AUTOMATION AND ELECTRONIC EQUIPMENT

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Summary

The increasingly widespread use of electronic technology in animal production has brought about profound changes in work methods. Electronics delivers enormous advantages that affect virtually every production process, permitting greater control of the animals and improving the quality of work. In livestock farms, electronics and automation are most commonly deployed at the management level, enabling the farmer to access information from a farm database. In such applications, automated systems are used for collecting data on the physiological and health conditions of the animals. The

collected data are made available to the farmer, providing a general overview of the condition of the herd as well as detailed indications concerning the actions that need to be taken. A more advanced use of automation consists of devices that take part in the production cycle without the direct control by a human operator. These include self-feeders, which reference the information on the farm database, to determine the individual feed rations. The most advanced automation applications in animal production involves the use of robots—intelligent machines that are capable of interacting with their work environment. Robotics has totally transformed the nature of the operation by eliminating one of the most burdensome agricultural tasks, thereby improving management efficiency and indisputably enhancing animal welfare.

1. Introduction

The genetic improvement of animals has brought about profound changes in farm management: on the one hand, the greater focus on the genetic characteristics of each individual animal requires access to timely and comprehensive information for planning reproductive activities; on the other hand, the increased productive specialization of the animals means that, in order to fully exploit the potential offered by genetic improvements, it is essential to take the utmost care with the feed rations and veterinary care.

Livestock farmers are continually confronting a dynamic, complex, and rapidly changing situation. In this context, the adoption of automated solutions makes it possible to access reliable and complete information about the animals' condition in real time, while also supporting the use of devices that can intervene promptly and appropriately, interacting with each individual animal. The automation of certain barn activities has long been established on livestock farms. However, the use of processes guided by complex logic is a more recent development, which generally requires the use of electronic technology and personal computers for managing the database of the farm's animals.

2. Automation

The automated systems most commonly used in animal production concern the following two objectives: (a) *control of feeding*, which can be implemented using self-feeders that dispense to each animal (as recognized by means of its "electronic code") the quantity of feed saved in the computer's memory, which is determined by a nutrition software program; and (b) *monitoring of the animal's physiological and lactation parameters* using the sensors positioned on the animal or installed in the milking parlor that measure (i) milk yields (milk meters); (ii) estrus, through activity monitoring (pedometers); and (iii) mastitis, by measuring the electrical conductivity of the milk.

3. Automatic Identification of Animals

The most salient characteristic of livestock farm automation systems is the opportunity to tailor operations to the needs of each individual animal. This is only possible if there are subsystems capable of recognizing the animals as they interact with the automated systems. The automatic identification systems currently on the market are derived from those used in industrial automation. The operation of these devices is based on the decoding of electromagnetic signals received from an emitter (responder) worn by the animal.

The systems used in animal husbandry consist of the following elements (Figure 1):

- a fixed part, composed of a transmitter–receiver (antenna) that continually broadcasts electromagnetic signals
- a part worn by the animal (responder) that is activated by the electromagnetic signal broadcast from the antenna and transmits a code in reply

This system, now extensively tested and available in a wide variety of types, is called the *transponder*.

