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Research Article

Design and Implementation of Athlete's Knee Health Monitoring System Based on Cloud Computing

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To learn about the health care of athletes in the knee joint, real-time to monitor the health of the human knee joint according to the cloud. The system uses a depth camera to collect the data information of the human lower limb alignment and obtains the spatial coordinate position of the human lower limb alignment through deep learning; then analyzes and processes the video sequence of the human lower limb alignment, including the wavelet function decomposition of the lower limb alignment information and reconstruction, and finally, the monitoring results were obtained by the knee joint scoring method. The system has completed the design of software and hardware and realized the method of extracting the coordinate information of the main joint points of the human body based on neural network. The health monitoring algorithm finally obtained the knee joint health status of the subjects through the evaluation system. By comparing the real health status of the subjects, the reliability of this research work was verified. The experiment shows that the monitoring error of the system is less than 10%, and the overall error is only 6%. The KSS standard score of the subjects is consistent with the monitoring and evaluation of the system, and the score trend is basically the same. For the situation that the overall score of the system is lower than the KSS standard, after communication and analysis with orthopaedic experts. It is speculated that it may be due to the subjective estimation of the subjects when measuring KSS, and the system monitoring algorithm is relatively strict and more objective. It is proved that the system designed in this paper can effectively monitor the health of athletes' knee joint.

1. Introduction

Nowadays, the large-scale development of sports has intensified the competition between countries, especially the continuous development of the world Olympic movement, which has brought increasingly fierce competition to competitive sports, so that in the rapid development of high technology, it is necessary to do a good job in the effective training of athletes, gradually improve the overall sports ability of athletes, and bring athletes better sports results. As for the monitoring of athletes' physical fitness indicators, it is mainly to promote the testing and development of physical fitness. In the process of scientific data training and sorting, continuously improve the effective testing of physical fitness indicator monitoring database system and shorten the gap of athletes' physical fitness reserves. In the process of showing the competitive performance of physical athletes, it is necessary to stimulate the enthusiasm of athletes' training, fully understand the physical condition of athletes, and adjust the training plan of athletes [1].

In the field of the traditional knee joint health monitoring, the main research techniques are gait analysis, the method by studying the patient's lower limb power line (hip, knee, and ankle) changes of the kinetic parameters in the process of walking, and then to quantify the health status of the skeletal system and the adjustment ability of the nervous system, which reflects the patient's health. However, the traditional equipment is cumbersome to wear and difficult to operate, and there is direct contact between the body and the monitoring equipment, which affects the monitoring results of the subject in the monitoring process to a certain extent. Although there are many researches on human pose estimation based on deep learning at present, there is a lack of researches on human knee joint health by monitoring human lower limb force line. Smart medicine has developed rapidly. With the help of the Internet, cloud computing, medical big data, and other new generation information technologies, build intelligent medical equipment systems and platforms, upload personal physiological health data through intelligent terminals, quickly get remote guidance from doctors, and extend traditional medical services to communities and families for health management and chronic disease prevention. The overall architecture of the system is shown in Figure 1. The data of the examinee after various physical examinations and tests in the Internet/community hospital, such as height, weight, blood oxygen, and blood routine, and the ECG data measured by the wearable ECG monitoring device designed in this paper are uniformly transmitted to the middleware device. The middleware integrates all sign data and forwards it to the cloud platform and mobile app through wireless transmission protocol. The data on the cloud platform is for doctors to diagnose and put forward health suggestions. Users and authorized relatives can view the test results of themselves and their relatives through the smartphone app [2]. Node middleware is between medical device resources and applications and completes the data forwarding between devices and applications. Middleware carries out interface forwarding and data processing in the process of forwarding without worrying about the problem of data return. The browser side and the Java side use node.js as the middleware. The node calls the interface published by the Java back end, and the node can publish the HTTP interface to the browser side. The front and back ends are separated, and the local front-end development call interface will have cross-domain problems. Build a local HTTP server with node.js and forward it when judging the access interface URL, which perfectly solves the cross-domain problem in local development. The middleware system is located on various medical hardware devices, which can manage multiple medical devices and coordinate the scheduling of equipment resources. At the same time, the middleware system is located under the application program, which can respond to the call requests of multiple applications at the same time and realize the caller's operation of medical devices and real-time acquisition of health monitoring data, and the access mode of HTTP/HTTPS communication technology can make the application program not limited by the platform and compatible with various mainstream platforms such as windows and Android [3]. Medical wisdom to get rapid development, with the aid of the Internet, cloud computing, large medical data such as a new generation of information technology, building intelligent medical equipment system and platform, through the intelligent terminal upload personal physiological health data, quickly get the doctor remote instruction, the traditional medical service extending to the community and family for health management and disease prevention.

