Research Article

Daily Physical Activity of College Students Based on Embedded Accelerometer

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With the development of microelectronics and sensor technology, sensors can be widely integrated into mobile phones and mobile devices, and the use of accelerator sensors to monitor human movement has a wide range of application prospects. The human body's behavior in daily activities is closely related to the individual's physical and mental health. Therefore, scientifically preparing and monitoring the daily exercise of the human body is very important for fitness planning and improving physical health. This article introduces an embedded acceleration sensor to investigate the daily physical activities of college students.

The article lists several accelerometers commonly used to detect human physical activity, confirms the basic status of the human body motion database, and obtains the database construction process. This article selects 100 students from a certain city who participate in resources and use acceleration sensors to detect their daily physical activities for a week. The test result is that among the students surveyed, the wearing time of computer students is 5228.1 minutes for boys and 5557.3 minutes for girls; sports health science students wear 5028.9 minutes for boys and 4878.3 minutes for girls; police school students wear 6598.7 minutes for boys and 6524.1 minutes for girls.

1. Introduction

Due to social changes, insufficient physical activity and constant unhealthy behaviors have become the norm in people's lives. Monitoring daily exercise can help people establish healthy and intelligent eating habits, intelligently manage daily exercise volume, and improve people's healthy living standards. There are many daily activities of the human body: running, walking, climbing, falling, sitting, standing, etc. The relationship between energy consumption and these different daily exercises is also different, so it is important to monitor and identify these daily exercises.

The acceleration signal is the real speed signal produced by the body movement in the daily life of the human body. By effectively processing this signal, the way the human body moves can be determined. There is a significant negative correlation between physical activity and disease mortality and many chronic noncommunicable diseases. Exercise can improve people's overall health by improving health, preventing disease, improving disease treatment effects, and increasing physical exercise.

The innovation of this article is the introduction of embedded accelerometer technology. It first analyzes commonly used acceleration sensors and discusses where people most often place acceleration sensors. It makes statistics on the correct recognition rate, and false alarm rate of the three actions to detect the usage of the acceleration sensor. Finally, a 7-day daily physical exercise survey was conducted for the college students participating in the study.

2. Related Work

Regarding the sensor, related scientists have done the following research. Castell et al. performed a detailed evaluation of 24 identical units of a commercial low-cost sensor platform against a reference analyzer. They evaluated their ability to measure changes over time and a range of environmental conditions. The results show that their performance is
different in space and time. Because it depends on atmospheric composition and meteorological conditions, performance varies from unit to unit. This makes it necessary to check the data quality of each node before use. Castell et al. implemented and tested a variety of indicators to evaluate whether the sensor can be used for high accuracy or lower accuracy [1]. Dong et al. proposed a collaborative UAV navigation algorithm that allows the main aircraft (equipped with inertial and vision sensors, GPS receivers, and vision systems) to improve its navigation performance (in real-time or in postprocessing stages), using line-of-sight measurements of a formation flying aircraft accompanied by a GPS receiver. The key concept is to integrate differential GPS and visual tracking information in an extended Kalman filter-based sensor fusion algorithm. The analysis shows the potential of the developed method, mainly stemming from the possibility to exploit precise magnetic and inertial independent information [2]. Zhang et al. considered orthogonal frequency division multiple access, two-way relay wireless sensor network security resource allocation. The joint problem of subcarrier allocation, SC pairing, and power allocation is formulated with and without cooperative interference. It maximizes the confidentiality and rate SC allocation policy under the limited power budget of the relay station and orthogonality. The optimization problem is shown as mixed integer programming and nonconvex. For scenes without cooperative interference, Zhang et al. proposed an asymptotically optimal algorithm based on the dual decomposition method and a suboptimal algorithm with lower complexity. Finally, they evaluate the proposed scheme through simulation and compare it with the existing scheme [3]. Chen et al. outlined the recent investigation. Among them, vision and inertial sensors are used at the same time to perform human action recognition more effectively. The focus of their investigation is the use of visual sensors and inertial sensors. Because these two types of sensors are cost-effective and commercially available, more importantly, they both provide 3D human motion data. They outlined the components needed to achieve data fusion of vision and inertial sensors. In addition, they also introduced publicly available data sets, including visual and inertial data captured simultaneously by vision and inertial sensors [4]. Deng et al. have developed an easy-to-handle framework. They aimed at random geometry and used the potential advantages of physical layer security in a three-layer wireless sensor network. In such a network, sensory data from remote sensors is collected by receivers with the help of access points, and external eavesdroppers intercept the data transmission. Deng et al. also derived a new compact expression for the overall average security rate. The numerical results confirmed their analysis and showed that multiple antennas at the access point can enhance the security of the three-layer WSN. The results show that increasing the number of access points will reduce the average security rate between the access point and its associated receiver [5]. Hu et al. discussed the important issue of the balance between target detection quality and lifetime in wireless sensor networks and proposed two target monitoring schemes. One solution is to use sensing frequency for target detection. It allocates the sensing time that is currently only part of the sensing period to the entire sensing period. Another solution is target detection with adjustable sensing frequency. It adjusts the sensing frequency on those nodes with remaining energy. The simulation results show that the second scheme can increase the network life by more than 17.4%, and the weighted detection delay can be reduced by more than 101.6% [6]. Fei et al. provide tutorials and surveys of the latest research and development work using multiobjective optimization techniques to resolve conflicts between wireless sensor networks. They outlined the main optimization goals used in wireless sensor networks and elaborated on various popular methods envisioned for multiobjective optimization techniques, for example, the series of scalarization methods based on mathematical programming, the series of optimization algorithms based on heuristic/meta-heuristics, and various other advanced optimization techniques. They summarized a series of recent studies on multiobjective optimization technology in the context of wireless sensor networks and discussed a series of open problems that need to be solved in future research [7]. These methods provide some references for our research. However, due to the short time of related research and the small sample size, their research has not been recognized by the public.

