# A Design of Long Jumping Device Based on Infrared Scanning and Data Collecting Technology

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**Abstract.** A standing long jump device based on infrared scanning technology was proposed for the aim of detecting and analysing the sports achievement of a group of people. The equipment is make of a standing long jump range finder, an infrared scanning range device, and a cloud platform for data management. The output of the measurement data is achieved through converting electrical signal produced by the instrument into a digital signal. The triangular formula and the minimum value algorithm were applied to deal with the distance data measured by the infrared light device. The function model of instantaneous data acquisition can effectively solve the measurement errors caused by the slight movement of tester's toes or heels. In addition, the device also has intelligent cross-line alarm function. Compared with the previous rangefinder equipment, this device can achieve a high level of measurement accuracy and upload real-time data to the cloud platform for analysis.

## 1 Introduction

In recent years, a variety of theoretical perspectives have been advanced to provide an understanding of the determinants of usage[1]. With the rapid development of Internet, Internet of Things[2], cloud computing[3] and other information technology in the global field, the rapid growth of data information has brought serious challenges and valuable opportunities to many industries. Therefore, today's information society has already entered the big data[4] era. The development of large data not only changed people's daily life and work, business mode of operation, but also led to the scientific model of the occurrence of a fundamental change[5]. Large data is a collection of data that can not be perceived, acquired, managed, processed, and serviced by conventional machines and hardware and software tools for a certain period of time. Network large data refers to the "human, machine, material" ternary world in the network space mutual interaction and integration generated by the Internet and access to large data, referred to as network data. By generating, collecting, storing and analyzing data on a large data basis, extracting useful values in different areas to provide advice or support decisions, resulting in different levels of potential value.

Intelligent system test system is a kind of automatic detection of a number of human body system, including long jump tester, finger pulse tester, vital capacity tester and many other subsystems. It is an important part of physical training as a test item for students' physical fitness test. Through the training of long jump, to promote the comprehensive development of young people has a very important role. "National Student Physical Health Standard" provides a long jump is junior high school, high school, college annual physical fitness test items. The traditional long jump test is painted on the ground jumper, next to the tape, the referee through the naked eye reading, and record the student's long jump results. This method of error is large, and data records, statistics, management are more trouble. In accordance with the Ministry of Education planning, legislation long jump and all test items should be universal access to intelligent instruments, and equipped with data management software to provide exercise prescription. The current use of conductive rubber and infrared on the tube ranging device is low, the installation of trouble, not equipped with data management system to provide exercise prescription. According to the existing devices have low accuracy, the start line is not set up alarm device, and the small movement of the foot after the jump caused by measurement errors or other issues. Some effective solutions has been given in this paper.

In this paper, an Internet-based student physical health intelligent test equipment has been designed, which involves infrared ranging[6-7] and large data technology. It intends to develop an intelligent terminal, through the intelligent development of young people's daily sports, not only enrich the extracurricular activities also collected young people's physical health data. The use of infrared sensors with fast response, long life advantages. Through the controller and processor control infrared sensor transmitter and receiver components to complete the data collection, processing, recording,

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automatic completion of the data sort update and achieve the entire process of measurement automation. This means can effectively solve the current measurement means there are many inconvenience. Intelligent terminal through the collected data on the young athletes to give statistics, analysis, and uploaded to the cloud platform for comparing the different schools and regions of the physical quality of young people. It has an important reference role in the development of relevant national strategic development.

## 2 Device system structure

The program according to the principle of infrared light curtain, automatic measurement of long jump distance. The athlete is taking off at the takeoff. There is a separate infrared tube at the jumper line to determine whether to step on the line foul. When the athletes landed, the ground's infrared detection area was blocked. The system records all measured data. According to the algorithm to calculate the final long jump results. When the jump is finished, the athlete gets out of the detection area. The system waits for the next player to measure at the takeoff point. The measured data will be analyzed, counted and uploaded to the cloud platform.

Figure 1 is the legislation of the long jump range finder system structure diagram. The system consists of information reading device, data transmission device, function key group and data processing module and so on. The information reading device is composed of identity card identification, fingerprint identification, camera and the like, and is used for recognizing the identification information of the tester. The function of the data transmission device is to upload or download the measured data. Function key group is based on the different conditions of use of the tester for key operation, to achieve accurate measurement process. The data processing module realizes the acquisition, analysis and recording of the measurement data.

