A Design of Lightweight Walking-Assisted Skeletal Robot

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Abstract. At present, the robot is in a full swing state in various industries, and intelligent equipment can be seen everywhere. With the development of science and technology, the intelligence, reliability and functional extensibility of the exoskeleton robot have to be further improved. Most of the robots sold in the existing market are service robots, domestic robots, and so on, while walking-assisted robots are few. Taking into account the above mentioned, this project is committed to the design and improvement of a lightweight walking-assisted skeletal robot which is composed of STM32 controller, sensor detection, feedback module, action module, mobile APP client and other units. It can identify the step width and pace to the STM32 data, through the gait and stability analysis, real-time adjustment of transmission device to drive the bone mechanical body, help the old man and the security of the disabled to walk. The system could be used for different operating modes of the pressure, acceleration, the heart rate and other non electrical parameter detection and processing.

Keywords: Robot; Walking-assisted; Sensor network; Coordinated control.

1. Introduction
The detection and control model of the system is improved from the traditional single sensor detection method to the multi-sensor detection method. Non-contact sensor is adopted to reduce the detection and feedback time. It has a strong adaptability to the environment, and the use effect is very prominent in the situation of human walking and sports. Meanwhile, the mode switch is easy to operate and the system is simple and convenient, especially suitable for amateurs[1]. The system in the existing basis can also extend the function based on the user's needs. For example, a Bluetooth module can be used to upload and store user’s information. Using the Internet of Things technology, through the exchanging and processing of information, it can also achieve a full range of intelligent identification, location, monitoring and management. So that it can monitor the health of the elderly and children, and treat them timely, which brings broad application prospects[2].

2. The Overall Design of System
2.1. System Composition and Working Principle
Due to the limited hardware resources involved in this design, the closed-loop control gait robot is taken as an example. Gait simulation bionic robot is composed of STM32 controller, sensor detection and feedback module, action execution module, mobile phone APP client and so on. The system can detect and process many non-electrical parameters, such as pressure, acceleration, heart rate and so on under different operation modes[3]. The data of APP image scanning fitting and walking speed of mobile phone can be transmitted to STM32, STM32 and then the gait and stability analysis can be analyzed through sensor feedback network, and the transmission device can be adjusted in real time to drive bionic mechanical limbs and help the elderly and the disabled to walk safely.
diagram of the system is shown in Fig. 1.

![System block diagram]

Figure 1. System block diagram.

2.2. Basic Requirements of Control

1) Control requirements of gait walking:
   a. When the plantar pressure sensor detects the presence of pressure everywhere on both feet, it will keep standing without walking instructions.
   b. To execute walking instructions when the paw pressure test of one foot approaches 0.
   c. When the MPU6050 module detects that the bending degree of the leg reaches the maximum threshold, it controls the reverse rotation of the steering gear.
   d. Heart rate module detects heart rate data through Bluetooth transmission, but only by mobile phone APP, and it can be viewed in real time on the mobile phone.

2) Design requirements of APP interface:
   a. Video button is for being responsible for calling system camera for recording.
   b. Picture display component is to display the last shot of the picture.
   c. Heart rate display module can be used to observe heart rate in real time.

3. The Design of System Hardware

The STM32 MCU, mobile phone camera module, pressure sensors, acceleration sensors, yuntai motor system module instrument selection and circuit connection. And the choice of sensor placement, and the design of the emergency stop button[4-5].

3.1. Brief Introduction and Debugging Method of MPU6050

The MPU6050 is the world's first all-of-the-six-axis motion processing assembly, a three-axis gyroscope and a three-axis acceleration sensor, introduced by the InvenSense, and contains an IIC interface for connecting external magnetic sensors, which can be used to a digital motion processor (DMP: Digital Motion Processor) hardware acceleration engine, by the main IIC interface, the complete nine-axis attitude fusion algorithm can be output to the application end.

With DMP, we can use the motion processing database provided by InvenSense company to realize attitude calculation very conveniently, which can reduce the load of motion processing operation on operating system, and greatly reduces the difficulty of development at the same time.

As shown in Fig. 2, the MPU6050 module is used in this design. Through the joint call of four MPU6050 modules, the inclination angle at the corresponding joint is collected to accurately calculate the steering
gear rotation angle. Fig. 3 shows the location of the MPU6050 module.

**Figure 2.** MPU6050 module. **Figure 3.** Location of MPU6050 module.

### 4. The Design of System Software

Points multi-sensor real-time feedback regulation pattern overall architecture design, the sensor information processing and program design produce different control signals[6]. At the same time, in this system, preliminary design of a new repeatable wipe the gait data: walking cameras recorded video calling through the App, the acquisition of image scanning analysis, can the gait information entry, operation, the range of sensors and other parameters setting and adjustment, has realized the facilitation, intelligent gait simulation system, at the same time also more complete specific to the adjustment of the whole system. The control flow of the system is shown in Fig. 4.

### 5. Experiments and Results

The prototype is shown in Fig. 5. After on-line debugging, the system can realize the predetermined function and meet the requirements of the original design. However, because the steering gear has less power, it can only be used as a demonstration, which is as shown in Fig. 6, it's as a parameter chart obtained by a walking cycle sensor. Table I is a set of sampling data when walking, which verifies the feasibility and correctness of the design scheme of the system, and provides technical support and reference for further expansion of the function of the system.

![Control Flow Diagram](image)

**Figure 4.** The control flow of the system. **Figure 5.** The prototype.

![Prototype Image](image)
Figure 6. Changes of pressure for one travel cycle and acquisition data status of MPU6050.

Table 1. A set of sampling data when walking.

| A walking cycle | 6 points' voltage value (V) | When not in contact | Front foot contact | Contact of arch part | Full foot contact | The heel began to leave the ground | Foot bow is off the ground | The forefoot is off the ground |
|-----------------|-----------------------------|---------------------|-------------------|--------------------|-----------------|---------------------------------|---------------------------|-------------------------------|
| 6 points' voltage value (V) | | | | | | |
| Left 1          | 1.00466                     | 3.14128             | 3.27985           | 3.29919           | 3.29516         | 3.29919                        | 1.08281                   |                               |
| Left 2          | 0.96679                     | 2.08505             | 3.05830           | 3.29677           | 3.29113         | 1.69271                        | 0.96679                   |                               |
| Left 3          | 1.04816                     | 1.04978             | 1.08281           | 3.29597           | 1.05783         | 1.14484                        | 1.02158                   |                               |
| Right 1         | 3.29436                     | 3.29838             | 3.29919           | 1.03125           | 3.29838         | 3.29516                        | 3.29919                   | 1.02158                       |
| Right 2         | 3.29919                     | 3.29919             | 1.04414           | 1.12873           | 1.67658         | 3.29758                        | 3.29436                   |                               |
| Right 3         | 3.27663                     | 1.12631             | 1.11826           | 1.07153           | 1.21494         | 1.12631                        | 3.29838                   |                               |

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