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CYCLE RECORDING IN TRACK AND FIELD COMPETITIONS OF RFID

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ABSTRACT

Automatic cycle record in track and field competition has been a difficult problem for a long time. The rapid development of RFID promises the possibility of its realization. This paper studies the data acquisitions and processing in RFID, according to the cycle record in distance race, proposes the non-artificial methods to record cycles in RFID. It can not only avoid human errors but also improve the accuracy and reliability of the results. The automatic of cycle records in track and field competitions is more important for small basic competitions.

Keywords: *RFID, Automatic Cycle Record, Application Study, Track and Field Events*

1. INTRODUCTION

In the distance race, tens of athletes compete in the fields with the length of 400m. The statistics of cycles are usually artificial, which not only costs lots of energy but also exist many errors. In recent years, with the rapid development of RFID, the realization of automatic cycle record becomes possible [1-5]. In many competitions, the levels of athletes are different, and the cycle statistic is always a big problem. Besides the lots of human and material sources, the artificial way has many errors [6-9]. To improve the fairness, the rank and performance of each athlete should be judged correctly. According to existing problems, many companies start studying automatic cycle recording devices, which has been used in marathon. For example, the auto metering and cycle recording devices in Berlin Marathon, uses 135 kHz passive radio frequency technology [10-13]. The device is very small and cheap, but the recognition distance is only within 15cm. A company in Shenzhen studies automatic cycle recorder. The device for athlete to carry is high frequency half active radiofrequency card. Likely, due to the limits of the recognition distance, he buries the antenna under the endpoint runway. The reconstruction of runway is very expensive [14-18].

With the study and expansion of automatic cycle record in track and field competition will improve kinds of existing shortages in current records. But current methods only realize a function, which could not replace the recorder's job. Some studies and explorations are still needed [18-20].

Seen from the current studies, some problems should be valued:

- Transform runway. It is very big and expensive.
- The function is monotonous and unable to realize automation totally
- The operation interface isn't beautiful, and the functions are not perfect.

Although some problem existed, with the continuous development of science and technology, the automatic cycle record must replace the tradition ones, and become the fashion. This paper proposes the method to realize non-artificial automatic cycle record of RFID, which could not only solve the surveillance in longer distance but also propose a better plan for collision technology.

2. RFID

RFID has been developed rapidly since the 1990s, which has been applied to industrial automation, commercial automation, transportation controlling and management, etc. For example, in many electronic toll stations exist in high way in European and American countries, only by RFID label on the car can be withheld automatically, no need to stop. Australia applies its RFID products to baggage management in airports. Swedish installs RFID system on the trains so that the dispatchers can real-timely hold the situations, which not only benefits for management but also reduces the possibilities of accidents. Germany BMW Company applied RFID to its car production

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pipeline. In 1993, our government made a plan for gold card engineering, which purposes at speeding up propelling our great nation-level projects of the civil economic information progress [5-9]. So the development of RFID and its application are rapid. Now, as a new kind of emerging automatic identity technology, it will be popularized in China soon.

2.1. Basic Principle

The most basic RFID system is comprised in three parts:

- Electronic tag: consists of coupling elements and parts. Each tag has unique electronic code, which is to mark object on the material. The information stored can be got in untouched way for read/write by RF reader.
- Reader: a device for reading/writing electronic tag information in RF technology
- Antenna: transmit RF signal between electronic tag and reader

The RFID structure and basic principle is shown as Figure 1.

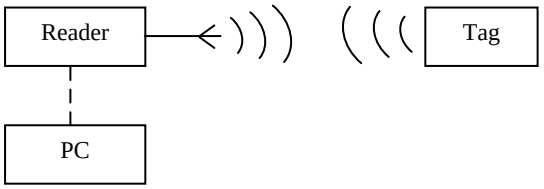

Figure 1: RFID structure and basic principle

All the function principle and design structure of readers can be simplified as two basic modules: HF interface and controller unit. HF interface includes transmitter and receiver. Its function includes: generating HF power to start electronic tags and provide energy; modulating transmitter signal for tags; receiving and demodulating the HF signal from tags.