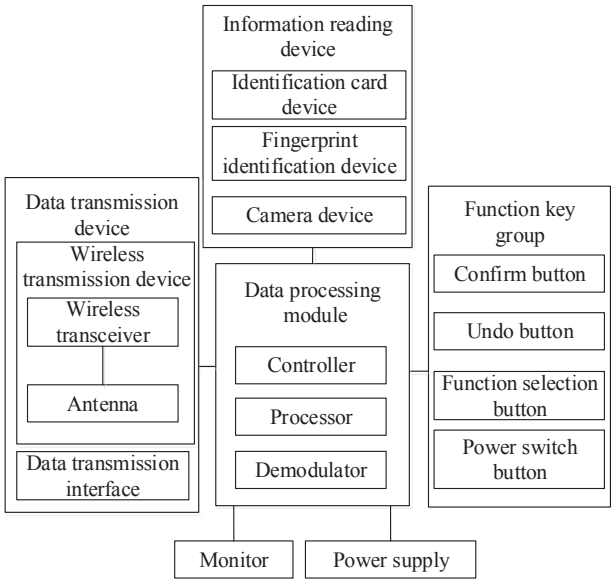


**Fig. 1.** System framework of the long jump range finder

Figure 2 shows a system for infrared scanning range devices. The circuit mainly includes infrared transmitting circuit, anti-over line module, modulation circuit, control circuit and so on. Infrared emission circuit for transmitting infrared beam sensing long jump distance. The anti-crossing module can effectively prevent the tester from crossing the start line when taking off. The modulation circuit is used to generate a data signal for transmission. The control circuit guarantees the overall function of the device.

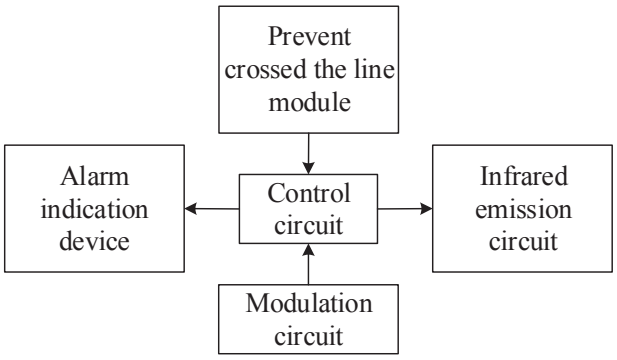


**Fig. 2.** System structure frame diagram of the infrared scanning range device

## 3 Installation of the device

The device (as shown in Fig. 3) consists mainly of three parts: (1) the long jump range finder (as shown in Fig. 4) for data read, store, upload; (2) the infrared scanning range device based on the infrared distance measurement principle (as shown in Fig. 5); (3) the data management cloud platform for large data statistics and analysis.

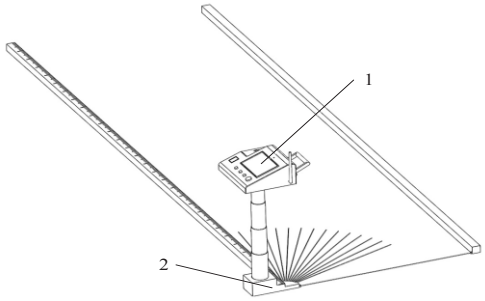


**Fig.3.** Simulation of distance measuring device

Where Device 1 is a Standing Long Jump Range Finder, and Device 2 is an Infrared Scanning Range Device, which radiates infrared lights to detect the distance data of human's feet. The long jump range finder (Fig. 4) remotely downloads the test list via the antenna. The tester performs personal information reading through the identification card or the fingerprint identification. Face Recognition Pinhole Camera Shoots the taster's face information. Test information is confirmed and tested. The results will be confirmed by the confirmation button to confirm the results, at the same time, the system will automatically store data and call out the next tester information. The display shows personal results. To retest, revoke the data with the Undo button. If someone is absent, press the Undo button to temporarily record

the person's score as 0 and save it with the confirmation button. The function selection button allows you to select different modes. The saved data is uploaded to the data center via the antenna. The data can be stored in the range finder. The bracket is used to support the range finder, and the telescopic bracket can reduce the overall volume of the device, easy to install and store.