2. Literature Review

Kim and others designed and implemented an agent system that can monitor blood pressure, pulse rate, respiratory rate, body temperature, and other vital signs, attached to wireless sensors [4]. Baptista et al. designed and implemented a remote video medical diagnosis system, which relies on the Internet of things technology to realize the medical diagnosis process of doctors and has multifunctional modes such as online consultation and video conversation [5]. Shaw and Sergent designed and developed an ECG monitor and realized remote monitoring with an intelligent terminal with Android system [6]. Srba et al. believe that through the establishment of medical management system, people's health problems can be basically guaranteed, and then everyone can be treated. With the development of science and technology, it has had an impact on people's life in all aspects. For people's health, many high-tech measuring instruments have emerged one after another [7]. Kuwabara et al. believe that these measuring instruments adopt advanced measuring sensors, which can measure and detect people's heart rate, body temperature, and sleep status, so as to record people's life trajectory and understand people's health status. This type of measuring instrument usually has Bluetooth function, which can send the detected data to the mobile terminal, and then, the mobile terminal can analyze the received data and generate a more intuitive curve [8]. Wadugodapitiya et al. believe that with the development of mobile technology, mobile terminal devices become more and more popular, and the price is very low. At present, mobile phones have become an important part of people's life [9]. Knapik and Salata believe that with the proposal of Android technology, many mobile phone developers have begun to develop Android phones, such as Huawei and Xiaomi. The health management system is designed and developed on the basis of Android platform, so as to realize the health management based on mobile terminal. At the same time, the system can also process the received data to analyze the health status of human body [10]. Raju et al. believe that although these existing methods play a certain role in human health management, they need to spend a lot of time and money, which is difficult to achieve for those with poor economic ability [11]. Ciba et al. believe that with the development of the concept of physical examination, more than 70% of residents in the United States can enjoy health management services. Health service institutions in the United States have long proposed a health management platform with relatively perfect functions, which can not only manage electronic medical records but also make appointments and purchase drugs [12]. Selistre et al. proposed a set of advanced health management system. The system wears a small medical sensor on the human body, and then, the human health data can be collected through the mobile terminal. Then, the mobile terminal will analyze the collected data and judge the health of the human body [13]. The overall framework of human knee health monitoring system is shown in Figure 2.

In this context, we designed an intelligent health monitoring system that can monitor the parameters of human vital signs in real-time, continuously and for a long time, and developed a portable ecg monitor for real-time monitoring and analysis of human ecg signals, improving the nonreal-time transmission of ecg signals in the existing health monitoring platform. The intelligent health-monitoring platform designed

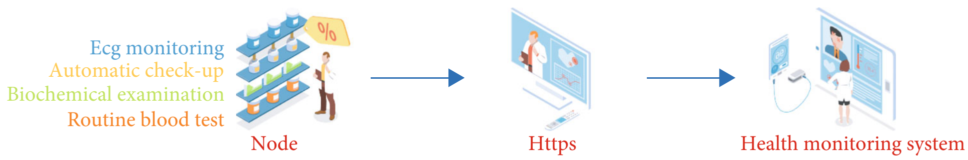

Figure 1: Overall architecture of intelligent health monitoring cloud platform.

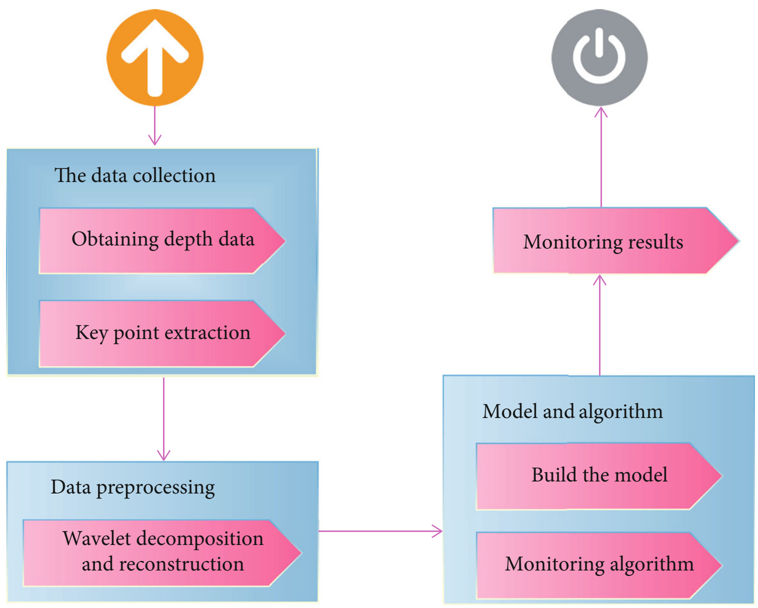

Figure 2: Framework of human knee joint health monitoring system.

