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Design of Physical Training Assistant System Based on Intelligent Health Management System

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Abstract: *Physical fitness refers to the general term for the physical fitness level of athletes, which is the ability to train in daily life. Over the years, with the continuous development of various training technology products, many new big data and other technologies have played an important role and function in improving the technical level of athletes' physical fitness. The body has the ability to hide in the body in terms of body structure, function and regulation, material energy conversion and storage, etc., as well as the comprehensive exercise ability displayed through the external environment. Therefore, sports training are the main means of development and improvement. Physical fitness is one whose magnitude cannot be measured with complete clarity. For a long time, the enhancement of physical fitness and the consumption of physical energy during the scientific and rational arrangement of the game have relied on the experience and experience of the coach. However, many times it is not very scientific and accurate, especially at the basic level of training. There is a lack of efficient physical fitness monitoring and analysis systems to provide coaches and athletes with scientific support for physical fitness training. The method of physical training also stays at the level of experience, and it is impossible to better combine traditional theory and practical data, resulting in more professional and accurate training methods and methods. Therefore, this paper designs a set of athlete physical training assistant system based on the decision support layer of the comprehensive health management system. It could provide strong technical support for athletes to scientifically and rationally use physical fitness, master their own physical fitness characteristics, and better play their competitive level. According to the above test results, this paper concluded that the system could support 25 DAT terminals under the pressure environment generated by the input data of the stress test, and the pressure requests 10 packets per second. The fault-tolerant transmission distance was 220M, and the fault-tolerant transmission distance was 60M, with strong fault tolerance. Test results demonstrated that the system was qualified and met the established requirements.*

Keywords: *Athlete Physical Training, Auxiliary System Design, Integrated Health Management System, ID3 Algorithm*

1. Introduction

At present, in the process of preparing for major competitions in the professional teams of clubs around the world, only the coaches' previous team-leading experience and the players' proprioception are used for physical training, which has many defects and deficiencies in various aspects. In order to make the physical training monitoring of athletes more scientific and objective and quantitative, the application of various monitoring methods plays a crucial role in more accurate testing and evaluation of athletes' usual training results and competition status. Therefore, when establishing an auxiliary system for physical training of athletes, it is necessary to monitor in all directions. At the same time, there should be a focus on monitoring, and a comprehensive study on the monitoring methods and indicators of physical fitness training of football players should be carried out in many aspects.

This paper combines machine learning algorithms to improve the recognition and discrimination of data sets with continuous characteristics, so as to design a set of athlete physical training assistance systems. It provides reference for athletes to provide specific physical training practices, which explores the realization of scientific auxiliary improvement programs.

2. Literature Review

With the development of science and technology, more and more people are interested in the training and control of athletes' physical fitness. Many advanced technologies are integrated into the physical training system of athletes. Xiong D designed and implemented a physiological planning system. In the system, the athlete's ECG, EMG and 3D acceleration could be acquired and analyzed simultaneously. The analysis results could be fed back to the coaches to solve the problem that the athletes' body data cannot be collected and analyzed in real time [1]. Li C demonstrated a golf-assisted training system. Artificial intelligence and big data were used to realize the transition from experience-based exercise training methods to human motion analysis methods [2]. Erickson C C investigated physiological cardiac changes in long-term exercise training. He proposed a method for distinguishing heart disease from heart disease in athletes using electrocardiography and echocardiography [3]. WatsonP summarized the extent to which data acquisition methods were used in practice to monitor athletes in order to assist in the implementation of an athlete monitoring system related to logistical situations [4]. Scott S N focused on post-exercise recovery routines, with a particular focus on athletic performance. He also provided an updated consensus on post-exercise recovery and glycemic management in patients with type 1 diabetes [5]. Based on binocular stereo vision measurement and wireless sensing theory, Li H studied the measurement and analysis methods of athletes' motion displacement parameters. The movement rules of athletes were analyzed and revealed, which provided theoretical guidance for athletes' attitude identification and physical training [6]. Dan W discussed the use of principal component analysis (PCA) as a dimensionality reduction and visualization tool to assist decision-making and communication when analyzing complex multivariate datasets related to athlete training [7]. Kenichiro focused on the injury characteristics of young athletes and sorted out the physical characteristics of children as they grew up. He also grasped the actual situation of Japanese adolescent athletes' injuries, and summarized the activities of Japanese sports organizations regarding the prevention of injuries in adolescent athletes concerned by sports plastic surgeons [8]. Ding L used temperature-dependent near-infrared spectroscopy (NIRS) technology to collect athlete's urine spectrum to evaluate the feasibility of rapid detection of basketball players' movement status [9]. Strahorn J review investigated the acute effects of physical or psychosocial interventions on testosterone and cortisol responses in elite men's rugby league players, with subsequent correlations between physical performance domains (such as strength, explosiveness, sprint performance) or key performance indicators (such as coach-determined skills) [10]. However, these studies did not have a deep and comprehensive discussion on the auxiliary physical training of athletes.

