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Trends in Agricultural Technology Advancements: Insights from US Patent Analysis

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Introduction

Growing global demand for food, fiber and fuel requires the adoption of sustainable agricultural practices. To address environmental concerns while increasing societal benefits, a transition to conservation approaches and sustainable intensification pathways is essential. Technological advancements in agriculture offer significant opportunities to facilitate this transition.

Patents are a key indicator of technological progress and provide valuable insights into the direction and focus of future innovation. As a form of intellectual property rights, patents protect inventions and foster further innovation. This study aims to analyze prevailing trends in agricultural technology advancement by examining active patents in the United States from 2014 to 2024, providing insights into the current landscape and future directions of agricultural innovation.

Methodology

The patent search was conducted using the Lens.Org website. The terms included for the search equation were used: "agricultur*", "farm*", or "crop.", which included text in title or abstract. The asterisk (*) was used to include all words related to these roots. The following filter was also applied to the search: i) granted date spanning from 01-01-2014 to 04-01-2024; ii) a title is available; iii) the jurisdiction is within the United States; iv) the patent has an Active Legal Status; and iv) document type of Granted Patent. The search yielded a total of 10,207 patents.

To ensure the accuracy of our analysis, we first removed duplicate entries from the dataset. Duplicates were identified and eliminated based on the patent titles. The distinct function from the dplyr package in R was used to filter out duplicate records, retaining only unique titles in the dataset. After removing duplicates, 8,089 patents remained.

The classification of types of patents was implemented following the one proposed by Moreno et al. (2024). Briefly, each patent was manually classified into eight distinct categories as follows: 1. Automation, Control and Robotics; 2. Biotechnology & Bioengineering; 3. Computing & Cloud Technology; 4. Data Acquisition & Communication Technologies; 5. Data Science & Artificial Intelligence; 6. Information Systems; 7. Manufacturing Technologies & Equipment; 8. Resource-related Technologies.

Table 1. Agricultural Technology Classification and Keywords Overview

Categories	Keywords
1.Automation, Control and Robotics	Control, Implement, Machine, Vehicle
2.Biotechnology & Bioengineering	Plant, Compositions, Herbicidal, Acid
3.Computing & Cloud Technology	System, Transmission, Cloud
4.Data Acquisition & Communication	Sensor, Monitoring, Data, Crop
5.Data Science & Artificial Intelligence	Machine Learning, Supervised, Predictor
6.Information Systems	Management, Information Systems, Processing
7.Manufacturing Technologies & Equipment	Harvester, Header, Adjustable, Implement
8.Resource-related Technologies	Treatment, Irrigation, Greenhouse, Energy

Results

The most prevalent categories of patents filed in the United States over the past decade were Automation, Control, and Robotics; Biotechnology & Bioengineering; and Manufacturing Technologies & Equipment. In contrast, the less frequent categories included Computing & Cloud Technology, Data Acquisition & Communication Technologies, and Information Systems. The different categories are interrelated (Figure 1).

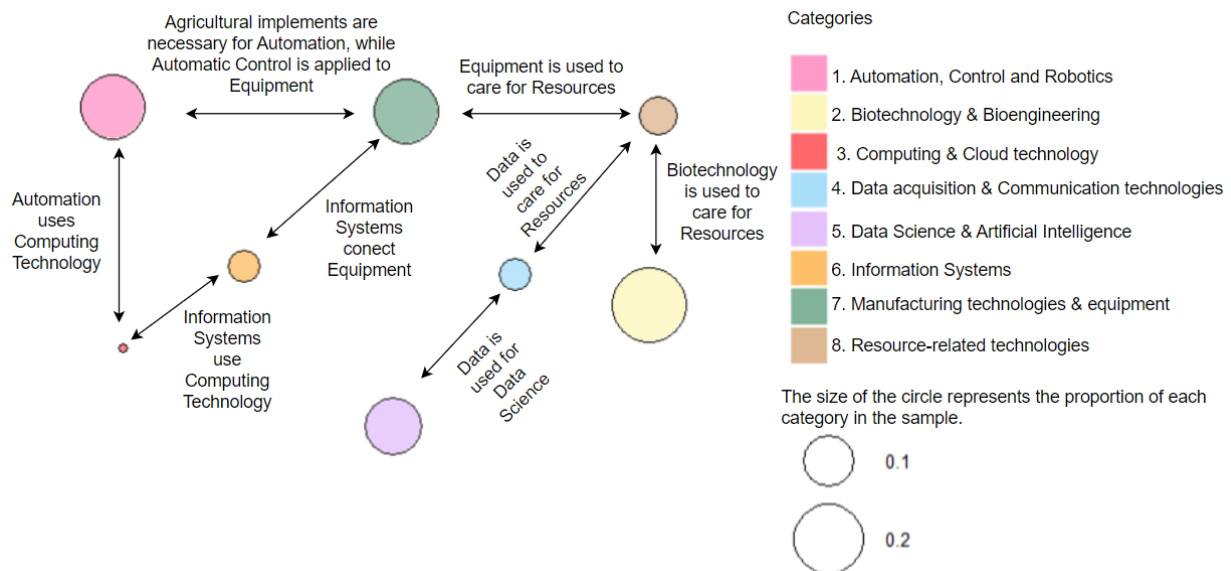


Figure 1. Patent analysis presented as the relationship between patent categories (1. Automation, Control and Robotics; 2. Biotechnology & Bioengineering; 3. Computing & Cloud Technology; 4. Data Acquisition & Communication Technologies; 5. Data Science & Artificial

Intelligence; 6. Information Systems; 7. Manufacturing Technologies & Equipment; 8. Resource-related Technologies) and their frequencies based on a sample of agricultural patents filled from the last decade (2014-2024) for the United States. The arrows reflect the interrelationship between categories and the size of bubbles of each patent category reflect the proportion of patents filled during the last decade relative to the total sample size (n = 8089).

Conclusion

This study provides a detailed analysis of trends in agricultural technology advancements based on active patents in the United States from 2014 to 2024. The classification framework provided by Moreno et al. (2024) offers a robust method for categorizing and understanding these advancements, which can guide future research and development efforts. The relatively low frequency of patents in Computing & Cloud Technology, Data Acquisition & Communication Technologies, and Information Systems highlights potential growth areas that could further revolutionize agriculture through digital transformation. The interrelated nature of these technological categories underscores the need for an integrated approach to agricultural innovation.

Bibliography

Moreno, José C., et al. "A pending task for the digitalisation of agriculture: A general framework for technologies classification in agriculture." *Agricultural Systems* 213 (2024): 103794.