in this paper can continuously monitor the parameters of human vital signs in real-time for a long time and transmit the data to the cloud platform and mobile APP in real-time. Doctors can monitor the data of the cloud platform and feedback the results to the user's smartphone APP for display and preservation. Users can view their health history data through an APP on their phone. When a certain vital characteristic parameter of the user is abnormal, the cloud platform and mobile APP can provide real-time warning, so that the user can get timely treatment, which is of great historical significance for long-term monitoring of chronic disease.

3. Cloud Platform Software Function Process Design

The system design uses a multiserver distributed architecture, each node is loosely coupled, the dependence on the reliability and availability of the underlying products is reduced, and the scalability is better. Especially with the expansion of application scale, the marginal cost will be lower. In order to solve the disadvantages of waste of resources and poor flexibility of hot deployment, we use the scalable hot deployment method, which can deploy without interrupting the operation of web server, which greatly improves the development efficiency. The main functions of the intelligent monitoring system designed in this paper include receiving monitoring data in real-time, dynamically displaying data, analyzing the legitimacy of verification data, querying historical data, and other functional modules and can give a comprehensive health status detection report for the measurement results of different data according to the standard reference value of vital signs data within the normal range [14].

3.1. System Requirements. The construction of Oracle database needs to clarify the multiple functional requirements of the system application environment. In the process of physical fitness index monitoring, combined with the functional characteristics of sports ball, we should do a good job in the effective evaluation of sports ball energy index system. In the process of physical fitness training, coaches should ensure a reasonable amount of data collection, make a comprehensive analysis of the data, and realize the effective storage of physical fitness index monitoring data. To analyze the information needs of athletes, we should do a good job in the analysis of the needs of trainers, combined with the actual needs of sports ball lovers, and realize the effective test of data.

3.2. Parameter Setting. The athlete information is set as shown in Figure 3.

The setting of athletes' personal information needs to determine the names, photos, and sources of athletes, as well as the age and sports level of athletes. The determination of physical fitness index monitoring index is mainly combined with a kind of competitive ability characteristics of athletes, reflecting the advantages and disadvantages of athletes' physical reserves,

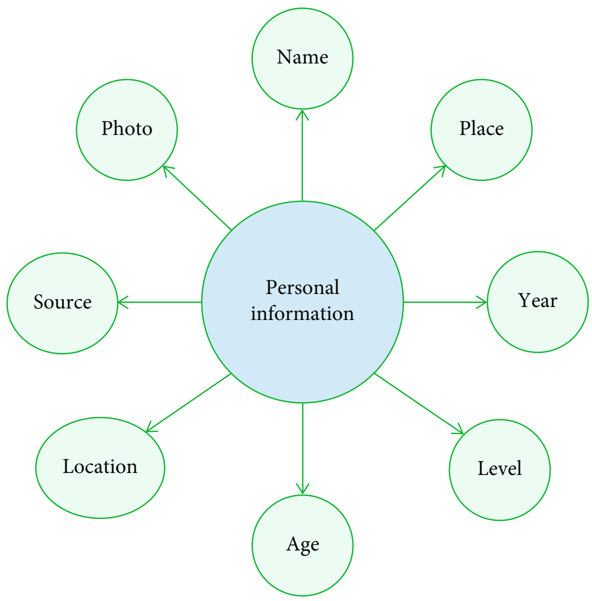

Figure 3: Athlete information setting.

and optimizing the setting of athletes' subjects. And the process of mobilizing physical fitness development, combined with a kind of daily training of coaches, is doing a good job in reflecting the monitoring indicators of physical fitness indicators.

3.3. Data Processing and Monitoring Algorithm

3.3.1. Wavelet Decomposition and Reconstruction. Due to the interference of uncontrollable factors such as jitter and environment in the process of human movement, the obtained hip knee ankle angle information carries a certain degree of error, which has a great impact on the accuracy of knee health monitoring algorithm. In order to obtain accurate hip knee ankle motion information and improve the robustness of the algorithm, wavelet decomposition is used to filter the motion data and separate the real motion information from the complex environment. The wavelet decomposition process is shown in Figure 4.