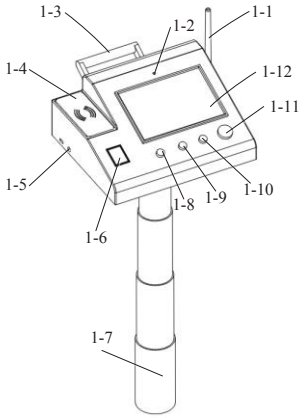


**Fig. 4.** Simulation of standing long distance rangefinder

The labelled parts in Fig. 4 are named as follows: 1-1. Antenna, 1-2. Pinhole Camera, 1-3. Handle, 1-4. Card Panel, 1-5. Data Transfer Port, 1-6. Fingerprint Identification, 1-7. Telescopic Stand, 1-8. Confirm button, 1-9. Undo button, 1-10. Function selection button, 1-11. Power switch, 1-12. Display.

Infrared scanning range device (Fig. 5) installed in the flat ground, by the rangefinder installation hole, infrared light screen range finder, infrared transmitter, reference scale and other components. The rangefinder mounting hole is used to install the range finder. Infrared light curtain rangefinder for fixed angle emission ranging infrared light curtain. Infrared emitters mounted close to the ground jumper position are used to prevent the tester's toes from crossing the start line. The reference scale is used for distance reference. When the tester's foot falls into the range of the rangefinder, the infrared scanning range device uses the infrared distance measurement principle to measure the distance between the tester's heel and the infrared light curtain. The device converts the resulting beam signal into a level signal and outputs it, and then generates a digital signal through the modulation circuit for data transfer. The processor calculates the triangular formula for the resulting measurement data and finally derives the actual jump distance of the tester.

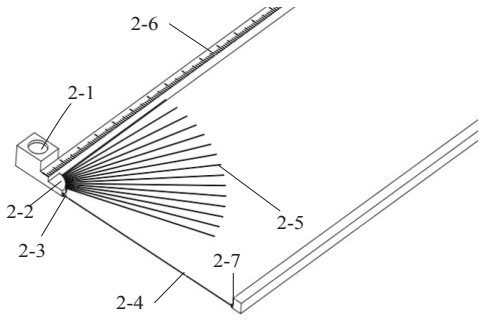


**Fig. 5.** Simulation of infrared scanning range device

The labelled parts in Fig. 5 are named as follows: 2-1. Mounting holes, 2-2. Infrared light curtain instrument, 2-3. Infrared emitter, 2-4. Infrared light beam, 2-5. Infrared light curtain, 2-6. Reference scale, 2-7. Infrared receiver.

