

Retraction

Retracted: Design and Research of a Foul Detector for Long Jump Stepping on a Jump Line Based on the Wireless Sensor Network

Wireless Communications and Mobile Computing

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their

agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] L. Jiang and H. Yan, "Design and Research of a Foul Detector for Long Jump Stepping on a Jump Line Based on the Wireless Sensor Network," *Wireless Communications and Mobile Computing*, vol. 2021, Article ID 5641284, 8 pages, 2021.

Research Article

Design and Research of a Foul Detector for Long Jump Stepping on a Jump Line Based on the Wireless Sensor Network

Liao Jiang¹ and Hong Yan² 

¹Humanities and Social Science Department, Sichuan Vocational College of Health and Rehabilitation, Zigong, 643000 Sichuan, China

²School of Leisure Sports, Chengdu Sport University, Chengdu, 61000 Sichuan, China

Correspondence should be addressed to Hong Yan; 100386@cdsu.edu.cn

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In view of the problems of the judgment of the referee in international long jump competition, such as the omission and wrong judgment, a real-time, accurate, and effective detection instrument is designed. The sensor carried on the athlete is used as the detection element of the foul, which ensures the accuracy and timely information acquisition and effectively prevents the wrong judgment and the missed judgment. The system data is transmitted by the wireless sensor network, which is highly safe and reliable. The experimental results show that compared with the traditional artificial judgment results, the long jump crossover line foul detector based on the wireless sensor network can realize the accurate detection of the number of fouls. The judgment error is lower than the requirements of track and field rules for detection tools, which has great practical value and economic significance.

1. Introduction

With the rapid development of high technology, science and technology have gradually penetrated into all levels of sports and the use of high-tech means to assist sports has become the top priority of many national scholars [1]. More and more attention has been paid to the scientific rationalization of sports competition, so a large number of high-tech products have emerged as an auxiliary means of sports competition judgment. For example, in international and domestic competitions, terminal electric timing, laser ranging, electronic anemometer, and so on are widely used. However, in international and domestic competitions at all levels, it still completely depends on the naked eye of the referee to judge whether the step jump of athletes is successful or not and the use of high-tech electronic instruments is still rare. In the general low-level competition, most of them generally use to pull a thin rope at the forefront of taking off and moving. When the athlete touches the thin rope when stepping on the jump, resulting in the change of the static state of the thin rope, the referee will judge if the test jump is invalid.

In the actual competition, because the stepping and jumping time is very short, it is often difficult for the referee to see whether the athlete commits a foul. When very close to the string, the referee can only judge according to whether the string changes or not. There will be a certain misjudgment rate which causes many unnecessary disputes.

The main feature of information technology is to realize intelligence by combining the computer, network communication, detection, and other technologies to form an integrated information network and various intelligent information systems [2]. A more scientific and reasonable arbitration system can be designed by using computers to record the technical and tactical information on the competition site during the competition. It is helpful for athletes' training and competition in the future. It helps coaches make precompetition arrangements, competition guidance, and postcompetition summary. Using computer technology, athletes can receive audiovisual guidance from experts from different countries and fields at the same time and in the same place, so as to carry out the best training and competition. Electronic technology is applied for the first time in the

Tokyo Olympic Games, and the 1992 Olympic Games adopted satellite communication technology. The 1996 Atlanta Olympic Games and the 2000 seed Olympic Games played a very important role in Internet electronic technology and e-commerce. The light room system of the 100 m FOI landing point was used for the first time in the 2008 Beijing Olympic Games, which can accurately determine the competition result in a few milliseconds. No matter how close the result is, it is always the case in the end.

The wireless sensor network is a wireless network composed of a large number of sensor nodes deployed in the monitoring area [3–8]. These sensor nodes generally have the characteristics of low hardware cost, small volume, and limited energy and computing power. They are connected with each other through wireless communication, so as to monitor the whole target area. The WSN is a new science. It spans many professional fields such as sensor technology, wireless communication technology, and embedded technology. It is a research hotspot highly concerned by domestic surgical scholars. The WSN originated from the defense and military field of the United States. With the continuous progress of relevant technologies, its application field has gradually penetrated into all aspects of our production and life. The emergence of the wireless sensor network has attracted worldwide attention and is considered to be one of the most affected technologies in the 21st century. Wireless sensor network technology will enter the field of industrial automation and industrial measurement and control [9–11]. It is a good choice to apply wireless sensor network technology to track and field sports.

