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Collision-free process technology for arrayed multipoint devices in coffee machines

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Abstract

Coffee machines have become very popular in recent years, but their lack of functionality still requires a great deal of manual maintenance, which inevitably has many hidden dangers. Coffee machines with radio frequency identification systems (RFID) are more effective in reducing losses due to manual labor, and increasing efficiency. However, collision problems in RFID systems can seriously affect the performance of the system. In this paper, we propose a specific solution to such problems by proposing a collision-free process technology for arrayed multipoint devices. And this technique is successfully applied in a coffee machine. Through design experiments, after 10,000 repeated tests, no collision error occurred. The problem of collisions in coffee machines with RFID mechanisms has been successfully solved.

Keywords: RFID; collision-free process technology; coffee machines.

Practical Application: The collision-free process solution for arrayed multipoint devices can solve the RFID collision problem very well. This method makes the coffee machine more efficient and can also be used in many other intelligent food instrument products.

1 Introduction

As one of the world's top three beverages, coffee has always been popular worldwide (Yalçinkaya et al., 2022). People have done a lot of research on coffee. Coffee can improve the sensory quality of tobacco leaves (Hu et al., 2023). Coffee husk, cassava bran, and water can be made into biodegradable bio-composites (Muñoz Pabon et al., 2022). The beneficial and harmful effects of coffee on the human body have been carefully studied and daily intake levels have been recommended to ensure good health (Chavez et al., 2022; Mostafa, 2022).

The rising sales of commercial and domestic coffee machines in recent years can be seen in the popularity of coffee machines among consumers. However, the functions of existing coffee machines are not complete, and many functions can only be realized by human beings. Existing coffee machines are far from being intelligent products. For example, the food bags are required to manually scan one by one for identification when putting coffee beans into the coffee machine, which is time-consuming and labor-intensive. Manual handling can be negligent and lead to some food bags being left out. If these foods have an expired shelf life, they are still put directly into the coffee machine and they are sold. This is a serious risk to the food safety of the coffee (Wang et al., 2017). Contactless automatic identification technology is the solution to these problems (Song et al., 2020).

As a mature contactless automatic identification technology, radio frequency identification (RFID) is composed of a reader and an electronic tag (Tanner, 2016). Its basic principle is to use the spatial coupling characteristics of radio frequency signals to realize the automatic identification of static or dynamic objects to be identified. It has the advantages of convenient reading, fast recognition speed, large data capacity, long service life, and wide application range. As the data carrier of the RFID system, the electronic tag is composed of a tag antenna and a special chip (Rajalakshmi et al., 2022), the chip stores the information that can identify the target, and its data can be repeatedly erased, with a high utilization rate and good security.

2 Collision problems in the RFID system

With the increasing demand for application scenarios, multiple readers and multiple electronic tags in RFID systems replace the previous one reader to one tag. This inevitably avoids the problem of collisions (Li et al., 2019).

The RFID system's main two kinds of collision problems are multiple readers' collision and multiple electronic tags' collision (Choong et al., 2022). The multiple readers' collision problem, that is, the interference of adjacent readers in the signal crossing area leads to the reduction of the read-write range of readers, and sometimes the tags can't be read accurately. Another multiple electronic tags' collision problem is multiple tags communicate with only one reader simultaneously (Samsami & Yasrebi, 2020).

When the functions of adjacent readers overlap, the interference between multiple readers and the electronic tag may be caused when multiple readers read the same tag at the same time. The same electronic tag receives signals from several readers at the same time. In this case, the electronic tag can't correctly parse the query signal sent by the reader. However, the reader itself can detect the collision generation, and solve the problem by communicating with other readers. Therefore, the subsequent

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design section on collision prevention also focuses on collision prevention of multiple tags.

Multiple tag collision refers to the problem that the reader can't read the tag information correctly because it receives signals from multiple labels at the same time (Ahmed et al., 2018). Each tag responds at some point after the reader has issued the recognition command, or the other tags respond before one tag has completed the response. This will cause the signals between tags to interfere with each other, and multiple tags will send data to the reader at the same time, which will cause the reader to fail to correctly identify these tags.

3 Program on conflict prevention mechanisms

In order to prevent the coffee machine a reader on the appearance of multiple electronic tags lead to information read error, need a kind of anti-collision mechanism to ensure that each time only read to the only corresponding electronic tag information, this paper proposes the following two solutions.

Solution 1: The RFID reader sends an electromagnetic wave to the outside through the winding coil at regular intervals, the winding coil on the electronic tag receives the electromagnetic wave emitted by RFID reader after charging, and emits the information to the outside. After receiving the information emitted from multiple electronic tags, RFID reader starts to analyze the signal strength, judge the location of multiple electronic tags from the reader through the signal strength, keep the closest electronic tag and record the unique ID number of this electronic tag.

Solution 2: By structural design, there is only one electronic tag on each reader at the same time and in the same space. The spacing between adjacent readers is set to 60 mm to prevent the reader from interfering with each other. The reader reads the electronic tag information periodically. Due to the structure limitation, each reader can read only one electronic tag information, which effectively prevents multiple electronic tags from being read by one reader. When RFID reader winding coil is designed, the coil antenna's transmit power is considered simultaneously, and the power is limited in a certain range to ensure that the electronic tag information can be read only within 2 cm of the reader antenna. This method can effectively ensure that only one electronic tag information can be read in horizontal and vertical directions.

