THE ROLE OF DIGITALIZATION IN THE AGRICULTURAL 4.0 – HOW TO CONNECT THE INDUSTRY 4.0 TO AGRICULTURE?

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Abstract

In this time, many authors have reached to the conclusion that development of digital technology and applications are regarded as an important factor in their economic growth and development in the agricultural production. The improvement of mechanization of field work, machinery and equipment is a continuous process. We are witnessing the spread and agricultural use of the more and more modern equipment, which reflects to the technical and technological level of the area. The current paper is analyzing the connections between the tasks of the Agricultural 4.0 and Industry 4.0. In our study we systematize the following area: Industry 4.0, "Smart Farming", Internet of Things (IoT), Cloud Computing, and Big Data.

1. Introduction

Hungary is a historical agricultural country. This country produces corn, sunflower, wheat, pork, fruit, milk and many other foods. Agriculture, rural area and farmers are of particular importance when it comes to digitalism modernization reform. Our ability to handle these three problems properly has a great problem on Hungary's development for the future [1]. In this time, many authors have reached to the conclusion that development of digital technology and applications are regarded as an important factor in their economic growth and development in the agricultural production. The improvement of mechanization of field work, machinery and equipment is a continuous process. We are witnessing the spread and agricultural use of the more and more modern equipment, which reflects to the technical and technological level of the area [2].

2. From Industry 4.0 to Agricultural 4.0

Industry 4.0 is a name for the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of Things and cloud computing. Industry 4.0 creates what has been called a „Smart Factory". Within the modular structured smart factories, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the Internet of Things, cyber-physical systems communicate and cooperate with each other and with humans in real time, and via the Internet of Services, both internal and cross-organizational services are offered and used by participants of the value chain [3].

Cloud computing is a kind of computing method based on the internet, which enables shared software and hardware information to be delivered to computers and other equipment on demand. The end users do not need to know basics of the "cloud" or have professional knowledge concerning this, or control directly. All they need to know is what kind of resource they actually require and how to receive relevant service through the internet. Cloud computing describes a new way of adding, using and exchanging IT service based on the internet which involves providing dynamic, expandable and most of the time virtualized resources by using the internet. Generally speaking, cloud computing has the following five features: on-demand service, internet access, resource polling, rapid elasticity and calculability [4].

IoT in this way some sensors connect the internet, so as to operate certain programs and realize remote control. The central computer can Smart Agriculture Based on Cloud Computing and IoT realize concentrated management and control of machine, equipment and personnel based on the internet and improve production and life through more detailed and dynamic means. This is useful for integration and harmony between human society and the physical world and is regarded as the third wave of information industry development following computer and internet. Major IoT technologies include radio frequency identification technology, sensor technology, sensor network technology and internetwork communication, all of which have been involved in the four links of IoT industrial chain, namely, identification, sensing, processing and information delivery [3].

In terms of definitions, Agriculture 4.0, in analogy to Industry 4.0, stands for the integrated internal and external networking of farming operations. This means that information in digital form exists for all farm sectors and processes; communication with external partners such as suppliers and end customers is likewise carried out electronically; and data transmission, processing and analysis are largely automated. The use of Internet-based portals can facilitate the handling of large volumes of data, as well as networking within the farm and with external partners [4].
Other terms frequently used are "Smart Agriculture" and "Digital Farming". It is based on the emergence of smart technology in agriculture. Smart devices consist of sensors, actuators and communication technology.

3. The Main Stations of Agricultural Development

Agriculture 1.0

Situation in the early 20th century. A labour-intensive system of agriculture with low productivity. It was able to feed the population but required a vast number of small farms and a third of the population to be active in the primary agricultural production process.

Agriculture 2.0

This phase of farming began in the late 1950s when agronomic management practices like supplemental nitrogen and new tools like synthetic pesticides, fertilizers and more efficient specialized machines allowed to take advantage of relatively cheap inputs, thus dramatically increasing yield potential and growing returns to scale at all levels [5].

