AGRICULTURE 4.0 – ROBOTIC APPLICATIONS

AGRICULTURA 4.0 – APLICACIONES ROBOTICAS

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Abstract: The current trend in agriculture is called Agriculture 4.0 it corresponds to the integration of Robotics, Big Data, Information and Communication Technologies (ICT), Internet of Things (IoT) among others to precision agriculture (PA) and Smart farming, in order to obtain better results from the available resources, satisfying the current demand for agricultural products. This article presents the bibliographic review of the main current robotic applications in agriculture, addressing the call of agriculture 4.0.

Keywords: Agricultural Robots, Agriculture 4.0, Precision Agriculture (PA), Smart Farming

Resumen: La tendencia actual en agricultura es denominada Agricultura 4.0 corresponde a la integración de la Robótica, Big Data, Tecnologías de la Información y la comunicación (TIC), Internet de las Cosas (*IoT*) entre otras a la agricultura de precisión (PA) y *Smart farming*, con el fin de obtener mejores resultados a partir de los recursos disponibles, satisfaciendo la demanda actual de productos agrícolas. El presente artículo presenta la revisión bibliográfica de las principales aplicaciones robóticas actuales en la agricultura atendiendo el llamado de la agricultura 4.0.

Palabras clave: Robots Agricolas, Agricultura 4.0, Agricultura de precisión (AP). Agricultura Inteligente.

1. INTRODUCION

Agriculture 4.0 is the evolution of precision agriculture (PA) and Smart Farming that including Robotics, Big Data, ICT, IoT, among others, to improve the productivity of crops in order to satisfying the food increasing demand due to population grow, according to Food and Agriculture Organization FAO to 2050 the population achieve 10 Billion and the terrain available to agriculture the water and other resources are decreasing.

In this article current agriculture robots and applications are presented and its general architecture applied to Agriculture 4.0.

2. AGRICULTURAL ROBOTS

Today, there is considerable effort aiming to advance in robotic technologies to be used in the field in different segments: academic, research, development, as well as industrial.

Figure 1 presents different approaches to robotics applications in agriculture by different universities, laboratories and industries around the world.

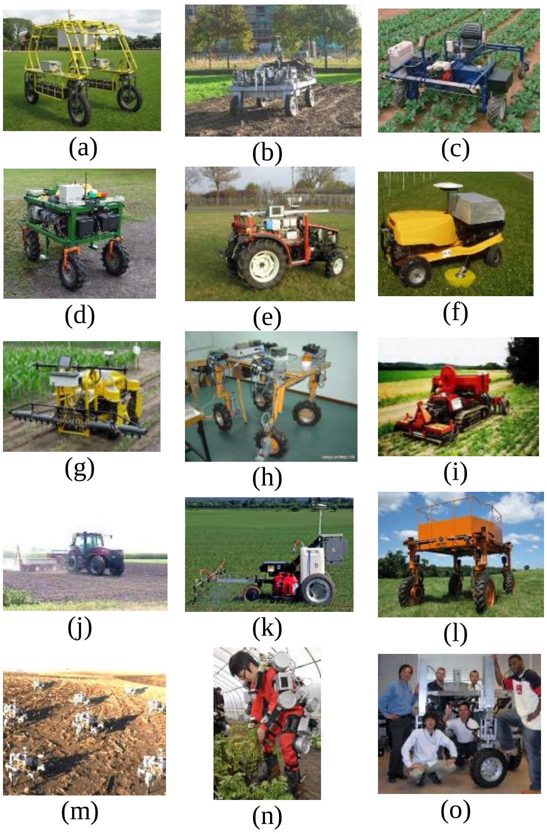

Figure 1 Robotic applications for precision agriculture.

Figure 1 shows distinct robotic applications: a) RAM by NEPAS and Embrapa, (Godoy et al., 2010); b) Weeding Robot by Tijmen Bakker (Bakker et al., 2010); c) Autonomous Crop Vehicle of Tillett and Hague Technology Ltda; d) The Weedy Robot from the Faculty of Engineering and Computer Science University of Applied Sciences Osnabrueck (Ruckelshausen et al., 2006); e) Autonomous tractor developed at Copenhagen. University (Have et al, 2002); g) Hortibot by Rasmus Jorgensen. (Jørgensen et al, 2006); h) The Supportive Autonomous Vehicle for Agriculture by Piraeus Institute of Technology in collaboration with University of Thessaly (Tressos et al, 2007); i) The Modulaire tractor; j) Autonomous guidance projects at the University of Illinois at Urbana-Champaign (Qin Zhang et al, 2001); k) Weed Management by Norwegian Institute for Agricultural and Environmental Research (Berge et al, 2012); l) AgriBot, precision agriculture robotic platform by NEPAS and Embrapa. (Tabile et al, 2011); m) Prospero, Collaborative robots for agriculture by David Dorhout; n) Exoskeleton by Tokyo University of Agriculture, (Toyama et al, 2009); o) The AgRover robot Iowa State Lie Tang (Khot et al, 2006).