RFID system links the externals in RS232 or RS485 interfaces of reader, and conducts data transformation. The basic flowing is shown as follows:

- Readers transmit wireless electronic carrier in transmitting antenna;
- When the tag gets into the zone of transmitting antenna, the tag is stimulated. It transmits its code in antenna.
- The receiver antenna receives the carrier from electronic tag. Transform it to reader in modulator of antenna. After the decoding of readers, it will be sent to central information system for relative processing.

2.2. RFID in Cycle Record

During the competition, athletes can't carry big or heavy devices. As an untouched automatic identity technology, RFID automatically recognizes the object and get relative data in RF signals, no requirements of manual intervenes, which can be used in various bad environments. The RF tag can be taken in their bodies as their identities. A complete series of RFID system can be comprised of reader and electronic tag. Tag circuit send internal ID Code and reader receive such ID code.

According to real requirement, the acceptance area of reader is more than 10m. Although it is a passive microwave frequency section (915MHz, 1.8GHz, 2.45GHz and 5.8GHz), the functioning area can reach tens of meters [16]. But such frequency section reflects the body (water), which is not suitable for human. So we use 433MHz active RF tag. It automatically sends data to reader in own RF energy, in modulating scattering way, with bigger distance reaching 30m.

The work flowing of reader and electronic tag can be shown as Figure 2.

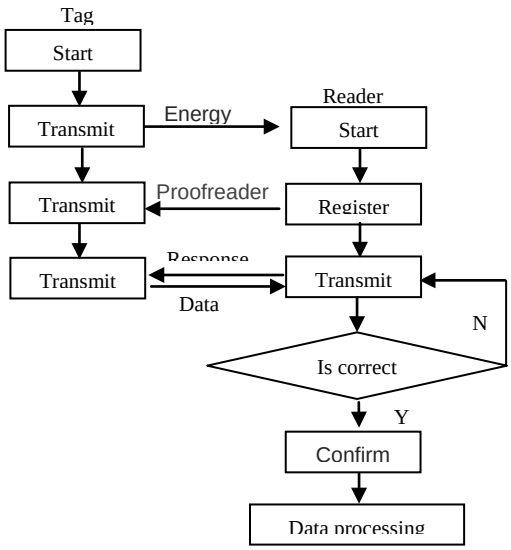

Figure 2: Work flowing between electronic tag and reader

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2.3. ALOHA Algorithm for Recording Performances of Many People

Reader can complete the recognition of tag within its functioning area successfully. In current RFID systems, usually use time-division multi-channel method to avoid collision and transform the data correctly between reader and transponder. This protocol is called collision resolution protocol, short as CRP. It usually has for different ways: SDMA, FDAM, TDMA and CDMA. This design uses ALOHA algorithm.

The multiple address method of ALOHA system is a free TDMA, or called as random multiple access. ALOHA is applied to ROM. Only if a data packet can be used, it can be sent from transponder to reader at once. Such transponder can be continuously sent to reader in a periodical cycle, and the transforming time is only a small part of repeating time. Two transponders can set their data in different time sections, to avoid mutual collisions.

In ALOHA system, data packet g and certain time t_0 equals to transmitting transponder. The mean exchanging data packet content G meets the average in a time section T. The mean exchanging data packet content G can be presented as:

$$G = \sum_{1}^{n} \frac{\tau_n}{T} r_n \tag{1}$$

In formula 1: τ is transforming keeping time of a data packet, n=1,2,3……indicates the number of transponders, r_n =0、1、2……is the number of data packet from transponder n in T

Throughput is measurement of data transformation rate in data communication system. In communication system, it bases on data bit and number of groups processed in a second. To RFID system, when throughput S is 1, data packet is transformed without collisions. Throughput is 0 indicating no data transmitted or unable to read data correctly due to collision. The mean throughput S of transforming channel is:

$$S = Ge^{-2G} \tag{2}$$

The probability of transmitting data packet successfully is q, which can be calculated in mean exchanging data packet contents G and throughput S:

$$q = \frac{S}{G} = e^{-2G} \tag{3}$$

To meet the acquirements of sports, some problems must be solved:

(1) Avoid collisions when many athletes ran across the effective area of antenna almost at the same time;

(2) Real-time responding of device when athletes run across fast. We propose the countermeasures as follows.

