Research Article

Research on the Design of Bright Clothing for the Elderly Based on Intelligent Detection of Lower Limb Posture Antifall Sensors

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In this paper, we construct a model for intelligent detection of lower limb posture fall prevention sensors, conduct an in-depth study of bright clothing for the elderly with smart detection of fall prevention, and design an article of colorful clothing for the elderly based on intelligent detection of lower limb posture fall prevention sensors. In this paper, the overall system scheme is determined according to the application, including the characteristic position of the device to be worn, the establishment of the reference coordinate system, and the setting of the overall system architecture. The data acquisition, transmission, and saving functions are realized, and the two-step extended Kalman filter, complementary filter, and DMP-Kalman filter are used to solve the posture angle of the measured object. The feasibility of the prototype was verified by testing the daily behavioral activity data and fall behavior data of the elderly, and the collected data were processed and analyzed by three data fusion algorithms, which proved the effectiveness of the algorithms, among which the DMP-Kalman filter algorithm has better performance. From the test results, the design of this paper can detect the posture angle of the human body more accurately, which provides a practical reference for fall detection equipment. Using clothing as a carrier, the fall detection and warning module is integrated with clothing to study an article of intelligent clothing for fall detection and warning for the elderly. A core issue in the integration process is the influence of the clothing on the detection module when the human body is moving. The effect of the material and loft of the clothing on the model is studied through experiments. The results of the two indexes, i.e., sensitivity and specificity, of the integrated model and the model not integrated with the clothing are around 98%. The experimental results of the material and loft of the clothing within a specific range have little influence on the model. The final intelligent garment design scheme was determined on this basis.

1. Introduction

In the context of an increasingly aging population and a growing number of people with lower limb disabilities, the general nursing staff is no longer sufficient to meet the population’s needs. In addition, there is already a severe shortage of caregivers, and nearly half of the elderly and disabled are currently unable to receive medical assistance [1]. With the rise of artificial intelligence technology, new robots have emerged in many industries, which not only effectively alleviate the shortage of professional caregivers but also improve the ability of elderly and disabled people to live independently [2]. At present, the research on fall detection and prevention technology of walking robots is relatively small, and the technology is not mature enough; the walking robots cannot accurately and quickly identify the user’s fall status and give protection measures, so it is necessary to improve the ability to walk aids to detect and prevent falls, which not only brings excellent security to the life of the elderly and disabled patients but also reduces a lot of burden for families and society [3]. This is not only a great safety guarantee for the elderly and disabled patients but also a significant burden for families and the community. Five parts are realized by studying the human posture recognition subsystem requirements: data reception, data processing, network training, action recognition, and database establishment, and the visual program interface is built using Python language [4]. The data is received through the wireless serial module of the host computer and saved as CSV data files; the data is processed by noise reduction and

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The training network model is held, and the parsed, and the input data is used to recognize the action. The training network model is held, and the efforts are recognized by parsing the saved network model and inputting the target data.

Wearable sensor-based human posture recognition is an emerging field with an increasingly wide range of applications. For example, medical health, our country has accelerated the aging, and for the elderly, health care is critical. If not rescued in time, a typical fall may bring incalculable consequences to the elderly [5]. Caring for the health of the elderly reflects the level of development and civilization of the country. Daily monitoring of the elderly, abnormal behavior (such as falls, fainting), alarm, etc., are current research hot issues, and these are inseparable from human posture recognition. In terms of smart home, smart home has the advantages of safety, speed, humanization, and personalization, which makes people feel the comfort and convenience brought by various modern technologies to the environment, which accelerates the intelligence of the society as well as the city [6]. In the coming decades, home intelligence is bound to grow by leaps and bounds, an inevitable choice for people seeking a higher standard of living. As one of the key technical points, wearable human behavior recognition technology is of great research value [7]. Clothing is the largest transaction object of e-commerce, so the demand for virtual fitting and clothing display is also getting stronger. At the same time, there is also an urgent demand for digital preservation, virtual collection, and trying of the gradually disappearing fine national costumes [8]. To achieve a better virtual fitting and display effect, human posture recognition is one of the critical technologies. In addition, people are not satisfied with only warm and beautiful clothes. Therefore, the development of various functional clothes is also a hot topic for clothing design and production enterprises, such as sports monitoring, anti-theft and robbery, emotional monitoring, positioning and so on. In the design and development of available clothing, adding some relevant sensors for target data collection and monitoring is the critical link [9]. In the new textile materials research and development, there has been a combination of new textile materials and wearable human posture recognition research; from power consumption, node layout, and other considerations, human posture recognition, the new functional textile materials research and development have played a supporting role.

