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Artificial Intelligence in Agriculture: An Overview.

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An early definition of what *Artificial Intelligence* comes from Computer Science: "*Artificial Intelligence* is concerned with the study of computers that do things that at the moment, people do better".[1] On the other hand, a more comprehensive definition is given by[2] who define *Artificial Intelligence* as: "The area concerned with building artificial artifacts that exhibit intelligent behavior." The whole question goes through the premise of what is considered intelligent. Defining intelligence is not trivial. Depending on the approach, the meaning can be completely different. For example, in a philosophical context, it means human intellectuality; in a psychological context, it is linked to the ability to solve problems; in the rational approach, it means "thinking" correctly; and in an emotional context, it relates to dealing with feelings.

In general, the definition of *artificial intelligence* goes through the interrelation of four dimensions that are defined by[3]: 1-think like humans; 2- act like humans; 3-think rationally; and 4- act rationally. In our agricultural context, I prefer to define intelligence according to dimensions 3 and 4, remembering that a rational system does "what is right" based on what "it knows".[3] In this choice, I limit myself to the rational component due to two intrinsic characteristics of all agroecosystems: a) they are extremely complex systems; b) they are systems where the knowledge representation must contain a very high dynamic component. That is, they are very challenging systems in Cartesian understanding, so if we include the human subjective component, the solution of models for an AI is complicated and perhaps unattainable in our current stage of scientific-technological development.[4]

Thus, a proposed definition of *Artificial Intelligence* for Agriculture (AIA) is a sub-area of knowledge that intends to rationally emulate conditional behaviors in the face of unstructured and dynamic agricultural environments. Emulating conditional behaviors rationally means the extensive and intensive use of mathematical logic to model situations and environments where conditional situation of parameters is the

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key and definitive or constant information and data do not exist (or exist for a short time). Unstructured and dynamic environments refer to three parameters: the on-the-go agricultural environment constituted by an off-road substrate changeable in time and space, agricultural objects composed by living beings (plants and animals) of the fragile and fractal spectrum and by interfaces and interrelated influences between different agricultural systems and environments. All these components follow a conceptual structure modelled by mathematical chaos, which is greatly influenced by initial conditions.

In this conceptual context of an AIA[5] the *artificial intelligence* research area can be divided into seven major areas: 1-Knowledge Representation (KR); 2-Understanding natural language; 3-Learning; 4- Planning and problem solving; 5- Inference; 6-Search; and 7- Computer vision. Of these seven areas, the only one that is not (yet) widely applied in agriculture is natural language understanding, and all others are significant in the context of my definition of AIA.

Knowledge Representation (KR) deals with how the AI represents the world, represents itself, and its related tasks. This area focuses mainly on the types and forms of data structures, from a terrain map to a database of agricultural pests. Learning is the algorithms and system architectures that enable an AI to learn through various modes, such as observing an event, data mining, guessing alternatives right and wrong, and finally, having data structures annotated by a human. Planning and problem-solving are the core of agricultural robotics, and this AI deals with the ability to plan actions necessary to accomplish a goal or solve a problem. Inference in an AI makes it possible to obtain answers from incomplete information. It is the touchstone in systems that need to make decisions autonomously, such as diverting from anobstacle in a crop. Search in terms of AI means efficiently examining a KR and from problem-solving and inferences to find the correct answer or make the right decision.Furthermore, finally, the computational vision is about automatic signal sensing and image processing systems that allow AI to improve actions or increase data structures and KRs. All these seven areas are not isolated when thinking about an IA, in many situations, mainly in agricultural situations, there is a recurring entanglement between each of these areas depending on the relevant objectives. An example is given by[6]which explains that a precision agriculture system can generate a vast amount of data that configure big data from sensors (data structure - KR), then the use of search techniques mine (Search) data that through AI techniques extract knowledge (ML – learning). This knowledge can be used to validate hypotheses (Inference) that guide a computer vision system based on digital cameras (Computer Vision) that obtain images. These images can be used according to[7] for a disease detection system through segmentation techniques coupled with Deep Learning (DL) techniques (Image Processing-Computer Vision) that will enable the planning (Planning) of a application phytosanitary by a drone-sprayer (problem-solving).

Conclusion

AI is one of the fulcrums of Agriculture 4.0 and is at the forefront of the so-called digitization of agriculture.[8] Together with robotics[9] and connectivity,[10] they will raise the world agricultural standard to a scale never seen before. Transforming all farms, from small to large, to the new state-of-the-art farming paradigm: all will be Smart Farms[11] As a humble and naive recommendation, I suggest that everyone who works in agriculture: start studying AI.

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