3. Design Method of Athlete's Physical Training Auxiliary System

3.1 Integrated Health Management System

(1) Decision tree

Decision tree is one of the classic algorithms in the field of machine learning, which can be used for both classification and regression [11-12]. Decision tree is an algorithm for classifying attribute features with known feature attribute probability. The important concept in decision tree is node, which is divided into root node, parent node, child node and leaf node according to the location of the node. Each decision tree has only one root node and can have multiple parent nodes, child nodes and leaf nodes [13]. The root node is at the top of the split node. The parent node and child node are intermediate nodes produced by the splitting process. Leaf nodes have no child, which are at the end of each branch. Each leaf node corresponds to a unique categorical attribute. When the decision tree splits to the leaf node of each branch, the branch stops splitting. Decision tree splitting stops when all branches reach leaf nodes, as shown in Figure 1.

The construction of decision tree is to use a certain attribute to divide the data set at the current node into subsets with high purity and low uncertainty according to certain feature division criteria. By repeating the above splitting process, a decision tree is generated. Decision tree classification is to divide the data according to the constructed decision tree and sequentially use the relationship between the splitting attribute and the threshold at the corresponding node [14].

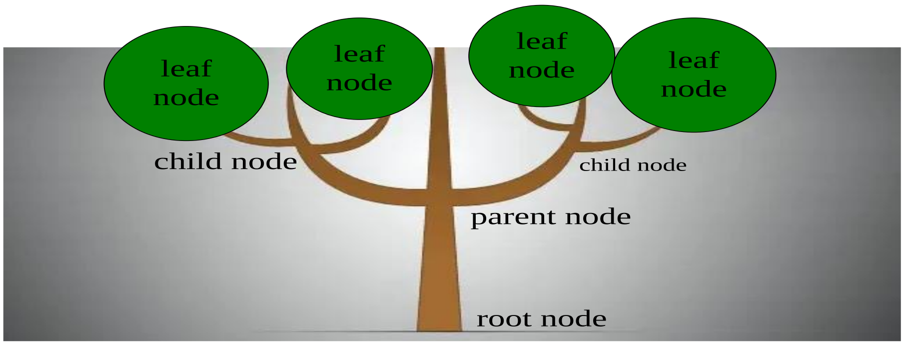


Figure 1: Decision tree model diagram

(2) ID3 algorithm

According to the characteristic that the larger the entropy value of the information entropy is, the lower the stability is, the ID3 algorithm is a decision-making process that uses the information entropy to measure the information [15]. When splitting an attribute at the current node, the selected attribute corresponds to a unique classification situation. At this time, the attribute contains the most information, and the attribute is selected for splitting. The formulas for calculating information gain are as follows:

$$\inf o(Y)=-\sum_{a=1}^{n} p_a \log_2^{p_a} \tag{1}$$

$$\inf o(Y)=-\sum_{b=1}^{m} p_b \inf o(b) \tag{2}$$

$$Gain(C)=\inf o(Y)-\inf o_C(Y) \tag{3}$$

(3) C4.5 algorithm

The C4.5 algorithm uses the information gain ratio to measure the importance of attributes. The main improvements are as follows [16]:

1) Through the information gain ratio, the splitting attribute is selected, which overcomes the deficiency of information gain that tends to select attributes with multiple attribute values as the splitting attribute.