In order to make the track and field competition more fair, just, open, and accurate and create a good competition environment for athletes to obtain excellent results and referees, this paper refers to the relevant provisions on the field facilities of long jump and triple jump in the modern IAAF sports field management, according to the laser receiver. Based on the working principle of the transmitter and the characteristics of individual differences of athletes, a foul detector for long jump stepping on the jump line based on the wireless sensor network is designed. The main difficulty lies on how the shooting device can more accurately replace the foul line and assist the referee to complete the penalty task. The hardware of the detector is composed of a transmitter, a receiver, an integrated voltage regulator, and an audible and visual alarm. It can judge whether an athlete breaks the line in the process of long jump according to the signal provided by the receiver. The wireless sensor network is applied to the system data transmission, which greatly ensures the accuracy and security of the data.

2. Wireless Sensor Networks

2.1. Overall Architecture of Wireless Sensor Networks. The wireless sensor network is composed of N node networks; each node network is composed of a central node and several ordinary nodes [12, 13]. The central node is responsible for transmitting the data collected by ordinary nodes. The overall architecture of the scheme is shown in Figure 1.

After collecting the data of the node network, the node network extracts the keyword set from the plaintext data, then, establishes an index according to the keyword set, and encrypts the plaintext data to obtain the ciphertext. The central node transfers the ciphertext data and the corresponding index to the data center.

2.2. Sensor Node Structure. The sensor node has a simple structure, mainly including a sensor module, processor module, wireless communication module, and power supply module. Its structure is shown in Figure 2.

Sensor nodes are randomly used in different environments, such as disaster areas, battlefields, factories, and buildings. They are interested in physical phenomena, such as temperature, humidity, light, pressure, earthquake, or motion sensing [14]. Sensor nodes use sound and visual information as moving objects for voice and can capture image sensors. After processing by sensor nodes, it can be transmitted to the base station through the sensor network. The wireless sensor network has the characteristics of military and health. The visual information is the most intuitive information perceived by people. The image sensor is to detect and provide visual information for tracking and monitoring. The visual sensor network is the choice of many social organizations.

2.2.1. Protection Facilities. A mechanism for checking and tracking large-scale intruders is necessary. Through visual processing, events can be detected and analyzed and the visual information of interest can be transmitted to the base station. A few years ago, NASA's Jet Propulsion Laboratory (JPL) opened a sensor network.

2.2.2. Military Intelligence. Image sensors can capture high-quality images, observe the command status, improve reliable threat assessment and tracking capabilities, and improve combat and monitoring capabilities [15].

The rapid development of sensor networks has constantly exposed new problems and undeveloped applications. Various sensor platforms, different levels, and different network platforms should optimize the labeling cost of sensors through different sensor functions and interfaces [16] and solve the basic understanding of perceived uncertainty [17]. Performance optimization and higher priority should be given to test algorithms; two recent examples are the learning and scientific wireless signal cannon, which is an effort based on RSS. Applications can better promote this by discovering and displaying correct and effective distributed systems and reduce the cost of testing and initial deployment through appropriate low cost, economic efficiency, and flexible platforms.

2.3. Data Transmission Scheme. In this scheme, the data transmission adopts the "Panda-Hunter" model proposed by Ozturk et al. This model has become the basic model to study the location privacy protection of the source node. In this model, wireless sensor network nodes are deployed in the living environment of pandas to monitor the living habits of pandas. The monitoring data is sent to the base station in the network through the node that monitors the