Agriculture 3.0

"Precision Farming" started once military GPS-signals were made available for public use.

Precision Farming entails solutions for:
- Guidance: early adopters in the mid-1990s were using GPS-signals for manual guidance. They built further on technology used in aerial spraying. The first automatic steering solutions appeared in the late 90s. During the 2000s, guidance accuracy was improved to 5 cm.
- Sensing & control: during the 1990s, combine harvesters were equipped with yield monitors based on GPS location. The first automatic Variable Rate Application (VRA) started at the same time. Low fertiliser prices and high technology costs initially limited adoption of variablerate technology. In the early days, VRA was based on soil sampling input, but performance improved drastically based on data gathered by yield monitors.
- Telematics: Telematics is a technology used to monitor vehicle fleets. It appeared in the early 2000s, and was inspired by the transportation industry. It is based on cellular technology and allows the optimisation of the logistics processes on the farm (Figure 1).
- Data Management: Farming software has become widely available since the birth of the PC in the early 80s.
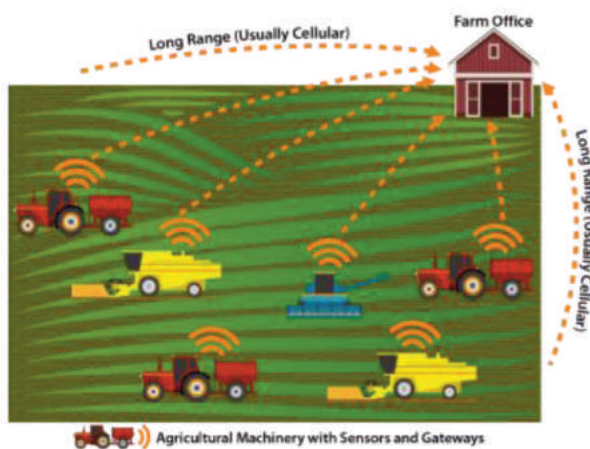

Figure 1. Precision farming [6]

Agriculture 3.0 can be seen as the gradual introduction of more and more advanced and mature Precision Farming technologies.

The focus is moved from pure efficiency in terms of cutting costs to profitability which can be seen as objectively and creatively seeking ways to lower costs and enhance quality or develop differentiated products.

Agriculture 4.0

A new boost in precision agriculture can be observed around the early 2010s based on the evolution of several technologies:
- Cheap and improved sensors and actuators
- Low cost micro-processors
- High bandwidth cellular communication
- Cloud based ICT systems
- Big Data analytics

As of the 2010s, smart technologies are also increasingly fitted as standard features on tractors, combine harvesters and other equipment, like [4]:
- Smart control devices (on-board computers)
- Many sensors for the operation of the machine and the agronomic process
- Advanced automation capabilities (guidance, seed placement, spraying, etc)
- Communication technology (telematics) embedded in the vehicle.

This evolution happens in parallel with similar evolutions in the industrial world, where it is marked as "Industry 4.0", based on a vision for future manufacturing. Accordingly, the term "Agriculture 4.0" is often used in farming. Agriculture 4.0 paves the way for the next evolution of farming consisting of unmanned operations (for example BoniRob) and autonomous decision systems. Agriculture 5.0 will be based around robotics and (some form of) artificial intelligence [7].

By Harold et al. [7] the digital agriculture offers new opportunities through the ubiquitous availability of highly interconnected and data intensive computational technologies as part of the so-called Industry 4.0.

Digital Agriculture can leverage the smart use of data and communication to achieve system optimization. The tools that enable digital agriculture are multiple and varied, and include cross-cutting technologies such as computational decision and analytics tools, the cloud, sensors, robots, and digital communication tools (Table 1). In addition, field-based activities are enabled by geo-locationing technologies such as Global Positioning Systems (GPS), geographical information systems, yield monitors, precision soil sampling, proximal and remote spectroscopic sensing, unmanned aerial vehicles, auto-steered and guided equipment and variable rate technologies.