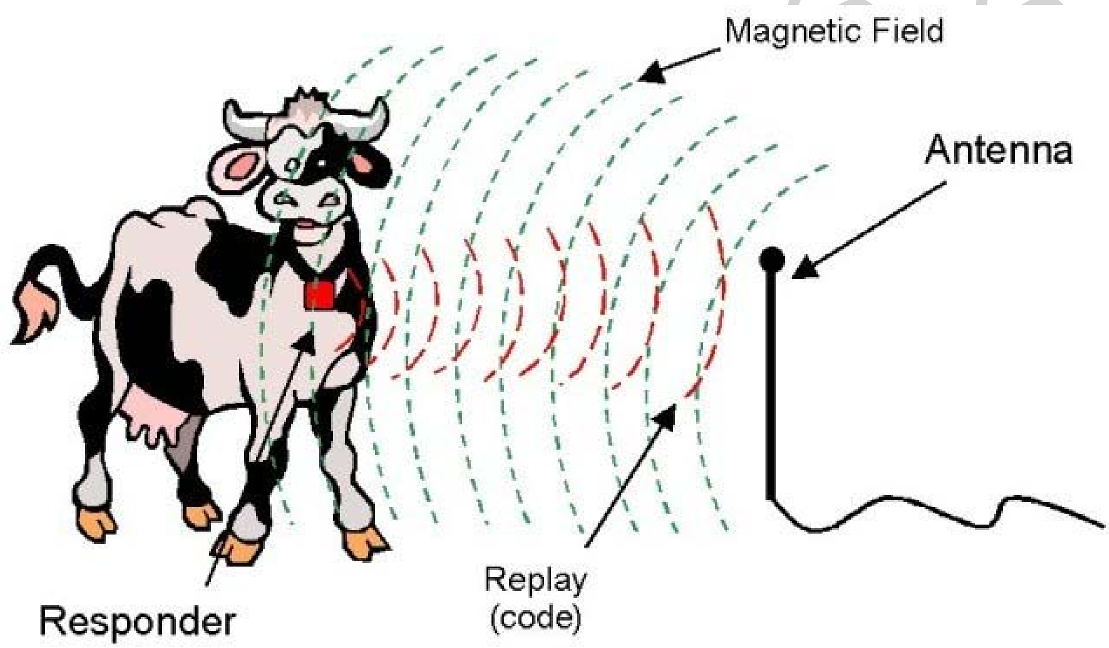

Figure 1. Transponder system for the automatic identification of animals

The earliest commercial automatic identification systems date back to the first half of the 1970s. In these systems, the responder was generally attached to a collar. The technology of identification systems has since progressed, with a reduction in the number and size of components. In particular, microelectronics has made it possible to replace many electrical components with integrated circuits. The consequent diminution in responder size has permitted a shift from collar-worn devices to miniaturized chips incorporated into tags affixed to the animal's ear, as well as the latest injectable responders, whose circuit is embedded in a glass capsule measuring just 2.12 mm in diameter and 12 mm in length, enabling it to be injected subcutaneously. The ISO 11784 and 11785 regulations published in 1996 define certain technical characteristics for transponders that guarantee the uniqueness of the code associated with each responder and assure compatibility between systems of different makes.

In livestock farming, automatic identification systems are generally used in two types of applications. In the first application, the transponder is an integral part of an automated system. Its function is to identify the animal for the control system. Such systems generally employ a fixed antenna, positioned inside a stall (feeding station, milking stand) or along a forced route (entrance to milking parlor, automatic weighing system; Figure 2). The second application involves the recording of events concerning the state of health or reproductive history of the animal. In this case, the automatic identification system simply has the function of acquiring, saving, and displaying the animal's identification code. This application uses portable antenna transponders that, when held near the animal, permit its reliable identification and thereby eliminates the difficulty and risk of error associated with visual recognition of the code. The subsequent data entry and recording operations are performed by the tender of the livestock using a keyboard and display, which is normally incorporated into the portable antenna. These systems are of particular interest in the case of small ruminants and in pig farming.

