people for the success of this endeavor that is much more ambitious than bringing the first man to Mars.

References:

All publications from the ESYS project and references cited therein. ESYS stands for "Energy systems of the future" and is a big project of the German national academies involving about 100 renowned scientists. More information: http://www.energiesysteme-zukunft.de/publikationen/

Eberhard Umbach studied physics at the Technical University Munich; Diploma: 1975, doctoral degree: 1980, habilitation: 1986; research stay at Lawrence Berkeley Laboratory and at Stanford Synchrotron Radiation Laboratory: 1980–1981. Assistant professor at TU Munich: 1986-1987, associate professor at Stuttgart University: 1987-1993, full professor, director of Physics Institute, Würzburg University: 1993-2007; CEO (Vorstandsvorsitzender) of Research Center Karlsruhe: 2007-2009; Founding President of KIT (Karlsruhe Institute of Technology, full merger of University of Karlsruhe and Research Center Karlsruhe): 2009-2013; Vice President of Helmholtz Association and Coordinator of research field Energy: 2007-2013; retirement: 2013.

Additional appointments: external Scientific Member of the Max-Planck-Society, Fritz-Haber-Institute Berlin: since 2001; President of the Deutsche Physikalische Gesellschaft: 2006-2008, Vice President: 2008-2010; President of CLUSTER (Consortium of 12 leading Technical Universities in Europe): 2012-2014; member of acatech, National Academy of Science and Engineering, corresponding member of Göttingen Academy of Sciences and Humanities; member of the Executive Board of acatech.

Research activities in energy systems and in surface science (soft condensed matter, liquids; analysis of structure, dynamics, optical, electronic properties; development of new experiments and methods such as spectro-microscopy and soft X-ray scattering).

PEOPLE AND THINGS: COMPLEXITY 4.0 AND ARTIFICIAL INTELLIGENCE

Klaus Mainzer

The global problems of mankind (e.g., energy, mobility, urbanization, nutrition, financial markets) are cross-over to specialized disciplines of science and need interdisciplinary studies in complex systems science and technoscience. In sociotechnical systems, information technology (IT) and artificial intelligence (AI) are growing together with societal infrastructures of people (e.g., industry 4.0, smart grids, smart cities), in order to handle the complexity of human civilization. In the Internet of Things (IoT), "things" (e.g., wearables, cars, machines, robots) are equipped with sensors and AI-functions to support automation and communication. Obviously, machine learning algorithms are breakthroughs of AI leading to more self-organization and autonomy. But, how far can/should we go with more autonomy of technical infrastructure? AI technologies only deliver technical support, no human competence of interdisciplinary problem solving. Increasing complexity of our civilization needs reflection on the foundations and laws of systems dynamics in order to guarantee safety and reliability of AI-technology.

References:

Mainzer, K.: *Künstliche Intelligenz. Wann übernehmen die Maschinen?* Springer: Berlin 2016;

Mainzer, K.: *Information. Algorithmus – Wahrscheinlichlichkeit – Komplexität – Quantenwelt – Leben – Gehirn - Gesellschaft*, Berlin University Press 2016;

Mainzer, K.: *Die Berechnung der Welt. Von der Weltformel zu Big Data*, C.H. Beck: München 2014;

Mainzer, K.: *Thinking in Complexity*. *The Computational Dynamics of Matter, Mind, and Mankind,* Springer: New York 5th enlarged edition 2007;

Mainzer, K., Chua. L.O.: *The Universe as Automaton* (with), Springer: Berlin 2011.

Klaus Mainzer studied mathematics, physics, and philosophy (1968-1972), Ph.D. (1973) and habilitation (1979) at the university of Münster; Heisenberg-scholarship (1980); 1981-1988 professor for foundations of exact sciences at the University of Constance, vice-president of the university of Constance; 1988-2008 chair for philosophy of science, dean, director of the Institute of Philosophy (1989-2008) and founding director of the Institute of Interdisciplinary Informatics (1998-2008) at the University of Augsburg; 2008-2016 chair for philosophy of science and technology, director of the Carl von Linde-Academy and founding director of the Munich Center for Technology in Society (MCTS) at the Technical University of Munich (TUM); since 2016 TUM Emeritus of Excellence; member of several academies and interdisciplinary organizations (e.g., The Academy of Europe/Academia Europaea in London, European Academy of Sciences and Arts in Salzburg, National Academy of Science and Engineering (acatech) in Berlin) and guest-professor in Brazil, China, Japan, South-Korea, Russia, and USA.

Research interests are mathematization and computer modelling, complex dynamical systems, complexity and computability, artificial intelligence (AI), big data technology, and philosophy of science and technology.