3. Investigation Methods of Daily Physical Activity of College Students

3.1. Acceleration Sensor. The acceleration sensor is a sensor used to measure the acceleration of a placed object. Its physical components mainly include masses, springs, dampers, sensor elements, and control loops. When the equipment object accelerates, the sensor measures the inertial force of its equipped mass and calculates the acceleration value of the equipment object according to Newton’s second law. Due to the different sensitive components of the sensor, the accelerometer sensor can be divided into capacitive, inductive, piezoresistive, strain, piezoelectric, etc.

Generally, accelerometer sensors use the characteristics of crystal deformation due to acceleration. This deformation is very serious, so when calculating the relationship between the generated stress and the applied acceleration, the acceleration can be converted into an output voltage. Of course, there are many ways to make acceleration sensors, such as piezoresistive technology, capacitive effect, hot air effect, and light effect. But the most basic principle is the combination of distortion and measurement of acceleration distortion. It converts the measured quantity into output voltage, and each technology has its own capabilities and challenges [8].

Compared with using multiple sensors, using a single accelerometer for motion detection has the following advantages.

(1) Portability: the sensor is convenient to carry, does not restrict users, and is more convenient to wear. The collected data is also more real and effective, and the usage scenarios are wider.
(2) Low complexity: the sensor has low power consumption and simple peripheral circuits. The amount of data in the data is compact, easy to use, and easy to calculate.

(3) It is easy to integrate: a single sensor detection circuit can be easily integrated into existing portable equipment.

(4) Low cost: the cost of a single sensor detection scheme is low, which is very convenient for business development.

The technical indicators of the accelerometer include the following:

(1) Technical indicators of sensitivity: for an instrument, generally, the higher the sensitivity, the better, because the more sensitive it is, the easier it is to feel the acceleration changes in the surrounding environment; the change of the output voltage becomes larger accordingly, so the measurement is easier and more convenient, and the measured data will be more accurate.

(2) Technical indicators of bandwidth: bandwidth refers to the effective frequency band that the sensor can measure. For example, a sensor with a bandwidth of hundreds of Hz can measure vibration; a sensor with a bandwidth of 50 Hz can effectively measure vibration.

(3) Technical indicators in terms of range: the range required to measure the movement of different things is different, and it should be measured according to the actual situation.

The three-axis acceleration sensor is easy to maintain and light in weight. By collecting 3D acceleration data, the movement state of the object can be accurately reconstructed without knowing the direction of the object’s movement.

Acceleration sensors are widely used in all walks of life. The main applications include collision warning, earthquake monitoring, motion control, image rotation, automatic correction of electronic compass, pedometer, handshake control, protective cover, and hard disk protection [9]. Figure 1 is the three-axis accelerometer interface circuit.