Facing the social problem of an aging population, many countries and regions have taken the elderly users as the target population, and related design theories have been proposed from the perspective of the innovative design of products and services, including designing for accessibility, universal design, and inclusive design. With the development of different design concepts centered on elderly users, the idea of inclusive design is evolving in the world's aging process, and its theoretical contents are widely spread due to social trends [10]. The theory of inclusive design is based on the development and continuation of barrier-free and universal design and was first proposed in European countries [11]. The practical application of its theory allows products to consider the needs of various users as much as possible in the design process, expand the range of users, balance the needs and interests between users, designers, and suppliers, and treat each level of user groups relatively [12]. Therefore, in the aging society, the concept of inclusive design is of great value in meeting the user needs of groups such as the elderly and promoting the development of social equity. With the rise of mobile medical care, the development of new technologies, such as intelligent sensing, and the popularity of personalized health concepts and wearable products have rapidly occupied the market, among which wearable products related to health care have become one of the most promising fields. With their wearability and intelligence, medical wearable products can monitor human body data, record and process a large amount of information, and upload the data to the cloud to predict users’ health and increase their awareness of self-health management's positive significance in reducing morbidity [13]. Medical wearable products can help the elderly monitor their health, predict diseases, assist in treatment and rehabilitation, help children understand the various functions of their parents’ bodies, improve the quality of life of the elderly, and bring convenience to their lives.

### 2. Related Works

Nowadays, with the rapid development of technology, especially the mobile Internet, people’s communication methods are also changing rapidly, and various intelligent interaction methods are changing people’s daily lifestyles at any time. Intelligent interaction involves vision, network, sensing technology, and other information technology, which can improve people’s perception of immersion, give people a novel way of interaction experience, and make the interaction more smooth, natural, and humanized. Human posture recognition is the basis of intelligent interaction and is a crucial technology to improve interaction experience and intellectual fashion life [14]. Human pose recognition is a hot topic in pattern recognition and has many applications. The research in human posture recognition also follows the international frontier and has achieved specific results in the study and its industrialization part in the field of human posture recognition [15]. The human behavior recognition technology based on visual images started earlier, the theory is relatively mature, and its correct rate is high, such as the human behavior recognition system researched and developed on DHN database, the recognition rate is 90-95%. The accuracy rate of human posture recognition based on Kinect video is not very satisfactory; the Kinect-based video is only limited to the field of view that the Kinect camera can capture [16]. In the research human posture recognition field, for example, a better set of motion capture devices is based on optical sensors for human behavior recognition; such optical sensor-based devices are one of the most significant limitations of the impact of ambient light.
Fall detection technologies have been more widely studied in elderly fall protection. At present, fall detection technologies are divided into three categories: video-based fall monitoring technologies, audio-based fall monitoring technologies, and fall detection technologies based on wearable devices [17]. People install cameras in the activity area of the elderly and use coarse elliptical models and particle filters to process the collected human images to determine the occurrence of abnormal behavior. Saco-Mera and Hernández-Patiño proposed an improved detection algorithm combining human body aspect ratio, effective area, and center change rate to optimize video-based fall detection technology, which can determine a fall when the above three conditions are met and within a specific time, effectively reducing the false judgment rate [18]. The wearable fall detection technology can be carried around, and the algorithm can determine whether the human body has fallen by real-time monitoring the human movement status. A device that can be placed on the chest, the device consists of a combination of acceleration sensors, tilt sensors, and gyroscopes, and the change in acceleration, the difference in the coordinates of human activity, and the change in the angle of the tilt of the chest to determine the positive fall, if the tip of the chest changes by 70°, then it can be considered a positive fall. Using acceleration sensor, pressure sensor, and magnetic sensor combination type fall detection system, to acceleration, pressure, tilt angle change whether to reach the threshold value to judge the fall, if considered as a fall can be sent through the Bluetooth timely GPS, shorten the rescue time, experience, the system has a certain degree of effectiveness.

