Industry 4.0 and Agriculture 4.0 – The same or different?

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Introduction
The terms Industry 4.0 and Agriculture 4.0 are currently frequently used in the public debate on the future development of the sectors. However, a closer analysis reveals, that both the content of the individual terms and their possible interrelationships are insufficiently clarified. In many cases, everyone associates their own image and imagination with them. This leads to the fact that although everyone uses the same term, very different ideas are associated with it. This is a very poor basis for a common orientation, which is what the pair of terms is intended to achieve.

A structure is to be created here within the framework of a VDI/VDE guideline committee on the topic of "Status of the use of Industry 4.0 - Technologies in Agricultural Engineering". The discussion covers several stages. It is based on the current understanding of the term Industry 4.0, with its structure and objectives. In the transition from Industry 4.0 to agriculture, the sectoral differences between industry and agriculture must be analysed in order to determine the direction of the degree of mechanisation. Based on this, the current status of structures of Industry 4.0 in agriculture in practice and theory will be presented using various examples from the arable and livestock farming. Altogether it is shown that in many cases a broadly coordinated understanding of the terms of the group concerned is necessary. Therefore, this contribution is also intended as a basis for discussion with the expert public in order to further develop the general understanding on this basis.

History of terms
The term "Industry 4.0" became widely known with the Hannover Fair 2013. It goes back to an initiative of the German Federal Government in 2011. To date there is still no binding definition
of the concept Industry 4.0, but a generally accepted understanding is emerging. The term "Agriculture 4.0" has arisen to follow on from this. However, this term is even more difficult to grasp. Up to now, “Agriculture 4.0” is little more than a kind of promotional buzzword, claiming the most modern IT and production concepts and techniques for agriculture. Often, “Agriculture 4.0” is just a new coat, meaning digital techniques in agriculture and precision farming, like in Roland Berger Focus – Farming 4.0 [1]. In order to find a sound definition of “Agriculture 4.0” as a revolutionary stage of agricultural production, generations 1.0 to 3.0 of agriculture must be defined first, and then the revolution that lead to 4.0 must be described as a second step – if there is any revolution at all, justifying a new generation 4.0. Due to the lack of such historic clarification, the term “Agriculture 4.0” will be avoided in this work. Some authors already see an upcoming “Agriculture 5.0” at the horizon [2,3].

Understanding Industry 4.0

Over the last 270 years, industry has developed within the framework of so-called "industrial revolutions". The first industrial revolution began in the second half of the 18th century with the development of the steam engine. The second revolution took place towards the end of the 19th century, with the development of mass production and the use of electrical energy. In the second half of the 20th century, the third industrial revolution began, characterised by the automation of production using electronic and IT approaches.

Every industrial revolution involves a fundamental change in the production paradigm, made possible by the development of one or more technologies that trigger a fundamental change in established ideas and practices. However, their effects are not limited to production; they touch and influence the whole of society.

The current stage, caused by the fourth industrial revolution, is known as Industry 4.0. This differs from the third industrial revolution in that it focuses on the networking of the various automation modules.

Despite the current widespread use of the Industry 4.0 concept, it is difficult to find a clear definition. The term is best described by its components.

From a purely technical point of view, Industry 4.0 approaches can be summarised by the term networking. Instead of managing different machines, sensors, etc. individually as in the past, Industry 4.0 is based on cyber-physical systems (CPS), which can be flexibly connected and used; and on the equally flexible service-oriented architecture (SOA), which enables the use of the necessary software components. [4] This also improves the possibility of simulating processes, right up to the digital twin of the process. However, the networking and service-
oriented character of Industry 4.0 goes beyond the boundaries of purely technical aspects and enables the design of new business models [5]. From this, the following implementation options [6] can be derived for the smart products and services to be offered by Industry 4.0:

**Digital individualisation**: digital media significantly simplify the offer of individualised products and services. This includes the entire production chain from the customer's request to its realisation.

**Flexibilisation**: Industry 4.0 allows, for example, the possibility to react quickly to fluctuations in demand by making production capacities more easily scalable (e.g. through smarter plants and simplified capacity procurement) and by providing more data about the environment and the company itself.

**Demand-orientation/ "X-as a Service"**: service orientation is transferred to business models, which in turn is facilitated by increasing the amount of data and flexibility. This allows, for example, products and services to be offered and invoiced according to the extent of use.

**Sustainability**: by allowing better planning and control of production processes through digitisation, it is possible to save resources, for example through cost- and load-optimised production programmes for energy-intensive processes. Additional reductions in the demand for resources are possible through the availability of extended and near-real-time data from production and the supply chain; for example, through the early detection of quality problems.

**Consistent process orientation**: the networking capabilities enable each value-added stage in the supply chain (internal and external to the company) to call up information about the overall process. This allows for a customer and employee-oriented organisation of work.

**Automated knowledge and learning**: increasing the amount of data and the level of automation in Industry 4.0 environments prove to be ideal conditions for using self-learning functionalities. The data can come from beyond the company's boundaries, for example, through IoT approaches. In addition, the systems concerned enable extended and simplified knowledge management in companies.

**Collaboration competence**: in line with end-to-end process optimisation, Industry 4.0 approaches reduce the collaboration effort between value-added partners. For example, it is possible to know the current stock and available capacity of suppliers.

**Productivity optimisation**: all the above implementation options contribute to an increase in productivity. Optimisation options can be found at various levels, from the strategic orientation of the company to the operational management of production processes.

Although these implementation options have been analysed for the machinery and equipment sector, the benefits identified are also relevant for agriculture. However, the implementation of
a highly flexible and distributed architecture is not without challenges. The desired fast connection in the production chain also requires a corresponding data exchange. However, this requires appropriate standardisation or standardised interfaces and data formats between components from different manufacturers. 