Animal-focused technologies include radio frequency identification (RFID chips) and automated (robotic) milking and feeding systems, among others. Controlled-environment agriculture (greenhouses, indoor farms, etc.) is also increasingly enabled by digital technologies such as sensors and robots. Digital agriculture can potentially accumulate large amounts of data, and analytical capabilities that facilitate the effective employment of these data are key implementation factors.

Agriculture will follow other industrial sectors in that the benefits from digital technologies will materialize and become a source of increased production efficiencies once ubiquitously available data are effectively employed [8]. In a global economic environment, a nation's agricultural competiveness and ability to sustain critical natural resources will be strongly tied to its ability to innovate in these aspects of the production system. The question is not whether the global agricultural industry should adopt digital technologies, but how this adoption process can occur in an environment that encourages it to fully capitalize on the potential production gains.

Table 1. Enabling technologies for digital agriculture [7]

Production environment	Type of technology	Purpose and benefits
Cross-cutting technologies	Computational decision tools	Use data to develop recommendations for management and optimize multitudes of farm tasks
	The cloud	Provide efficient, inexpensive, and centralized data storage, computation, and communication to support farm management
	Sensors	Gather information on the functioning of equipment and farm resources to support management decisions
	Robots	Implement tasks with efficiency and minimal human labour
	Digital communication tools	Allow frequent, real-time communication between farm resources, workers, managers, and computational resources in support of management
	Geo-locationing (GPS, RTK)	Provide precise location of farm resources (field equipment, animals, etc.), often combined with measurements (yield, etc.), or used to steer equipment to locations
	Geographic information systems	Use computerized mapping to aid inventory management and to make geographical crop input prescriptions (fertilizer, etc.)
Field	Yield monitors	Employ sensors and GPS on harvesters to continually measure harvest rate and make yield maps that allow for identification of local yield variability
	Precision soil sampling	Soil at high spatial resolution (in zones) to detect and manage fertility patterns in fields
	Unmanned aerial systems	Unmanned aerial systems (UAS, or drones) Use small, readily deployed remote-control aerial vehicles to monitor farm resources using imaging UAS
	Spectral reflectance sensing	Measure light reflectance of soil or crop using satellite, airplane, or UAS, imaging, or field equipment–mounted sensors, to make determinations on soil patterns, crop
	Auto-steering and guidance	Reduce labour or fatigue with self-driving technology for farm equipment (including robots); can also precisely guide equipment in fields to enable highly accurate crop input placement and management
	Variable rate technology	Allow continuous adjustment of application rates to precisely match localized crop needs in field areas with field applicators for crop inputs (chemicals, seed, etc.)
	On-board computers	Collect and process field data with specialized computer hardware and software on tractors, harvesters, etc., often connected to sensors or controllers
Livestock	Radio frequency ID	Transmit identity data with tags attached to production units (mostly animals) that allow data collection on performance as well as individualized management
	Automated milking, feeding, and monitoring systems	Perform milking or feeding operations automatically with robotic systems, often combined with sensors that collect basic biometric data on animals, thereby reducing labour needs and facilitating individualized animal management

4. Two digital areas of agricultural machinery – The tools of geo-locationing by John Deere

The StarFire 3000 receiver (Figure 2.) picks up satellite signals from the Global Positioning System GPS and has the capability to use GLONASS satellites (Russian navigation satellite system, similar to GPS) to maintain guidance performance even in shaded conditions and other unpredictable environments. Moreover, the receiver is designed to utilize satellites as low as 5 degrees above the horizon. Due to the improved satellite availability, the StarFire 3000 provides a more reliable position. John Deere terrain compensation technology with the StarFire 3000 receiver provides the capability to detect the roll, pitch, and yaw of the vehicle. So the receiver can compensate accordingly to ensure true vehicle position with respect to the ground throughout the field [9].