3. Smart Clothing Model Design for the Elderly Based on Intelligent Detection of Lower Limb Posture Antifall Sensors

3.1. Intelligent Detection Model Construction for Lower Limb Posture Fall Prevention Sensor. The human posture data acquisition is mainly divided into two parts, one is the hardware part, which is responsible for collecting the human posture data and transmitting it to the PC via Wi-Fi module, and the other is the software part, which receives and stores the human posture data collected by the hardware part and performs data calculation via the PC-based host computer. The system framework diagram of the human posture data acquisition device is shown in Figure 1. The MEMS sensor made by microelectronics and micromechanics processing technology is a miniature electromechanical system. In athletes’ daily training, MEMS sensors can be used to perform 3D human motion measurements, record each movement, and coaches analyze the results and compare them repeatedly to improve the athletes’ performance. With the further development of MEMS technology, the Price of MEMS sensors will also be reduced, which can be widely used in mass gyms. Compared with the traditional sensors, they are small, lightweight, and easy to carry, and their low cost is more suitable for mass production. Considering that real-time detection requires data transmission to a computer for calculation, if wired communication is used, it will not only make the whole device redundant and confusing but also will affect human activities and significantly limit the range of human activities and the magnitude of activities, so to avoid many drawbacks, we use a wireless module for data transmission [23]. The role of the wireless module is to
replace the serial connection wire between two devices to achieve wireless data transmission. For example, the two microcontrollers connected to the module, respectively, if the serial port transceiver operation can be done, the microcontroller does not have to control the module; this is very convenient for the reality of wireless communication. Modules are generally used in pairs to transmit data in a half-duplex manner; the baud rate and communication channel pairs of the two modules must be the same.

The raw motion data collected by MEMS sensors will inevitably have noise due to environmental factors and manufacturing processes, which will impact the pattern recognition of posture and often require noise suppression. The signal of the filter is very smooth in the passband and slowly decreases in the stopband until it is reduced to 0. The frequency of human motion is relatively low, generally not more than 20 Hz, and varies significantly from 0 to 5 Hz, and the sensor is easily affected by environmental noise and high-frequency interference during the detection process; to eliminate this noise effect through the low-frequency signal and attenuate or suppress the high-frequency signal, it has the maximum flat amplitude response curve in the passband, which has been widely used in the field of communication, and also has a wide range of uses in electrical measurement, which can be used to detect the signal. Butterworth’s low-pass filter design process is as follows:

1. To achieve the transformation of digital filters to analog filters, the essence lies in the conversion of technical indicators \([a]\) into \([w]\); the transformation method is roughly impulse response invariant method and \(z\)-transformation method; the transformation is

\[
a = \sum_{i=1}^{\infty} \tan \left( \frac{w}{2} - \frac{2}{T_s} \right). \tag{1}
\]

In the impulse response invariant method, the system’s transfer function can be transformed into a transfer function by sampling the unit shock response \(g(t)\), and the sampling process is

\[
h_{t-s} \approx \sum (t + nT_s) \times g(t) \times \sqrt{nT_s} - \sigma g(t). \tag{2}
\]

This method can achieve a stable transformation of the transfer function to the system’s transfer function. Still, with a small number of samples, overlap may occur in the frequency domain and produce a distortion condition. This situation does not happen in the \(z\)-transform, and the relationship for the \(z\)-transform mapping is
\[ s = \sum \left[ \left( \frac{z + 1}{z - 1} \times \frac{T}{2} \right) \times \left( \tan \frac{w + T}{2} \right) \right] \]. \quad (3)

