The journey towards autonomous agriculture

Global agriculture has developed at an exponential pace in the last three decades. This growth has been fueled by the ever-rising global population and food demand. Technological advancements in countries such as Brazil, Russia India and China have contributed significantly to this development.

Fields and orchards across the world have seen deployment of advanced technologies and sound agronomic practices. Focus has been on soil preparation and conservation, chemical and biological crop protection improvements, orchard environment evolution and plant genetics. These applied agronomic techniques gave a boost to productivity, but also required a new level of mechanization in agriculture, with complex machine designs, based on mechanical and hydraulic subsystems, to guarantee a stable and reliable application of these technologies. This was the birth of Precision Agriculture.

With the miniaturization and power increase of computers, precision agriculture started to move to a new level –digital agriculture. But this concept had a breakthrough when the Global Positioning System was opened for civil use, after 1990. It created a whole new set of possibilities, bringing the concept of Precision Agriculture to a real time interaction between the machine, the agronomic data and the field. A little over 10 years later machines with autopilot, touchscreen and joysticks started to become common in the most developed agricultural areas, and before 2010 most of the machines in growing countries such as Brazil, Argentina, Russia and Australia, also had precision agriculture systems installed. This created an exponential jump in farming productivity, but at the same time, the operations to manage all these parameters to achieve a higher yield became more complex. Although the computerized systems provide a lot of information, it is still operator skill that impacts the final decision for many of the machine parameters, and that can drastically affect the final productivity result.

But why all this history of agricultural mechanization and precision agriculture if the objective is to talk about automation and robotics in agriculture? Because these are the base technologies that are needed to start developing automated functions, that can lead to a fully autonomous machine to perform these functions in agriculture. Unlike autonomous automobiles, in addition to sensing the environment and deciding speed, direction and other complex safety parameters, an autonomous agricultural machine has to perform agronomic and industrial functions, taking into consideration very complex and unstructured environments, adapting its operation to various unpredictable situations without human intervention, while still guaranteeing a high yield level at minimum cost, since most agricultural products are commodities with market constrained prices.

So, if it is so difficult to develop these machines, why have they been receiving so much attention in the last few years? The main and most critical reason is skilled labor shortages! With labor moving to the cities, there is strong pressure to be able to cope with the increased need for food, due to population growth and development in emerging countries. This is even more critical when specialized labor, with the right skills to operate the complex machinery that today is present in agriculture, is required. Machine manufacturers have been improving interfaces and automating functions, but there is still the need to have skilled operators on the machines, making critical decisions during field work.

The COVID-19 pandemic now represents an additional pressure, where food availability and security had to be guaranteed, while social distancing and travel bans made it almost impossible for many of the agricultural operations to keep working, creating an additional

gap between labor need and availability, heating up the discussion about digitalization and automation across the globe. If autonomous machines could perform some of the labor-intensive applications, the remaining resources could be redeployed to maintain other essential activities.

So, when starting to discuss what we really need to develop autonomous agricultural machinery, we can list six key technology areas of focus – command and control user interfaces, sensing and perception, planning and optimization, machine and process automation, data management and communication. These various elements need to work in coordination to achieve growing levels of autonomy, moving from level three – enhanced operator support – through level four, with supervised autonomy, up to level five, with full autonomy capabilities.

But in addition to these technical areas, there are challenges with the standardization protocols, legislation and public/cultural attitudes to implement this technology on farms. For example, even if all legislation is approved and the engineers are confident and compliant with all safety protocols, being ready to release an autonomous machine in the field, would you feel confident letting your children playing near it? So, to bring autonomy alive there is much more than technical expertise involved, there is the need for political and cultural change in society.

For many years there has been significant research efforts across the world towards agrobotics, mostly supported by universities and research centers, but in the last five years much of this research was spun off to become startups, that have attracted significant investment and are arriving on the market with different concepts of robotic solutions. Some of note are Naio, ecorobotix, Ibex, FarmWise and Earthsense, all in the area of weeding and crop protection – by far where most of the initial open field farms opportunity lies, adding the elements of enhanced employee safety and sustainability to the positive equation of robotics. Another strong growth area is fruits specific robots, such as Agrobot for strawberries, Vitibot for grapes, and abundant for apples. Some of the most interesting concepts are from SwarmFarm from Australia or DOT from Canada, that bet on the multipurpose platform concept, where different implements can be attached to an autonomous platform to perform multiple activities, aiming to reduce farmers' capital expenditure on many, independent machines. Some of them are also focusing on different business models, where robotic machines would not be sold, but a team would take the machines to the field, program them to perform a task and then go to the next farm: a complete "robot as a service" platform. This concept would help to break the bottleneck in training farmers on how to operate robots, making their introduction much faster.

At the same time, the major agricultural machinery manufacturers have been following the autonomous path starting by automating machine functions and developing concepts of autonomous tractors, that combined with smart implements, can revolutionize big farm operations, such as the autonomous tractor concepts presented by CNH Industrial, parent company of Case IH and New Holland Agriculture, with real, wide scale autonomous operation in the fields of Kentucky, USA in 2016. Some have also partnered or acquired startups to gain faster access to technology.

But there is an area of robotic operations that is not in the future, it is already making the difference in open fields – UAVs, the generic definition of the drones and other aerial equipment we can see flying over fields across the world. Initially used for scouting, they are rapidly expanding their use to other areas of operation, including targeted application of crop protection products and even harvesting – with some interesting concepts of tethered drones with cameras and automated arms being used for fruit harvesting by startups such as the Israeli Tevel Aerobotics.

From a market close to $213 million in 2015, mostly comprised of automated milking robots, it is forecasted that the agriculture robotics market will reach over $20 billion by 2025, with a strong growth of UAV (drones) and driverless ground machines, according to data collected by a Research and Markets Company study of March 2020. This shows that there is not only a desire, but also a market opportunity to accelerate deployment of robotics in fields and orchards across the world. The people and companies that arrive first, with the best solutions, will have a “green ocean” to grow, becoming the new reference point in the agricultural sector.

Sergio Soares
Innovation Systems & Agronomic Design Leader
CNH Industrial – Technology