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RFID-Based Key Technology for Fresh Food Quality Inspection

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Radio frequency identification (RFID) as a new type of automatic identification technology features non-contact recognition, quickly target lock-on, big data, high confidentiality, and strong anti-interference. Operated within a short time, it has been infiltrated into many fields. Today, food safety issues have aroused people's wide concern, especially in the quality of fresh foods. In this context, RFID will find its application in the food fresh quality inspection, in conjunction with the state of the art, to get the food safety issues resolved smoothly. Now here discusses and analyzes the key technologies that are applicable to this field.

1. Introduction

Today food safety incidents occurred frequently not only cause great losses to the global economy, but also pose a threat to people's health. In the United States, foodborne diseases are still rife as a serious public issue. According to the new data revealed by the Food Safety Forum, there are about 2 ~ 4 million people who contract some diseases due to food poisoning per year in China (Crovato et al., 2016). Therefore, the great challenge we face together now is how to respond to the food safety issues. As the existing treatment means are nothing else than administrative management and the spot random inspection for the food quality, we often fail to timely make a thorough inspection on the foods and never ensure the due safety of foods due to backward equipment and low efficiency in the inspection process (Khankhaje et al., 2017; Frattini et al., 2016). The way the bar code on the food package is scanned with available technologies can not trace back to the sources of foods so that the food safety would be a long-lived issue in the prior technologies.
In regard to the food safety issues, there are three parts we have to concern, i.e. the food quantity, the food quality, and sustainable development of food. Now our analysis and discussions focus on food quality. It is RFID technology that this issue can be relieved (Kumar et al., 2016; Cattuto et al., 2010; Digiampaolo & Martinelli, 2012). With this technology, a specific spot inspection station built can inspect various foods and compare the test results to the food quality standards as specified. Only those which comply with the safety standards are allowed to access to the market for circulation, unless otherwise stated (Montaser and Moselhi, 2014; Nysveen and Pedersen, 2016; Prinsloo and Malekian, 2016). For problematic foods, we also locate and track them to determine where and why some issues occur, in addition to the reputation adjustment and reassessment made for the food production units.

2. Technology principle

As a non-contact automatic identification technology, RFID acquires diverse data from radio frequency signals and auto-recognized objects, while, in conjunction with the network system and database system, it achieves worldwide sharing for item tracking information. Unlike the traditional barcodes, RFID technology enables batch reading without manual intervention. It can fully develop its advantages such as environmental and lifecycle encryptions and so on (Salmerón et al., 2014; Fan et al., 2015). The main principle of the RFID system is to use the reader-writer and the attached tags thereon to achieve electromagnetic coupling, also called inductive coupling, which may also be used for data communication. In this way, the tagged items will be recognized in a touch-free manner. The reader-writer sends the signals to the antenna which then in turn sends radio waves to the radio frequency tag (Li et al., 2012; Youm et al., 2017). The tag will return these

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signals to the radio waves after receiving them. Then the signals received via antenna will be decoded as data recognized by the computer.
Compared with other wireless systems, RFID is characterized by the fact that communication is asymmetric with one peer, the reader or interrogator, taking on the role of the transmitter and the other, the tag, the role of the responder. Instead of creating its own transmission, the tag modulates or reflects the electromagnetic waves emitted by the reader to communicate. To some extent, this is the reason for the success of RFID: this technique allows a somewhat complex reader to be used with a very simple tag of small size, which can be built at low cost. A small number of fixed or mobile readers can be used with numerous tags to construct very large systems at relatively low cost.

2.1 Electronic tags

The electronic tag emerges as a carrier for identifiable information, in which data format is usually conventional. In the internal working process of the system, the reader-writer can send energy signals. After receiving these signals, the electronic tag can rectify the information therein for electronic tag. Additionally, microwave energy is mainly reflected by the ASK in the tag into the reader-writer. At this time, the reader-writer receives the data called out in the tag after receiving the modulated signals as returned. Figure 1 shows the working principle of electronic tags.

