TELECOMMUNICATIONS FOR DATA COLLECTION AND DISSEMINATION IN AGRICULTURAL APPLICATIONS

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Keywords: Wired communication, wireless communication, serial bus, USB, CAN bus, LAN, RF, IrDA, Bluetooth®, WiFi, on-farm networks.

Contents

Summary

The advances in computers, machinery and electronics, as well as agriculture production technologies have transformed U.S. agriculture from a state of broad scale mechanization to a state of mechanization with precision. The implementation of such technology advancements demands for effective and efficient data telecommunication capabilities, both wired and wirelessly.

This chapter intends to provide an overview of existing wired and wireless data telecommunication technologies applicable to modern agricultural applications. The basic principles and features of some commonly used data telecommunicating means, such as serial bus, universal series bus, CAN bus, RF, IrDV, Bluetooth®, WiFi, LAN and WLAN, are introduced here. A few examples of using the introduced data telecommunication methods in agricultural applications are also provided.

1. Introduction

As one of the most important engineering achievements in the 20th century, agricultural mechanization has greatly improved farming efficiency and helped to produce sufficient foods to feed the people of the world. The new challenges to today's agriculture include the decline in cultivated land, a reduction in skilled farm workers, more rigid environmental protection requirements, and many more people to feed. The advances in precision agriculture and agricultural machinery, as well as in information technology, are transferring agricultural production from a state of broad scale mechanization to a state of mechanization with precision. Precision agriculture provides agricultural producers a promising method for maximizing profitability through optimizing production based on small grids of a field. For example, farmers are now indeed capable of fertilizing different parts of their field at different rates quickly and efficiently to achieve a maximum return on their farming costs. To fully benefit from the advancements in precision farming technology, it is essential for site-specific production information to be displayed "on-the-go" on the machinery while the producers are performing various field operations. Telecommunication and dissemination of collected data is one of the key elements in automated real-time precision farming operations.

The convergence of sensing, computing and communication technologies for agricultural applications has led to the creation of a new technology — agricultural infotronics systems. An agricultural infotronics system (AIS) is a framework of wirelessly networked on-farm production data management systems.

The basic functions of AIS are to collect, process, and transmit the "ready-to-use" site-specific production data to the user on the machinery while performing the field operation. For instance, when an agricultural sprayer is applying nitrogen on the field, the AIS will sense the location of the sprayer in the field, and supply an appropriate prescription of nitrogen for the specific site to the sprayer wirelessly and in real-time to support precise variable rate nitrogen application. To accomplish this task, a bare-bone AIS consists of a GPS receiver for collecting the sprayer location data, a database for providing site-specific nitrogen prescription data, and a data dissemination network for real-time data communication. Similar to the variable rate nitrogen spraying operation, almost all the agricultural production operations are implemented using mobile agricultural equipment, such as tractors, sprayers and combine harvesters, the telecommunication for data collection and dissemination plays a critical role in an AIS.

This chapter aims to provide an overview of telecommunication technologies applicable to agricultural infotronics system. The following sections are planned so that Section 2 will review data collection technologies commonly applied in agricultural production, Section 3 will describe data dissemination technologies commonly applied on agricultural machinery, Section 4 will explain the basic technologies for on-farm networking, Section 5 will introduce a few successful examples of applying data telecommunication technologies in support of effective site-specific agricultural production, and Section 6 will briefly discuss the technology trends in data telecommunication and their applications to agricultural production.

2. Data Collection in Agriculture Production

Field data collection is very important for efficient precision operations in agriculture production; and reliable and prompt data communication between sensing and data processing units is essential to make the sensed field data useful to operators in the field. Machinery positioning in the field during operation is one of the most common field data collection tasks in today's agriculture production. The machinery position provides the essential information for all kinds of site-specific management and provides the critical information for machinery navigation. GPS receivers are widely used on agricultural machinery to measure the absolute position in global coordinates directly using satellite-based positioning technology. In some applications, the relative position of the machinery to the travel direction is also very important. In those cases, inertial sensors are often used to determine the relative position. To improve the positioning accuracy and robustness, an integration of GPS and inertial sensors can provide a complementary correction for agricultural vehicle applications. Such an approach, that is, using multiple positioning sensors, could provide precise navigation information to guide a piece of agricultural machinery traveling along the crop rows in conducting various farming operations. Kalman filter technology is often applied to fuse the signals from the complementary sensors for abstracting robust and accurate data to support real-time field operations.