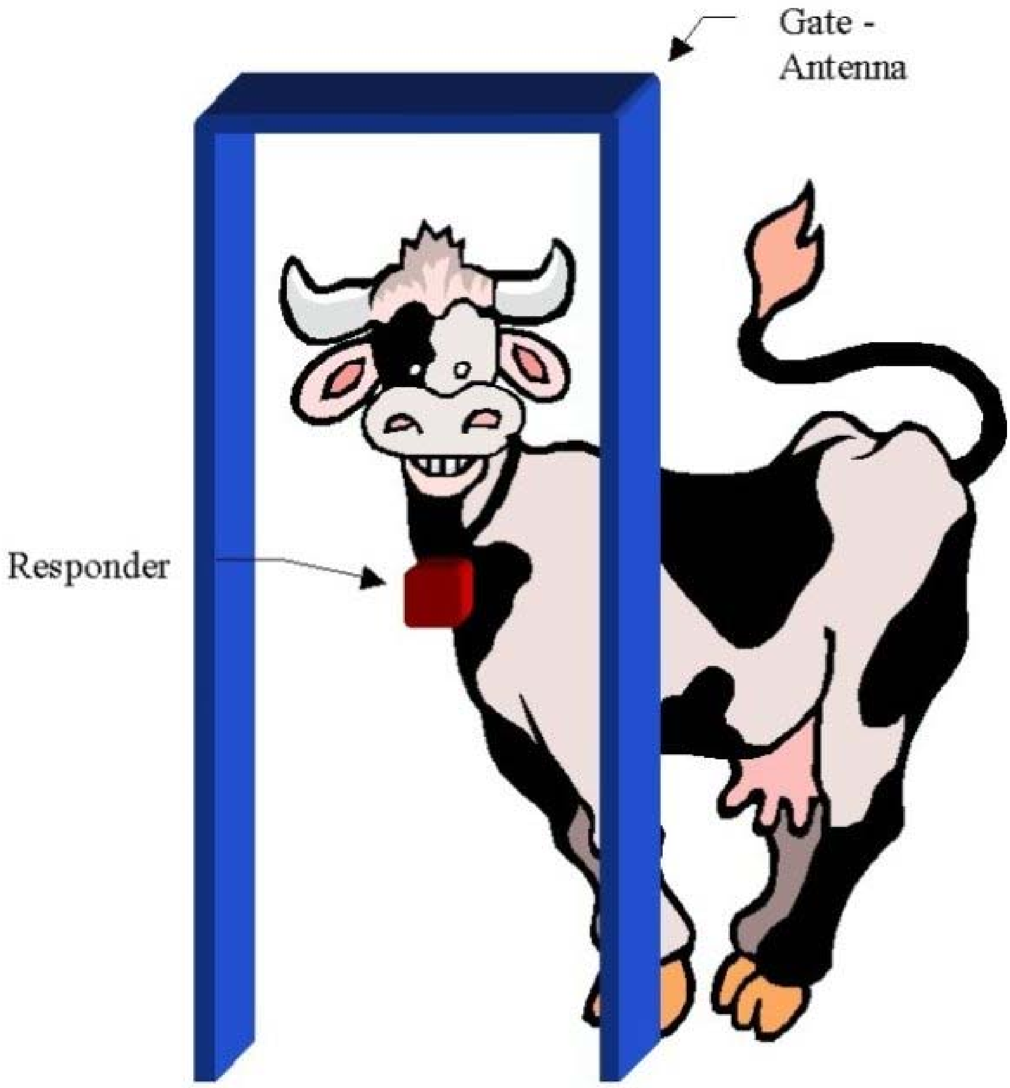

Figure 2. Automatic identification of the animals upon passage through a gate

Within these two spheres of application, automatic identification systems can be classified as a function of the responder's position on the animal:

- *Collar:* This is the most commonly used and extensively tested solution (Figures 1 and 2). The responder is embedded in a plastic tag that is strapped to the animal's neck. The position of the collar allows for easy and reliable identification of the animals, with the antenna installed either along a forced route (entrance to milking parlor) or at a fixed location (self-feeder).
- *Cuff:* Another very common solution is to attach the responder to the animal's leg. In this case, the responders can be equipped with a sensor and internal memory for recording data (number of steps) that is transmitted together with the code at the time of identification. In this case, the devices are called pedometers (Figure 3).
- *Ear tags:* In this case, the responder is affixed to the animal's ear (Figure 4). It is generally associated with a tag for visual identification, and offers the advantages of low cost, ease of application, and compact size, making it particularly suitable for smaller animals. On the other hand, the likelihood of loss is high (3–5%).
- *Injectable:* The responder is injected under the skin using a special instrument. The most suitable injection point for this type of application is under the *scutulum* cartilage (at the base of the ear), both for protection against knocks and by virtue of the reduced sensitivity of this tissue, which makes application relatively painless for the animal. The risk of loss is very low. However, there have been problems with mechanical breakage of the responder (1–2%). The frequency of breakage is significantly lower for small sized responders (19 or 23 mm; Figure 5). Another drawback of this solution is the greater time needed to recover the responder after slaughtering the animal.
- *Ruminal bolus*: The responder, encapsulated in a ceramic or plastic support, is introduced into the rumen (Figure 6). Compared with ear tags, this solution has a lower risk of loss, and compared with injectables it affords better protection against breakage. Furthermore, the responder can be recovered reliably and relatively quickly at the time of slaughter.