After wavelet decomposition and reconstruction of the original human hip knee ankle motion signal, the interference of noise on the useful motion signal can be effectively prevented, which is helpful to the high-precision analysis of the subject's knee joint health.

3.3.2. Model Construction and Monitoring Algorithm. The angle data of hip knee ankle will change obviously during the movement of human body, and the change of time series can directly reflect the health status of knee joint. Under dynamic conditions, the human body has speed, acceleration, cycle, and frequency, which are affected by other factors such as center of gravity while affecting each other, and reflect the motion process of human body together [15]. The simplified human motion model constructed by this system for human hip knee ankle is shown in Figure 5.

In Figure 5, the torso of the human body is represented by OA, the femur of the human body is represented by Bo, and the tibia of the human body is represented by BC, so the motion state of the human hip knee ankle can be represented by the included angle θ_1 between Bo and BC, and the included angle θ_2 between the trunk and the vertical axis represents the change of the center of gravity during human movement. θ_1 and θ_2 can be expressed by equations (1) to (2).

$$\theta_1 = \arccos\left(\frac{BC \times BO}{|BC| \times |BO|}\right). \tag{1}$$

$$\theta_2 = \arccos\left(\frac{OA \cdot Y}{|OA| \cdot |Y|}\right), \tag{2}$$

where Y is the unit vector of the vertical axis.

The construction of human body simulation model is helpful to extract appropriate motion indicators and lay a foundation for the realization of accurate monitoring algorithm. Knee score is an intuitive index to evaluate the degree of knee injury, select treatment scheme, and evaluate treatment effect. It is a questionnaire evaluation. The subjects fill in the form according to their specific situation; finally, it was handed over to the doctor as an important basis for evaluating the health status of the subject's knee joint.

The system uses the American Knee Society score (KSS) as the reference and guidance of the monitoring algorithm of the system. The standard evaluates the overall function and shape of the knee joint through the knee score and function score, solves the shortcomings of other knee scoring standards, such as incompleteness and insensitivity, and more accurately evaluates the self conditions of the joint; it can reflect the real health status of the subject's knee joint to the greatest extent [16].

Referring to KSS standard and combined with the characteristics of noncontact system, this paper extracts and integrates the flexion change, over extension, hip knee ankle motion angle, acceleration, and other relevant dynamic parameters into a monitoring algorithm and obtains the index function of the monitoring system to evaluate the health status of knee joint, as shown in formula (3)

$$S = F\left(N, T, \theta_1', \theta_2', \alpha\right), \tag{3}$$

$$\theta_1' = f(\theta_1), \theta_2' = f(\theta_2), \tag{4}$$

where T is the duration of exercise, N is the number of exercises completed in T time, α is the acceleration of the movement process, F and f are the relevant scoring methods of the monitoring system, s is the final monitoring result score, and the system score is divided into four levels according to the KSS standard: <60 points are poor, ≥60 ~ ≤69 points are acceptable, ≥70 ~ ≤84 points are good, and ≥85 ~ ≤100 points are excellent.

According to the scientific knee-scoring standard, the system designs a monitoring algorithm in line with medical theory to achieve the goal of quantifying the health degree of knee joint as the traditional wearable method. Finally, the health obtained by the monitoring algorithm is visually fed back to the subjects [17].