2) After constructing the decision tree, the pruning operation is performed.

3) Continuous attributes can be discretized, which can handle both discrete and continuous attribute types.

4) Training data with missing attribute values can be processed.

The C4.5 algorithm defines an information splitting specification similar to conditional entropy:

$$Spl_C(Y)=-\sum_{b=1}^{m} p_b \log_2^{p_b} \tag{4}$$

$$GainRatio(C)=\frac{Gain(C)}{Spl_C(Y)} \tag{5}$$

In the formulas: m is the attribute C has m values; $Spl_C(Y)$ is the information amount contained in the attribute C in the current sample Y; $GainRatio(C)$ is the information gain ratio corresponding to the attribute C.

Formula (4) is very similar to Formula (1). Formula (1) is to calculate the information entropy corresponding to the classification category of the current sample set. However, Formula (4) is based on attribute C. The sample set of the current node is divided into m subsets, and m subsets of attribute C are calculated at the information expectation at the current node.

(4) CART algorithm

The CART algorithm is classification and regression trees. The Gini exponential splitting property is adopted, and the splitting criteria are as follows.

$$Gini(Y) = 1 - \sum_{a=1}^{n} p_a^2 \tag{6}$$

$$Gini_C(Y) = \sum_{k=1}^{m} \frac{N_k}{N} Gini(k) \tag{7}$$

In the formulas: n is the classification situation corresponding to the sample set Y, there are n kinds, which can be 2 classifications or multiple classifications. $Gini(Y)$ is the $Gini$-index value of the current sample set Y. p_a is the probability corresponding to category a of the sample set. N means that the total number of samples in this sample set Y is N. m means that attribute C has m values, and the current sample can be divided into m subsets. N_k is the total number of samples corresponding to the k-th subset. $Gini_C(Y)$ is the split value of $Gini$ split by attribute C.

3.2 Functional Requirements of the System

(1) Collection of physical fitness raw data

The collection of athletic data is done by a collector designed and placed on the athlete. Athletes should be able to collect the basic data shown in Table 1 during training and competition.

Table 1: Raw data that can be collected

Name	Symbol	Meaning
Body temperature	T	Typical body temperature
Heartbeat	C	Human heartbeat
Acceleration vector	A	The acceleration and direction of the current movement with the gyroscope as the fixed coordinates

Athletes often engage in intense exercise and therefore have high demands on the physical and biological properties of the terminal [17]. First, the terminal and support sensors are nearly inaccessible between players, and body parts that align with the torso motion vector must be handled. The second is strong impact resistance, and the third is sturdy portability that doesn't easily fall or move. The device has a built-in gyroscope and currently has no pose requirements. In addition, external heart rate (wrist or neck) and body temperature (underarm) sensors have excellent biological properties, such as moisture resistance, non-toxicity, softness, stable connection transmission line, etc.

1) Body temperature T

Infrared body temperature sensors are used to obtain body temperature information of athletes. The body temperature accuracy obtained by this type of sensor and back-end processing circuit is moderate (the error is 0.2 degrees), which is suitable for the acquisition accuracy required by this system. Infrared body temperature sensors have good biological properties because they do not come into contact with the skin [18].

2) Heartbeat C

Heartbeat information is acquired using piezoelectric thin-film sensors. Piezoelectric film has a unique property, it is a kind of dynamic strain sensor. It is very suitable for monitoring the vital signs of human epidermis or implanted inside the human body. This sensor is suitable for the collection of heartbeat information in this system.

3) Acceleration vector A

Acceleration (vector) information is acquired using two-by-two orthogonal acceleration sensors and gyroscope (angular velocity) sensors. Some related sensor products can obtain this information by cascading the sensors and physically placing them orthogonally.

(2) Physical fitness data

The physical energy processing data is mainly based on the acceleration vector A. First, the raw data is collected wirelessly, and then calculated in real time by the data collection server. The main processing data is shown in Table 2.

