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Future trends: business view and high-tech

In this content, we will talk about the macro-design of SPA that will surely appear in the coming years and also about future technological trends in SPA applied to viticulture and arable crops.

Figure 1 attempts to represent the relationships that surely one will find in the coming years in agriculture. A layer further north, we can find agriculture's problems, where soil, plants, climate, pests, diseases, environment, food production, fibre and energy, etc., are encountered. A layer further south, we can find society's problems, i.e. consumers, business models, transparency, food traceability, etc. A central layer, where we can find the hardware (agricultural machines, robots, sensors, etc.); the communications, fundamental in the communication between equipment and in the use of the Internet of Things sensors (IoT); and the data, normally produced by the various sensors and by the activity itself. The intermediate layers will be the layers of the software itself, because it will connect the central layer and the layers to the north and south, processing in real time a multitude of operations in a timely manner. In this scheme, two types of intelligence are also presented, human intelligence and artificial intelligence. The first is associated more with the semantics of the processes and the second is associated more with the time of processing large volumes of data, as well as the machine learning algorithms that will surely give great support to decision-making in the agriculture of the future.

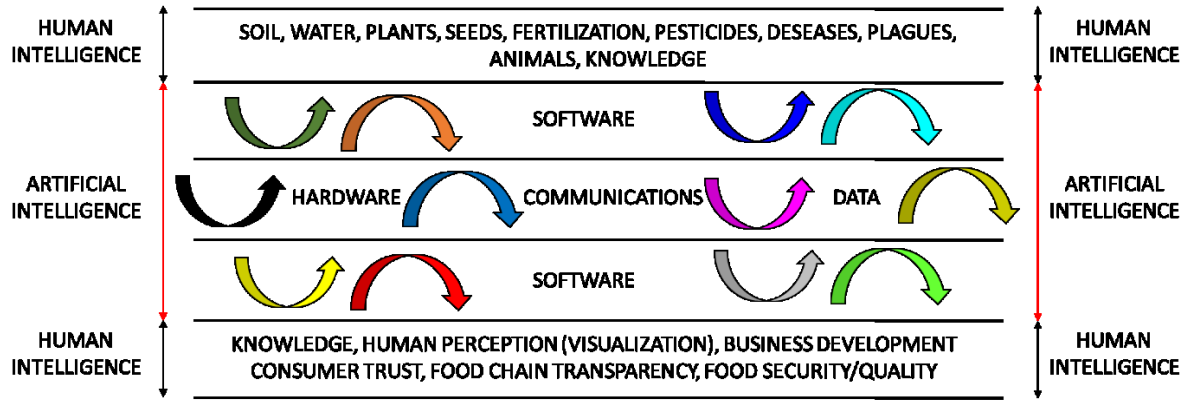


Figure 1 - Vision of Sustainable Precision Agriculture in the near future.

For these machine learning algorithms, data (Figure 2) will be a precious fuel, however for agricultural activities, there will be a lot of big challenges, at least the ones that are associated with IoT sensors and field measurements: (i) IoT sensors need communications and in the actual state of the art, farmland communications are not the same as city land communications. A lot of projects are going on in terms of standards for IoT communications (SigFox, LoRa, NbIot, etc.), however, in terms of business models, none of them has gained any visibility in terms of solutions for agricultural purposes. (ii) Any sensor needs calibration and maintenance otherwise data quality will be compromised. Calibration and maintenance is an expensive service and at this stage, the farmers are not willing to pay it. (iii) Different sensors, produced by different manufacturers, to measure the same parameter, with different calibrations curves, will be questioned in terms of data standardization and that will be for sure a huge challenge in terms of data usage.

In resume and considering Figure 2, from "data lake" to "data wisdom", data quality, data integration and data standardization will play an important role in the overall process, otherwise self-learning algorithms will be confused with "data trash".