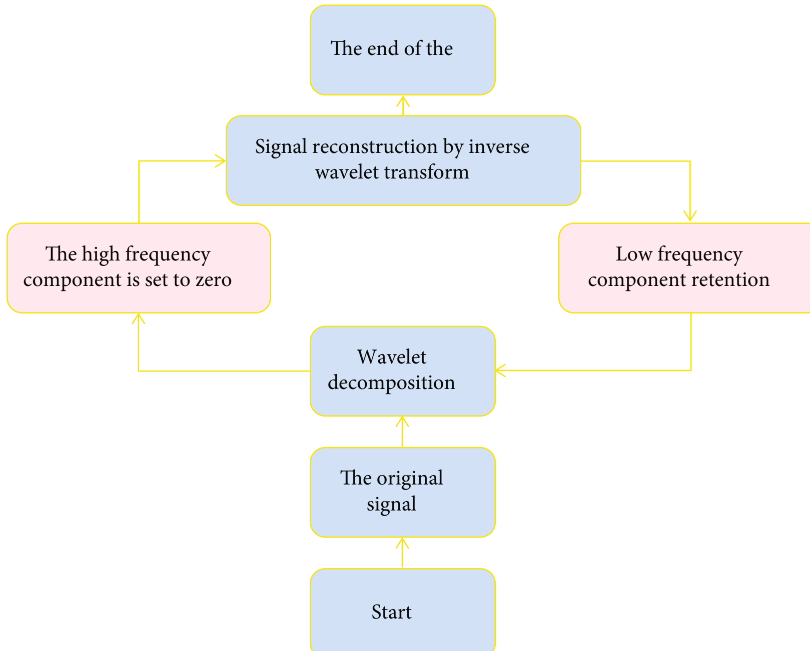

Figure 4: Wavelet decomposition and reconstruction.

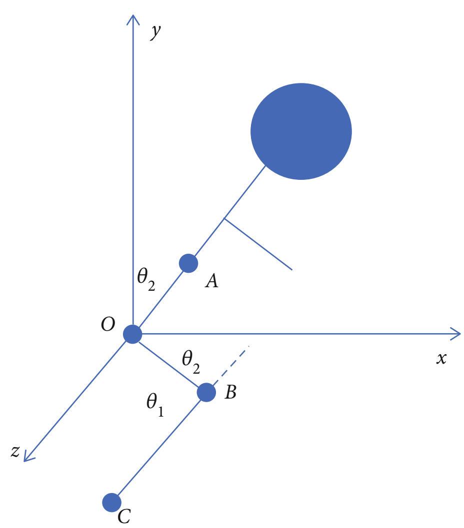

Figure 5: Simulation model.

Table 1: Basic information of some subjects.

Test number	Gender	Age	Height	Weight
1	Male	24	179	74
2	Male	45	175	71
3	Male	28	176	62
4	Male	29	173	53
5	Male	30	178	67
6	Male	35	177	75

4. Experimental Results and Analysis

In order to verify that the human knee health monitoring system studied in this paper can monitor the knee health, this paper tests the system. In order to reduce external interference as much as possible and weaken other factors that may affect the monitoring results, the test sites are in a clean room with good light [18]. During the test, the subjects need to follow the simulated healthy mannequin to do walking, squatting, leg flexion, and other related movements and keep consistent with the movements of the model as far as possible. Considering the great differences in the health status of human knee joints of different ages and genders, this paper will test several randomly selected subjects, and the information of some subjects is shown in Table 1.

In Table 1, subject 1 and subject 6 had no related knee diseases, and both had the habit of daily exercise; subject no. 2 has occasional uncomfortable symptoms in the knee joint due to his older age and seldom participates in physical exercise activities at ordinary times; subjects 3 ~ 5 had good physical fitness and no related knee diseases, but also lacked daily exercise. The above subjects had no other health-related diseases and were able to live a normal life outside the test period.

Through the relevant tests of knee health monitoring on the subjects in Table 1, the data waveforms of multiple groups of subjects are obtained. Now the hip knee ankle motion data of subjects 1 and 2 are excerpted, as shown in Figures 5 and 6. Figures 5 and 6 show the knee health monitoring process of subjects 1 and 2, respectively, in which the waveform of a represents the movement of the center of gravity of subjects, that is, the movement change of the included angle between the plumb line and the trunk; B represents the motion signal obtained by a after wavelet decomposition and reconstruction;

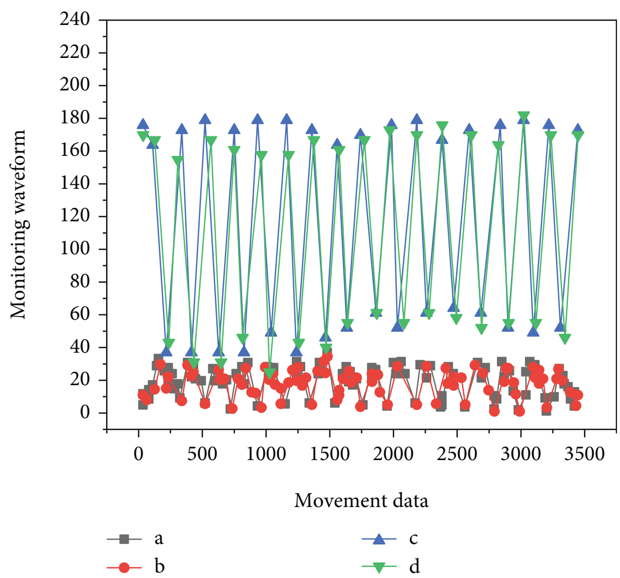

Figure 6: Motion data of subject 1.