The fast Fourier transform coefficient has always been a relatively robust feature in the acceleration-based human action recognition. The DFT transformation of $N$-point sequence $w(n)$ in the time domain is defined as follows:

$$W_{\text{DEF}}[k] = \sum_{n=0}^{N-1} w[n] e^{-j2\pi kn/N}, \quad 0 \leq k \leq N - 1,$$

$$y = \arg \max_{m_j} \sum_{j \in N(x)} D(y_j = m_j), \quad i = 1, 2, \ldots, N; \quad j = 1, 2, \ldots, K,$$

$$P(Y = m_k) = \frac{\sum_{n=1}^{N} D(y_i = m_k)}{N}, \quad k = 1, 2, \ldots, K,$$

$$P(X^j = a_j | Y = m_k) = \frac{\sum_{n=1}^{N} D(x^j_i = a_j, y_i = m_k)}{\sum_{n=1}^{N} D(y_i = m_k)}, \quad k = 1, 2, \ldots, K,$$

where $D$ is the indicator function, $P(Y = m_k)$ is the prior probability of the training sample set, and $P(X^j = a_j | Y = m_k)$ is the conditional probability of training sample set.

Although the FFT coefficient is a relatively robust feature, the conjugate symmetry of the Fourier transform results in half of the data redundancy in the frequency domain after the FFT. In addition, the presence of FFT coefficients in the complex domain will also bring inconvenience to processing [10]. In addition to FFT coefficients, discrete cosine transform (DCT) coefficients are also more practical frequency domain features. Discrete cosine transform (DCT) is a transformation defined for real signals, and the
real signal obtained in the frequency domain after transformation is also a real signal. For a real number sequence \( w \{ n \} \), its N-point DCT transformation formula is as follows:

\[
W_{\text{DEF}}[k] = b(k) \sum_{n=0}^{N-1} w[n] \cos \left( \frac{\pi k (2n + 1)}{2N} \right), \quad 0 \leq k \leq N - 1,
\]

where \( b(k) \) is the added coefficient and \( P \) is the posterior probability.

The training data set is represented by the following formulas:

\[ Z = \{(x_1, y_1), (x_2, y_2), \ldots, (x_N, y_N)\}, \]

\[ x_i = (x_i^{(1)}, x_i^{(2)}, \ldots, x_i^{(m)})^T, \quad i = 1, 2, \ldots, N, \]

\[ W_a(T) = -\sum_{i=1}^{n} \frac{|T_i|}{|T|} \log_2 \frac{|T_i|}{|T|}, \]

where \( x_i \) is the \( n \)-dimensional feature column vector of sample points, \( x_i^j \) is the \( j \)-th feature of the \( i \)-th sample, \( |T| \) is the total number of training samples, and in \( |T_i| \), according to \( n \) different values of feature \( a \), divide the training sample set \( T \) into \( n \) subsets.

The feature space is divided into positive and negative categories, and the classification decision function is as follows:

\[ y = f(x) = \text{sign}(\alpha^* \cdot x + \beta^*), \]

\[ \mu_i = y_i \left( \frac{\alpha}{\|\alpha\|} \cdot x_i + \frac{\beta}{\|\alpha\|} \right), \]

\[ \theta = \sqrt{\frac{1}{n \sum_{n=1}^{n} (a[n] - \bar{a}[n])^2}}. \]

The acceleration sensor data acquisition system can be divided into two parts: the data acquisition terminal and the data receiving terminal. For example, Figures 2 and 3 are the system block diagrams of the data acquisition end and the data receiving end, respectively.

According to the type of acceleration, sensors mainly include piezoresistive sensors, piezoelectric sensors, capacitive sensors, and service sensors. Piezoelectric accelerometer sensors mainly use changes in propagation resistance to detect acceleration. It generates different voltages reflecting the actual acceleration according to different changes. Therefore, the piezoelectric sensor can directly transmit current information without complicated electronic connections, which is its greatest value. The basic structure of a piezoelectric accelerometer sensor is similar to that of a differential pressure resistance sensor. The main difference lies in the wide application of materials such as piezoelectric crystals and piezoelectric ceramics. The piezoelectric sensing material that causes the acceleration to change replaces the pressure difference resistance material. The capacitive acceleration sensor refers to the use of the capacitive principle. The capacitive sensor with adjustable polarization gap has the advantages of good sensitivity, good water resistance, and small size. It is very intelligent in vehicle control systems and is used in applications such as mobile platforms. The accelerometer servo sensor is highly enclosed measurement and control system. It has superior maneuverability, wide dynamic range, and excellent linear characteristics. It can be applied to precision inertial navigation control system and inertial control system [11].
Acceleration sensors can be used in the field of human health monitoring. It can be used to measure a person's blood pressure, pulse, heart rate, and other indicators. This information from the human body may be useful for diagnosis and medical treatment. Since the acceleration sensor can perceive the user, it can also be used in the field of portable device perception. It can understand what the user is doing, what is the relationship between the user and the portable device, whether it is in the pocket or manually, and so on. By highlighting useful information, many different and interesting functions can be developed. For example, in the field of human exercise energy evaluation, pedometers with accelerator sensors have been developed. This can effectively determine the number of steps and distance taken by the human body, as well as the ratio of the number of steps taken by a person to the energy consumed, and use these to calculate energy. Over time, the consumption of the human body is vital to human health and other aspects of life [12].