Figure 2. An John Deere 6150R with the StarFire 3000 Receiver (The photo has been made by the authors)
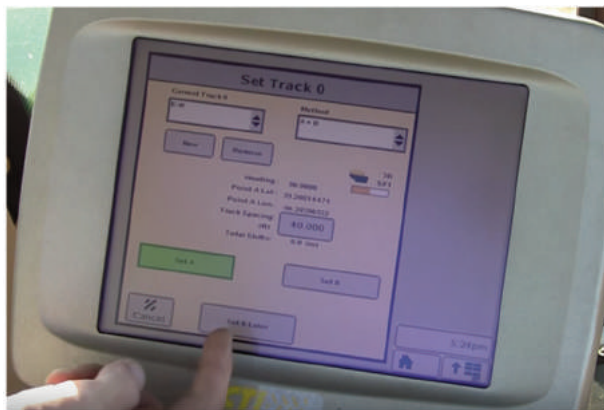

Figure 3. Set the A-B line for the AutoTrack on the GreenStar 3 2630 Display
(The photo has been made by the authors)

A variety of John Deere precision applications can be ran on the GreenStar 3 2630 Display (Figure 3) with a StarFire 3000 receiver regardless if it is planting or harvesting season, or for any application in between. The GreenStar 3 2630 display supports the following activations [9]:

– AutoTrac: with the GreenStar 3 2630 display coupled with an AutoTrac activation can provide automatic guidance with integrated AutoTrac, AutoTrac Controller, or AutoTrac Universal.
– Pivot Pro: brings all the benefits of AutoTrac to applications needing automated tracking in circle mode.

– Section Control: reduces input cost by automatically turning implement sections off in previously covered areas and turning them back on precisely to decrease skips.
– RowSense: provides the best in automatic guidance, by pairing up row feeler data with satellite positioning data, when harvesting row crops with a combine or self-propelled forage harvester.
– iTEC Pro: automates end row functions to reduce operator stress and increase efficiency, while consistently managing headland space.
– Machine Sync: provides combine harvest automation, harvest logistics, coverage map sharing, and guidance line sharing functionality.

5. Data exchanges standards in the digital farming by AgGateway

For the agricultural machinery industry, it has been of vital importance that the end customer, the farmer, can decide freely among individual products, and can combine machinery of different manufacturers. This has been achieved via uniform interface standards e.g. the three-point hitch or the ISOBUS connection between tractor and implement (Figure 4).

Figure 4. The date relationship between the tractor and implements with Isobus [9]

The Agricultural Industry Electronics Foundation (AEF) and AgGateway are considered the key players to promote interoperability in the primary agricultural production chain. Since decades ISO-11783 (ISOBUS) is the de-facto standard between tractors and implements of different brands. The AEF an independent international organization, has been founded for the implementation and further enhancement of ISOBUS. But over time its work is expanded to include other important areas such as Electric Drives, Camera Systems, Farm Management Information Systems, High speed ISOBUS and Wireless In-field Communication, developing guidelines and transferring the gained knowledge to ISO level [11].

6. Conclusions

Agriculture has a long and proud past history in applying digital systems including farming operations. Although there have been significant strides forward in improving the leading of farm managers there are still areas for improvement.

Agriculture differs from industry in several aspects but smart technologies can also be used in agricultural production. In the development of technical elements of crop production the development of digital played a dominant role in the past few years. The focus of the digital development of power and working machines was on the more precisely determination of the location

of machine-relations. The data flow between data collector sensors and the central processing unit is regulated by international standards during the operations. All data collected during the operations can evaluated by using the modular built resource planning systems. GPS controlled agricultural robots work in plant production and in animal husbandry. Smart farming makes use of GPS services, machine to machine (M2M) and Internet of Things (IoT) technologies, sensors and big data to optimize crop yields and reduce waste. Company leaders and senior executives need to understand their changing environment, challenge the assumptions of their operating teams, and relentlessly and continuously innovate [12].

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