The mapping relationship between the frequency \( a \) of the analog filter and the frequency \( w \) of the digital filter in Equation (3) is nonlinear. When \( w \) goes from 0 to \( \pi \), \( Q \) changes from 0 to \( +\infty \); when \( w \) goes from 0 to \( -\pi \), a change from 0 to \( -\infty \). Since \( a \) is proportional to the tangent trigonometric function \( \tan(2w) \), the axis is mapped to the unit circle using linearity. So, on the premise of giving a series of technical indicators \( w_p, w_i, a_p, \) and \( a_i \) of the digital filter, Equation (2) can be translated into the technical hands of the analog filter as

\[ a_p = \sum \left[ \tan \left( \frac{w_p}{w_i} \right) + \tan \left( \frac{2}{w_i} \right) \right]. \quad (4)\]

Following the technical specifications obtained in Equation (4) designed by the Butterworth filter model

\[ G_j = \sum \left( C^2 - a^2 \right)^n + (C^2 - 1), \quad (5)\]

\[ N = \sum_{p=1} \log \left( \left( a' - 10^p \right) + \log \frac{a}{a_p} \right). \quad (6)\]

\[ G(s) = \sum \frac{(p - 2n) \times j}{(p + j)^{2n} - 1}. \quad (7)\]

We have made an exoskeleton with a simple structure, adjustable in length and bendable and twistable in the joint part of the lower extremity, equipped with a sensor part, a mechanical design worn on the lower human extremity. The research on the lower limb exoskeleton is very early and has received much attention from various aspects. Due to its evident and prominent role in the field of rehabilitation, people who are more and more concerned about the quality of life have developed rapidly. The advantage of an external structure that provides confirmation, support, and protection to all parts of the human body is that it is an aggregate that combines both support and protection functions [24]. In addition, the most popular and researched technology worldwide is the combination of lower limb exoskeleton technology and rehabilitation training, using appropriate control methods to control the exoskeleton part so that the mechanical structure worn on the patient’s body can drive the patient to carry out the corresponding rehabilitation movement, and finally achieve the purpose of restoring the patient’s ability to move. According to the needs of our research, our lower limb exoskeleton part adopts a retractable slide structure made of white steel material, which can be retracted mainly to consider the wearing needs of people with different body sizes so that the wearer can adjust the suitable length according to other people, and make the wearer move freely. The whole structure is divided into two sections, carrying two composite sensors for the thigh section and two composite sensors for the calf section. To meet the needs of human activities, the degree of freedom at the connected joints is relatively high, generally to meet the five degrees of freedom. The human lower limb has three movable joints: hip, knee, and ankle; the movement of the lower limb mainly includes: (1) giant forward swing of the thigh, small backward swing, and lateral swing; (2) bending and slight twisting of the knee joint; (3) twisting of the foot around the ankle joint in the horizontal plane and twisting of the foot around the ankle joint in the vertical plane.

3.2. Model Design of Bright Clothing for the Elderly with Fall Prevention and Intelligent Detection. The working principle of the fall prevention device is to detect the motion signal of the human body through the acceleration sensor, use the posture recognition algorithm to determine the current motion posture of the human body quickly, and determine if the risk of falling timely open the protective airbag, thus playing a role in reducing the fall injury of the elderly [25]. Therefore, the fall injury prevention device has high requirements on the posture recognition algorithm’s real-time accuracy. At the same time, the design of the antifall device should be small, lightweight, and easy to wear the design principle, to minimize the impact on the user’s life; its hardware design mainly consists of the main control chip, power chip, motion sensor, airbag, and Bluetooth serial module. The power supply chip provides the power supply for the device; the motion sensor converts the user’s motion parameters into electrical signals and transmits them to the central control chip; the main control chip collects and processes the motion sensor signals in real-time and determines whether the user is in the process of falling if so, it issues a warning signal and triggers the airbag; the airbag component inflates in time when it gets the trigger signal to protect the user’s safety; the Bluetooth serial module is used in the experimental research stage to transfer the airbag to the user. The function of the Bluetooth serial module in the empirical research stage is to upload data to the computer. In the standard configuration of the product, the Bluetooth serial module function is to realize the data communication between the antidrop device and the cell phone APP or computer software, which can use the cell phone to send a distress signal or learn the online firmware update. The overall structure of the fall injury prevention device is shown in Figure 2.