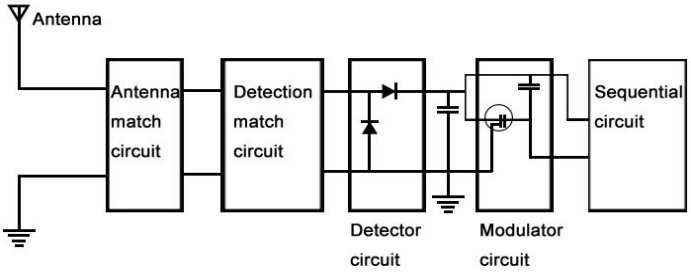

Figure 1: Working principle of electrical tags

Electronic tags are mainly divided into active and passive types. The active tag inlays auto power supply system with sufficient energy, works reliably with good signal. It enables remote transmission and limits the counts in the use of tags when designing batteries with various lifespans. And besides, it can also be used where data transmission is limited. Many labels will only allow several reads and writes in a year. The disadvantage of the active label is that it has a limited service life in the use. Transmission distance will gradually decrease with the consumption of the battery, worsening the work efficiency. The passive tag has no battery inlaid and works depending on external power supplied by the coil and the antenna. Only when the tag accesses to the working environment and the antenna will receive the electromagnetic wave, can coil generate inductive current. After that, the rectifier will supply power to the tags. Table 1 shows the analysis of tag performance.

Table 1: Comparison between active and passive tags

	Active tag	Passive tag
Energy source	Sustainable self-power	Powered by electromagnetic induction
Working distance	100m	20-30m
Storage energy	16K	Max. 128
Signal intensity	Low	High
Average price	High	Low
Working years	2-4	Long-term

According to data in the table, every process in food safety management involves the food quantity, and the parameters in the surrounding environment will also change over time. Use UHF and HF tags with far-range reading distances where the system is applicable. For cost efficiency, passive tag can identify containers, and tag recovery can reduce costs.

2.2 Reader-writer

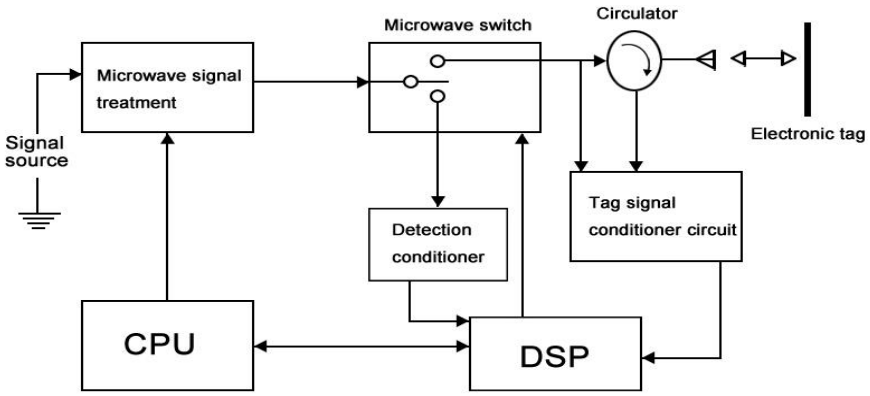

Figure 2: Working principle of reader-writer

The reader-writer usually consists of microwave signal sources, signals, switches and conditioning circuits, circulators, standard antennas, DSP, CPU, as shown in Figure 2.
Its main working principle is that the microwave RF signals generated in the microwave signal source are all modulated and amplified by the circuit. The information in the CPU is modulated onto the carrier wave, and RF energy with the command can generate after it is amplified. Microwave radio frequency after conditioning the electronically controlled microwave switch can directly perform detection, and after A/D sampling, it feeds into the DSP chip to store and process the digital signal. DSP chip can transmit various information via the port to the CPU for processing, after proofreading, the field and microwave signal intensities of the tag will be displayed, as well as the frequency and power of various signals. After receiving the tag information, standard antenna sends it to the detection circuit via circulator. In addition to this, various parameters and information in the electronic tag are measured after A/D sampling and DSP chip preprocessing in order to achieve the function of a visual reader-writer.
At the end of the first step of the RFID process, the tag is charged and ready to communicate with the reader. As already noted, this communication is asymmetric in that the energy of the electromagnetic field transmitted by the reader is the sole source of power used for data transmission by either device. In both inductive and capacitive coupling systems, the tag modifies the electromagnetic field in such way that changes can be observed by the reader, which decodes and interprets them as data. However, the details of how this modification is carried out differ significantly between the two systems, which adopt distinct techniques.