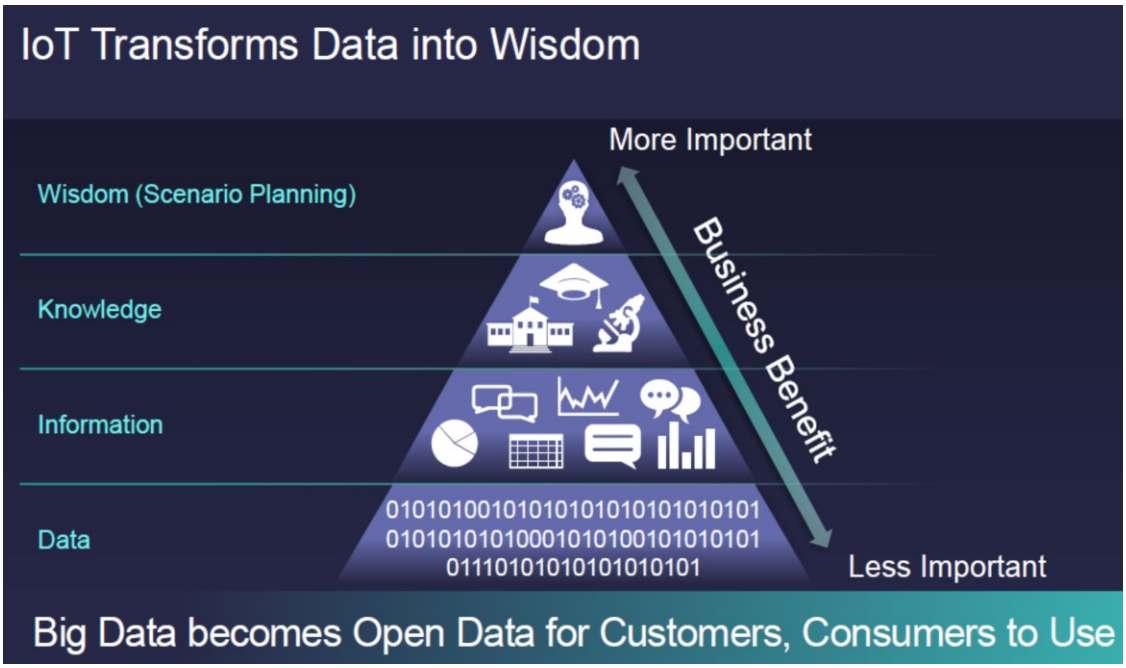


Figura2 – Big data challenges.

Within the SPARKLE project, a foresight analysis has been done to identify growing technological trends regarding arable crops and vineyards. A temporal series of patents and scientific publications were analysed. All that information is presented in the report "R2.2 Results of the Foresight Analysis", available at SPARKLE Project webpage (http://sparkle-project.eu/). This report is a very useful tool as a reference guide for the latest trends in SPA.

Figure 3 describes the main technological clusters identified in this analysis. The cluster analysis discovered the presence of five and seven technological groups, respectively, in viticulture and arable crops. Among the identified clusters, it is possible to distinguish between enabling technologies and application technologies. The enabling technologies are the basis on which the applications are developed and are the same in viticulture and arable crops ("Data processing", "Measurement and data detection", "Data transfer"). The remaining clusters are related to technological applications and are focused on different phases of cultivation ("Harvesting/Pruning" and "Vineyard

care" in viticulture, "Planting/Soil working", "Harvesting/Manipulation" and "Irrigation/Fertigation" in arable crops) and on "Agricultural vehicles".