The development of bright clothing is based on functional clothing, which integrates wearable technology into clothing to form its characteristics; such characteristics refer to its ability to store, transmit, and transform signals. The realization of this ability needs to rely on a combination of innovative material research and development, intelligent design innovation, manufacturing improvement, and other technological levels to complete the design process's complexity. Although the design of intelligent clothing can refer to the design method of functional clothing, it also needs to consider its brilliant effect and the difficulty of making the clothing comfortable when electronic components and other devices are combined with the dress, so it is essential to propose and improve the design framework of bright clothing. By establishing the intelligent clothing design framework system, taking it as a guide, with the help of scientific research and development power, investment
The design framework of smart clothing is proposed concerning the development and design model of protective clothing. The design framework of intelligent clothing is shown in Figure 3.

The design of intelligent clothing can be divided into the following: (1) to obtain the perception of the external environment of the human body, the need for their state, and the development of new functions and to determine the intelligent needs of clothing. After the emergence of functional clothing with protective effects in unique environments, people also hope that clothing can respond to changes in the external environment or internal state to maximize the value of clothing, and clothing that incorporates a flexible fabric sensor for life protection and monitoring, through the collection and analysis of various parameters of the human body's state, to discover potential possible damage and provide early warning, so that the user's health is protected. Thus, by simulating the human life system, we can know the perceived needs of the human body's external environment and its state and analyze similar products in the market, as well as conduct research and investigation on users, identify and understand the target users, conduct a multifaceted assessment from user perception, product experience, and product acceptance, and find the users' physiological needs for clothing in terms of comfort and functionality, aesthetics, product value, and price, as well as their psychological needs for clothing use. Price and other psychological conditions as well as user habits and use of the environment to user-driven needs, you can develop new functions, determine the intelligent needs of clothing, and prepare for the realization of clothing intelligence. (2) The realization of clothing's perception, feedback, and response function. Without affecting the aesthetics and comfort of clothing based on its means of realization are mainly the following two major types of methods: the first type is the use of smart clothing materials; when the external environment changes or stimulated, fiber length, shape, color, temperature, and other corresponding changes, including shape memory materials, phase change materials, etc. The second type is the module embedded or flexible into the clothing people wear daily to adapt to the characteristics of the clothing itself [26]. And make the corresponding feedback, the organic integration into the clothing, the use of sensors to sense human physiological information, and through the feedback, a mechanism to transmit information to the intelligent module, to master the human body's various body condition indicators, and even according to the feedback to the information on its analysis. The human body takes corresponding improvement measures to achieve the intelligent effect of clothing. (3) Combined with clothing...
design, the intelligent module, and clothing organic combination to complete the intelligent clothing design. This part mainly considers how to combine the intelligent module with the garment. The use of innovative clothing materials to achieve the organic combination of intelligent textiles and clothing are especially two methods: one is to weave intelligent fibers into ordinary fibers or interweave with standard threads, and the other is to compound the material or make it modified through the method of dyeing and finishing processing. There are also two methods to organically combine modules with clothing: one is modularization technology, which embeds electronic components into clothing textiles as accessories of clothing; Second, based on the new fiber flexibility technology, the required electronic components and equipment, sensors and textiles are combined to maintain the original softness and comfort of clothing.

4. Analysis of Results

4.1. Analysis of Intelligent Detection Model of Lower Limb Posture Antifall Sensor. Falls are common in older adults, but it is challenging to define them strictly. Therefore, falls are usually compared with people’s daily behavioral activities. The hardware can obtain accurate posture data, and the algorithm can correctly solve the posture angle is crucial to the system design. This chapter presents the basis for determining falls by analyzing the difference between human fall behavior and other everyday behaviors. The regular and orderly operation of the hardware provides essential services for the software and algorithms, so the functional testing of the hardware is a crucial part of the process. Whether the relevant performance of the hardware circuit has imperceptible problems and errors and whether it meets the expected standards also has a guiding reference for the subsequent improvement of the circuit design. Hardware-related functional tests mainly include power supply, sensor performance, Bluetooth, and other available tests. During the hardware circuit testing, several ground sets in the circuit (such as digital ground, analog ground, and power ground) should first be tested before power is applied to see if they are connected. And check whether there are apparent PCB soldering and soldering problems to confirm that there are no errors before authority on the circuit power supply to determine. The power supply is a prerequisite for the hardware circuit to work. Whether the power supply is stable and the ripple is within an acceptable range is particularly critical to the circuit operation’s stability and determines whether the circuit can work effectively in the long term.

