A New Research of Detection Device for Smart Wearable Equipment Step Counting Function

Peipei Li¹, Yi Zhao¹, Yanfeng Yang², Yong Liu¹, Jianyu Hu¹ 
¹Chongqing Institute of Metrology and Quality Inspection, No.1, Yangliu North Road, Yubei District, Chongqing, China 
²Chongqing Municipal Public Security Bureau, No.311, Jinshi Avenue, Yubei District, Chongqing, China 
Email: qingxianwawa05@126.com

Abstract: This article analyzes the current research status of smart wearable devices, proposes a step detection method for the smart wearable device, completes the hardware design and software programming of the device, and develops a test device for step counting function of smart wearable equipment. By testing the relevant products and collecting data, the relevant test results are given. The development of this device provides professional and credible testing data and results to the vast number of consumers and the general public. It can promote the innovation and development of the smart wear industry and deep integration with other industries and technologies. It also has great significance for testing institutions and enterprises.

1. Introduction
With the development of science and technology, more and more traditional devices have become intelligent. The intelligent devices are becoming smaller and portable. For example, in recent years, smart wearable devices have appeared in the market, such as smart bracelets, smart watches, smart rings and smart necklaces [1]. Smart wearable devices can record real-time data of exercise, sleep, part of diet in daily life, and synchronize these data with electronic communication tools such as mobile phones and tablets through Bluetooth or WiFi. According to the synchronized data, it can guide a healthy life.

One of the important functions of smart wearable devices is to record the walking steps of users every day, and counting these steps is realized by recording the number of wrist swings in the process of walking. At present, there is no special testing device on the market for the accuracy of the data recorded by smart wearable devices. Because the trajectory of the arm swing is not on a plane when people are walking, the transmission of swing device cannot simulate the trajectory of arm swing when people are walking. It would lead to inaccurate test results [2]. If people wear intelligent wearable devices directly on their wrists to test, it will make the tester feel tired. Moreover, it requires counting the steps of walking manually, which is also easy to lead to inaccurate results. Therefore, it is necessary to test this index. The test device for step counting function of smart wearable equipment developed in this paper provides technical support for promoting the innovation and development of intelligent wearable industry and other industries.

2. Operating principle
The overall system consists of three-axis motion platform, three-axis motion platform driver,
controller (control computer), auxiliary connection / detection equipment and acceleration waveform file. 3-axis motion platform: choose linear motor with good acceleration performance. 3-axis motion platform: select the multi-axis motion driver of Copley controls, with CANopen network interface. Control computer: choose x86 system computer which is widely used and has wide range of options. The operating system will use windows 10 series and use VS development environment and .Net technology architecture. Auxiliary connection / detection device: most smart wearable equipment implemented apps for Android system, and Android phones are selected as auxiliary connection devices. Google provides DDMS (the Dalvik debug monitor) service of Android system, which worked as a part of SDK debugging tool, and this service can capture Android screen display. The working principle is shown in figure 1.

![Figure 1. Block diagram of operating principle](image)

### 3. Software architecture

The human-device interface communicates with the acceleration waveform analysis module, the equipment step reading module, the motion calculation module and other modules. Control module: communicate with the upper computer, and convert the command to the drive module, which can be in the form of software; Driver module: support CANopen / EtherCAT protocol module, with 3-axis drive capability [3]. The communication protocols are CANopen and EtherCAT. The software architecture is shown in figure 2.

![Figure 2. Block diagram of software architecture](image)

The software flow chart is as follows: it reads the acceleration file and confirms the accuracy of the data firstly. Then it reads the description length, sampling rate, confirms the length of the acceleration package. Finally, it confirms the cumulative displacement of the x, y, z axes and the position at this
moment. If it did not exceed the travel distance range, the position of the next moment would be sent to drive and start counting. If the measuring range is exceeded, it will return to the initial state and the following operations will be repeated. See Figure 3 software flow chart for details [3].

![Software flow chart](image)

Figure 3. Software flow chart

4. Test device
The test device for step counting function of smart wearable equipment includes a pedestal. This pedestal is equipped with a first driving mechanism and the first driving mechanism is connected with a first connecting base. The first connecting base is equipped with a second driving mechanism and the second driving mechanism is equipped with a second connecting base. The second connecting base is equipped with a third driving mechanism and the third driving mechanism is equipped with a connecting block. The components of the device are as follows: The first linear motor 1, the first actuator 7, the first connecting seat 8, the second linear motor 2, the second actuator 9, the second connecting seat 10, the third linear motor 3, the third actuator 11, the third connecting seat 12, the connecting plate 4, the connecting block 5, and the baffle 6[4]. The structure of the test device is shown in figure 4 for details.
Set the travel distance of X-axis as 50-70cm, Y-axis as 30-50cm; Z-axis as 20-40cm, i.e. the first mover 7, the second mover 8 and the third mover 11 are all reciprocating, and the moving distance would be 50-70cm, 30-50cm and 20-40cm respectively. The motion frequency of the first linear motor 1, the second linear motor 2 and the third linear motor 3 is 0-25Hz. When the motion frequency is low, the state of walking is simulated; when the motion frequency is high, the state of running is simulated [5].

