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A real-time automated system for monitoring individual feed intake and body weight of group housed turkeys

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ABSTRACT

Feed conversion is an important production trait in turkey breeding; the measurement of an individual bird's feed efficiency is important in identifying the most genetically superior individual. The development of a real-time automated feed intake and body weight monitoring system is described in this paper. The system integrated multiple feed and body weight weighing stations consisting of electronic scales, radio frequency identification (RFID) devices and data communication modules. A distributed and client-server-based system architecture with multi-threading software design was developed. This system architecture allowed for a real-time data acquisition capability when a large number of stations were required. A structured query language (SQL) database management system was developed to record and manage the dynamic feed intake and body weight gain data of individual birds. The developed system also offers a powerful research tool for studying poultry feeding behavior under group housing conditions.

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1. Introduction

Feed conversion ratio (FCR), defined as the amount of feed taken to achieve a unit of body weight gain, is an important trait in turkey breeding. To select individual birds with an efficient FCR, computer and modern electronic technologies have been applied to monitor bird feed intake, body weight and FCR (Hulsey and Martin, 1991; Xin et al., 1993; Yo et al., 1997; Savory and Mann, 1999; Puma et al., 2001). However, these published studies measured the feed intake either for individually housed birds or a flock of birds whose individual IDs were not discernable. Such data, while useful for describing individual or group feeding behavior, fall short in determining the feeding behavior and feed intake of individual birds kept in a group as normally found in a production setting. From the standpoint of genetic selection, it is highly desirable to raise birds in groups, allowing them to interact with one another and reliably measure the feed intake and body weight gain of the individual bird.

Apart from monitoring individual birds housed in groups for breeding purposes, the real-time dynamic data of feed intake and body weight provides an important basis for turkey feeding behavior and welfare research. Useful and interesting behavioral information such as pecking force, feed swallow interval, meal duration, and frequency distribution can be obtained from such a system. However, to develop the proposed monitoring system, there existed a number of technical challenges. The most important of these challenges was that each bird needed to be rapidly and correctly identified in a flock whenever it entered a feeding station. Radio frequency identification (RFID) techniques have been adopted in the past. It has been considered as a new technology for a well-structured traceability system for data collection (Sahin et al., 2002) and also been used for a remote health-monitoring for piglets (Reiners et al., 2009), as well as for automated wireless recording of chewing and ruminating behavior in cattle (Kononoff et al., 2002; Nagl et al., 2003) and for beef traceability (Shanahan et al., 2009). RFID technology has also been utilized in an intelligent and comprehensive animal management system (Taylor and Mayer, 2004), tree identification in manual harvesting (Ampatzidis and Vougiouskas, 2009) and a dynamic physiological measurement system (Eigenberg et al., 2008). All of these applications have provided practical examples of RFID-based animal monitoring systems, but little information was found in the literature concerning a RFID-based turkey or poultry monitoring system (Swalander, 2006).

There are four fundamental requirements for a real-time automated turkey feed intake and body weight monitoring system. First, the ID of each bird needs to be detected instantly as a bird enters a feed station. Second, the data from the feeder and body scales must be transmitted to a central computer at a high enough rate

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to ensure real-time data acquisition performance. Since the data transmission rate from a scale is typically low (2 Hz), a commonly used serial communication which is based on a port-polling mechanism is not suitable when a large number of scales are connected to a central computer. Third, the raw data needs to be processed, filtered, organized, and then stored in a database management system for convenient user access and utilization. Fourth, the system must be easily reconfigurable to allow flexible number of feeding stations to accommodate different flock sizes.

The objectives of this research were: (1) to develop an automated feed intake and body weight monitoring system for studying feed conversion ratio and feeding behavior of individual turkeys in a group setting; and (2) to evaluate the performance and reliability of the developed system through live trials.

2. Materials and methods

The monitoring system consisted of hardware and software subsystems. The hardware subsystem included a mechanical framework of feed stations, electronic devices (RFID components, electronic scales and communication modules) and a central computer. The software subsystem comprised two independently executed programs: a hardware monitoring and data acquisition program, and a data processing and management program.