It is especially critical that the sensor reads the raw data related to attitude correctly and that the DMP function works properly. Reading the device address of 1 × 71 for the sensor MP9250 and 1 × 48 for the magnetometer indicates the correct device. After initialization of the DMP, the FIFO sampling rate is set, the DMP firmware is loaded and enabled, and if the DMP memory can be read and written correctly, the DMP is helped successfully. When the sensor is at rest, the measured acceleration in the z-axis should be $g$ (the value is about 9.8 m/s); the actual measurement results are the raw data measured by the sensor and the results of the conversion from 16-bit data to decimal data: the data measured by the gyroscope may have a significant error in the axial direction due to installation errors, etc. The measured angular velocity at rest and the comparison of its correction results are shown in Figure 4.

The calibration process of the magnetometer is as follows: the sensor is continuously changed at each position, enough data are collected, and the measured data in the three axes are derived from the deviation values, which are calibrated and plotted for comparison. The diagram of the calibrated magnetometer is shown in Figure 5. The design uses a Bluetooth-enabled controller to control the circuit and the sensor’s data transmission. A Barron filter with a ceramic antenna is used to match the 50Ω impedance of the CC2541 to send and receive data in the 2.4 GHz band range. Use USB dongle and packet sniffer software to make the board broadcast data for wireless packet capture to achieve the board’s Bluetooth function part of the test; to view the board’s Bluetooth performance, if the board and
the phone’s communication function problems, this method can be located on the issue. Complete the hardware connection, open the packet sniffer software and click on send and receive, keep the board in the broadcast state, and open the cell phone board for BLE connection; packet sniffer can capture the BLE slave broadcast packets, BLE slave broadcast three channels (respectively, 37 (2402 MHz), 38 (2426 MHz), and 39 (2480 MHz)). The packed boxes are 6517, 6787, and 6164; the number of error packets is 9, 15, and 14, and the false alarm rate is 0.14%, 0.22%, and 0.23%, respectively; the wireless transmission effect is good. In addition, the effective transmission distance of Bluetooth was tested, and the connection and data could be sent within 5 m with a low false alarm rate in the absence of obstacles.

The preprocessing data method in the construction of the fall detection model is the same for the 90 normal and 1000 abnormal gait behavioral data collected. The 3-axis acceleration and 3-axis angular velocity data are processed to obtain their corresponding vector and amplitude sums. The different gait characteristics cause this difference during walking, which is different from the trend of continuous movement in a single direction. It is different from the trend of constant movement in a single order. Still, the alternating fluctuations of the seasonal changes are relatively fixed, with most of the regular cycle changes within 3 seconds, and the cycle length of each gait varies [27]. The cycle is fixed because people will have gait habits when walking, but the gait in each process will have different degrees of slight changes. Normal and five different abnormal gaits exist with varying degrees of variation in gait cycle motion due to the reduction of human locomotor ability caused by disease, making the difference between odd and normal gait when walking. The critical issue of the fall warning system research is to distinguish normal and abnormal gait effectively, and at a later stage, if necessary, to achieve the classification of abnormal gait, so it is feasible to analyze and discriminate the human gait by using intelligent sensor detection to establish a fall warning model.

4.2 Research on the Design and Implementation of Intelligent Clothing for the Elderly Based on Intelligent Detection of Lower Limb Posture Antifall Sensors. In this paper, the Mann–Whitney U test was used to test whether there was a significant difference in the maximum impact force when cushioning fabric was added to the hip and knee; the data were analyzed and processed by SPSS software. The final result was $P = 0.1 > 0.05$, which did not have a significant difference, indicating that the force attenuation of the cushioning fabric for a specific range of forces on the knee and hip during the fall. The ability of the cushioning fabric is not affected by the different protection parts [28]. When there is no protective material (without considering the acceleration direction), the maximum acceleration value when the human body falls sideways is much larger than the maximum acceleration value when the human body falls forward. According to Newton’s second law, the full impact force on the hip is currently more significant than the leading force on the knee. Regression analysis was used to test the correlation between the hip and knee under different size fabric conditions and the maximum impact force on the critical parts of the human body; for the hip position, $P = 0.46$, which is significant; for the knee position, $P = 0.097 > 0.05$ is not substantial. The maximum impact forces under different conditions at the hip and knee are shown in Figure 6.