Both of these solutions can meet the need for anti-collision, but the first solution is expensive and takes up a large space, which is not conducive to mass production. The second solution is more suitable for use in coffee machines because of its low production cost.

4 Application of anti-collision technology in coffee machines

A coffee machine with RFID function was designed in this paper. The food radio frequency identification mechanism is set up to collect the information on the food packaging bag systematically. This food radio frequency identification mechanism includes transfer identification component, positive component, cutting component, and barrier component. The purpose of the transfer identification component is to transmit the food packaging bag and radio frequency. The purpose of the aligning component is to limit the trajectory of the food packaging bag in the process of transmission. The purpose of cutting component is to cut the food packaging bag and collect the material; The purpose of the barrier component is to cut the bag when the bag auxiliary positioning. Through this food radio frequency identification mechanism, the coffee machine can realize the integration of system transmission, identification, unpacking, coffee beans storage, and effectively carry out radio frequency identification for each food packaging put into the coffee machine, reducing the phenomenon of missing and improving work efficiency.

The driver hardware structure used in the coffee machine includes 8 bean boxes RFID readers, 1 bean bin RFID reader, and MCU main control board (Sisavath & Yu, 2021). RFID recognition readers are distributed according to Figure 1. The SPI interface can complete the communication between each reader and the main control board, and send the card information identified by the RF reader back to the MCU main control board (Baskoro et al., 2020). The RFID reader adopts NXP's MFRC522 chip, which has the advantages of high-precision modulation and demodulation technology, integrates a variety of contactless communication methods and protocols, supports fast Crypto 1 encryption algorithm, supports system low power consumption, and it also has SPI, UART two kinds of communication interfaces. The electronic tag is an NTAG213 tag, which can be repeatedly erased and encrypted. The main control board adopts an STM32F103 high-performance processor, equipped with RS485, RS232, SPI, and other communication interfaces.

4.1 Uniqueness of information

NTAG213 tag is used in the coffee machine, and each tag has a unique 10-digit ID number. According to the unique ID number, the background binds all kinds of information about disposable coffee bean boxes, including manufacturers, product names, production dates, warranty periods, etc. This tag has a 10-digit identity ID number to ensure the uniqueness of the information.

4.2 2D array method of electronic tag positioning

There is not just one disposable box on a machine and when multiple disposable boxes are mounted on the machine, the positioning of the boxes is one of the challenges to overcome.

In this coffee machine, RFID readers are installed in order, each reader is assigned a reading address D1, D2, D3, D4, D5, D6, D7, and D8. Each reader has enabling switches CS1, CS2, CS3, CS4, CS5, CS6, CS7, CS8. Through the two-dimensional array list,

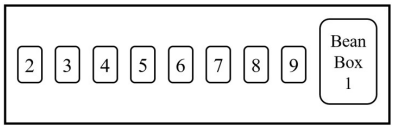

Figure 1. The RFID reader distribution diagram.

Table 1. Collision-free two-dimensional array table of multi-point devices.

	D1	D2	D3	D4	D5	D6	D7	D8
CS1	box 1							
CS2		box 2						
CS3			box 3					
CS4				box 4				
CS5					box 5			
CS6						box 6		
CS7							box 7	
CS8								box 8

each magazine position information can be accurately obtained. Take the second coffee bean box as an example, the operation information is shown in Table 1. When it is necessary to obtain the information of the second coffee bean box, open the reader enable switch CS2, and read the D2 address. The information returned at this time is the information of the second coffee bean box.

4.3 Reading of information

Under the guarantee of anti-collision mechanism and two-dimensional array, the system can accurately read the information on each tag. The RFID reader first obtains the electronic tag type, and after successful acquisition, reads the 10-digit identity ID number of the electronic tag according to the electronic tag type. MCU main control board adopts RS485 bus communication, based on MODBUS communication protocol and the upper computer for data communication and transmission.

5 Experiment and prospects

5.1 Experimental tests and results

In order to verify the accuracy of the array type multi-point recognition without collision process technology in the coffee machine. We place the readers in accordance with the position spacing in the coffee machine, assign each reader an electronic tag, and then use the reader to read the corresponding electronic tag in turn. Test the read status of each of the 8 readers repeats 10000 times at a single point. Tests whether two or more electronic tags occur when the reader reads the multipoint reader array. Then set different working conditions to repeat the above operation, and record the test results. The result shows in 10000 times test, does not have any time reader doesn't read the data phenomenon is found, and a reader will only read corresponds to an electronic tag, doesn't appear more than one reading phenomenon. And in different working condition the test results are all the same.

5.2 Prospects

According to the experimental test results, the collision-free process solution for arrayed multipoint devices can solve the RFID collision problem very well. The research results of this technology can not only be applied in coffee machines, but also in many intelligent food instrument products, such as intelligent beverage machines, intelligent nutrition mixing machines, and so on. Therefore, the collision-free technology of array multi-point equipment has great practical value. And it is worthy of being promoted and used.

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