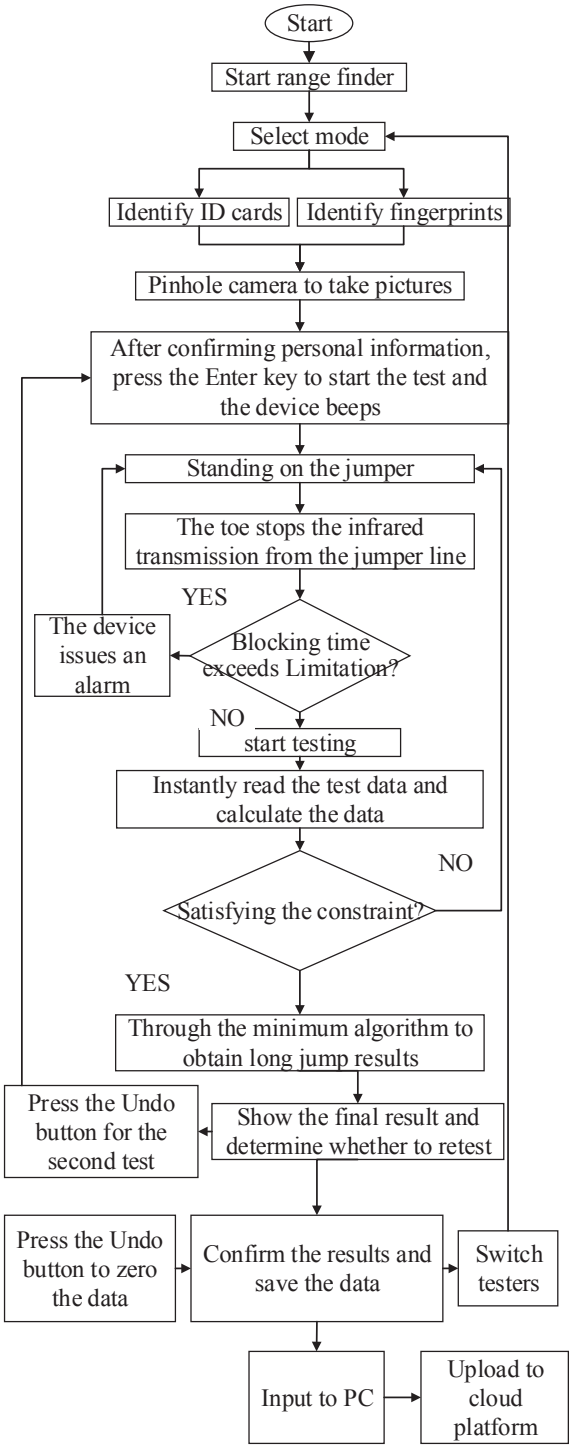


**Fig. 6.** Flow chart of long jump test

When all the tests are completed, the stored data can be uploaded to the PC by wireless or wired transmission for data statistics, analysis, and uploaded to the data management cloud platform. Cloud platform not only includes the test of the name, gender, age, performance and other details, but also can analyze the personal data and the overall data, showing the recent changes in their physical data trends and the difference with the average

data. In addition, the system will give specific recommendations based on the individual's own situation. Through the improvement of diet or related exercise to help the testers to strengthen or improve physical fitness. In addition, parents can real-time view student physical data through the relevant mobile APP, so as soon as possible concerned about the healthy growth of students' physical fitness. Detailed test process is shown in Fig 5.

## 4 Principle of distance measurement

When the infrared photoelectric tube receives the pulse signal of the launch tube, the instantaneous change in the luminous flux causes the current to change. Infrared receiver through the op amp circuit differential, amplified signal and the threshold comparison circuit output pulse signal, and finally sent to the processor detection. When the luminous flux of the receiving tube changes, the reverse current will change, equivalent to the receiving tube resistance changes. As the receiving tube cathode through the bias resistor, so the voltage will change. The transmit modulation signal is a pulse with a very small duty cycle, and the input electrical signal of the receiving tube is also a pulse signal with very small pulse width. This signal is fed into the op amp differential circuit by capacitive coupling. Having a fast response, low noise, and output is not affected by the characteristics of the DC component of the photocurrent.

The use of infrared radiation is the principle of non-proliferation, because the infrared light through the other substances when the refractive index is very small, so long distance rangefinder will consider the infrared. Infrared transmission takes time. When the infrared ray is emitted from the range finder, the infrared ray is received by the distance meter when the reflector is reflected back. And then according to the infrared from the time of receipt to be received and the transmission speed of infrared can calculate the distance.

### 4.1 Innovation

#### *4.1.1 Triangle formula-based distance measuring*

Infrared light curtain into a fixed angle continuous launch ranging infrared light curtain. According to the formula:

$$Hn = Ln \cdot sin\alpha_n \quad (1)$$

where $\alpha_n$ *(n=1,2,3...)* is regarded as the angle between the jumper and the measured infrared rays at the heel position, Ln is regarded as infrared beam length, *Hn* is regarded as jump distance (as shown in Fig 4). The formula draw the distance data (the result can be accurate to *0.1mm*). And then according to the minimum algorithm to compare the size of *H1 ~ Hn*, the resulting minimum value for the measured heel and jumper between the distance, that is, long jump results. In addition, to avoid the measured data interference outside the working range, the constraint condition is added: $Ln\ cos\alpha_n < L$ (*L* is the starting line length).