For hip protection, the maximum impact force when padded with three-dimensional knitted fabric is smaller than the total impact force when there is no cushioning material, which means that the three-dimensional knitted fabric has a specific cushioning effect (Figure 7). In summary, when the size of hip protection material is $24*10*7$ (cm), the maximum impact force is the smallest, and the protective effect...
is better; when the knee protection material is $17*8*12$ (cm), the full impact force is the smallest.

After integrating the fall detection and warning module with the clothing, the model’s results can be obtained; the sensitivity and specificity of the two indicators and the model’s results before integration are above and below $98\%$. It can be concluded that the clothing material and looseness within a specific range have little effect on the sensitivity and specificity of the two indicators and the model’s results before integration are above and below $98\%$. It can be concluded that the clothing material and looseness within a specific range have little effect on the

Figure 5: Calibrated magnetometer diagram.

Figure 6: Maximum impact force at the hip and knee under different conditions.
model. On the one hand, it is because the jitter generated by the garment during human movement is within a particular field, and the impact of jitter on the model within the range is negligible; on the other hand, it is because the sensor adopts digital filtering technology to reduce the effects of external noise on the data effectively, plus the model synthesizes the 3D acceleration and 3D angular velocity into a one-dimensional metric during data processing, so that the jitter
generated by the garment can be reduced during data acquisition and processing. Jitter is filtered out during data acquisition and processing, resulting in a negligible impact on the model caused by the relative motion existing between the module and the human waste after good integration with the garment, so it can be concluded that within a specific range of different thicknesses of clothing fabrics and different loose-weight clothing styles have almost no impact on the model. The above results designed device and algorithm recognition model can discriminate the human fall posture in real-time and has a good detection effect, which confirms that the support vector machine-based human posture recognition model has certain practicality. The results of the fall-proof intelligent detection clothing recognition are shown in Figure 8.

5. Conclusion

Older people belong to a high incidence of falls, and some falls can cause serious injuries or even death, which affects the physical and mental health of older people and, at the same time, brings a heavy burden to families and society and falls of older people have become an issue of social importance. Human posture recognition technology has been applied in many fields, and the requirements for the correct rate of human posture recognition in various areas are getting higher and higher. Therefore, to facilitate the study of human posture recognition, this topic designs and implements a human posture recognition system based on wearable sensors, proposes intelligent sensor detection for human posture recognition and achieves an excellent correct rate. This paper uses the quaternion method to update the posture information of the human body. It uses three algorithms of two-step extended Kalman filtering, complementary filtering, and DMP combined with Kalman filtering to compensate for the posture information of acceleration and magnetic field strength measured by the sensor for the angular velocity posture information and solves to derive the posture angle of the measured object and then proposes the basis of fall determination, the designed fall detection system is tested. The feasibility of the prototype is verified by testing the daily behavioral activity data and fall behavior data of the elderly, and the algorithm’s effectiveness is demonstrated by processing and analyzing the collected data with three data fusion algorithms. This paper studies an intelligent garment for fall detection and early warning of the elderly by integrating the fall detection and early warning module with the garment as a carrier. The experimental scheme investigates the influence of the garment material and the loft on the model. The sensitivity and specificity of the two indicators of the integrated model are around 98% of those of the model before integration with the garment. The final design of the smart garment is based on the final model before integration. In this paper, although the two models were established separately through many experiments, and the experiments verified the feasibility of the models, there are still problems of individual variability. The number of samples is not abundant, and as many subjects as possible should be found to conduct the experiments several times when the conditions allow for improving the accuracy of the models. Meanwhile, the fall detection method with high recognition accuracy should be explored in depth in subsequent research. In studying adaptive impedance control fall prevention systems, this paper only discusses the highest incidence of forwarding fall, which is not comprehensive enough to consider.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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