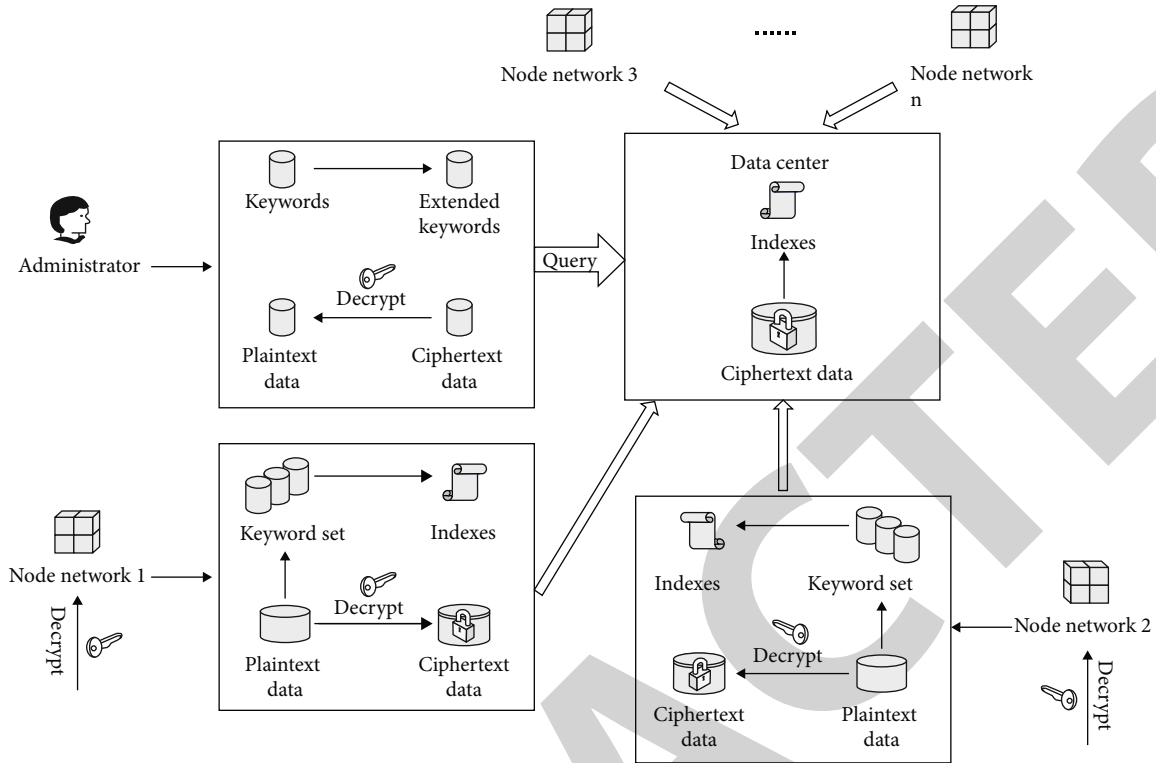


FIGURE 1: Overall architecture of wireless sensor networks.

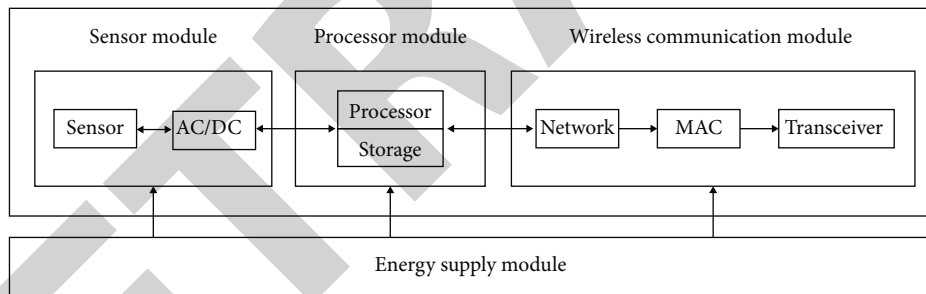


FIGURE 2: Sensor node structure.

target by forwarding data packets hop by hop. For this model, the goal of designing the source location privacy protection protocol is to change the original shortest path routing and forwarding packet mode and increase the time for attackers (i.e., hunters) in the network to track to the source node location, that is, the security time of the source node. In addition, considering the factors of network performance, relevant privacy protection protocols should also consider ensuring the strength of privacy protection, optimizing packet transmission delay, and network energy consumption and improving the performance of the protocol. The specific steps of data transmission are as follows.

2.3.1. Step 1: Network Initialization. The base station initializes the flooding data packet of ordinary nodes in the whole network. After completion, each node reports its own relevant information to the base station through the message data packet. After the initialization phase is completed, all

nodes in the network obtain the minimum hop value to the base station. The base station holds the geographic location information of each node and the minimum hop value between each node and the base station. According to the hop value between the network node and the base station obtained by the base station after the initialization stage, the base station creates a hop distance value table, sorts the nodes according to the hop value in the table, and creates node triples in turn. In the routing stage, any two nodes in each triplet can be used as the phantom source node of another node. After the station broadcasts, each node establishes a complete neighbor list.

2.3.2. Step 2: Select the Transition Node from the Source Node. As shown in Figure 3, s represents the original node and B represents the basic node. When the network sensor node senses panda activity, the nearest panda sensor node becomes a data transmission node, that is, the original node

C sets the initial value of group random stride $htra$ to 0. $hmin$ is the minimum random stride and the maximum random stride in $hmax$. The source node randomly selects the nearest node and sends a packet containing active panda data and source node coordinates. If the $htra < hmin$, the $>node$ continues to select adjacent nodes in $hmin < htra < hmax$, the group is sent, and a random number R is created between 0 and 1. If $r > 0.5$, the node will become a transition node; otherwise, adjacent nodes will be randomly selected to continue transmitting packets. When the $hmin < htra < hmax$ cluster sends the $htra = hmax$ value, the node does not select the switching node, that is, Z .

2.3.3. Step 3: Select the Expected Phantom Source Node Using the Transition Node. Bus node Z uses the neighborhood information in its neighborhood list to calculate the distance from the previous node A and uses d to represent the distance between nodes A and Z . The equation established between linear node A and transition node Z starts from the transition node, and the node coordinates are multiplied by the coordinates in point D as the coordinates of the pseudophantom source node. The specific process is shown in Figure 3.