Figure 1: Typical data management process in farming

Field data are normally collected either during regular production operations, such as the site-specific yield data collection during the harvest, or from special data collection operations, such as soil compaction surveys. While some of the data can be automatically collected using a computer controlled data acquisition system, many of the field data collections have to be done manually limited by the sensing technology. In general, field data management for precision farming consists of a four-step process of field data acquisition, data transportation from mobile devices to an office computer for processing, data analysis, and data transportation from the office computer to an on-machinery device to support the production operations (Figure 1).

Other than being time consuming and requiring special skills requirement in processing field data, the off-line data process illustrated in Figure 1 is another major obstacle in supporting efficient and effective agriculture production. To overcome these difficulties, a wirelessly networked agriculture data management system can automatically manage the data to collect, transport, and present agriculture production data during different farming operations. Figure 2 shows the conceptual illustration of such an automated field data management system. According to the data management processes illustrated in the figure, the field data collection is automatically implemented using the computer controlled data acquisition system installed on operating agricultural machinery in the field. The collected data is then transported wirelessly to a remote data processing center for analysis in real time using some pre-developed precision agriculture data management tools. Appropriate field operation instructions are derived based on the processed real-time field data and delivered back to the operating machinery for implementation. The core of this automated field data management system is data processing tools, and the essential infrastructure of the system is the data communication (either wired or wireless).

