~~The topic precedes: Precision agriculture mapping – drones~~

~~9~~B9. Decision making made on Internet of Thinks data

~~The topic follows: No~~

Human beings have cultivated lands and breed animals to obtain food for their survival since ancient times. This practice – agriculture – has evolved a long-term progressive process from Agriculture 1.0 to *Agriculture 4.0*.

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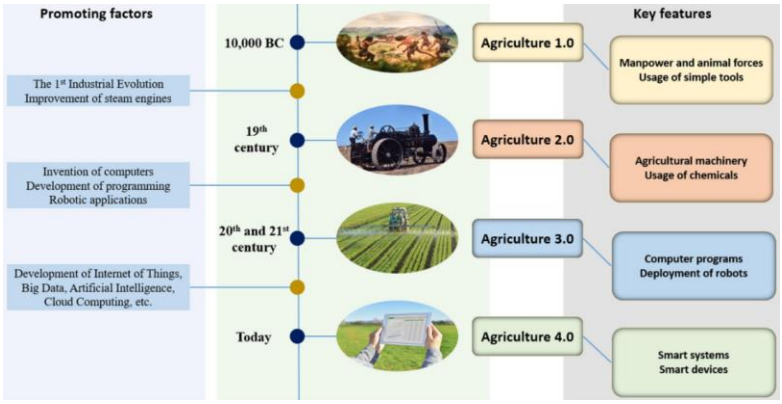

Agriculture 1.0: traditional agricultural replying on the manpower and animal forces, simple tools like sickles and shovels were used, humans still cannot get rid of heavy manual labour, the productivity remained at a low level.

Until the 19th century, steam engines were widely used to provide new powers in agriculture. It came to the era of Agriculture 2.0 when various agricultural machineries were operated by farmers manually and plenty of chemicals were used. Agriculture 2.0 significantly increased the efficiency and productivity of farm works.

In the 20th century, Agriculture 3.0 emerged from the rapid development of computing and electronics. Computer programs and robotic techniques allowed agricultural machineries to perform operations efficiently and intelligently.

Nowadays, the evolution of agriculture steps into *Agriculture 4.0*, thanks to the employment of technologies like *Internet of Things*, *Big Data*, *Artificial Intelligence*, *Cloud Computing*, *Remote Sensing*. The applications of these technologies can improve the efficiency of agricultural activities significantly.

Advantages of Internet of Things and developed low-cost sensors aim at optimizing the production efficiency, increasing quality, minimizing environmental impacts, and reducing the use of resources like energy and water.

Decision Support System (DSS) is a computer architecture based on processing of the Big Data able to assist the user by providing him with a valid support. The decision maker provides guidance on:

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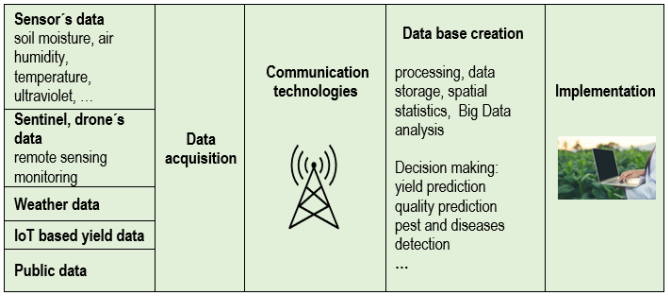
- availability of all information necessary for understanding the problem,
- possibility of exploring data from different points of view and according to the user's needs,
- possibility of assessing the scenarios resulting from the choices made.

The close relations between the system and its user makes it necessary to have a strong customization regarding the various types of decisions and data coming from different sources.

The figure illustrates data flows from sources to the database and final data processing



DSS provide collecting and processing of spatial data, data in time, machine-generated data, process generated data and human sourced data.

Agricultural yield is closely related to geographic location termed as *spatial data* and it is stored as coordinates to locate an area. Crops various stages such as seeding, fertilizing, pest management, weeding, water supply, harvesting represent *data in time*.

Machine generated data includes data from sensors, unmanned aerial vehicles, GPS. These data from new technologies may vary from sounds to images.

Process generated data includes data collected from farms such as information on planting, monitoring, and recording of the farming process such as seeding fertilizer application.

Human-sourced is previously recorded human experiences sourced: experiences which were previously stored as books are digitized and stored to provide accessibility.

DSS can be applied in agriculture with the support of **experienced agricultural experts**.

What are advantages of DSS in the precision agriculture?

- Support the farmers in maintaining control over all variables necessary to assess decisions.
- Help by providing numerical forecasts, even in the very short term.
- Can be managed remotely.
- Store all information by creating a historical database.

DSS automatically collect, organise, interpret and integrate information. Useful data can be drawn suggesting the most appropriate actions to respond to different farm needs, whether they are long-term strategic or tactical decisions to be taken in the short term.

DSS offer farmers an important negotiation tool. So far, only a small percentage of agricultural enterprises use it, on average it is around 7% in Europe, around 11% in the USA. And mostly they are only partial applications, the full deployment of DSS is still awaited.

What is the future of the application of DSS in agriculture?

The technologies that use DSS are also constantly developing. Moore's Law[*1] is still valid, scientific knowledge will not stop and will offer more new applications.