The distance between node A and node Z is as follows:

$$d = \sqrt{(x_z - x_a)^2 + (y_z - y_a)^2}. \quad (1)$$

The distance between node P and node Z is as follows:

$$|PZ| = \sqrt{(x_p - x_z)^2 + (y_p - y_z)^2}. \quad (2)$$

The distance from node p to node Z is k times the distance from node Z to node a , that is,

$$\sqrt{(x_p - x_z)^2 + (y_p - y_z)^2} = K \sqrt{(x_z - x_a)^2 + (y_z - y_a)^2}. \quad (3)$$

The slope of linear equation of node A and Z is as follows:

$$k = \frac{(y_z - y_a)}{(x_z - x_a)}. \quad (4)$$

The linear equation of nodes a and Z is

$$y - y_z = k(x - x_z). \quad (5)$$

Because node P is on the linear equation constructed by nodes a and Z , so,

$$y_p - y_z = k(x_p - x_z). \quad (6)$$

Get

$$x_p = \frac{(y_p - y_z)}{k + x_z}, \quad (7)$$

$$y_p = k(x_p - x_z) + y_z.$$

Substituting equation (7) into equation (3) gets

$$x_p = x_z \pm Kd \sqrt{\frac{1}{1+k^2}}, \quad (8)$$

$$y_p = y_z \pm kKd \sqrt{\frac{1}{1+k^2}}.$$

Therefore, the coordinates of the expected phantom source node P are

$$P_1(x_p, y_p) = P_1 \left(Kd \sqrt{\frac{1}{1+k^2}} + x_z, kKd \sqrt{\frac{1}{1+k^2}} + y_z \right),$$

$$P_2(x_p, y_p) = P_2 \left(x_z - Kd \sqrt{\frac{1}{1+k^2}}, y_z - kKd \sqrt{\frac{1}{1+k^2}} \right). \quad (9)$$

The transition node uses the coordinate information of the source node in the data packet to calculate the distances $|P_1S|$ and $|P_2S|$ from P_1 and P_2 to the source node, respectively; take the farthest point of P_1 and P_2 to the source button P . When conversion is required, Z sends the data packet to the selected phantom source P and the information about the coordinate position from the source code to the data packet will be deleted. The conversion point selects the phantom source required by SP according to the coordinates of the expected phantom source required by P , the transition Z sends the data packet to the adjacent code closest to the expected phantom source required by P and forwards the selected neighbor code of the data packet just above the expected position of the phantom source node P within the communication range of the sensor receiving the data packet, at which time the node is selected as the phantom source node.

2.3.4. Step 4: The Phantom Source Node Sends the Data Packet to the Base Station along the Shortest Path. The phantom source node selects a neighbor node whose hops to the base station are less than its own hops to the base station to forward data packets. The node receiving the packet still forwards it according to the above conditions until the packet is sent to the base station node.

3. Ware Design of the Foul Detector for Stepping on the Jump Line in Long Jump

3.1. Transmitter Principle. The laser emitter is a microwave quantum amplifier that obtains a highly coherent microwave beam. The working medium of the laser is a high-speed electron beam, which moves in a periodic magnetic field. The