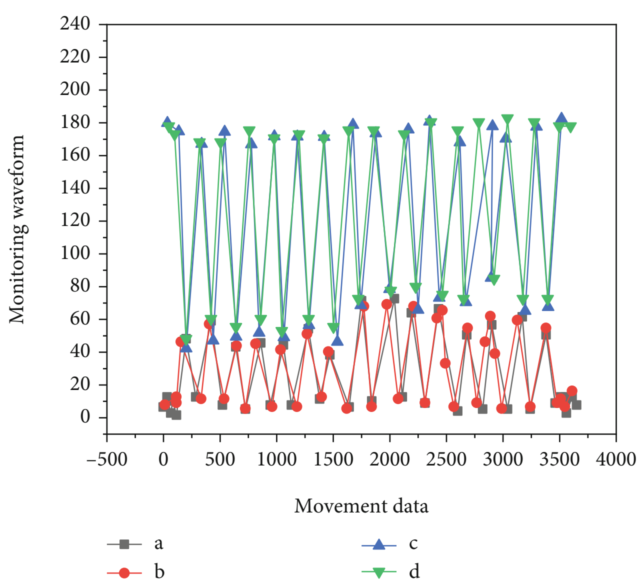

Figure 7: Motion data of subject 2.

Table 2: Knee joint health monitoring results of some subjects.

Test number	Motion cycle	Number of movements	Matching degree	Evaluation score
1	1.769	16	86.424	94
2	2.276	14	73.667	75
3	1.852	15	70.161	82
4	1.752	16	76.333	87
5	2.076	15	78.254	88
6	1.764	16	83.152	91

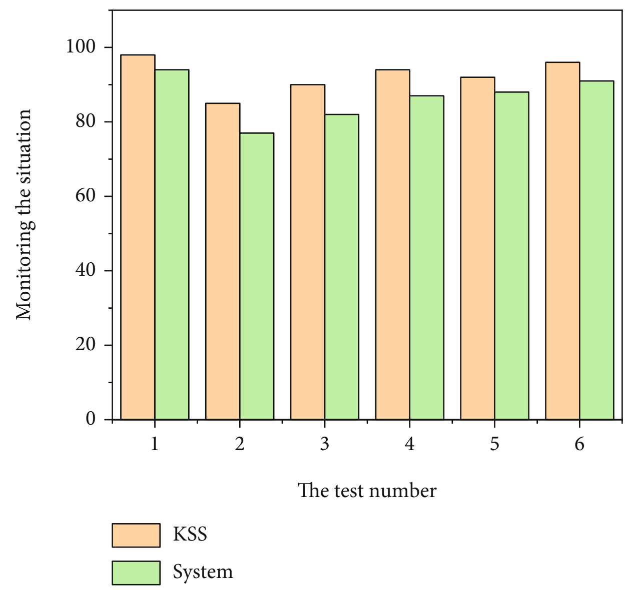

Figure 8: Comparison between KSS standard and system results.

C represents the real-time motion signal of the subject's knee joint, which is the motion of the included angle formed by the subject's hip, knee, and ankle; D represents the motion signal of C after wavelet decomposition and reconstruction. It can be found that the signal after wavelet decomposition and reconstruction is smoother and reduces the jitter and burr of the signal, that is, it can effectively suppress the noise interference generated in the process of motion [19–21].

According to the comparison between Figures 6(b) and 7(b), it can be seen that the signal peak in Figure 6(b) is more stable, which indicates that the center of gravity of subject 1 can well assist the hip knee ankle movement during the monitoring process; comparing Figure 6(d) with Figure 6(d), it can be seen that the hip knee ankle motion signal in Figure 6(d) is smoother than that in Figure 7(d). Through the simple analysis of the motion waveforms of the two subjects, it is concluded that the motion completed by subject 1 during the knee health-monitoring period is better than that of subject 2. After the subject completes the test of the knee health monitoring system, the knee joint health monitoring results of some subjects are obtained, as shown in Table 2 [22–24].