Table 2: Processed data based on raw data

Name	Symbol	Meaning
Vertical acceleration vector	A_1	The vertical component of A calculated by A
Horizontal acceleration vector	A_2	Horizontal component of A calculated by A
Vertical velocity vector	V_1	Current vertical velocity calculated using A_2
Horizontal velocity vector	V_2	Current horizontal speed calculated using A_2
Vertical height	H_1	Current altitude using A_1 points
Mileage	S_1	Current running mileage with A_2 points
Interval mileage	S_2	The running mileage in a certain time interval is obtained by subtracting S_1
High jump	H_2	The maximum height reached by a certain jump
Jump distance	S_3	2 times S_2 when H_1 is 0

3.3 Design and Implementation of the System

(1) Terminal design

Drawing lessons from the technology in the aerospace industry, the use of acceleration sensors and gyroscopes can easily measure and control the movement trajectory of athletes [19]. For external heartbeat (wrist or neck) and body temperature (armpit) sensors, good biometrics are required, such as moisture resistance, non-toxicity, softness, etc. There is a reliable transmission line connected to the DAT.

The back carrying scheme is adopted to realize the terminal carrying. The athlete wears a simple vest with DAT on the back. DAT is protected by a soft shell and wrapped around a flexible elastic fabric or material [20]. Acceleration and attitude sensors are built into the vest sandwich. When the athlete puts on the vest and places the heartbeat and body temperature-sensing patches in designated locations, the DAT goes to work. The advantage of the back carrying scheme is that the DAT is relatively close to the collection site, and it is not easy for athletes to contact each other's DAT devices during competition, which does not have much impact on the athletes themselves.

(2) Composition of terminal modules

A DAT data acquisition and transmission terminal is designed, which is placed on the athlete. The main task is to collect athletes' movement information and bounce information. The device contains the following main hardware modules: ARM embedded system, which is mainly used for preliminary operation and upload execution after data acquisition; Accelerometer A/Gyroscope, Body Temperature Sensor T, Piezo Film (Heartbeat) Sensor P; 802.2a/b/g/n-based wireless transmission chip, TCP/IP protocol stack chip, Ethernet chip; other necessary modules, such as power supply, FLASH, SDRAM, LCD, etc.

The schematic diagram of DAT hardware is shown in Figure 2.

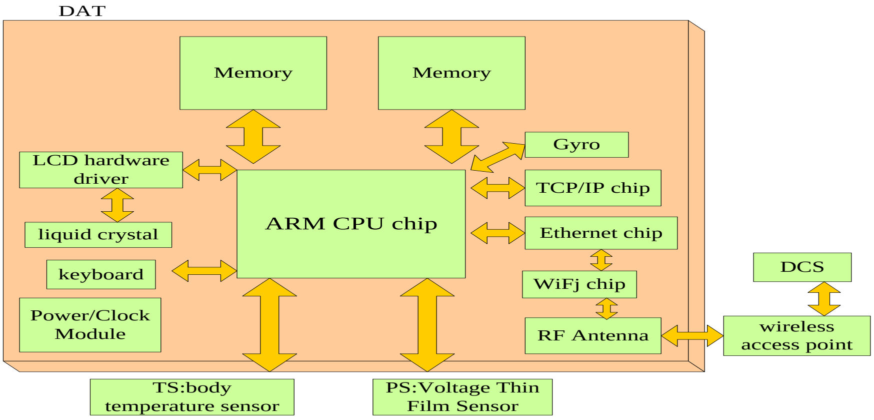


Figure 2: DAT circuit logic

The sensor group refers to a sensor group formed by three single-axis acceleration sensors and gyroscopes in space orthogonally. TS is an external body temperature sensor, PS is an external piezoelectric film (heartbeat) sensor. DAT uses UCOS (U Control Operation System) operating system, that is, micro-embedded real-time system to support, and uses software or hardware TCP/IP protocol stack [21].