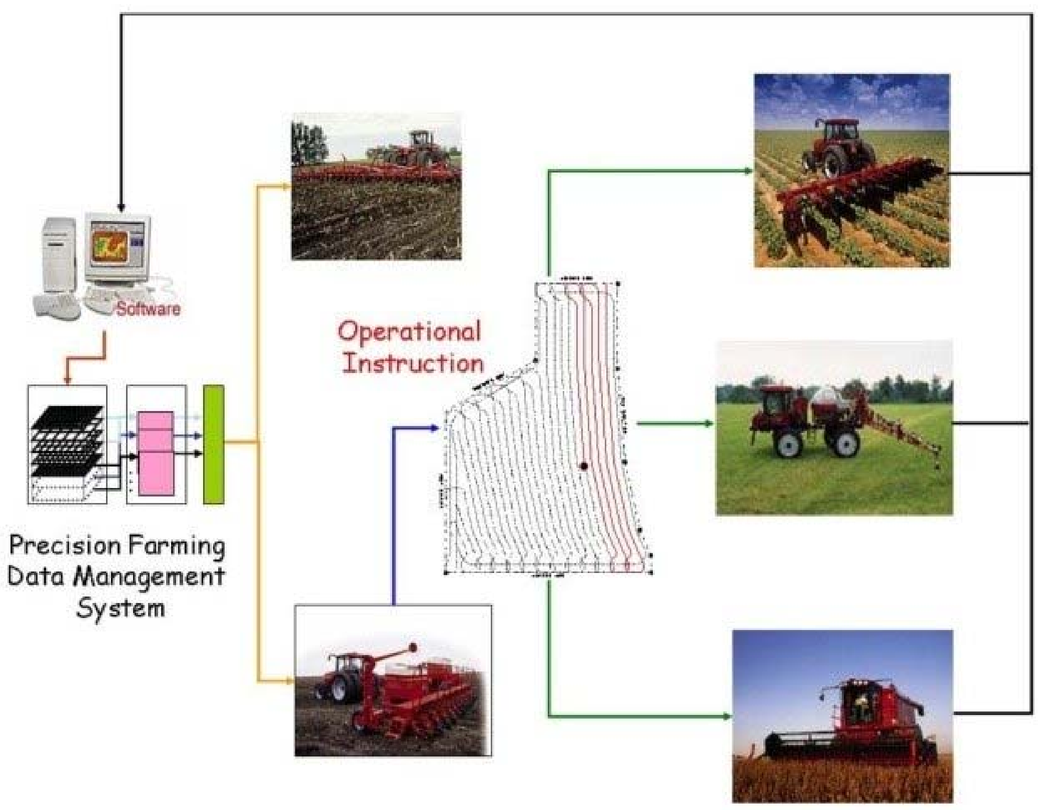

Figure 2: Conceptual illustration of automated field data management using AIS

3. Wired Data Communication in Agriculture

3.1. Wired Data Communication Methods

Wired data communication is the basis for all data communication. In computer-based data acquisition, the computer has to accept input signals and/or send output signals to regulate the data acquisition via some type of wires or cables. The data transmission over wires and cables is also called the wired data communication, in comparison to the wireless data communication. It is common to call a device either sending signals to the computer or receiving signals from the computer the *peripheral*. Some examples of peripherals are the display monitor, the sensors, and the actuators. Normally, data communication between the computer and the peripherals can be achieved either in parallel or serial mode. In data collection and dissemination operations on agricultural machinery, the data communication is always carried in serial mode.

The serial mode of data transmission sends bits of data one at a time along a single conductor in the format of a high or low voltage signal, and is mandatory for transferring data to and from data storage devices. Some terms frequently used in serial data transfers include *mark*, *space*, *character*, and *cluster*. A *mark* is always represented by 5 V and is a logical 1, and a *space* is always represented by 0 V and is a logical 0. The marks and spaces are grouped into a *character*, often one byte of data consisting of eight marks and spaces. A character is normally separated from others using a start bit (a space), a stop bit (a mark) or a parity bit. The assembly of the start bit, the character, the stop bit, and parity bit is defined as a *cluster*. The rate of data communication is determined by how many bits per second can be transmitted, and is defined as the *baud rate*. Some typical baud rates for wired serial communication are 100; 300; 600; 1,200; 2,400; 4,800; 9,600 and 19,200 baud.

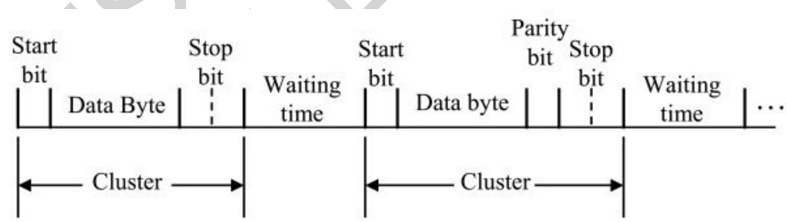

Figure 3: Illustration of asynchronous data communication

Because of the cluster structure, data communication in a serial mode can be transmitted intermittently, and each device can transmit data at the time it needs to, just like two people talking over a telephone. This type of data communication method is termed *asynchronous* communication. In asynchronous communication, data flows along the line in spurts – one cluster at a time, as illustrated in Figure 3. During the data communication, the transmitter sends a cluster (eight bits of data, for example) bounced by the start and stop bits and then may wait a period at its own discretion. Following transmission of a cluster, the final stop bit leaves the line in a mark status, a condition in which it remains until the next start bit switches the line to a space status. In the case of continuous data transmission, the waiting time will be zero. An important characteristic of asynchronous communication is that the transmitter and receiver need essentially the same clock frequency so the characters will not be misunderstood.

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Biographical Sketches

Prof. Qin Zhang was born in China. Zhang received a Ph.D. degree in agricultural engineering from the University of Illinois at Urbana-Champaign, Urbana, Illinois, USA in 1991; a M.S. degree in agricultural engineering from the University of Idaho, Moscow, Idaho, USA in 1988; and a B.S. degree in mechanical engineering from Zhejiang Agricultural University, Hangzhou, China, in 1982.

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