3.2. Physical Activity. The physical activities of daily life can be divided into work, housework, sports, entertainment, and so on. There is no doubt that exercise has a positive effect. Appropriate exercise can maintain the health and physical fitness of any age and reduce the risk factors of various chronic diseases. This non-drug, economical, convenient, effective, and nontoxic method plays a vital role in improving people's quality of life and health. Studies have shown that moderate exercise and proper nutrition can stimulate the growth and development of children and adolescents. It can also improve cardiopulmonary function, increase endurance, reduce body fat, and increase strength and many other health benefits [13]. This article randomly selected 80 boys and 60 girls from a certain school to investigate their physical activity levels during study days and weekends. The results are shown in Table 1.

Unhealthy lifestyles cause college students to suffer from various chronic diseases, such as type 2 diabetes, high blood pressure, fatty liver, digestive diseases, and decreased immunity. This is not just a problem of modern life, but it continues to affect their learning status and physical and mental health. The severity of these problems requires urgent research on physical activity and healthy lifestyles. Physical exercise has a certain stimulating effect on the brain health and cognitive ability of college students, and it is of great significance to improve the learning ability of students. In addition, physical exercise also plays an important role in improving the mental health of students. It can effectively treat depression and other mental illnesses by reducing reading pressure, developing communication between students, and enhancing self-confidence [14].

Physical activity can increase blood pressure, and endurance training can increase cerebral perfusion blood flow from 14% to 25%. The total cerebral blood flow of a healthy person exceeds the demand for brain metabolism. Some exercise-induced increases in blood flow can not only be directly directed to the motor area (of the cerebral cortex) but can also increase blood perfusion in other areas of the cerebral cortex. From a long-term development perspective, regular physical activity can promote cerebral blood flow and reduce blood viscosity. Elderly people suffering from atherosclerosis have insufficient cerebral perfusion, and these changes may affect the improvement of brain function. Even in the resting state, the cerebral blood flow of people and animals who exercise for a long time is still increased. It is accompanied by an increase in the formation of blood...
vessels in the main cerebral cortex motor area and the dentate gyrus. The latter is the plastic area of the hippocampus of the adult brain, which is the area of the brain responsible for the integration of learning and memory [15].

Physical activity enhances the individual’s immediate excitability by stimulating the neural activity of the brain’s reticular tissue. But this kind of stimulation cannot maintain long-term effects, and a moderate increase in excitement is conducive to improving concentration. Physical activity can accelerate the passage of tryptophan, the precursor of serotonin, through the blood-brain barrier. When serotonin in the brain increases, it has an immediate calming effect.

The concept of “police school sports” is to enhance the physique of the police academy students. Its direct purpose is to improve the actual combat of punishment of illegal crimes and promote good skills and self-defense capabilities in the future. It enriches the cultural life of the police and promotes the purposeful and conscious physical and social activities carried out to promote spiritual civilization.

The waveform of the acceleration signal cannot be directly identified by the classifier nor can it be used to effectively represent human motion features. Therefore, we need to perform feature extraction on the acceleration signal, extract the useful information as the feature value, and then combine the classifier algorithm to identify the human motion. At present, the feature extraction techniques often used in the field of human motion recognition can be divided into time domain feature extraction, frequency domain feature extraction, wavelet extraction, etc.

3.3. Embedded Processor. Embedded system consists of hardware and software. It is a device that can operate independently. Its software content only includes the software operating environment and its operating system. The hardware content includes various aspects including signal processor, memory, and communication module. Compared with the general computer processing system, the embedded system has great differences; it cannot realize the large-capacity storage function, because there is no matching large-capacity medium; most of the storage medium used has E-PROM, EEPROM, etc. The software part uses the API programming interface as the core of the development platform.

Embedded processors can be divided into 4 categories: microcontrollers, embedded microprocessors, digital signal processors, and SoCs/programmable SoCs. Embedded microprocessors are the core of mid-to-high-end embedded systems.