2.3 Selection of sensors

The integration of sensor technology and RFID technology can make it possible to perceive a variety of information such as ambient temperature, humidity, and illumination which will be output using wireless communication technology, together with their various changes. When carrying out temperature control, some companies uses the integration of the two to preserve the wines. A temperature sensor inside the tag can send temperature gradient to the general platform in a timely manner, by which it is determined whether the wine is kept fresh. The parameters in each process when circulating have different impacts on food. Based on the nature of the foods, sensors can be used to measure which parameters will have a greater impact on the foods as required in the surrounding environment. In this process, it is ensured that the data format should be compatible with the radio frequency equipment. Only in this way can the reader-writer be able to receive information.

2.4 Software selection in RFID system

The first step is to well establish a food safety database and communication network. A service network is also required in order to ensure the complete information can be transmitted in the circulation process, including those about the seller, the manufacturer and the operator in the network. For all food safety data, there must be special labels corresponding to them in attempt to record the information and parameters of each process. An algorithm assessment is performed for food safety. Some products with various storage methods have different quality systems so that it is required to establish standards for various foods, including a good assessment model. It is also possible to provide various sales proposals according to the quality assessment. As edible information and treatment technology for each food are different, the plain even-odd-even algorithm

is also subjected to these changes. Then we need to deal with data in the whole food circulation process based on practical conditions.

2.5 Detection system

The detection system mainly uses various equipment and instruments to perform reasonably detection in order to process and analyze the signals correctly. In this way, diverse information about objects under test can be available, which are in turn input into appropriate information processing equipment to be ready for the control system.

The database is a specialized system that manages data in a computer system. The database system is not developed from an application, but in data management, all data is stored in the database that interfaces to management system, various applications, and application programs. In this way, data in the database can be easily used.

The information assessment system, based on various corporate data as acquired, in accordance with standards as developed, makes an assessment on units, re-identify the company reputation and impact factors, etc.

The graphics system as a query and display system can display results in diverse ways, and it also allows the enquirers to get more intuitive and effective experience and clear results.

3. System architecture program

3.1 Process of analytic system

The market access in fresh food can not solely depend on various measures taken by government authorities, but parallelly, an effective way should be integrated to inspect food quality. It is required to propose a RFID models in combination with actual conditions and incorporated with existing technologies. The first step is to inspect various fresh foods that enter the market, compare and match the measured results with the inspection standards in the system. The internal indicators in the system are designed for inspection as required in the market. If data and indicators measured by the test fall within the scope of standards, the food is determined to be qualified and safe, and can be allowed to access to the market for circulation. Otherwise, the food is unsafe and unqualified, and banned to enter the market. Such foods should return to producers. Test results and various business information will be promptly input into the database, based on which to re-evaluate the company's credit rating in combination with the food class and other various information, then spreading this information via the network so that consumers can query ratings of various foods and producers on the market via the Internet. Figure 3 shows the system process.