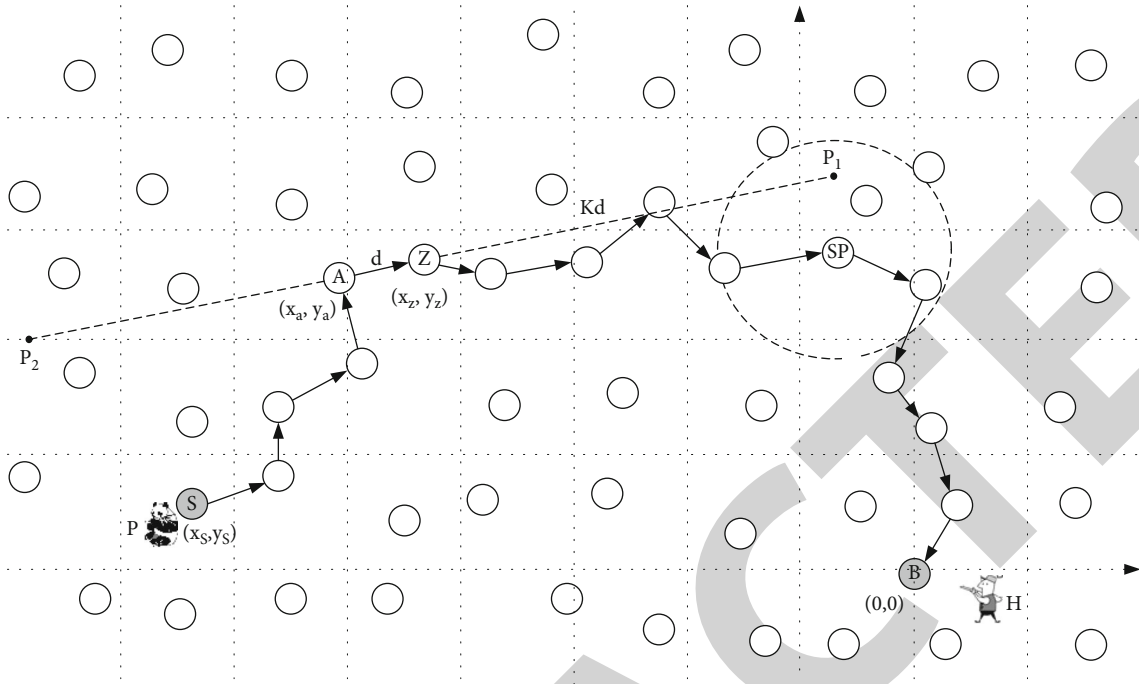


FIGURE 3: Node selection process.

minimum laser wavelength can cover microns and the maximum can reach the range of X-rays. Except for free electron lasers, the basic working principles of various lasers are the same. It includes excitation (or pumping), working medium with a metastable energy level, and resonant cavity [18]. Excitation leads to more stimulated radiation than stimulated absorption, which realizes the inversion of the particle number. The working medium has the property of the metastable energy level, which can be amplified. The resonator can produce positive feedback, shape self-excited oscillation, and maintain. The key is to convert the light-emitting device into a light-emitting tube, which can transmit light to a long-distance light source. If you want to get the peak value of the large pulse current, you can make the average value of the pulse current of the low-power led consistent with the DC current to obtain the peak radiation power. There is a positive correlation between the effective transmission distance of the transmitter and the peak power of the pulse. The relationship between the peak current of the pulse and the loadable DC current is $IP = IM \times To/TD$, where IP is used to describe the maximum current of the pulse, IM is used to describe the maximum current that can be borne under the working state, To is used to describe the oscillation operation cycle, and TD is used to describe the upper flat top width of the pulse. Therefore, when the power of the transmitter is increased, the corresponding peak current IP is also increased and the IM value is fixed. Increasing their ratio can increase the pulse peak current. The designed sensor control circuit needs to ensure that the upper flat top width of the pulse is minimized.

3.2. Receiver Principle. The receiver has high light penetration performance and low energy consumption. The receiver

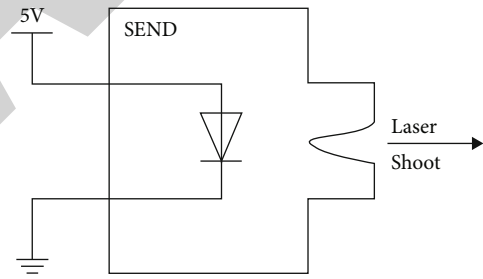


FIGURE 4: Transmitter circuit.

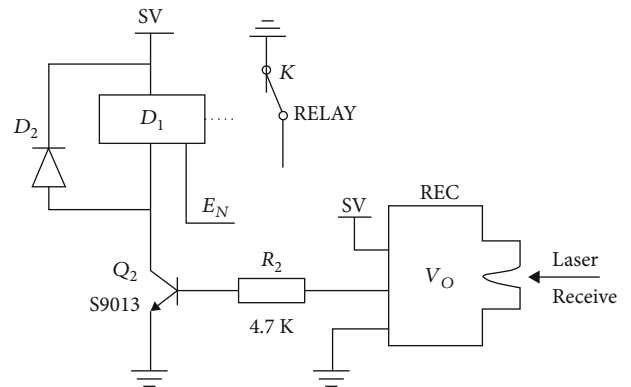


FIGURE 5: Receiver circuit.

collects the signal transmitted by the transmitter, amplifies the signal, filters out the worthless band [19], and transmits the required signal to the interface circuit of the alarm. In order to improve the detection accuracy of the foul detector for stepping on and crossing the line in long jump, 2Cu photodiode is generally used as the photoelectric conversion