The embedded system takes installation as the core processor as the core and is equipped with necessary peripheral interface components. Low-level integrated systems usually use 4/8/16-bit microcontrollers as integrated processors, and middle- and high-level integrated systems usually use built-in 16/32-bit microprocessors or 32-bit utility programs. In embedded microprocessors, DSP is used as the underlying processor. The design of integrated systems has important development trends and directions. From function integration to system integration, it involves the further development of systems based on more and more chips and technical logic, from semi-independent equipment to deep integration of software. The purpose of electrical design technology development is to create an application system. The number of peripheral components is the least to meet the specific requirements of the programmable system integrated into the chip [16].

The embedded system works by embedding the CPU into the target system or the controlled system. But in different embedded systems, the form and degree of embedding are different. According to the closeness of the connection between the embedded system and the general computer, the embedded form can be divided into full embedded mode and semiembedded mode.

The embedded system that adopts the whole embedded way has the following characteristics.

1. It has an independent processor system and has a complete input/output system, which can independently complete the functions of the system
2. The high-end CPU supports embedded operating systems and can develop applications with complex functions
3. It is generally a portable handheld device, and its working environment is generally unattended, mobile space, high altitude, or other environments with harsh conditions
4. The power supply method generally adopts battery power supply. In some cases, it can also directly use the mains 220 V power supply, and the system can design the conversion and voltage stabilization circuit by itself. Higher-end devices often combine

| Gender | Boys ($n = 80$) | Girls ($n = 60$) |
|--------|----------------|-----------------|
| Meditate (min/d) | Study day | 505.42 ± 61.85 | 527.08 ± 57.94 |
| Meditate (min/d) | Weekend | 513.57 ± 83.1 | 512.51 ± 73.54 |
| Light physical activity (min/d) | Study day | 347.54 ± 56.31 | 326.75 ± 55.12 |
| Light physical activity (min/d) | Weekend | 355.45 ± 49.64 | 340.97 ± 34.75 |
| MVPA (min/d) | Study day | 46.45 ± 17.48 | 39.84 ± 15.76 |
| MVPA (min/d) | Weekend | 37.78 ± 25.15 | 36.65 ± 24.52 |
domain feature extraction is mainly to mean, variance, peak value, and energy. The frequency of acceleration. Common time domain features include to directly extract vector features from the time waveform feature extraction. Time domain feature extraction is mainly acceleration signal, and the frequently used methods are carried out quickly and efficiently. In classification identification, there are many methods for feature extraction of acceleration signal, and the frequently used methods are time domain feature extraction and frequency domain feature extraction. Time domain feature extraction is mainly to directly extract vector features from the time waveform of acceleration. Common time domain features include mean, variance, peak value, and energy. The frequency domain feature extraction is mainly to first perform the fast Fourier transform of the acceleration signal and extract the feature vector from the frequency domain of the signal. The commonly used frequency domain features include FFT coefficient and energy spectral density. Compared with frequency domain features, time domain features are less computationally expensive and can better characterize different human actions, so time domain feature extraction methods have been widely used.

Acceleration is everywhere in life. In the daily activities of the human body, such as brushing teeth, washing face, walking, and running, acceleration, the so-called “acceleration signal”, refers to the human body motion signal generated by human body movement in daily life. By effectively processing such an action signal, it can determine what type of action the signal produces, thereby determining the purpose of the person performing the type of action. It uses acceleration sensors to study and track human movement; first of all, it is necessary to build a human movement database [17]. For example, Figure 4 is a schematic diagram of the basic status of the human body movement database.

An excellent data acquisition platform needs to meet the conditions of robustness and durability, real-time data transmission, sufficient sampling rate, low power consumption, and convenient wearing [18]. This article selects a three-axis acceleration sensor, coupled with the embedded microprocessor ADuC7026 as the control core. It combines the Bluetooth module, FLASH data storage module, and keyboard module to form a high-precision data acquisition device [19]. Figure 5 shows the database construction process.

When the accelerometer is subjected to acceleration, the supporting beam will bend and deform, which will cause displacement of the mass. Since the supporting beam is an oblique beam, its bending main axis is not perpendicular to the surface of the structure but at a certain angle. Therefore, this displacement has both a component perpendicular to the surface of the structure and a component parallel to the surface of the structure. The component perpendicular to the surface of the structure causes the capacitance gap formed by the mass and the electrode to change. Since the relative area of the capacitor plate is fixed, the magnitude of the mass displacement along the surface component of the vertical structure can be obtained by measuring the change of the capacitance. It then obtains the magnitude of the inertial force through the displacement, that is, the acceleration, so as to realize acceleration detection.