[1] **Moore's Law***: Moore's Law is the principle that the speed and capability of computers can be expected to double every two years, as a result of increases in the number of transistors a microchip can contain. Over time, the details of Moore's Law were amended to reflect the true growth of transistor density. First, the doubling interval was increased to two years and then decreased to around 18 months. The exponential nature of Moore's Law continued and created decades of opportunity for the semiconductor industry and the electronics that use them. So, Moore's Law has been able to continue to really push computing to the outer edge."

~~What is the future of the application of DSS in agriculture?~~

There are 10.3 million agricultural holdings in the EU, and 66% of them have an area of less than 5 hectares. Totally, 171 million hectares of land are used for agricultural production – that's about 40% of the total area of the EU. However, it is a fact that only 3% of agricultural enterprises in the EU farm on 100 hectares or more of agricultural land – which makes up approximately half of the EU's used agricultural area.

A full 65% of farms in the Union have an area of less than 5 ha, but only 7% of farms have an area of more than 50 ha.

Among the Member States, this difference is most striking in Romania, where 92% (~~i.e.~~ i.e., 3.1 million farms) are smaller than 5 ha, but only 0.5% of the total number of farms farm on 50 ha or more hectares (they farm 51% of the country's agricultural land). Larger farms (at least 50 hectares and more) are in Luxembourg (52%), France (41%), Great Britain (39%) and Denmark (35%).

From the given data it is clear that **small and medium-sized agricultural business entities** are the basis of agriculture throughout the EU. This is why the subsidy policy of the European Commission after 2020 is aimed precisely at **supporting these farmers**, and that is why the mandatory capping and degressive nature of direct payments is envisaged. The goal is for the subsidies to be aimed at the development of real small and medium-sized farmers, and not giant agrarian holdings.

The future use of state-of-the-art technologies in agriculture will not be possible without **subsidies from the EU and national states**. It is expected that by 2030 the number of DSS applications will at least double, by 2050 the use of DSS for farm management should be widespread.

Being a key part of sustainable agriculture, DSS will become more and more robust. The increased connectivity of technologies and the multiplication of smart devices on the field will stimulate the accumulation and storage of data. Actors from the sector will have the ambition to make DSS more ergonomic and user-friendly. Companies already offer mobile interfaces on smartphones and tablets, that are easy to handle and can be used in real time, directly on the field. Such developments allow more farmers to use DSS, since, at the end of the day, they are the final recipients and users of new technologies which will revolutionize agriculture.

Summary:

Decision Support System (DSS) is a computer architecture based on processing of the Big Data and IoT able to assist the user by providing him with a valid support. DSS provide collecting and processing of spatial data, data in time, machine-generated data, process generated data and human sourced data. Advantages of DSS in the precision agriculture: a) support the farmers in maintaining control to assess decisions, b) help by providing numerical forecasts, even in the very short term, c) store all information in a historical database. DSS automatically collect, organise, interpret and integrate information. Useful data can be drawn suggesting the most appropriate actions to respond to different farm needs, whether they are long-term strategic or tactical decisions to be taken in the short term. The future use of state-of-the-art technologies in agriculture will not be possible without subsidies from the EU and national states. It is expected that by 2030 the number of DSS applications will at least double, by 2050 the use of DSS for farm management should be widespread.

Naformátováno: Ohraničení: Pole: (jednoduché, Automatická, 0,5 b. šířka čáry), vzorek: Žádný (Akcent 6)

Naformátováno: Mezera Za: 6 b.

nastavil formátování: Čeština

~~**Moore's Law**[*]: Moore's Law is the principle that the speed and capability of computers can be expected to double every two years, as a result of increases in the number of transistors a microchip can contain. Over time, the details of Moore's Law were amended to reflect the true growth of transistor density. First, the doubling interval was increased to two years and then decreased to around 18 months. The exponential nature of Moore's Law continued and created decades of opportunity for the semiconductor industry and the electronics that use them. So, Moore's Law has been able to continue to really push computing to the outer edge."~~

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Study sources:

Zhaoyu Zhai José, Fernán Martínez 2020 *"Decision support systems for agriculture 4.0, Survey and challenges"*, Computers and Electronics in Agriculture, Vol. 170, DOI:
DOI: 10.1016/j.compag.2020.105256

Javaregowda, M., Indiramma, M. 2019 "Role of Big Data in Agriculture", International Journal of Innovative Technology and Exploring Engineering 9(2), pp 3811-3821~~,~~
DOI: 10.35940/ijitee.A5346.129219

https://en.wikipedia.org/wiki/Decision_support_system

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Key words:

agriculture 4.0,
Internet of Things,
Big Data,
artificial intelligence,
cloud computing
remote sensing,
spatial data
data in time
machine generated
process generated
human-sourced

Naformátováno: Mezera Za: 6 b.

nastavil formátování: Barva písma: Text 1

nastavil formátování: Barva písma: Text 1

Naformátováno: zarovnání na střed

Naformátováno: Mezera Za: 6 b.

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nastavil formátování: Bez podtržení, Barva písma: Automatická

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Změněn kód pole

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Naformátováno: Odsazení: Vlevo: 0 cm