PEOPLE AND THINGS – HOW FAR AUTONOMY MAY GO? AUTONOMOUS MULTI-AGENT SYSTEMS, CONTROLLING LOGISTICS AND PRODUCTION

Otthein Herzog

Cyber-Physical systems map the real world to a virtual one based on their sensors and on acquired knowledge about the signals and their interpretations. This knowledge is the basis for a world model to act upon which is necessarily restricted to the application on hand. However, with the introduction of “Smart Services”, this architecture has been extended to an agent-based architecture where an agent is able to exhibit “Beliefs, Desires, Intentions” [Wooldridge, 2000] and to communicate and negotiate with other agents. Therefore, there is now the opportunity to model large-scale distributed and decentralized systems with agents which relate to the real world on the one hand through Cyber-Physical Systems, and which, on the other hand, are able to – at least by local decisions – move such systems towards an optimal design point through their joint emergent behavior.

Industry 4.0 concepts lend themselves towards an implementation by such an architecture as smart machinery, smart production facilities, smart products must be integrated (Kagermann et al., 2013, p. 5). The goal is to increase the robustness, efficiency, and productivity of dynamic production and logistics processes in an extremely dynamical environment with many interdependencies and relations of real objects and their digital twins, the agents. This process environment is changing continuously, must be continuously monitored, coordinated, and optimized. This means that the agents' world model must be extendable through learning based on a set of (initially externally defined) assumptions about their goals and their counterparts. The (concurrent) negotiations aiming at the optimality of processes are distributed search processes for an agreement among two or more participating agents Therefore, the agents must find (mutual) best response behaviors, e.g., anticipate results of activities and adapt themselves accordingly, even insofar as to select appropriate partners for successful results. This anticipatory behavior [Nadin] can be modelled according to the works of [Luhmann] who defines social systems to be originating through communication which reproduce themselves through further communication. Expectations as an emergent property of communications reflect and produce social order as the phenomenon of the Double Contingency is practically nonexistent as it constitutes only an unstable fixed point of dynamic systems,. also in a technical environment [Berndt].

However, as long as these learning agents have limited learning capabilities defined by the incorporated algorithms, and limited access to knowledge, their autonomy is basically restricted by these two properties, apart from hardware restrictions.

References:

Berndt, J.O., Herzog, O. (2016). Anticipatory Behavior of Software Agents in Self-Organizing Negotiations. In M. Nadin (ed.). *Anticipation across Disciplines*. Springer International Publishing: Berlin, pp. 231-253.

Berndt, J. O. (2015). *Self-Organizing Multiagent Negotiations - Cooperation and Competition of Concurrently Acting Agents with Limited Knowledge.* PhD thesis, University of Bremen.

Nadin, M. (2014). G-Complexity, Quantum Computation and Anticipatory Processes.In: *Computer Communication & Collaboration*, 2(1):16-34.

Kagermann, H., W. Wahlster, and J. Helbig (2013). *Recommendations for implementing the strategic initiative Industrie 4.0*. Final report of the Industrie 4.0 working group. acatech.

Luhmann, N. (1984). *Soziale Systeme*. Grundriss einer allgemeinen Theorie. Suhrkamp, Frankfurt, Germany.

Wooldridge, M. J. (2000). *Reasoning about Rational Agents*. The MIT Press, Cambridge, USA; London, UK.

Otthein Herzog received his Computer Science PhD from the University of Dortmund, Germany, in 1976. From 1977 to 1993, he worked for IBM Germany in various technical and managerial positions in software development, and in R&D of knowledge-based systems. From 1993-2009, he held the position of the chaired professor of Artificial Intelligence at the University of Bremen, Germany. Since 1998, he holds an Affiliate Professorship at the George Mason University, USA. Since 2010 he holds the Wisdom Professorship of Visual Information Technologies at Jacobs University Bremen. In 2015, he joined the CIUC, Tongji University, Shanghai, PRC, where he holds a Summit Program Professorship of Big Data Analysis for Sustainable Urban Planning.In 2006, he was elected as Fellow of acatech – the German

National Academy of Science and Engineering, and in 2008, as Fellow of the German Informatics Association. He is a member of numerous advisory boards, among them the Governing and Advisory Committee of the UNESCO International Knowledge Center for Engineering Sciences and Technology (IKCEST) in Beijing.

His research interests include Multiagent Systems for the coordination and optimization of complex processes in production and logistics, the semantic analysis of images and videos, Knowledge Management, and ICT for Smart Cities. He has published more than 270 refereed papers and books.