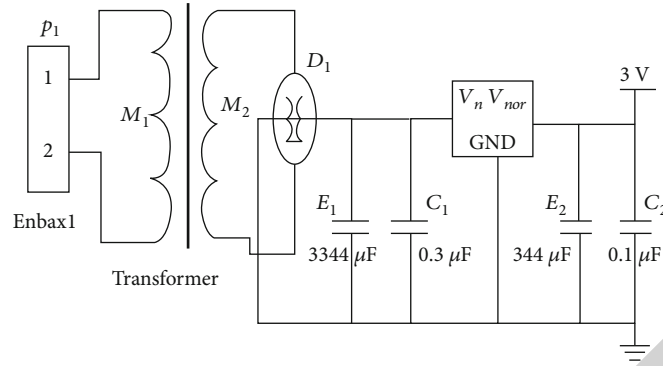


FIGURE 6: 7805 regulated power supply circuit.

receiver. The photodiode is encapsulated in transparent resin, which can receive laser light source and reduce the interference of background light. The diode has a spectral range of 370 to 1200 nm, and its peak wavelength $\lambda = 870\text{--}980$ nm is the most suitable laser-receiving device.

3.3. Related Circuit of the Foul Detector for Stepping on the Jump Line in Long Jump

3.3.1. Transmitter Circuit and Receiver Circuit. As shown in Figure 4, the transmitter circuit is the source working circuit of the detector, which can emit invisible red light and transmit the signal to the receiver to judge whether the athlete crosses the line and commits a foul when stepping on the long jump. The operating voltage of the transmitter circuit is DC +5 V and the operating current is 10 mA. The receiver is used to collect the signal transmitted by the transmitter and process the signal.

The circuit of the receiver is shown in Figure 5, where D_1 is a photoelectric receiving element. D_1 receives the laser optical signal from the transmitter and converts it into an electrical signal, which is amplified by a1a2a3, and A_4 outputs a high-level signal with a constant working voltage. D_1 is the receiving indication. If it is blocked, D_1 cannot receive 19 laser signals and the A_4 output level becomes low; the D_2 indicator light is on. When the level signal output by A_4 changes from high to low, the circuit interface of the audible and visual alarm device will work and send out a corresponding alarm. The selected resistance error shall be controlled to the lowest limit as far as possible, and metal film resistance is generally selected. The leakage of the capacitor shall be as small as possible. This device is a laser-receiving device. When the laser receiver receives the laser, V_O outputs low level, Q_2 does not turn on, the relay is in the released state, and E_N outputs high level. When the laser receiver does not receive the laser, V_O outputs high level. At this time, drive Q_2 is turned on, the relay has current flow, the relay is pulled in, and E_N outputs low level, as shown in Figure 5.

3.3.2. Integrated Voltage Regulator Circuit. The function of the voltage regulator is to keep the DC voltage in a stable state. The unstable DC voltage will become stable through it. The integrated voltage regulator has the advantages of

high voltage regulation accuracy, stable and reliable working state, uncomplicated working circuit, small size, and light weight. It is favored by various power supply circuits. The texture of selected materials varies in different application fields. Commonly used are metal circular and diamond packaging, dual in-line packaging, etc. In the practical production and application of electronic circuits, the fixed output regulator with three output interfaces is the most selected.

The voltage regulator with fixed positive output voltage is the 78xx series. The output voltage has various specifications such as 5 V, 6 V, 12 V, 18 V, and 24 V, and the maximum output current it can withstand is 1.5 A. The internal three protection circuit devices of the voltage regulator are limited current, overheating, and overvoltage. The reference voltage source has low noise, small temperature drift, and stable and reliable working performance. The 78xx series integrated voltage regulator is a three-terminal device, namely, the input terminal, grounding terminal, and output terminal. The application process is very simple and convenient.

Figure 6 shows a regulated power supply circuit with a positive 5 V DC output composed of the 7805 integrated voltage regulator to supply power to the system. IC adopts the integrated voltage regulator 7805. The transformer reduces 220 V AC to 8 V AC. D_1 is a rectifier, C_1 and E_1 are input filter capacitors, and C_2 and E_2 are output filter capacitors. When the output voltage is too high, the 7805 must be equipped with a radiator to prevent burning out the circuit.

As shown in Figure 7, lt1965 is a low noise, low dropout linear regulator, which can produce an output current of 1.1a and a voltage difference of 310 mV. The operating quiescent current is 500 mV, which can be reduced to less than 1 mV in shutdown mode and can efficiently manage the quiescent current state. When the voltage decreases, the value of lt1965 remains stable and the fluctuation range of the output voltage is 1.05~18.2 V. The lt1965 voltage regulator can operate smoothly under the output capacitor of less than 10mV. The internal protection circuit is composed of reverse battery protection, reverse current protection, and current constraint. If 5 V DC is input to the circuit, E_4 will filter the DC and use the voltage regulator to output 3.3 V DC.