Figure 3. Pedometer
The recognition system is housed inside a plastic tag tied to the animal's leg.

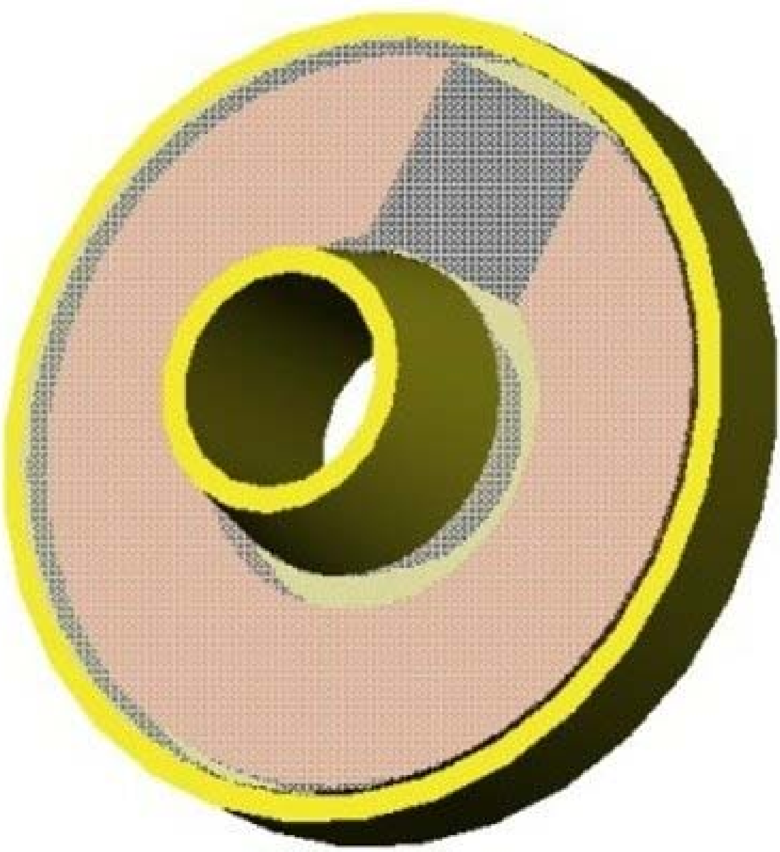

Figure 4. Ear tag (diameter 30 mm)
The responder is embedded in a plastic tag affixed to the animal's ear.

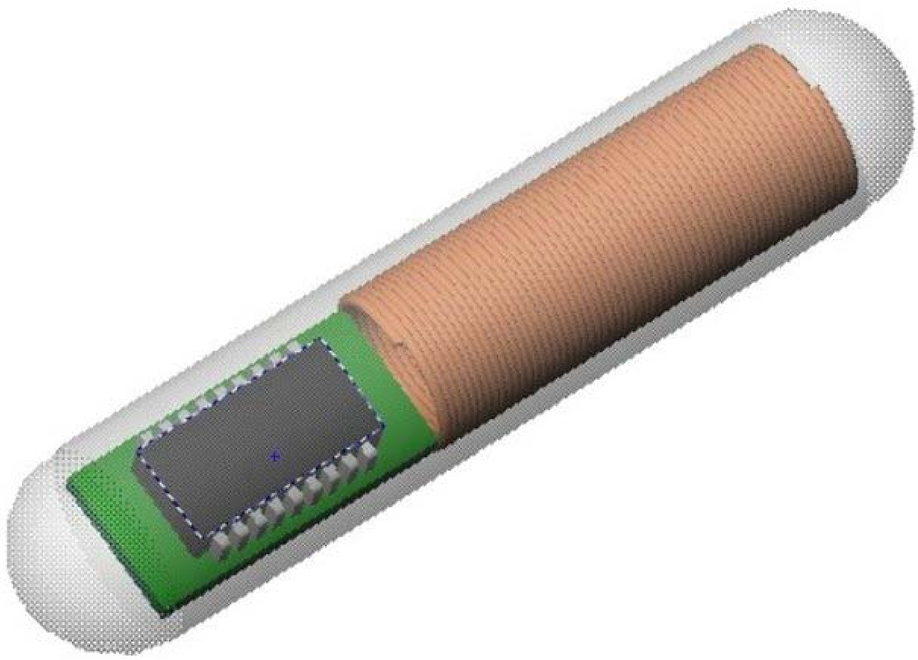

Figure 5. Injectable responder (length, 19–32 mm)
This device consists of a glass capsule inclosing electronics.

