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Green Future – Smart Technology: Field robotics in crop production – vision possible ?

Digital transformation for a sustainable agriculture

Typically technologies in the automotive domain as well as in industrial automation ("Industry 4.0") are addressed as innovation drivers. That is not wrong, however, mobile agricultural machines are navigating, communicating and (!) working. As a consequence quite several agricultural technologies are playing a pioneering role in innovation. A central aspect of the digital transformation in agriculture is the implementation of smart technology as a supporting tool of man to find sustainable solutions with respect to ecological, economical and social challenges of today and tomorrow.

In this context the technology-supported transfer of knowledge into sustainable processing is the central aspect. This statement is illustrated by the example of weed control: Knowledge of the kind of weed and its position could be generated by applying imaging systems and interpreting the corresponding data; the results are used for actuator control. By using a mechanical actuator, the process has highest ecological benefit as shown by the "Robocrop" (Garford) with image-based weed control between and within crop rows in ecological farming. However, the beginning of a paradigm shift in crop protection is visible, since the combination of imaging and mechanical weed actuators is now addressed to "conventional" farming by larger companies, such as Claas ("CULTI CAM") or John Deere ("AutoTrac Implement Guidance").

Knowledge – as we can see – is able to reduce resources, improve quality or implement processing with reduced environmental impacts. In many cases, however, high resolution information and processing takes time and is thus – in particular together with human workers – related to higher costs, at least as long as environmental costs are not directly taken into account. As a consequence a disruptive step in automation technology could close the gap to reach economical as well as ecological goals for a sustainable agriculture: the implementation of highly automated – "autonomous" – field robots in agricultural working environments.

Key technologies of field robotics

Knowledge generation could be supported by already existing information. Moreover, sensor systems are robotic key components for measuring machine data (such as current or pressure), agricultural material properties (such as seed, fertilizer, herbicides, water, crop) or environmental parameters (such as soil, obstacles or weather). The robustness of sensor data generation is of high relevance, in particular varying "noise sources" like dust, moisture, sunlight or vibrations have to be taken into account. As a consequence sensor data fusion and the implementation of smart algorithms are important methods for reliable field operation. Facing the complexity of the measurements and the need for high temporal and spatial information, imaging sensor technologies have been applied. It turned out that imaging has become one of the most prominent field of innovation at the Agritechnica in 2015 and as well in 2017, five innovations each have been awarded.

Another key technology for robotic solutions is related to the data management, which is already true for today's agriculture. The access to heterogeneous data sources - as for example

from agricultural machines, process or weather data – is still not completely solved, however, non-proprietary solutions are on the way such as the cross-manufacturer “agrirouter” (DKE) as a universal data exchange platform. It should be mentioned that innovative technologies based on low-cost technologies or consumer products can already have a high benefit for the farmer as well as for robots, examples are low-cost communication and sensor systems using Bluetooth and Sigfox connections (Fliegl, Pöttinger) or automated agricultural recordings with smartphones (Farmdok).

System-integrated simulation is another key technology for field robotics, since the large variability of sensors, environments and situations cannot be covered just by field experiments. Moreover, software can be directly transferred to real machines, thus simulation has become a major topic to focus on practical solutions (a research example of a completely digital field robot for orchards – “elWObot” – is given).

Field robotics – from automation to alternative concepts

Setting up new processes for autonomous systems has a strong impact on the complete process of crop production. The integration of humans is shifted from the machine to other areas of responsibility, such as remote control or setup of processes, however, also combined solutions with autonomous and non-autonomous machines are considered, thereby addressing a stepwise autonomation as well as legal and acceptance aspects. Implications of process analysis on the design of robotic vehicles are for example the size of the vehicles or usage of (modified) existing or new machines. Moreover, drones are no longer limited to scouting purposes but can be applied for low weight processes such as crop protection in vineyards.

A research example for an autonomous field robot based on a new design is “BoniRob” (Bosch, Amazonen-Werke, Univ. of Appl. Sc. Osnabrück). For this concept several aspects of autonomous field robots are shown: a realization of different application modules for the platform (“App concept”), a concept of different new vehicles based on the same platform, the integration of human remote workers and economics of robot application.

A complete system for applying small robot swarms has been developed by Fendt and partners within a research project (“MARS”) and is now on the way to be a product (labeled “XAVER”). The setup of the concept includes small cooperating robots and a cloud-based control. The sample application is maize sowing, however, the concept could be extended for a large range of agricultural applications.

The feasibility of “individual crop farming” has been shown in several research projects, but is now on the stage to be implemented in products (such as XAVER). Another example for individual crop treatment is implemented on large state-of-the-art machinery: In a cooperation Bayer and Bosch have developed small modules which can detect individual crops and apply crop protection with different selective herbicides (“Smart Spraying Solution”). The autonomation of existing tractors (optionally with some modifications such as taking off the driver cabin) has recently been shown by several companies (such as CNH), however system integrated solution concepts require further development. For feeding operations on the farm, several autonomous (small) systems have already been presented for specific operations. A new option is now presented by Strautmann with a complete autonomous process from feed intake to feed distribution based on an existing machine, thus the same machine can optionally be used for manual operation.

To summarize, field robotics in crop production and beyond has stepped from research to first prototypes and products and will probably change agriculture significantly compared to stepwise automation during the last decades. Further steps of the digital transformation in an interdisciplinary context will speed up this process. There is a high potential - as well as a high challenge - for creating a sustainable agriculture with respect to ecological, economical and social aspect by implementing smart field robotics technologies.