The acceleration data obtained when the sensor is placed on different parts of the human body to detect the same

### 4. Investigation and Experiment on Daily Physical Activity of College Students

The acceleration sensor can electronically detect the acceleration of a moving human body. The acceleration of the exercise can reflect the muscle load during the exercise, so that the energy consumption can be calculated. Acceleration sensor is the most advanced motion sensor, divided into piezoelectric type and piezoresistive type. Table 2 is currently common acceleration sensors used to record human activities.

The various human motion waveforms obtained by the accelerometer contain a large amount of information. The purpose of feature extraction is to obtain the information that can be carried out quickly and effectively. In classification identification, there are many methods for feature extraction of acceleration signal, and the frequently used methods are time domain feature extraction and frequency domain feature extraction. Time domain feature extraction is mainly to directly extract vector features from the time waveform of acceleration. Common time domain features include mean, variance, peak value, and energy. The frequency domain feature extraction is mainly to perform the fast Fourier transform of the acceleration signal and extract the feature vector from the frequency domain of the signal. The commonly used frequency domain features include FFT coefficient and energy spectral density. Compared with frequency domain features, time domain features are less computationally expensive and can better characterize different human actions, so time domain feature extraction methods have been widely used.

### Table 2: Several commonly used acceleration sensors.

| Product name | Model      | Specification details                  | Maximum recording time | Reliability and validity |
|--------------|------------|----------------------------------------|------------------------|-------------------------|
| Actigraph    | Single axis, three axis | Size: 2 × 1.5 × 0.6 cm Working frequency: 0.25–2 Hz | 22 d | 11, 21, 26, 26, 29 |
| Actical      | Single axis | Size: 1.1 × 1.5 × 0.4 cm Working frequency: 0.5–3 Hz | 45 d | 29, 30 |
| Actiwatch    | Dual axis  | Size: 1.2 × 1 × 0.35 cm Working frequency: 0.5–7 Hz | AW-16: 11 d         | 14, 30 |
| Tritrac-R3D  | Three axis | Size: 4.7 × 0.5 × 0.9 cm Working frequency: 0.1–3 Hz | 7 d | 5, 26 |

![Figure 4: Schematic diagram of the basic status of the human body movement database.](image-url)
motion varies greatly. During the research process, people often place accelerometers on the ankles, waist, and chest. The advantage of the ideal ankle joint position is that it is sensitive to the movement of the lower limbs and has a good effect on walking, running, and other activities. The disadvantage is that due to the high sensitivity of the inductor, the data noise generated is relatively large, and the durability is relatively poor. The advantage of the waist position sensor is that it can be easily adjusted, and some tactile devices can be easily placed on the human body [20].

It generates statistical data for three indicators: correct detection frequency, error detection frequency, and false detection frequency. The correct recognition between them means that after the user performs a certain action, the system will clearly recognize the action. Underreport means that after the user performs an action, the system will not be able to recognize the action. A false positive means that the user is performing some action. After it performs this action, the system will treat it as another operation. The statistics of the experimental results of the three actions are shown in Table 3.

In the process of squatting and jumping, different experimenters made different movements and jumping speeds, and some movements could not reach the threshold, resulting in false negatives. From the jumping movements in the table, it can be seen that the recognition times of women’s jumping is significantly lower than that of men, which is due to the difference in body weight and jumping range of men and women. As for the squatting movement, the recognition frequency of males is significantly lower than that of females. This is also due to the difference in body structure. At the same time, we have not imposed too many restrictions on the movements of the experimenters.

| Action | Total number of experiments | Correct recognition times | Number of false negatives | Number of false positives |
|--------|----------------------------|--------------------------|--------------------------|----------------------------|
| Take off | 150                        | 143                      | 6                        | 1                          |
| Run     | 150                        | 148                      | 2                        | 0                          |
| Squat   | 150                        | 139                      | 11                       | 0                          |
| Total   | 450                        | 430                      | 19                       | 1                          |

This experiment uses the GT3X series acceleration sensor, the specification is 3.8 cm × 3.7 cm × 1.8 cm, the weight is 27 g, the resolution is a 12-bit A/D conversion, the sampling frequency is 30 Hz, and the sensing range is ±3G. The acceleration sensor is designed on the basis of GT1M and is an upgraded version of GT1M, which can accurately measure the acceleration in the three-dimensional direction. As shown in Figure 6, the left picture shows the appearance of the acceleration sensor, and the right picture shows the structure of the internal piezoelectric sensor.