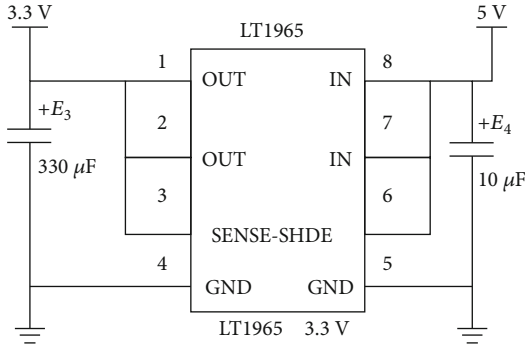


FIGURE 7: Lt1965 voltage stabilizing circuit.

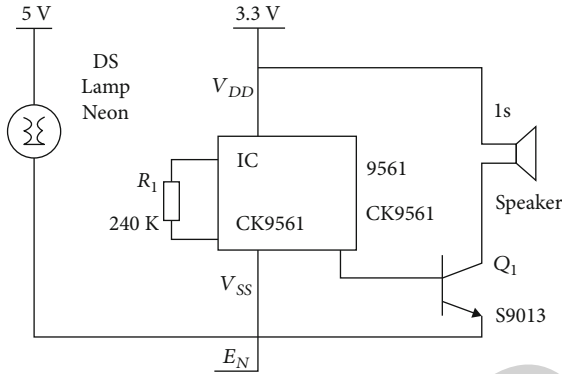


FIGURE 8: ic9561 circuit.

3.3.3. Audible and Visual Alarm Circuit. When the level signal output by the receiver circuit changes from high to low, it will drive the audible and visual alarm working circuit to generate the corresponding alarm, prompting athletes to cross the line and commit a foul when stepping on the long jump. When there is no optical signal in the receiver, the relay is pulled in, E_N is enabled, the voltage circuit is connected, and the audible and visual alarm circuit are operated. ic9561 outputs and amplifies the alarm signal and transmits the alarm signal outward through the speaker. At this time, the lamp power is turned on and the alarm is illuminated. The circuit of ic9561 is shown in Figure 8.

4. Experimental Results and Analysis

The sensor-based foul detector for long jump stepping on and crossing the line is connected with the pulse host through opposite shooting, and a low-voltage pulse is formed at the reflection end and receiving end of the pulse host to generate a closed circuit. If the athlete takes off and commits a foul, the pulse signal will be cut off and the power supply will be disconnected. In this case, the indicator light and alarm connected with the circuit transmit a warning signal, which provides a basis for the referee to judge whether the athlete crosses the line in the long jump. 100 testers of different ages were selected to detect the foul of stepping on the jump line in the long jump. 100 testers were randomly divided into 10 groups. The tester and manual referee designed in this paper were used to judge the foul of step-

TABLE 1: Test results of different test methods.

Group number	Fouls	Detector		Referee	
		Fouls	Error (%)	Fouls	Error (%)
1	20	20	0	20	0
2	18	18	0	18	0
3	22	22	0	21	4.55
4	19	19	0	19	0
5	25	25	0	22	12
6	31	29	6.45	26	16.13
7	28	28	0	27	3.57
8	30	30	0	30	0
9	17	17	0	17	0
10	29	29	0	23	20.67

ping on the jump line in long jump. The results are shown in Table 1.

It can be seen in Table 1 that when judged by the detector, the error of only one group of data is 6.45% but it meets the requirement that the judgment error of detection tools in the competition rules of the National Athletics Federation is less than 10%. When judged by the referee, there are 5 groups of data with varying degrees of error and the error of three groups is greater than 10%. Therefore, the foul detector based on the wireless sensor network can accurately detect the number of fouls and the detection accuracy is high, which has a certain application value.

In addition, considering whether the foul detection device will affect the normal performance of athletes in the competition, we strictly control and experiment the size and portability of the detection device to ensure the smooth progress of the competition. Many groups of experiments have achieved good results, which shows that the foul detection device in the invention will not affect the competition effect of the athletes while realizing the functions described in the paper.

5. Conclusion

In view of the inevitable problems of missing judgment and wrong judgment when the referee decides to step on the jump line in the international long jump competition, a real-time, accurate, and effective long jump step on the jump line foul detector is designed in this paper. The sensor carried on the athlete is used as the foul detection element to ensure the accuracy and timeliness of information acquisition and effectively prevent misjudgment and missed judgment. The system data is transmitted by the wireless sensor network, which is highly safe and reliable. The experimental test results show that, compared with the traditional manual judgment results, the foul detector based on the wireless sensor network can accurately detect the number of fouls and the judgment error is lower than the requirements of track and field competition rules for detection tools, which has great practical value and economic significance.

Data Availability

No data were used to support this study.

Disclosure

And all authors have seen the manuscript and approved to submit to your journal. We confirm that the content of the manuscript has not been published or submitted for publication elsewhere.