In Table 2, the matching degree is the motion fit between the subject and the simulation model. Compared with the monitoring results of the system, it can be seen that the evaluation results of subject 1 and subject 6 are higher, the evaluation results of subject 2 are the lowest, while the evaluation results of subjects 3 ~ 5 are relatively stable and the scores are in the normal range, this is highly consistent with the knee health status of each subject [25]. After the above six subjects conduct the KSS standard self-test and compare the monitoring situation of the system, the results are shown in Figure 8. From Figure 8, it can be seen that the system monitoring error is within 10%, the overall error is only 6%, the KSS standard score of the subjects is consistent with the monitoring and evaluation of the system, and the score trend is basically the same. For the situation that the overall score of the system is lower than the KSS standard, through the exchange and analysis with orthopaedic experts, it is speculated that it may be the result of the subjective estimation of the subject when measuring KSS, and the system monitoring algorithm is relatively strict and more objective [26]. The experts also pointed out that as long as the deviation is controlled at about 5%, the monitoring results of the system can replace the traditional evaluation method. To sum up, the evaluation results of the noncontact human knee health monitoring system designed in this paper are highly similar to the KSS standard, which can easily, quickly, and effectively obtain the subject's knee health status, thus providing a new tool for monitoring human knee health [27].

5. Conclusion

By studying the health status of human knee joint, this paper puts forward an athlete knee joint health monitoring system based on cloud computing. The system completes the design of software and hardware, realizes the method of extracting the coordinate information of human main joint points based on neural network, focuses on the wavelet decomposition and reconstruction of hip knee ankle motion data, studies and designs the human knee health monitoring algorithm, and finally obtains the subject's knee health status through the evaluation system. The reliability of this study is verified by comparing the real health status of the subjects, so the system can be used as an evaluation reference for medical staff or their own knee health monitoring. In the future, on the basis of current research and through the collection and accumulation of long-term data, a risk prediction function of factors related to potential disease events can be developed to further expand the application field of intelligent health monitoring system and provide scientific and effective basis for the prevention and treatment of chronic diseases.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] D. N. Bobunov, D. M. Shaidullina, N. R. Davtyan, and A. K. Iordanishvili, "Evaluation of the efficiency of therapeutic gymnastics for knee joint injuries in athletes of the senior age groups," *Advances in gerontology*, vol. 34, no. 2, pp. 287–292, 2021.

[2] M. Mundt, S. David, A. Koeppe, F. Bamer, B. Markert, and W. Potthast, "Intelligent prediction of kinetic parameters during cutting manoeuvres," *Medical & Biological Engineering & Computing*, vol. 57, no. 8, pp. 1833–1841, 2019.

[3] K. J. Wagner, M. J. Sabatino, A. J. Zynda, C. V. Gans, and H. B. Ellis, "Activity measures in pediatric athletes: a comparison of the hospital for special surgery pediatric functional activity brief scale and tegner activity level scale," *The American Journal of Sports Medicine*, vol. 48, no. 4, pp. 985–990, 2020.

[4] S. P. Kim, S. Y. Kim, and Y. K. Jeon, "Isokinetic study of knee and waist joint according to exercise experience of floorball athlete," *Journal of the Korean society for Wellness*, vol. 14, no. 2, pp. 499–508, 2019.

[5] I. Baptista, J. Abrantes, and T. Atalaia, "Vertical jump test assessment in non-athlete adults: systematic review," *Journal of human sport and exercise*, vol. 14, pp. S543–S557, 2019.

[6] T. Shaw and A. Sergent, "Improved performance after gluteus complex activation in a crossfit athlete presenting with knee pain," *Journal of Chiropractic Medicine*, vol. 18, no. 4, pp. 343–347, 2019.

[7] B. Srba, B. Pah, B. Avlc, B. Mb, and B. Tfbd, "An individualised approach to assess the sidestep manoeuvre in male rugby union athletes - sciencedirect," *Journal of Science and Medicine in Sport*, vol. 23, no. 11, pp. 1086–1092, 2020.

[8] A. Kuwabara, E. Kraus, and M. Fredericson, "Narrative review — knee pain in the pediatric athlete," *Current Reviews in Musculoskeletal Medicine*, vol. 14, no. 3, pp. 239–245, 2021.

[9] S. Wadugodapitiya, M. Sakamoto, S. Suzuki, Y. Morise, and K. Kobayashi, "In vivo stiffness assessment of patellar and quadriceps tendons by strain ultrasound elastography," *Bio-medical Materials and Engineering*, vol. 32, no. 5, pp. 257–266, 2021.

[10] D. M. Knapik and M. J. Salata, "Hip injuries in the contact athlete," *Operative Techniques in Sports Medicine*, vol. 27, no. 3, pp. 145–151, 2019.