Under the principle of voluntary participation, 100 college students from a certain city are selected to participate in the experiment. Among them, 52 are boys and 48 are girls. The subjects have normal growth and development and have no recent illnesses or fevers and other adverse health conditions [21]. As shown in Figure 7, the left picture shows the subjects’ average age, height, weight, and other body shape indicators and BMI values, and the right picture shows the average energy expenditure of students in physical activities of each department.
Figure 6: Schematic diagram of acceleration sensor.

Figure 7: Average body index and energy expenditure.

Figure 8: Wearing time and static activity time.
According to the classification model, the results of the comparative analysis of the wearing time distribution and the different activity intensities of the subjects, as well as the distribution of the wearing time of men and women, and the comparative analysis results of the individual activity intensities of different departments are obtained. The results show that according to the weekly physical activity monitoring, the static activity period of the school of computer and sports and health is much higher than other periods. It accounts for more than 75% of the monitoring time, that is, the total time of different activity intensities. The students showed significant differences, and the total time of individual activity intensity of girls was much higher than that of boys. For example, girls with different intensities are more active than boys, and the proportion is higher than that of boys [22]. As shown in Figure 8, the wearing time and static activity time of the surveyed students are shown. The left picture shows the data of boys and the right picture shows the data of girls.

Figure 9 shows the time data of the investigated students’ low-intensity activities, medium-intensity activities, and life activities. The figure on the left shows the data for boys, and the figure on the right shows the data for girls.

Compared with the students of the police school, the students of the computer science department and the sports health science department did not have high-intensity activities and strenuous activities. As shown in Figure 10, the police school students are engaged in vigorous and strenuous activities.

The content of the course is rich and varied. How to effectively achieve the teaching goals of the characteristic physical education curriculum within the limited class hours and the limited energy of the students is an important issue in curriculum development [23, 24]. The arrangement of courses for a certain police academy is to arrange courses for students of various majors according to the training objectives of each major. It made statistics on the beginning of the teaching content by checking the training plan of the undergraduate majors of the school [25]. The results are shown in Table 4: 1 means opening and 0 means not opening.

5. Discussions

Usually, the accelerator also has different sounds when collecting the gravitational acceleration and collecting the acceleration signal. Noise is usually caused by human body vibration, looseness or deflection of portable sensors, and interference from the system itself. Usually, it performs
initial processing before obtaining the characteristics of human motion signal [26]. Signal preprocessing techniques usually include noise reduction, reflection, and curvature correction.

When monitoring and describing human activities, the information collected is often about acceleration. This is not conducive to direct acquisition, grouping, and characterization. Therefore, the acceleration signal usually comes from window segmentation [27]. Window segmentation refers to the distribution of moving signals into smaller periods, and each cycle is called a window. The most common method is to use a scroll window to highlight characters, and the scroll bar divides the signal into several equal-length intervals. Sliding window is a simple and easy-to-use deployment technology, very suitable for real-time on-demand system [28].

In addition to the sliding window segmentation method, there are also event-based windows that are commonly used to segment signals. Event-based window segmentation refers to dividing the motion signal into segments with different time lengths, which is a variable time window. Each window represents an event, the start of the window represents the start of the event, and the end of the window represents the end of the event. Such segmentation is conducive to the division of events, which is very helpful for motion recognition. Another method is the action-based window. The action-based window segmentation also divides the motion signal into segments with different times. The difference is that a window represents a human action, and the start and end points of the window represent the beginning of an action and end.

Human beings can effectively protect the body’s activity through regular physical activity, promote metabolism, and prevent the loss of brain function. Moreover, the function of exercise is significant in the elderly, because the main cognitive functions of the elderly are gradually degrading. Relevant studies have confirmed that rats that have undergone long-term exercise will experience increased nerve growth. Physical activity may promote LTP through the following short-acting or long-acting mechanisms: increasing synaptic conduction, increasing the concentration of neurotrophic factors, resisting the effects of free radicals, and promoting neurogenesis [29].