The processing and storage of data on distributed systems, often outside the company, raises concern about data security. For this purpose, both software-based and methodical approaches are being developed. While the former are based on novel security applications and protocols, the latter focus on topics such as intelligent data control and anonymisation. The analysis of the definition of the term Industry 4.0 shows that this definition is still under development and discussion.

**Industry 4.0 approaches in agriculture**

When transferring the definition of Industry 4.0 to agriculture, it quickly becomes clear that agriculture is still characterised by additional aspects. Here, the environmental character of agriculture, which includes not only society and government but also nature, the environment, people, farm animals and the weather to a high degree, is particularly striking. The organisation of work is also structured differently in agriculture than in industry. This shows that the socio-economic, technical and ecological systems in agriculture are much more closely interwoven, making it more difficult to define the term Agriculture 4.0 in comparison with industry.

In order to explain the current status of Industry 4.0 approaches in agriculture, therefore, examples from arable and livestock farming are used and a differentiation and possibility of description is created on the basis of technology levels.

**Exemplary example from foreign trade: steering systems**

Steering systems started in the 2000s as simple local systems, which, for example, steered a forage harvester along the rows of maize using mechanical deflection sensors in row crop. The first tractors were kept on a given track by GNSS.

In recent years, these systems have been developed with great innovative power. Digital customisation is achieved by taking into account a specific implement, so that the working width of the implement is automatically taken into account for the track guidance via ISOBUS and the collaboration between implement and tractor.

Flexibilisation is achieved through standardisation. A steering system can now be mounted from a tractor to a self-propelled-machine or other tractor within minutes.

Demand-orientation is gaining ground through new business models. A "steering system as a service" does not yet exist at present, but the software activations, such as correction signals...
(RTK for 2 cm accuracy and long-term repeatability), which are subject to a charge, are only sold and invoiced if required.

Sustainability is the top priority when using a steering system. The working width of the machine is used optimally, double crossings are avoided and fuel and CO2 savings are achieved through optimal driving.

Automated knowledge and learning is currently not applied to the steering system. Only databases with lanes are built up, which can be used for subsequent processes. Automated learning does not take place at present, but is in preparation with teach-in procedures and intelligent lane planning systems. Lane planning systems will in future be supplied with field boundaries and the planned work process and the lane planning system will determine a proposed course of action for working the field in a self-learning manner and on the basis of collected experience values.

Steering systems are increasingly being given collaborative competencies. On the one hand, the correction signals are now often obtained via mobile phone from external service providers. In addition, steering systems are networked with each other, e.g. in order to exchange track lines or, by means of an electronic tiller, e.g. to automate overloading processes.

Productivity optimisation is the main objective when using steering systems. Due to the optimum use of the working width saves machining time and fuel. The crop yield is increased by minimising soil compaction.

This means that modern GNSS and online-based guidance systems fulfil a variety of features that make up Industry 4.0. In the coming years, these systems will be further developed and make an important contribution to the increasing automation requirements of farmers and contractors.

Exemplary example from the livestock farming: automatic milking system

Automatic Milking Systems (AMS) have been in use since the 1990s. Here the individual process steps of milking are automated. These include recognising the cow via a sensor, cleaning the udder, recognising and targeting the cluster to the individual teats of the cow, flow-controlled milking of the cow, removing the cluster and dipping the cow. The basic structure of the processing of individual process steps of AMS is basically comparable to machine tools in the Industry 3.0 sector.

In the field of digital individualisation, the AMS has started to work on both cow and product milk. For example, the alignment of the animals in the AMS is partly based on the stored body measurements. Another possibility here would be quarter-individual milking in terms of milking phase duration and milking vacuum depending on the animal's previous notification. In the
case of milk, the approach is to separate the milk individually according to animal and ingredient to enable individual marketing.

Flexibility is difficult to implement in the AMS due to the workload and continuous use. A possible approach here could be the AMS container, which accompanies the cows to the alpine pasture in the case of alpine pastures and returns to the barn in autumn.

In the field of automated knowledge and learning, the AMS offers great potential, as animal-specific data series are continuously generated. However, these data are not yet used consistently in the sense of Industry 4.0. The situation is similar with collaboration competence. Here, networking various automatic systems in the barn would result in many approaches for Industry 4.0. For example, a measured change in the milk quantity could lead to an automatic adjustment of the feed quantity. This intelligent linking of different automated systems also makes it possible to optimise productivity, which at the same time can lead to a change in the farmer's work structure in the system.

Overall, AMS offers great potential for Industry 4.0 approaches. The possibilities are partly considered, but not yet stringently implemented.

Discussion

When analysing Industry 4.0 applications in agriculture, it is striking that although much initially looks like 4.0, on closer analysis decisive aspects such as networking across sectors or individualisation and flexibilisation of production are missing. These technical solutions are therefore more likely to be classified as automated isolated applications of Industry 3.0.

Another aspect that is often shown is the gap between practical implementation and technologically possible realisation. An example of this is TIM for balers and tractors. Here implementation is slow although, with regard to Industry 4.0 approaches, other aspects such as lane transfer from the previous implement, e.g. combine harvester or swather, performance planning based on the power requirements of the combine organs or logistics planning based on yield estimates would be possible. Also in indoor farming, e.g. quarter individual milking based on past milking cycles or route optimisation of column robots according to the current movement data of the cows would correspond to the basic idea of Industry 4.0.

In many cases, these technological developments would only require appropriate adjustments and coordination. However, this requires a manufacturer-independent will, which is often hindered by company-specific interests. It is very clear that without networking across different manufacturers no application of Industry 4.0 in agriculture is possible, only the automation of individual machines.