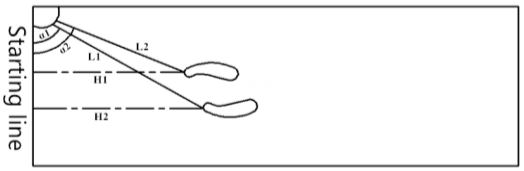


**Fig. 7.** Demonstration of data measurement

#### *4.1.2 Minimum algorithm analysis*

According to the C language circulatory thought, the obtained data are compared and the minimum result is obtained. The algorithm is as follows:

```
min=H[1];
    for(i=2;i<n;i++)
        if(H[i]<min)
            min= H[i];
printf(min);
```

where min is initial minimum parameter, *H[i] (i=1,2,3...n)* is the variable of each data obtained. Let *H[1]* be the initial minimum, and use the loop statement to compare the latter data with the previous one, and the minimum value is the result of the long jump.

#### *4.1.3 Function of preventing crossing the line*

In the actual long jump test process, because the tester intentionally or unintentionally lead to the toes beyond the jump line, causing foul behavior. The infrared emitter (shown at 2-3 in Fig 3) located at the ground jumper position is used to prevent the tester's toes from crossing the jumper. If the tester toes across the start line, that is, blocking the infrared beam, the device will issue an alarm tone. In order to avoid the tester in the take-off may pass the infrared beam lead to false alarm phenomenon, we add a timer program to the alarm system (very short time) according to the reasons for the faster acceleration and the shorter time when the tester takes off. The device will be alerted when it exceeds a certain amount of time.

#### *4.1.4 Function of instantaneous reading*

When the tester feet lands, to avoid the situation of tester's foot movement or other parts of the body into the scanning range due to the center of gravity instability. We have added a transient read measurement data program to the device. When the tester's feet fall within the scanning range, the infrared will instantly measure the distance between the heel and the instrument. The program can be collected in a very short period of time measurement data and save. The measured data will not affect the results originally obtained.

#### *4.1.5 Data management cloud platform*

Through the establishment of student physical health data management cloud platform, we can use large data technology for data analysis to get different regions, schools, age, gender, student physical growth. Different

regions/provinces/national education departments and health departments through the cloud platform for the data of students' physical health statistics. It plays an important role in supporting national strategy.

### 4.2 Problems and solutions

#### *4.2.1 Abnormal state processing*

Long jump range finder in the actual use of the process, the equipment administrator or the tester may lead to a variety of abnormal state. If the infrared array in a long time in the useless scanning state, not only consume energy, but also affect the working life of the instrument. Previously classified according to various exceptions problems that may arise. When an exception occurs, the finite state machine is used to switch the state to return to the normal state.

#### *4.2.2 Multiple MCUs compete for power issues*

This device requires a total of multiple single-chip synchronous work, synchronization signal's transmission and reception will be a single pin to complete the microcontroller. Due to the component parameters of the error and the power capacity of the original flash, there are individual microcontroller can not power or instantaneous power and power problems in the experimental process, resulting in synchronous high and low levels of the pin changes. As the single-chip receiver to receive the synchronization signal may be wrong to determine the synchronization signal to start work, so that the operation is not reliable. For this problem we can use dual power supply to solve.

#### *4.2.3 Outdoor environmental impact*

Outdoor test launch and receive spacing will be a greater degree of reduction, there are two main reasons impact. First, the sensitivity of the receiving head in the visible light environment will be reduced. Second, infrared wave attenuation in the outdoor environment is relatively large. So we can take the following solutions. First, the processing of cylindrical holes in front of the receiver and install the red filter can effectively reduce the impact of other visible light. The second is to increase the launch tube launch power. However, we need to adjust the duty cycle so that it does not exceed the rated power of the launch tube.

## 5 Conclusion

This field has designed an automatic distance measuring device based on infrared scanning. The use of infrared distance measurement principle for accurate long-distance jump. The triangular formula and the minimum algorithm are used to process the measured data to arrive at the final result. The function of preventing crossing the line and instantaneous reading ensure the effectiveness of the results. Data management cloud platform can achieve effective data sharing and application. After analysis, the device has the advantages of high efficiency, wide measurement range and stable performance.

On the basis of the existing research work, the circuit of the device function is designed by using other components such as single chip microcomputer. After the installation of the device is completed, cooperate with the local schools to carry out the testing work. The test results are analyzed to determine whether the device meets the intended design requirements. Optimizing the development of the cloud platforms and mobile devices APP. To make the program more convenient, humane and meet the needs of the masses of the use. On this basis as much as possible to reduce the cost of manufacturing equipment in order to better put into the market.

## 6 Acknowledgments

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