Agricultural Robots: drivers, barriers and opportunities for adoption

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Abstract. In the next decades, agriculture is to feed a rapidly growing population, while tackling changes in climate, overexploited resources, changes in markets and competition with other sectors. Agriculture is, therefore, expected to move towards a more sustainable intensification. In this context, robotic technologies are aimed to reduce labor, using fewer resources and improving agricultural productivity. There is growing demand and awareness of the potential use of such technologies in the farming industry. Public and private investments are driving technological innovation in recent years. Today's farm robots can perform a variety of fieldwork, from scanning a field identifying weeds and reducing the use of herbicides, to harvesting vegetables and soft fruits with high precision. Robots are expected to change the way crops are grown and how inputs are targeted. However, current adoption by growers remains limited.

Using a qualitative approach, this exploratory research analyzes perceptions towards the barriers, drivers and opportunities of robotic technologies to promote greater and sustainable crop production. Fourteen experts were interviewed in California, U.S. regarding their views on the adoption of agricultural robotic technologies.

Results showed that farm labor shortages and increasing labor costs were considered the key factors driving the adoption of robotic technologies. High up-front costs, lack of compatibility between farm equipment, and lack of awareness of potential benefits were the reported barriers for adoption. Experts recognized that adoption of technological innovations can be promoted by aligning needs, expectations and values. Increasing financial and technical support, flexibility in equipment design and compatibility, as well as training were identified factors that can potentially increase adoption of robotics. The research provided valuable insights for future research further exploring robotics in other regions to inform and promote greater adoption of agricultural robotics.

Keywords. *Robotics; Perceptions; Barriers; Facilitators; Adoption of robotics*

Introduction

In recent years, developments in global positioning systems (GPS) real-time kinematics (RTK), specialized sensors, actuators and interfaces are enabling the integration of automation systems, particularly agricultural robots (Emmi et al., 2014; Pederson et al., 2006). A large number of field operations can be executed by robots that in many cases provide more benefits than conventional machinery (King, 2017; Oetomo et al., 2009). From cultivation, weeding, scouting and application of inputs to harvesting operations, autonomous robots can demonstrate economic and ecological benefits (Emmi et al., 2014; Pederson et al., 2006). It is, therefore, of interest the increasing number of agricultural robots in the field going commercial. However, adoption rates and factors that promote or inhibit their adoption cannot be obtained from the literature. The present paper seeks to explore the perceived barriers, drivers and opportunities for the adoption of agricultural robots by experts and end-users.

Material and methods

A qualitative method was followed to provide exploratory insight into the perceptions of robotic technologies and to provide the basis for future research. A common way to develop new areas of research is through exploratory work (Patton, 2015). Interviews were conducted with agricultural experts. Experts are expected to be updated with the latest trends and therefore provide with a greater representation of the information. Kutter et al. (2011) defined experts as (1) persons who possess privileged access to decision processes and/or information about group of persons or (2) persons who are responsible for the design, development, implementation and/or control of solutions, strategies or policies. Interviewed participants were considered experts given their position within a work environment related to advance agricultural robotics and their experience in this field. Participants had various affiliations, as reported in Table 1.

Interviews lasted around 45 mins and transcripts were recorded to aid subsequent data analysis. An interview discussion guide was developed with mostly open (semi-structured) questions. This offered the interviewer the opportunity for pursuing questions in greater depth. The interviews were face-to-face or by phone. The interview followed three thematic areas exploring (1) perceptions of agricultural robotic technologies, (2) driver and barriers to adoption of these, and (3) factors to increase adoption.

Sample

Fourteen expert interviews were conducted in the state of California, U.S. (mainly in the Great Bay Area). The exploratory approach justified a small sample (Table 1). Contacts were established via emails and phone calls followed by face-to-face interviews. Due to the methods of sample selection, the results of the interviews are not generalizable to statements about the geographic areas considered. The exploratory data collected does provide information and insight about the current state of robotic technologies in the surveyed areas.

Table 1. Interviewees affiliation (*N=14*)

Institution	Numbers
Agricultural Robotic Firm	5
Research Institution & University	4
Private Food Manufacturer	2
Agricultural Consultant	2
Private Agricultural Services	1
Grower/Contractor	1

Data analysis

Experts' interviews were analyzed following Patton (2015) content analysis method to analyze qualitative material.

Results

Four main themes emerged; perceptions, drivers and barriers to robotic technologies in agriculture, and opportunities to increase adoption. The experts highlighted labor availability and costs as the main drivers for robotics adoption. Automation of field operations is considered a key to future production in the areas covered. While experts asked for precaution regarding data ownership and use, growers perceived data ownership as the least of their current concerns. In terms of barriers to adoption, initial investment and associated costs were significant, as well as, the lack of equipment compatibility and standardization.

The lack of engagement between developers and the farming community, and growers' resistance towards new technological innovation were also suggested as barriers. However, experts also highlighted these as potential factors to be addressed to promote adoption – demonstrations of technology and promoting robotics benefits to the farming community. Other opportunities identified included, economic incentives to support adoption; and public and private partnerships. Standardization was acknowledged as a necessity if economies of scale are to be realized. Significantly, education and training were noted as significant opportunities to promote adoption.

Discussion

This research showed that robotics hold greater potential for agricultural growth and their adoption is driven by the lack of labor availability and its related costs in the sampled area. This was also suggested by Fennimore et al. (2013) also discussing how the advantages of robotic automation over other traditional methods can promote their adoption (Pedersen et al., 2006). The main opportunity for robotics, therefore, is to address the labor deficiency in the area. However, according to experts, the investment costs of robotic equipment are limiting their adoption, which is related to cash flow problems faced by many growers. It is recognized that more affordable equipment combined with financial incentives can potentially promote adoption.

Although robotic automation was seen as key to future agricultural production in the area, experts suggested that greater communication is needed to highlight the benefits and economic gain of robotic automation in comparison to traditional methods. However, the importance of promoting robotic technologies suited to growers' needs was also recognized, mainly through the promotion of future strategies focused on public and private partnerships. Compatibility and standardization of equipment were barriers frequently reported in this study and in the literature (Adrian et al., 2005; Fennimore et al. 2013). It is notable that data ownership and protection were not considered barriers to the use of robotics in this study. However, this is in contrast with other studies in Europe (Kutter et al., 2011).

Growers' conservative response to technological innovation seems to limit adoption, but education and training were suggested as a way to encourage more openness towards robotics. Training relevant skills at college and university level would also prepare the next generation in farming to deal with a constantly changing technological sector. Demonstration of the technological benefits in field contexts was also noted to promote engagement between the end-users and the technology to be implemented.

Conclusion or Summary

This study provided valuable insight into the main factors affecting the adoption of robotic technologies as perceived by various agricultural experts. Labor availability and cost were the main driving forces for the development and adoption of robotics, while the main barriers were linked to the high investment cost and the lack of equipment standardization. It was recognized that education and demonstrations of robotic benefits and economic gains will effectively promote their adoption. However, since this research was exploratory and conducted with a small sample, a more in-depth study should be conducted to support the outcomes of this paper.

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