Conflicts of Interest

There is no potential competing interests in our paper.

References

- [1] Z. Lv, Y. Han, A. K. Singh, G. Manogaran, and H. Lv, "Trustworthiness in industrial IoT systems based on artificial intelligence," *IEEE Transactions on Industrial Informatics*, vol. 17, no. 2, pp. 1496–1504, 2020.
- [2] G. Dartmann, H. B. Song, and A. Schmeink, *Big Data Analytics for Cyber-Physical Systems: Machine Learning for the Internet of Things*, Elsevier, 2019.
- [3] M. K. Singh, S. I. Amin, S. A. Imam, V. K. Sachan, and A. Choudhary, "A survey of wireless sensor network and its types," in *2018 International Conference on Advances in Computing, Communication Control and Networking (ICACCCN)*, pp. 326–330, IEEE, Greater Noida, India, 2018, October.
- [4] X. Ding, H. Jianghong, S. Lei, X. Wei, and W. Zhenchun, "Research on dynamic topology of rechargeable wireless sensor networks," *Journal of Communications*, vol. 36, no. 1, pp. 133–145, 2015.
- [5] Z. Bo, X. Luo, L. A. N. Yubin, H. Zhihong, Z. Ming, and L. Jiyu, "UAV farmland information monitoring system based on wireless sensor network," *Journal of Agricultural Engineering*, vol. 31, no. 17, pp. 176–182, 2015.
- [6] W. Bin, Z. Zengping, and S. K. Yidelkun, "Design and implementation of pairwise node synchronization method for energy-saving wireless sensor networks," *Computer Applications*, vol. 41, Supplement 1, pp. 189–195, 2021.
- [7] F. Li Wenfeng and Xiuwen, "Survivability of wireless sensor networks," *Journal of Computer Science*, vol. 38, no. 3, pp. 625–647, 2015.
- [8] Z. H. Lv and A. K. Singh, *Big Data Analysis of Internet of Things System*, ACM Transactions on Internet Technology (TOIT), 2021.
- [9] J. Aponte-Luis, J. A. Gómez-Galán, F. Gómez-Bravo, M. Sánchez-Raya, J. Alcina-Espigado, and P. M. Teixido-Rovira, "An efficient wireless sensor network for industrial monitoring and control," *Sensors*, vol. 18, no. 2, p. 182, 2018.
- [10] S. Jeschke, C. Brecher, H. B. Song, and D. D. Rawat, *Industrial Internet of Things: Cybermanufacturing Systems*, Springer, Switzerland, 2017.
- [11] W. Y. Yi, K. M. Lo, T. Mak, K. S. Leung, Y. Leung, and M. L. Meng, "A survey of wireless sensor network based air pollution monitoring systems," *Sensors*, vol. 15, no. 12, pp. 31392–31427, 2015.
- [12] X. Yu, P. Wu, W. Han, and Z. Zhang, "A survey on wireless sensor network infrastructure for agriculture," *Computer Standards & Interfaces*, vol. 35, no. 1, pp. 59–64, 2013.
- [13] I. Butun, P. Österberg, and H. B. Song, "Security of the Internet of things: vulnerabilities, attacks, and countermeasures," *IEEE Communications Surveys & Tutorials*, vol. 22, no. 1, pp. 616–644, 2020.
- [14] P. Castillejo, J. F. Martinez, J. Rodriguez-Molina, and A. Cuerva, "Integration of wearable devices in a wireless sensor network for an E-health application," *IEEE Wireless Communications*, vol. 20, no. 4, pp. 38–49, 2013.
- [15] Z. Lv, R. Lou, J. Li, A. K. Singh, and H. Song, "Big data analytics for 6G-enabled massive Internet of things," *IEEE Internet of Things Journal*, vol. 8, no. 7, pp. 5350–5359, 2021.
- [16] C. Jiayu, Z. Zheng, F. Weidong, H. Yi, L. Jingru, and Z. Shiwen, "A fault detection algorithm for wireless sensor network nodes," *Computing Technology and Automation*, vol. 40, no. 1, pp. 38–42, 2021.
- [17] Y. X. Li, Y. Zuo, H. B. Song, and Z. H. Lv, "Deep learning in security of Internet of things," *IEEE Internet of Things Journal*, 2021.
- [18] C. Yansong and X. Kewen, "Intelligent information technology application association," *Procedures of 2011 aasri Conference on Artistic Intelligence and Industry Application (aasri-aiia 2011 V2)*, vol. 4, 2011.
- [19] Y. Gang, "Design and implementation of electronic detector for long jump take-off and cross line," *Electronic Technology and Software Engineering*, vol. 12, pp. 108–109, 2016.