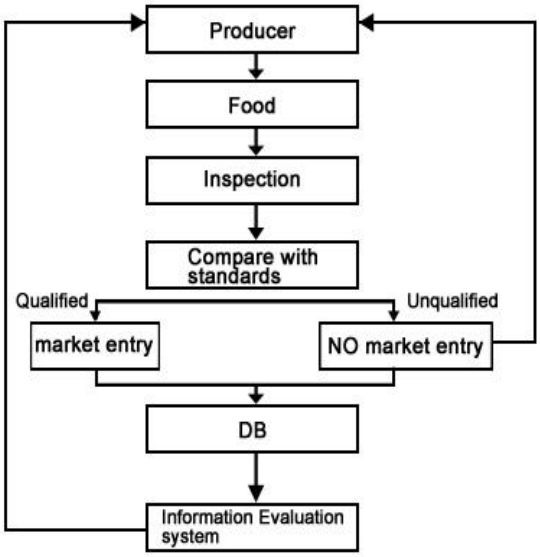

Figure 3: System process

3.2 System architecture

The whole system, as shown in Figure 4, consists of an RFID system, detection system, database, information evaluation standard system, network support device, and user system, etc.

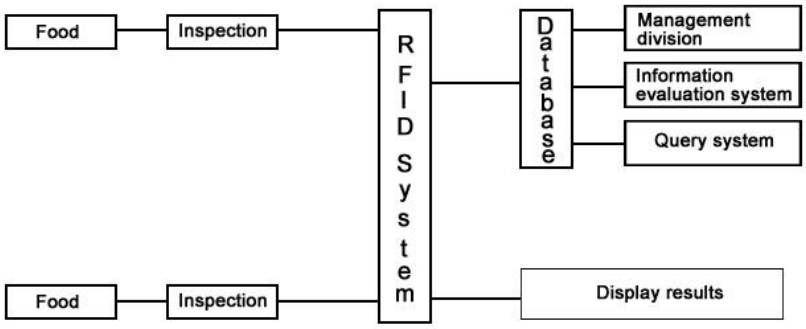

Figure 4: System architecture

In the whole process, RFID tags must be added to various fresh foods that will enter the market first, followed by the global quality inspection using the inspection system. While in parallel, all types of information to be inspected are uploaded to the RFID reader-writer and the database. Data should be processed and transmitted safely and quickly using an integration of equipment, RFID and detection system, in conjunction with sensors. The measured data should be compared with various data and indicators on the RFID tags, if mismatched, it means that the food quality does not comply with standards. They should be returned to the producers and forbidden to go to the market. RFID technology will easily trace back to the source of problematic foods and identify where the defective emerges. It is also possible to document the divisions where the issues have arisen into the system, and order them to carry out rectification and gives them penalties, also downgraded them internally in the database.

3.3 System implementation and strategies

In the use of the system, what is the most important is to ensure the accuracy of the test data, and while various types of data can access to the read-write device in a timely and effective manner. To achieve the precision and effectiveness of test data, some scientific means and precision instruments must be used. Data transmission resorts to a right sensor. Only in this way can we make sure that the instrument is accurate and effective.

Test data must be read into the RFID system via the sensor, and compared with the system standard. There are only two test results, i.e. entry to market and no entry to market, all of which must be recorded in the database. Some issues, if occur, should also be responded to producers and urge them to correct via network. Databases and rating are associated. In the rating system, there is acquired information entered for rating the company and then redefining its functions. Later the system releases test results to the community. All divisions can access to data to understand the status of all participating companies. For those who do not have rectification after the occurrence of issues, they may accept various forms of administrative penalties, fines or revocation of business licenses.

In the query system, various results from business products can be obtained and displayed in various forms, mainly including human-machine dialogues, graphics, and lists. In this way, competition pattern will emerge between businesses in a benign way. Query system helps consumers to recognize the relationship between food test and corporate reputation.

3.4 System features

The detection and RFID systems are integrated in the system to expand its advantages. The overall analysis shows that the system can improve information detection, storage and treatment processes, as well as data inspection process treatment capacity, using scientific methods and equipment. This system can greatly improve detection accuracy and efficiency, timely troubleshoot and reduce the occurrence of the issues. In particular, system standardization, advancement, and practicality all provide advanced conditions for supervising and tracking processes. Information transparency also allows producers and consumers to recognize and control relevant information. The supervision results are open to the society to promote healthy competition and benefit consumers.