6. Conclusion

Any physical activity that requires skeletal muscle energy is called physical activity. An increase in energy expenditure index leads to an increase in energy expenditure at the basal metabolic level. Lack of physical exercise and insufficient physical exercise are the main factors contributing to the deterioration of the physical health of our young people. In order to better formulate recommendations such as college students’ exercise recommendation, it is very important to accurately measure students’ daily physical activities. Measurement indicators include total energy consumption in a week, moderate-intensity activity time, and daily activity time. This article detects the embedded acceleration sensor for the three actions of jumping, running, and squatting. And 100 students who volunteered to participate in daily physical activities were tested, and the experimental results were obtained. This article starts a preliminary forecasting research, and given the limited data sources and academic level, there are unavoidable omissions in the research. The analysis of the status quo analysis stage is not thorough enough, only showing the changes of relevant indicators and lacking internal judgment and analysis. It is in the stage of theoretical research, and the grasp of the theory is not deep enough. Future research will continue to develop and use acceleration sensors to realize various applications such as recognition of human gait, use acceleration sensors to collect changes in human acceleration during walking, and extract characteristic parameters through data analysis and processing. The human gait recognition model uses a non-image-based method to identify the gait of different people for identity verification.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there is no conflict of interest with any financial organizations regarding the material reported in this manuscript.
References

[1] N. Castell, F. R. Dauge, P. Schneider et al., "Can commercial low-cost sensor platforms contribute to air quality monitoring and exposure estimates?" Environment International, vol. 99, no. 99, pp. 293–302, 2017.

[2] S. Dong, Z. Bi, Y. Tian, and T. Huang, "Spike coding for dynamic vision sensor in intelligent driving." IEEE Internet of Things Journal, vol. 6, no. 1, pp. 60–71, 2019.

[3] H. Zhang, X. Hong, J. Cheng, A. Nallanathan, and V. C. Leung, "Secure resource allocation for OFDMA two-way relay wireless sensor networks without and with cooperative jamming." IEEE Transactions on Industrial Informatics, vol. 12, no. 5, pp. 1714–1725, 2016.

[4] C. Chen, R. Jafari, and N. Kehtarnavaz, "A survey of depth and inertial sensor fusion for human action recognition," Multimedia Tools and Applications, vol. 76, no. 3, pp. 4405–4425, 2017.

[5] Y. Deng, L. Wang, M. Elkaslan, A. Nallanathan, and R. K. Malik, "Physical layer security in three-tier wireless sensor networks: a stochastic geometry approach," IEEE Transactions on Information Forensics and Security, vol. 11, no. 6, pp. 1128–1138, 2016.

[6] Y. Hu, M. Dong, K. Ota, A. Liu, and M. Guo, "Mobile target detection in wireless sensor networks with adjustable sensing frequency," IEEE Systems Journal, vol. 10, no. 3, pp. 1160–1171, 2016.

[7] Z. Fei, B. Li, S. Yang, C. Xing, H. Chen, and L. Hanzo, "A survey of multi-objective optimization in wireless sensor networks: metrics, algorithms, and open problems," IEEE Communications Surveys & Tutorials, vol. 19, no. 1, pp. 550–586, 2017.

[8] J. Brunink, J. R. Haak, J. G. Bomer, D. N. Reinhoudt, M. A. McKervey, and S. J. Harris, "Chemically modified field-effect transistors: a sodium ion selective sensor based on calix[4]arene receptor molecules," Analytica Chimica Acta, vol. 254, no. 1-2, pp. 75–80, 1991.

[9] P. Pattanaik, "Influence of adhesion layer on performance of surface plasmon resonance sensor," IET Optoelectronics, vol. 12, no. 4, pp. 168–175, 2018.

[10] J. Duan, D. Gao, D. Yang, C. H. Foh, and H. H. Chen, "An energy-aware trust derivation scheme with game theoretic approach in wireless sensor networks for IoT applications," IEEE Internet of Things Journal, vol. 1, no. 1, pp. 58–69, 2014.

[11] M. Pedersen, M. Meijerink, W. Olthuis, and P. Bergveld, "An IC-compatible polyimide pressure sensor with capacitive read-out," Sensors & Actuators A Physical, vol. 63, no. 3, pp. 163–168, 1997.

[12] J. Long, M. Dong, K. Ota, and A. Liu, "Achieving source location privacy and network lifetime maximization through tree-based diversionary routing in wireless sensor networks," IEEE Access, vol. 2, no. 2, pp. 633–651, 2017.

[13] P. Boselin, V. Sakthi, A. Babu, and T. C. Anand, "Mobility assisted dynamic routing for mobile wireless sensor networks," Social Science Electronic Publishing, vol. 3, no. 1, pp. 9–19, 2017.

[14] A. Remah and E. Khaled, "Performance and challenges of service-oriented architecture for wireless sensor networks," Sensors, vol. 2017, pp. 536–575, 2017.

[15] B. Adam, "Structural health monitoring using wireless sensor networks: a comprehensive survey," IEEE Communications Surveys & Tutorials, vol. 19, no. 3, pp. 1403–1423, 2017.