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Spotlight

Digital agriculture – or why agriculture 4.0 still offers only modest returns

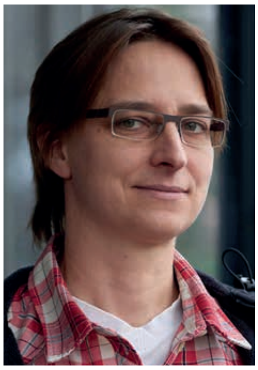

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Photo: TU Berlin, P. Arnoldt

Strolling through the stands of farm shows or perusing articles in the relevant magazines, it is hard to get away from the impression that agricultural engineering is already completely digitalised. But what really lies behind key phrases such as digital cropping and smart farming? Where and how have these technologies already gained footholds? And what is stopping their successful application elsewhere?

Development stages in precision agriculture

Let us look back almost two decades ago. Then, electronic control systems were making inroads into agriculture. Civilian application of GPS technology had become possible, and affordable. Science was researching the details of site-specific farming techniques. In short, the foundations of ”precision agriculture“ were being laid. At that time, the technical challenges involved manipulation of a machine through electronic control systems so that application rates could be altered during fieldwork without penalising the working quality. Parallel to this new generation in mechanisation, sensors were being developed to record the data upon which process control could be based. While mechanical process data always had to be collected on the machine during the work process, in the case of agronomic parameters this operation involved much additional effort in off-line processes and manual assessments. In this respect, a milestone achieved was the development of real time capable sensors for determining crop production relevant parameters.

After 20 years of research in “precision agriculture” there are nowadays many types of sensors for recording agronomically relevant parameters, as well as many farm management systems. Electronically controlled machines are state of the art. In fact, technology is now capable of automating cyber-physical systems by networking between different machines. This is what we call “agriculture 4.0“. However, it still cannot be claimed that precision agriculture has been widely established in crop production. Why not?

Simplifying something complicated: the role of smart technology

Data alone are not enough. Automatic data recording only helps farm results where the analysis of the collected material takes less time and allows more profit to be made compared with good management decision based on gut feeling and experience. The largest portion of added value deriving from the new technology, however, today lies with the machinery and not the agricultural products. For instance, futures trading on the commodity market has a much faster and more direct influence on value development of agricultural products than does, e.g., the quality of the product, or its yield, being increased in single-figure percentages through the application of site-specific management techniques.

There remains the advantage of time savings. Hereby, the task of agricultural engineering development is the creation of intelligent and simple to operate, so called “smart” systems. We call smart products those that appear cleverer than the user in that they deliver answers even before the question has been asked. An example: so-called fitness bracelets that record and analyse the wearer’s movements. The smartness of the equipment lies in the analysis of the values. Step count and heart frequency are below average. This finding leads to a treatment recommendation: exercise more! But the user still has to carry out these recommendations.

Second example, this time from precision agriculture. Easily the most successful crop plant sensor systems are those, that analyse, recommend, and then apply a treatment in one go, such as the so-called N-Sensors. Although the analytical procedure within the system is highly complex, such sensors are very easy to operate. In contrast to that, for instance yield mapping is an off-line approach which requires additional processing steps analysing the data on the PC. On top of everything else, the yield information gained from one harvest can only be set to use in the next growing season, representing a long-term investment with much manual input and benefits that are difficult to assess.

Challenges for sensors and automation technology in crop production

The challenges for sensor development lie in the required high temporal and spatial resolution and very different and difficult to measure parameters under most unfavourable conditions. The aim of new analysis methods is to combine the data and to fuse the different information layers in order to derive new knowledge. Additionally, automation of the data collection tasks is a requirement in the development of ”smart“ sensor systems. In the sense that the decision making is embedded in the sensor, so that the results are directly applicable on the machine for carrying out precise management actions.

But what exactly has the fitness bracelet mentioned above to do with the N-Sensor as far as content is concerned? Both sensors analyse data and process the material up to the point where recommendations for direct action can be deduced from the result. Additionally, both analytics are based on indicators not directly related with the actual target values. The ”fitness“ of the plant can be efficiently assessed through foliage chlorophyll content or green colour. But where the cause of the problem is not poor nitrogen supply but instead lack of moisture, then the system must have this additional information available. In this respect, intuitive interaction between man and machine is necessary, a point that also represents a great development challenge for sensors and automation technology in crop production.

From data sink to knowledge management

The more we appreciate the importance of the comprehension of detailed agronomic relationships, the greater the need for information towards better understanding these relationships. The more information available, the deeper the understanding and this requires in turn more data collection. The situation is therefore a loop within which, especially in recent years, more and more data was collected and increasingly intensified agronomic knowledge has been developed. Hereby, however, the practical application of directly usable agronomic knowledge has stagnated. Nowadays it still requires a considerable mass of statistics and software expertise for comprehensive application of precision agricultural technology.

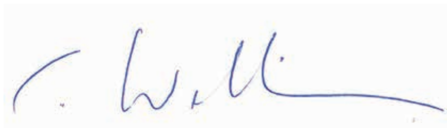
For further development of smart sensors, relevant information must be integrated in multi-causal decision-making systems in order to generate knowledge. The targets are complex systems that are easy to operate – solutions with systemic, comprehensive and transparent concepts, with good "usability" and simple application. There must also be a way for practical experience to flow into these integrated systems so that farmers, with the help of the technology, can develop their expertise further. A core theme in the development of decision support systems is the step from data storage over information retrieval to knowledge management involving large amounts of data. Currently, possibilities for the analysis of agricultural data and sensor data fusion are being expanded through application of multivariate statistical methods and machine learning techniques. Hereby, the system limits are increasingly expanded and nowadays holistic concepts for complete added-value networks are already in focus, whereby the mobile transmission of data is a basis technology for establishment of fully integrated systems enabling real time data fusion from different sources.

Digitalisation – Automation – Optimisation? Crop production in focus

What we are discussing here is knowledge management and intelligent systems. But, with all this "high-tech", are we able to concentrate clearly on our target? The crux of all the technical developments is creating a more efficient crop production. Automation and networking should serve the systemic control of the agronomic processes, not vice versa.

This is the environment in which the Leibniz Research Alliances' "Sustainable Food Production and Healthy Nutrition" innovation initiative "Food and Agriculture 4.0" focuses on the agricultural production process - intelligently connected, of course. Aim of the initiative is the interdisciplinary development of process technology basics for Agriculture 4.0. Where knowledge-based decision making shall ensure the satisfaction of social demands as well as individual producer's and consumer's requirements, in terms of yields and profits, while still taking into account the local, spatial, environmental heterogenities as well as global climate phenomena. For this purpose the research goal is to develop on one hand models of the agricultural production processes, adjusted to meet the specific conditions, and on the other hand automation technologies with which the processes shall be controlled such that the natural ressources can be retained or even improved and at the same time the product quality will be maintained.

The interoperability an digital networking of agriculture will enable new process control systems and new sales models such as online slurry sales points, exchange platforms where data is traded for advice, or online direct marketing. However, even with Agriculture 4.0, only what is sown can be driven home from the field. For instance, the weather risk will not be any the less, although the harvesting window might be better positioned by setting information technology to use. Hereby I finish with the summary that even Agriculture 4.0 will show only modest results if we do not take care that some of the value added through the new technologies is actually being associated with the agricultural products.



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