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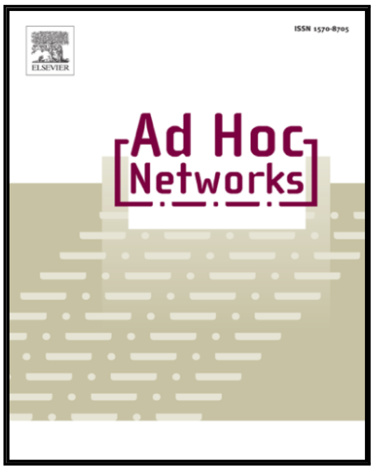

Internet of Underground Things in Precision Agriculture: Architecture and Technology Aspects

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Internet of Underground Things in Precision Agriculture: Architecture and Technology Aspects☆

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Abstract

The projected increases in World population and need for food have recently motivated adoption of information technology solutions in crop fields within precision agriculture approaches. Internet Of Underground Things (IOUT), which consists of sensors and communication devices, partly or completely buried underground for real-time soil sensing and monitoring, emerge from this need. This new paradigm facilitates seamless integration of underground sensors, machinery, and irrigation systems with the complex social network of growers, agronomists, crop consultants, and advisors. In this paper, state-of-the-art communication architectures are reviewed, and underlying sensing technology and communication mechanisms for IOUT are presented. Moreover, recent advances in the theory and applications of wireless underground communication are also reported. Finally, major challenges in IOUT design and implementation are identified.

Keywords: Internet of Things, Wireless Underground Communications, Sensing, Precision Agriculture, Soil Moisture

1. Introduction

World population will increase by 33% in 2050, doubling the need for food [124]. Yet today, up to 70 percent of all water withdrawals are due to food production. This demands novel technologies to produce *more crop for drop*. USDA Agricultural Resource Management Survey (ARMS) is the primary source of information on the financial condition, production practices, and resource use of America's farm businesses and the economic well-being of America's farm households. ARMS data show that *precision agriculture* has recently become a widespread practice nationwide. In Fig. 1, adoption rates of major precision agriculture approaches (bars) along with the total precision agriculture adoption rate (line) are shown for maize for each year of USDA ARMS publication (USDA ARMS 2015 version was under development at the time of this writing). It can be observed that adoption rate of precision agriculture for maize increased from 17.29% in 1997 to 72.47% in 2010 with similar trends observed for other crops such as soybean and peanuts. Aside from presenting a growing trend in the usage of precision agriculture in maize production, it is evident that as new technologies emerge, they are widely adopted by farmers.

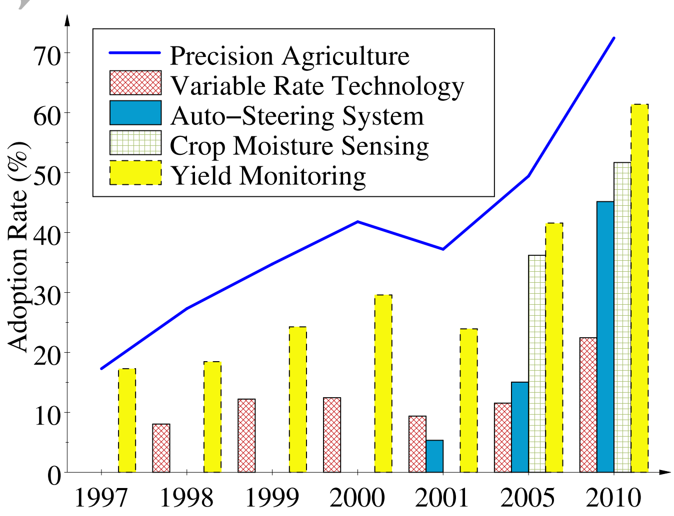

Figure 1: Precision agriculture technology adoption in maize production (USDA ARMS Data).

Among the various precision agriculture techniques, crop yield monitoring is the most widely adopted technique (61.4%). In addition, guidance and auto-steering system adoption jumped from 5.34% in 2001 to 45.16% in nine years. Use of equipment and crop location infor-

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