3.5 System strategies

In the process of equipment selection, the expensive RFID tags makes the cost of whole system hike up, so that it is not affordable for a division, but requires the joint commitment of society and the government instead.

The RFID first focuses on fresh foods, and then gradually expand its application fields after the technology has been mature.
It is unrealistic to conduct comprehensive inspections under current conditions. In order to improve quality inspection of fresh foods, sampling inspections can be used at some spots that may added more to expand the number and scope of samples so as to improve the safety of fresh foods.
The tags must be managed by the specialized division and agency to prevent unreasonable products from circulating. We should also intensify supervision and management power and constantly improve the laws and regulations against illegal behaviors. And besides, the government must involve to play a good coordination role.

4. Conclusions

The safety of fresh foods is a big issue the people more concern. This RFID detection system enables strict quality control of food products, stringent quality assurance, as well as identifications of which and why the quality issues occur. This method has satisfied the quality inspection requirements, though not yet mature now, RFID tags can be used where the work environment is a bit hostile, and there are more oil stains, and so on, various advantages must be used on a large scale.

References

Cattuto C., Broeck W.V.D., Barrat A., Colizza V., Vespignani V., 2010, Dynamics of person-to-person interactions from distributed rfid sensor networks, Plos One, 5(7), e11596, DOI: 10.1371/journal.pone.0011596.

Crovato S., Pinto A., Giardullo P., Mascarello G., Neresinic F., Ravarotto L., 2016, Food safety and young consumers: testing a serious game as a risk communication tool, Food Control, 62, 134-141.

Digiampaolo E., Martinelli F., 2012, A passive uhf-rfid system for the localization of an indoor autonomous vehicle, IEEE Transactions on Industrial Electronics, 59(10), 3961-3970.

Fan T., Tao F., Deng S., Li S.X., 2015, Impact of RFID technology on supply chain decisions with inventory inaccuracies, International Journal of Production Economics, 159, 117-125.

Frattini D., Falcucci G., Minutillo M., Ferone C., Cioffi R., 2016, On the effect of different configurations in air-cathode mfcs fed by composite food waste for energy harvesting, Chemical Engineering Transactions, 49, 85-90.

Khankhaje E., Salim R., Mirza J., 2017, Sustainable pervious concrete incorporating palm oil fuel ash as cement replacement, Chemical Engineering Transactions, 56, 445-450.

Kumar N., Kaur K., Misra S.C., Iqbal R., 2016, An intelligent rfid-enabled authentication scheme for healthcare applications in vehicular mobile cloud, Peer-to-Peer Networking and Applications, 9(5), 824-840.

Li T., Wu S.S., Chen S., 2012, Generalized Energy-Efficient Algorithms for the RFID Estimation Problem, IEEE/ACM Transactions on Networking, 20(6), 1978-1990, DOI: 10.1109/INFCOM.2010.5461947.

Montaser A., Moselhi O., 2014, RFID indoor location identification for construction projects, Automation in Construction, 39(4), 167-179, DOI: 10.1016/j.autcon.2013.06.012.

Nysveen H., Pedersen P. E., 2016, Consumer adoption of RFID-enabled services, Applying an extended UTAUT model, Information Systems Frontiers, 18(2), 293-314, DOI: 10.1007/s10796-014-9531-4.

Prinsloo J., Malekian R., 2016, Accurate Vehicle Location System Using RFID, an Internet of Things Approach, Sensors, 16(6), 825.DOI: 10.3390/s16060825.

Salmerón, J. F., Molina-Lopez, F., Briand, D., et al., 2014, Properties and printability of inkjet and screen-printed silver patterns for rfid antennas, Journal of Electronic Materials, 43(2), 604-617.

Youm S., Jeon Y., Park S.H., 2017, RFID-Based Automatic Scoring System for Physical Fitness Testing, IEEE Systems Journal, 9(2), 326-334, DOI: 10.1109/JSYST.2013.2279570.