When testing the accuracy of the step counting function of smart wearable device, firstly, fix the intelligent wearable device on the connecting block, then start the first driving mechanism, the second driving mechanism and the third driving mechanism respectively. The first driving mechanism drives the first connecting base of first driving mechanism to move in a straight line along the X axis; the second driving mechanism drives the second connecting base of second driving mechanism to move in a straight line along the Y axis, and the third driving mechanism drives the third connecting base of third driving mechanism to move in a straight line along the Z axis, because the third connecting base is connected with the second driving mechanism, and the second connecting base is connected with the first driving mechanism. Therefore, the motion track of the connecting block moves in the X-axis, Y-axis and Z-axis comprehensively. The first driving mechanism and the second driving mechanism and the third driving mechanism together move once, the test device has simulated one step of human walking [6].

The device can set variable parameters to provide three axial motion state simulations. Three axial motions are independent. At the end of the test, record the step data of the under test equipment, and compare with the pre-set steps of the device [7].

5. Test Results
In this paper, three representative smart wearable devices were selected for testing the step counting function. First, set the steps of the test device as 1000 steps, 2000 steps and 3000 steps respectively, and then tested the three product step counting functions of smart bracelet, smart watch and wristband in turn. The results present that the larger the number of steps, the step counting is more accurate. See Table 1, table 2 and table 3 for details.
### Table 1. Smart wearable device test data at 1000 steps

| Product name    | Smart Bracelet | Smart Watch | Wristband |
|-----------------|----------------|-------------|-----------|
| Product step counting (steps) | 942            | 1074        | 940       |
| Set device steps (steps)       | 1000           | 1000        | 1000      |
| Step counting error (%)        | -5.4           | +0.74       | -6.0      |

### Table 2. Smart wearable device test data at 2000 steps

| Product name    | Smart Bracelet | Smart Watch | Wristband |
|-----------------|----------------|-------------|-----------|
| Product step counting (steps) | 1900           | 2118        | 1890      |
| Set device steps (steps)       | 2000           | 2000        | 2000      |
| Step counting error (%)        | -5.2           | +5.9        | -5.5      |

### Table 3. Smart wearable device test data at 3000 steps

| Product name    | Smart Bracelet | Smart Watch | Wristband |
|-----------------|----------------|-------------|-----------|
| Product step counting (steps) | 2850           | 3159        | 2844      |
| Set device steps (steps)       | 3000           | 3000        | 3000      |
| Step counting error (%)        | -5.0           | +5.3        | -5.2      |

### 6. Conclusion

In this paper, the research status of the step function of intelligent wearable device is given, and the working principle diagram, specific circuit diagram and test results of the function detection device of intelligent wearable device are given. When carrying out the test, the test device can accurately detect the step counting function of the smart wearable device. The device is simple and easy to operate, which provides a good technical support for the laboratory and the enterprise to carry out the test of the project.

### Acknowledgments

First of all, I would like to express my gratitude to all those who helped me during the writing of this thesis. I gratefully acknowledge the help of director Zhao who offered me patient guidance in the project studies. In the preparation of this thesis, he provided me with inspiring advice. Second, I also owe a special debt of gratitude to all the colleagues. Due to their hard work on the project, I benefited a lot and academically prepared for the thesis. Last, I would like to express my gratitude to my family who supported me silently and gave me confidence.

### References

[1] Xie Lingqin, Shi Ping and Cai Wenjie 2015 Key technologies and development trends of wearable smart devices [J], *BME & Clin Med.*, **Vol.19**, pp.635-640.

[2] Xu Lu and Jiang Hong 2014 Research on Wearable Device Development Status and Countermeasures [J], *New Materials Industry*, **Vol.12**, pp.63-67.

[3] Chen Chunmou 2019 Key Technologies of Health Detection System Based on Intelligent Handring and Android System [J], *Microcomputer Applications*, **Vol.35**, pp.99-101.

[4] He Xiaolong, Shi Wenyue and Sheng Zhangqun 2016 A Research on the Availability of Smart Bracelet/Phone APP in Different Walking Speed or Road Surface for Step Calculation [J], *China Sports Science and Technology*, **Vol.52**, pp.122-127.

[5] Pan Jiayao 2018 Research and Realization of Intelligence Control Technique of Wearable Devices Based on Inertial Sensors [J], *Information Technology & Informatization*, **Vol.11**, pp.58-61.

[6] Hang Changzheng, Chen Xi and Zhou Yanning 2020 Research on a new generation of smart bracelet with long-term motion positioning trajectory recording [J], *Guangdong Science & Technology*, **Vol.1**, pp.66-68.
[7] Yan Yong, Lei Hang, Zhou Xiangbing and Liang Pan 2016 Based on the adaptive pedometer to realize three-axis accelerometer [J], *Journal of Northeast Normal University (Natural Science Edition)*, Vol.48, pp.79-83.