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This is why the digital transformation is both a revolution and a design challenge

In this essay, guest author Prof. Dr. phil. habil. Dipl. Phys. Klaus Kornwachs is looking into digital transformation and answers the question, whether it is a revolution or a design challenge.

When Thomas Newcomen invented the first practical steam engine in 1712 and James Watt patented his improved version in 1769, the world was astonished that it was even possible to transform heat into motion. This is understandable, given that there was no precise definition of energy at the time.

The history of technology teaches us that the development of a theory of thermodynamics and hence a common understanding of energy went hand in hand with the increasing use of engines to generate power. It was finally technically possible (and, in due course, theoretically comprehensible) to convert one form of energy into another on a massive scale.

The invention of the steam engine is not the only factor that led to the industrial revolution in England. Other reasons include the increasing accumulation of capital, the availability of plentiful raw materials, and a growing labor force resulting from the mass migration of impoverished farm workers to the new factories. Britain enjoyed special political privileges as a colonial power, enabling it to tap new sales markets overseas through its imperial policies, which increased demand for products such as textiles. The mechanization of agriculture and manufacturing processes, not to mention transport (the motor car), led in turn to the well-known economic, social, cultural, and political consequences of the industrial revolution.

One small detail that is often overlooked in this historical analysis is that in 1788, James Watt also invented the centrifugal governor, which he integrated into a later version of his steam engine to keep it operating at a constant speed. This could be regarded as the birth of automation, because these mechanical controls enabled the machine to operate regularly. It effectively broke the link between the machine's running time and the human operator's working time, because the need for someone to supervise the machine was replaced, at least to some extent, by a mechanism to keep it running at a preset rate.

Make no mistake about it: this governor was an early example of a small information-processing machine – albeit analog and mechanical.

In time, governors and other control systems were built using electrical components, and finally using electronic circuits. Analog signal processing merged with digital computing, and programmable machines emerged as the successors to electromechanical computers.

These programs are based on specific algorithms, which are in turn based on a mathematical model of the process the program is intended to control. The basic principle of control systems hasn't changed at all since then, but the technology used to implement them has. Another change is that we now use such systems to control organizational and technical processes at the same time, an approach that can be extended to cover entire value chains.

The most complex solutions currently envisioned are smart, model-based, self-regulating systems that control an entire process chain – from product design and manufacture to end-of-life disposal. They also support communication and service functions and can be used in the power grid to balance supply and demand, especially in connection with volatile renewable energy sources.

Autonomous systems

Today, we use the term "autonomous systems" to refer to all kinds of highly automated structures, robots, industrial plants, self-driving cars, connected household appliances, and even autonomous weapons systems. These are controlled in principle by extremely complex, intermeshed data processing networks; yet strictly speaking, they are all still controls or governors, as they derive their target values from past measurements. They learn from their own experience, i.e. from a mathematical analysis of collected measurement data, or in other words their recorded system history. This development is more than just an evolutionary process in which performance increases with each new generation of technology – it's more a case of automating automation.

» **Digitalization is a process of social renewal that offers immense scope for positive change.**

Prof. Dr. phil. habil. Dipl. Phys. Klaus Kornwachs, Physicist and technology philosopher

Digitalization isn't limited to technology

Technological change affects our organizational structures and the way we manage our resources. On the other hand, our social, legal and economic infrastructures have a certain impact on technological developments.

Many aspects of our social lives, political processes, and business activities are already controlled by algorithms. Despite their alleged capacity for learning from experience, and their ability to draw actionable conclusions from an analysis of previously collected data, the fact remains that they are written by humans. Algorithm designers deliberately gave them the ability to learn so they could relieve us of routine chores, while remaining within a set range of parameters.

The designers created models of the processes to be controlled by these algorithms, including business models. These algorithms could even be described as the ultimate incarnation of theories of business management and organization, just as algorithms used in a technical context need to reflect functional theories if they are to be effective. As a result, these theories have a huge impact on the way processes are implemented in the real world and the way we conduct our lives. But theories can go only so far.

This gives rise to two more questions, namely, whether such systematic processes are reversible, and who has the power to shape the outcome. Because it's no longer a question of whether autonomous systems are "doable" in the long or short term. The more important point is whether we really want this, and if so, what types of systems, their degree of autonomy, and how we foresee their functionality and usefulness. This is the design challenge.

Fears of a revolution won't be calmed by facile statements of appeasement. And it doesn't help that Industry 4.0 is described by insiders using warlike terms.

A better approach would be to describe digitalization as a process of social renewal that offers immense scope for positive change. This gives us the liberty to try out many different solutions, in the assurance that nothing is fixed and, as in science, most processes are reversible; the people who write the algorithms live in the real world and can design functionalities to match almost any situation.

Just as scientific theories are not immutable and last only until they are proven wrong, technology and the algorithms used to control and manage organizational processes are right only until failures prove otherwise. What we need is a well-balanced combination of courage and modesty to attack the hard challenge of implementing a digital transformation that will also transform society.

Reversibility is one thing, but shaping tomorrow’s technology also requires a willingness to accept other participants, i.e. co-determination. Too many cooks spoil the broth, as the saying goes, but not if their skills improve the recipe. Obviously, the desired functionality of high-tech systems must be co-determined by the business partners, down to the component level. Such participation is even an indispensable part of the business model.

For some time, attempts have been made to include prospective customers in discussions about the desired functionality of products, using diverse formats such as living labs, participatory design workshops, seminars, platforms, forum discussions, and projects. Whatever the format, the goal is to gain acceptance of certain solutions or provide future users with experience of products requiring sustainable behavior changes, for example. But this can hardly be described as co-development, not least because the skill levels are too disparate.

Nonetheless these formats – even though they are not as well developed as might be desired – provide an avenue for communicating results, giving advice on behavior change, and communicating experts’ and users’ views to the manufacturer.

Involvement and communication on all conceivable levels – especially among partners, customers and employees – creates a feeling of being a part of things. This emotional attachment will grow in importance as the technologies that determine the world we live in grow in complexity. And so, from this viewpoint too, there is no alternative to becoming actors in the digital transformation. It is both a revolution and a design challenge.

This article is a shortened extract from Klaus Kornwachs essay, which was published completely with the title "Digital transformation – Revolution or design challenge?" in the TRUMPF annual report 2016/17.

<p>Corné van Opdorp, 37 Jahre alt, Geschäftsführer ((c) Tim van der Most)</p>

<p style="margin: 0.2pt 0cm 0pt; line-height: 8.4pt; vertical-align: baseline;">Corné van Opdorp, 37 Jahre alt, Geschäftsführer ((c) Tim van der Most)</p>

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IST PHYSIKER UND TECHNIKPHILOSOPH. ER LEHRTE AN DEN UNIVERSITÄTEN COTTBUS UND ULM UND HAT SEITDEM DIVERSE GASTPROFESSUREN INNE GEHABT. KLAUS KORNWACHS IST ORDENTLICHES MITGLIED DER DEUTSCHEN AKADEMIE FÜR TECHNIKWISSENSCHAFTEN (ACATECH). VON 2001-2009 LEITETE ER DEN BEREICH „GESELLSCHAFT UND TECHNIK“ DES VEREINS DER DEUTSCHEN INGENIEURE (VDI). ER IST HERAUSGEBER UND AUTOR ZAHLREICHER FACHBÜCHER UND VERÖFFENTLICHUNGEN ZUM THEMA TECHNIK UND GESELLSCHAFT, U.A. DER EINFÜHRUNG „PHILOSOPHIE DER TECHNIK“ IM VERLAG C.H. BECK.