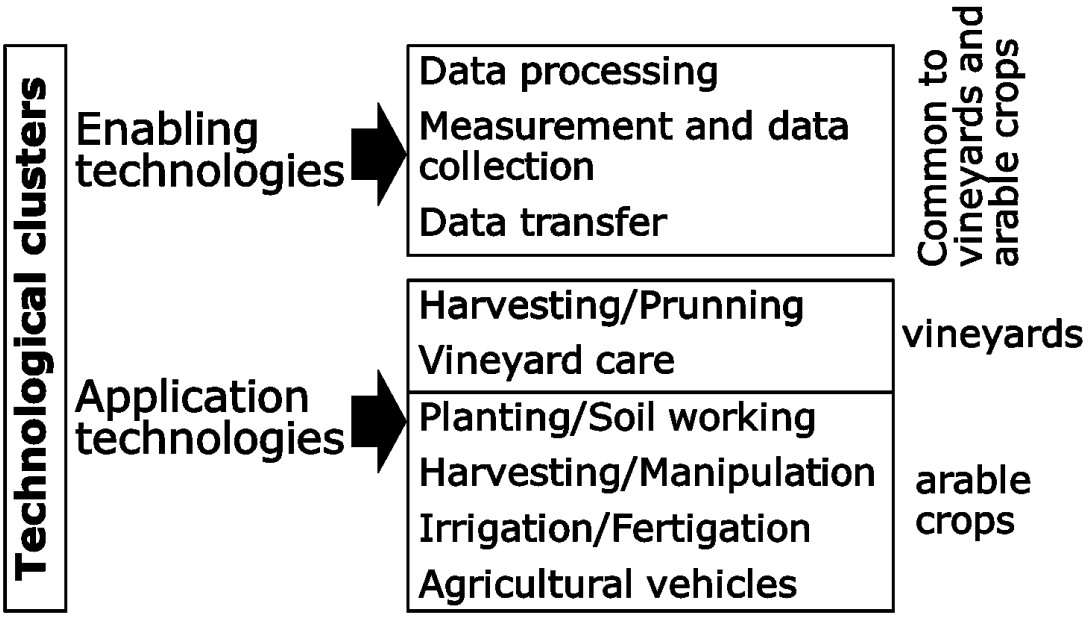


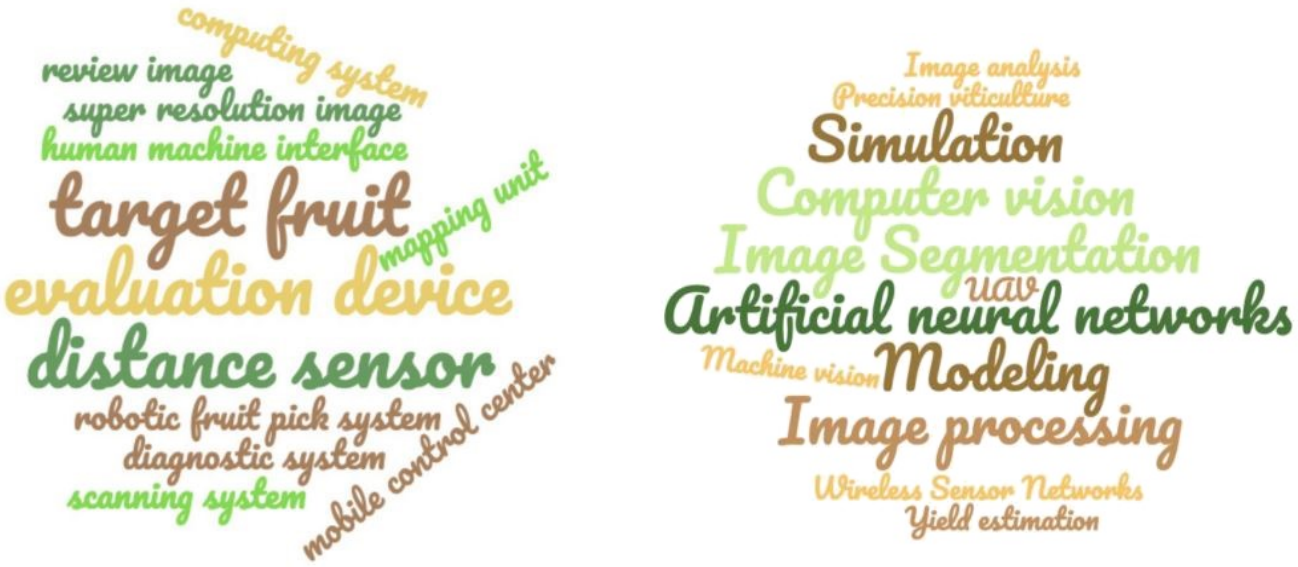
Figure 3 - Technological clusters identified by the foresight analysis.

As an example, we present the tag clouds for patents and articles for data processing technologies in vineyards and measurement and data collection in arable crops (Figures 4 and 5). The dimension of the tags is proportional to their frequency. Further information can be consulted in the above mentioned report and annexes.

For data processing technologies in viticulture (Figure 4), patents focused on human machine interface, diagnostic systems and image analysis (i). Papers analysis showed several expressions referred to image processing, wireless sensor networks and neural networks (ii).

Measurement and data collection patents analysis in arable crops (Figure 5) from 2011-2018 contain many expressions about irrigation and control systems; other references to optical systems and vehicles, comprising aerial vehicles, are present (i). The main tags for papers

from 1985 to 2018 are referred to image analysis but also to GIS, NDVI and satellite imagery (ii).



i **ii**

Figure 4 - Patents 2011-2018 (i) and papers 1985-2018 (ii) tag clouds for data processing technologies in vineyards.

i **ii**

Figure 5 - Patents (i) and papers (ii) tag clouds for measurement and data collection in arable crops.

Figure 6 gives a final synthetic view of technologies retrieved in the various clusters both in viticulture and arable crops.

The slots of Figure 6 containing the same patterns are painted in identical colours to highlight the recurrent technologies. Except for very general technological groups (e.g. "control systems" and "sensing systems"), at a deeper level of detail, the most frequent technologies are first "image processing" and "optical systems". Secondarily, "navigation" solutions and "aerial vehicles" are the most trending topics.

	Cluster	Technology				
Viticulture	Data processing	Control Systems	Image Processing	Navigation		
	Measurement	Control Systems	Image Processing	Optical Systems	Remote Sensing	
	Data transfer	Optical Systems	Sensing Systems	Navigation	Satellite Technology	
	Harvesting / Pruning	Robotics	Sensing Systems	Image Processing		
	Vineyard Care	Irrigation	Optical Systems	Aerial Vehicle	Sensing Systems	
Arable Crops	Data processing	Image Processing	Optical Systems			
	Measurement	Control Systems	Optical Systems	Aerial Vehicle	Image Processing	Satellite Technology
	Data transfer	Control Systems	Sensing Systems			
	Harvesting / Manipulation	Control Systems	Manipulators	Robotics		
	Planting / Soil Working	Control Systems	Autonomous Vehicles	Navigation		
	Agricultural Vehicles	Control Systems	Autonomous Vehicles	Aerial Vehicle	Remote Sensing	Image Processing
	Irrigation / Fertigation	Control Systems	Sensing Systems	Efficiency		

Figure 6 - Synthetic view of the most frequent technologies across the analysed clusters.

The main technological trends in patents are related to products on which the companies are investing, hence they are the main trends in the current market. Technological tendencies in scientific papers, instead, are more likely connected to solutions that probably will be on the market in the near future.

Bibliography and links

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