[11] V. Raju, P. K. Koorata, and Y. Kamat, "Case study for contact pressure improvisation with graded implant material in articular cartilages of knee joint," *Journal of Mechanical Science and Technology*, vol. 35, no. 3, pp. 1049–1054, 2021.

[12] M. Ciba, E. M. Winkelmeyer, J. Schock, P. Schad, and S. Nebelung, "Comprehensive assessment of medial knee joint instability by valgus stress mri," *Diagnostics*, vol. 11, no. 8, p. 1433, 2021.

[13] L. F. Selistre, G. H. Gonçalves, F. A. Vasilceac et al., "The relationship between urinary C-telopeptide fragments of type II collagen, knee joint load, pain, and physical function in individuals with medial knee osteoarthritis," *Brazilian Journal of Physical Therapy*, vol. 25, no. 1, pp. 62–69, 2021.

[14] K. Anagnostakos, C. Grzega, I. Sahan, U. Geipel, and S. L. Becker, "Occurrence of rare pathogens at the site of periprosthetic hip and knee joint infections: a retrospective, single-center study," *Antibiotics*, vol. 10, no. 7, p. 882, 2021.

[15] J. Wang and Z. Zhao, "Effect of soil microstructure on the small-strain shear modulus of saline soil," *Arabian Journal of Geosciences*, vol. 14, no. 1, pp. 1–12, 2021.

[16] F. Chen, "Athlete muscle measurement and exercise data monitoring based on embedded system and wearable devices," *Microprocessors and Microsystems*, vol. 82, no. 5, p. 103901, 2021.

[17] C. Mennitti, M. Brancaccio, L. Gentile, A. Ranieri, and O. Scudiero, "Athlete's passport: prevention of infections, inflammations, injuries and cardiovascular diseases," *Journal of Clinical Medicine*, vol. 9, no. 8, p. 2540, 2020.

[18] L. Yang, Z. Wang, P. Jiang, G. Yan, and K. Zhao, "Design of wearable wireless health monitoring system and status recognition algorithm," *Chinese journal of medical instrumentation*, vol. 44, no. 4, pp. 288–293, 2020.

[19] N. Choudhary, "Design and implementation of wildfire monitoring system," *International Journal for Modern Trends in Science and Technology*, vol. 7, no. 5, pp. 139–143, 2021.

[20] A. Iliadis, M. Tomovic, D. Dervas, M. Psymarnou, and A. P. Deligiannis, "A novel mhealth monitoring system during cycling in elite athletes," *International Journal of Environmental Research and Public Health*, vol. 18, no. 9, p. 4788, 2021.

[21] S. Zhao, "Research on scientific sports training of students majoring in physical education," *Revista Brasileira de Medicina do Esporte*, vol. 27, no. 5, pp. 460–463, 2021.

[22] S. J. Warden, W. B. Edwards, and R. W. Willy, "Preventing bone stress injuries in runners with optimal workload," *Current Osteoporosis Reports*, vol. 19, no. 3, pp. 298–307, 2021.

[23] S. E. Kim, C. C. Yong, and Y. L. Ji, "Early rehabilitation after surgical repair of medial and lateral collateral elbow ligaments: a report of three cases," *International Journal of Environmental Research and Public Health*, vol. 17, no. 17, p. 6133, 2020.

[24] J. B. Fields, S. Gallo, J. M. Worswick, D. R. Busteed, and M. T. Jones, "25-Hydroxyvitamin d, vitamin d binding protein, bioavailable 25-hydroxyvitamin d, and body composition in a diverse sample of women collegiate indoor athletes," *Journal of Functional Morphology and Kinesiology*, vol. 5, no. 2, p. 32, 2020.

[25] B. Raja, A. Firdous, A. M. Ishak, and M. Anand, "Design and implementation of health care video monitoring system based on rtos," *Indian Journal of Public Health Research and Development*, vol. 10, no. 4, p. 1260, 2019.

[26] S. Sato, Y. Nemoto, N. Takeda, Y. Kitabatake, and T. Arao, "Factors relevant to knee pain among independent community-dwelling older adults: a complete cross-sectional study," *Open Journal of Preventive Medicine*, vol. 10, no. 11, pp. 277–287, 2020.

[27] L. Boumaiza, J. Walter, R. Chesnaux et al., "An operational methodology for determining relevant drastic factors and their relative weights in the assessment of aquifer vulnerability to contamination," *Environmental Earth Sciences*, vol. 80, no. 7, pp. 1–19, 2021.