2.1. Mechanic system design

The feed station structure is shown in Fig. 1. One feed station was 63.5 L × 91.4 H × 45.7 W centimeters with an adjustable entrance for feeder access. The maximum width of the entrance was 45 cm. The frame was constructed by using 80/20 aluminum modular components (80/20 Incorporation, Columbia City, IN), which made the station easily adjustable and extendable during the prototyping process. Both body-weight scales (50 kg capacity ± 5 g resolution, SVI-50C, Acculab, Edgewood, NY) and feeder weight scales (20 kg ± 2 g, SVI-20B, Acculab, Edgewood, NY) were situated in protective tray bases (33 cm × 33 cm), and the height of the feeder scales were adjustable according to the height of the bird. Two transparent acrylic boards formed a V-shaped bird feeding entrance, which was adjustable by loosening the adjustment screws. The gate shaped antenna (RI-ANT-G01E-30, TI, Dallas, TX) was installed vertically behind the board on the right side. The antenna was placed perpendicular to the feeder frame and the ground to allow a parallel orientation to a RFID tag attached to the right wing of a turkey (Fig. 1).

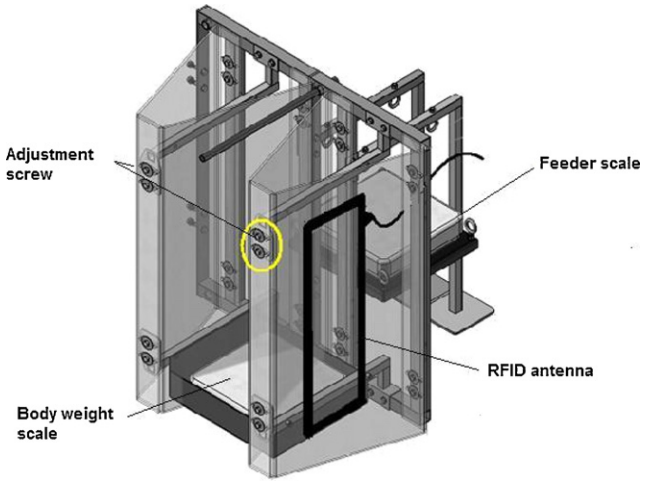

Fig. 1. The structure of a group-housed individual turkey feeding and body-weight measurement station.

2.2. Electronic devices and interfacing

Fig. 2 shows the architecture of the electronic system. Ethernet formed the communication backbone that connected the central computer (Dell Optiplex GX620 with a 2.8 GHz CPU and 1.5 GB RAM) to the communication devices attached to scales and RFID readers. A RFID reader (RI-CTL-MB6A, TI) came with a RS422/485 serial communication interface. The electronic scales used RS232 serial communication to transmit data automatically at 2 Hz frequency (or at 0.5 s intervals). Each RFID reader or scale was connected to a serial/Ethernet converter to communicate with the central computer via an Ethernet network (Fig. 2).

Our prototype system consisted of two feeding stations. The RFID tag reading system included an S2000 reader (with RS-

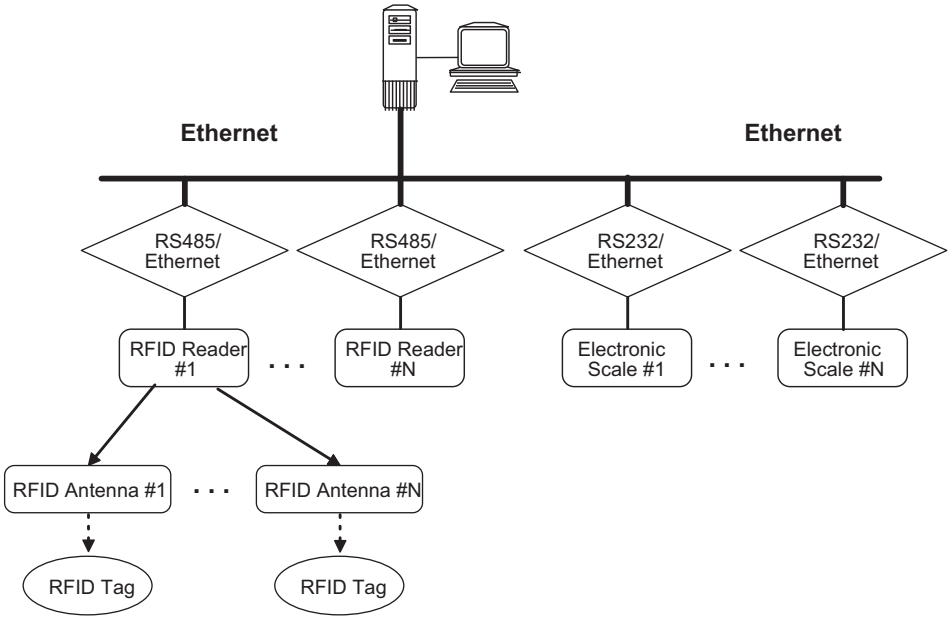

Fig. 2. Electronic system architecture for the real-time monitoring of feeding events and body weight of group-housed individual turkeys.