RFID reader controls wireless receiving circuits to real-timely supervision of network in CPU chip, and send the data in RS232; tag CPU controls wireless transmitting circuit to send its self ID information timely. Electronic tag timely sends its self ID information out, shown as Figure 3. τ Shows the time for sending data; T is delaying time. It is random, and its purpose is to avoid collision of sending data from many electronic tags in the same time.

Figure 3: Time interval of data

The time for tag to send data depends on wireless communication protocol. The data frame is definite:

FH	frame size	ID	checksum	Frame tail

Frame size: 1 byte, this frame size (exclude frame head, frame tail);

ID: 2 bytes, athlete card number;

Checksum: 1 byte, frame length and ID sum

Tag sends 6 bytes in a time. Set bit rate as 9600s, then τ =6.25ms.

In the process of data transmitting, at first, the collision should be solved. This paper uses ALOHA algorithm above. A data in a time is enough for reader to record cycles. So calculate the probability q of transmitting data packet successfully in a time. Imagine delaying of each tag is T_1、T_2……, $\overline{T}$ is the average of tag delaying, then

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$$G = \sum_{1}^{n} \frac{\tau}{\overline{T}} = \frac{n\tau}{\overline{T}} \quad (4)$$

$$q = e^{-2G} \quad (5)$$

When the athlete runs through the effective area for identity of antenna, the system must record the performance of each athlete without omission. The radius of 400-meter runway is 36.5m; the internal side of runway should leave 1.0m safe area. So the antenna should be set at the 1.5m internal side of runway at end point line. Use the directive antenna to read the tag within the area of horizontal 120° and vertical 85° . In this design, to promise enough reading time, coincide one side of antenna level reading area with end line, and read zone with effective area within 120° . But due to the receiving effective area of antenna is 30m, the receiving area is the length from end point to A.

Athlete running from first runway, curving angle cosine can be solved in cosine principle:

$$\cos A = \frac{b^2 + c^2 - a^2}{2bc} = 0.6486$$

$$\angle A = 49.56160$$

and

$$L = \frac{\angle A}{180} \pi R = 31.6m$$

The velocity of good 100-meter athlete is about 10m/s. After estimating, in the middle and long distance race, the time within the cover of antenna RF can reach more than 4s. The time for tag sends self ID information timely, in mean delaying $\overline{T}$. It can be sent in η times.

$$\eta = \frac{4}{\overline{T}} \quad (6)$$

Formula 6 is once successful probability. Due to Poisson principle, the transmitting successful probability within RF area:

$$\hat{q} = 1 - (1 - q^{\&})^{\eta} \quad (7)$$

Solve difference of $\overline{T}$ in formula 7. Set $\hat{q}'$ as 0. When $q^{\&} = 0.5$, q is max mum.

In this design, $\overline{T}$ is 0.5. In the effective area, fewer tags are, higher probabilities of successfully transmitting are. So when $\overline{T}$ =0.5s, n=27, $\hat{q}'$ =99.7%. q is minimal probability of successfully transmitting. In real competition, the number of athlete is at most 27, but tue to the differences of physical qualities, it is impossible for 27 people to run into the effective area. So the successful ratio is more than 99.7%.

3. CONCLUSION

Automatic cycle record of RFID in track and field competition will totally replace the current artificial method, which makes the sports to catch up with the time. This topic, base on automatic cycle record system, in the construction process, reader with collision-proof function is applied. It can read information from many electronic tags in the same time, with fast responding. If corresponding hardware and software added, RFID in athlete identity will become possible. The applicant area of RFID is continuously expanded; this paper realizes the cycle record in fields and RFID tag reading stably and reliably. Regulate it properly, so as to apply it to other competitions, like marathon and scramble racing, etc.

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