The robotic platforms previously described represent the different applications of robotics in Precision Agriculture (PA) engineering, e.g. application of fertilizers, data collection and weeding, among others. Different devices as electric motors, combustion engines, hydraulic systems, artificial vision, pH sensors, odometers, GPS (Global Positioning system), inertial navigation system and RF (radio frequency) are used. Most of these robots use Independent Traction Steerable Systems (ITSS). However, cases m and n in the figure 1 use legs and an exoeskeleton system. (Archila, 2016)

A general scheme of hardware architecture for an autonomous mobile robot for PA is presented by Emmi. L and Gonzalez-de-Santos. P. (2012). Figure 2.

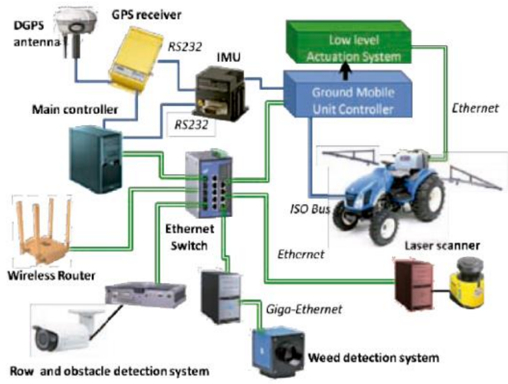

Figure 2 General scheme of hardware architecture for an autonomous mobile robot for PA (Emmi and Gonzalez-de-Santos 2012).

Figure 2 presents different sensors, controllers and communications systems to PA robotics applications. One may see the navigation system, weed detection system, scanner system, row and obstacle detection system and low-level actuation system, in a typical architecture. The authors proposed some improvement in the architecture presented in Figure 3. The ISObus standard and modular controllers are designed to specific tasks.

Figure 3 Architecture for agricultural robots (Emmi and Gonzalez-de-Santos, 2012).

The inclusion of agriculture robots or autonomous plant inspection (API) may positively influence production costs as presented by Pedersen et al (2006). The study showed, in the case of field scouting task, the total cost of 15.6 Euros/ha/year, using API with an approximate value of the API of 35.000 euros, including the GPS system. Conversely, the use of traditional methods implies the cost of 19.4 Euros/ha/year. The cost of this technology was 27 euros/hr. It is important to highlight that the sensors applied in the robot navigation sub-system influence API cost, consuming 23.62% of economic resources in the robot design (Archila et al 2013).

Most of the current agricultural robotics systems applied to agricultural environment are in the third category, Independet Traction Steereable Systems ITSS. They are robots that have special characteristics of torque and maneuverability. (Archila, 2016)

3. AGRICULTURE ROVERS

In the bibliographic review two applications considered as agricultural rovers were found, they are: Autonomous Prime Movers (APM) and AgriRover they will be presented in this section

2.4.1 Autonomous Prime Movers (APM)

Autonomous Prime Movers are "Agricultural Rovers" developed by Bergerman et al (2012). These vehicles were developed to special crops (like fruits, vegetables, horticulture an floriculture) in which needs intensive cultivation. This means that the cost is significantly high since it involves considerable work force. Regarding farm economy, the past decade presented the increase of 20% in the net value (from 38% to 58%). "In addition to labor costs, an increasing consumer demand for a safe, affordable, traceable, and high quality food supply, and the need to minimize the environmental footprint, represent key challenges for specialty crop sustainability in the United States. Given the past history of abundant supply of low-cost labor, few technological solutions to increase production efficiency have been viable. The current climate gives us an opportunity to use recent technological advances to not only increase efficiency in production of specialty crops but also to support a domestic industry in engineering solutions for specialty crops". (Bergerman, 2012)

Among the technological solutions, one may find The APM (Autonomous Prime Mover). APM are vehicles with "Reconfigurable mobility" and low-cost, equipped with lasers and computers. They may harvest and ease tough tasks. They consist of electrical platforms with automated routines as row following, row turn, and row entry. They are autonomous orchard vehicles that can be reconfigured and program tasks year-round for several operations.

Figure 4 presents workers using the platform in a crop of green apples.

Figure 4 Autonomous vehicle (Kohanbash et al 2012)

2.4.2 AgriRover

The AgriRover is a commercial platform developed in New Zealand by Manderson et al (2014) to be applied in PA. The author classified the robot as an Agricultural Ground Vehicle (AGV). The robot weights 150 kg with four 180 watt motors capable of handling uneven ground at 5 km/h and small slopes of less than 20 degrees. See Figure 5.

Figure 5 AgriRover, (Mendersen et al, 2013)

The AgriRover was developed to map and monitor within-paddock variability of grazed pastures. Several applications have been considered: mapping of soil properties of grazed pastures, spatial and temporal monitoring of soils and pasture, generation of prescription maps, soil real-time treatment or dye-marking of patches. This AGV has also general purposes such as a remote control and video feedback for other farms tasks. AGPS guided robot for the purpose of gathering dairy cows to the milking shed is being developed and will present all the features mentioned above.
The robot has four wheels drive and differential skid steering. It is classified in the category, according (Independent Differential (ID)). (Archila, 2016)

4. CONCLUSION

The article presents the review of agricultural robots and agricultural rovers applied to Agriculture 4.0 Describes its architecture and some applications in crops. It is important to develop more robotic applications and support agriculture 4.0 to meet the demand for food and the appropriate use of natural resources.

5. ACKNOWLEDGMENT

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