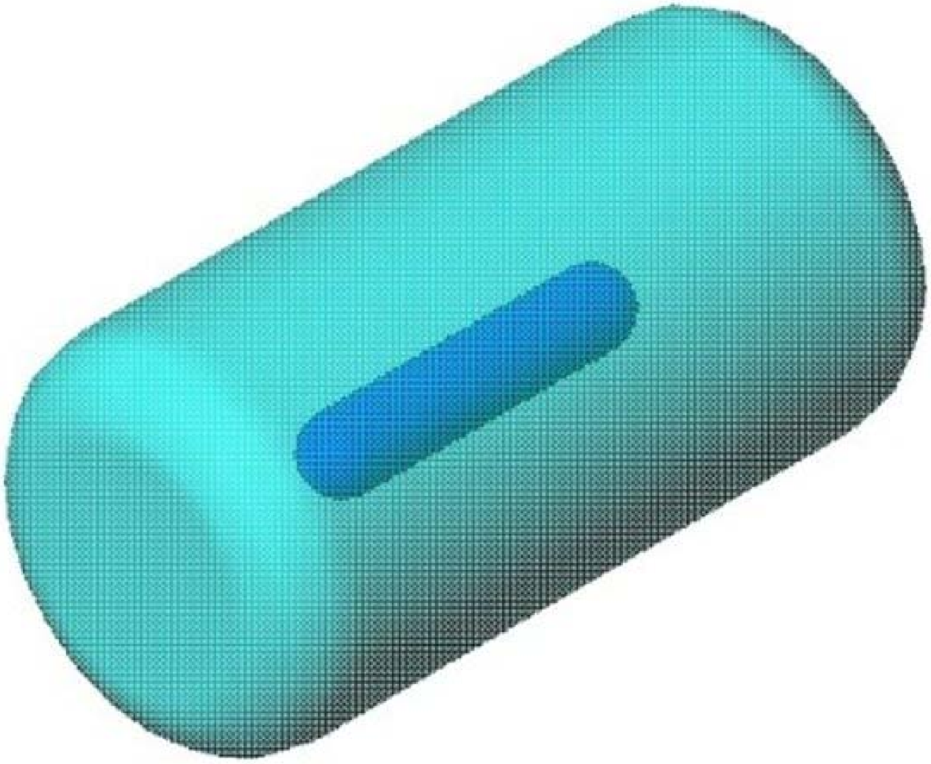

Figure 6. Ruminal bolus (length, 50–70 mm; diameter, 25–30 mm)
The responder is inserted in a ceramic or plastic support.

One of the most important characteristics of a recognition system is the maximum distance from which the antenna is able to excite the responder and receive its reply code. This distance depends essentially on the type of responder used and, in particular, on its size.

Depending on RF regulation in country of use, the reader antenna configuration used, and the environmental conditions, responders (as of 2003) have a range up to 100 cm. This makes the smallest injectable transponders suitable mainly for portable antenna applications, in which the antenna can be held near the injection point until the animal is successfully identified.

A very important factor that can influence the reading of the code is the directionality of the signals broadcast by the antenna and responder. In fact, these signals occupy a well-defined three-dimensional volume; it is therefore essential to position and orient the antenna so as to ensure that the animal will be identified under all circumstances.

4. Automatic Feeding

Self-feeders were among the first electronically controlled automatic devices used in animal production. The reason for farmers' interest in this technology is the opportunity that it offers to improve productive efficiency through precise control of the dispensed feed ration, and to "personalize" the ration as a function of each animal's yield.

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Biographical Sketch

Marco Cattaneo graduated in agricultural sciences from University of Milan and received his doctorate in agricultural engineering at the Institute of Agricultural Engineering of the University of Milan. He has been a consultant of the University of Udine on a research project on milking robotization coordinated by the Automation and Robotics in Agriculture (AUTARI) Research Consortium of Udine. He is presently a researcher in agricultural engineering at the Institute of Animal Nutrition of the University of Milan.