4. Experiment on the Auxiliary System of Physical Fitness Training for Athletes

(1) Physical fitness test of athletes

The fitness analysis system must complete the statistical collection of data, including the data that the fitness analysis business needs to collect [22]. By separating the data layer, calculation layer, model layer and view layer by layers, the unique design also retains some data interfaces and business rule interfaces, and maintains extensibility to expand physical business requirements. In this experiment, athletes were randomly selected, and the acquisition terminal DAT was used to measure and adjust the physical state of athletes during exercise. Figure 3 shows an athlete's heartbeat status during exercise. Figure 4 shows the state of body temperature collected by athletes during exercise.

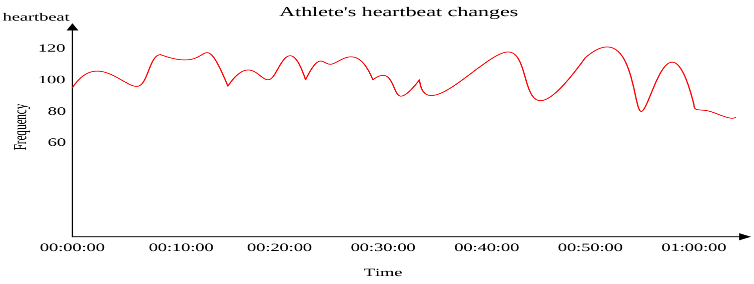


Figure 3: The athlete's heartbeat changes

As shown in Figure 3, the athlete's heart rate has been relatively intense during exercise. At nearly 1 hour, the movement slowed down and the heart rate gradually flattened.

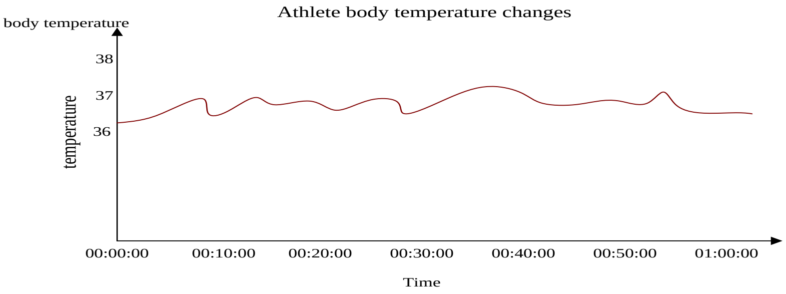
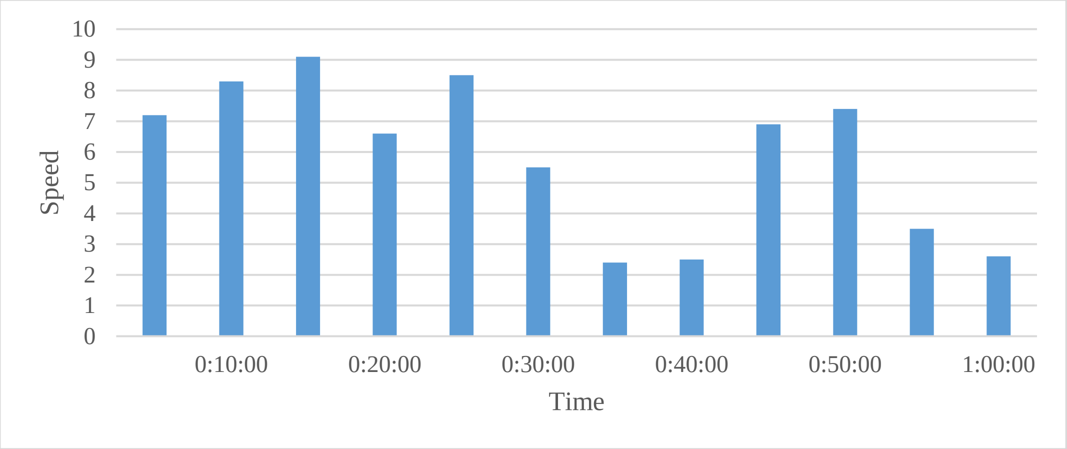


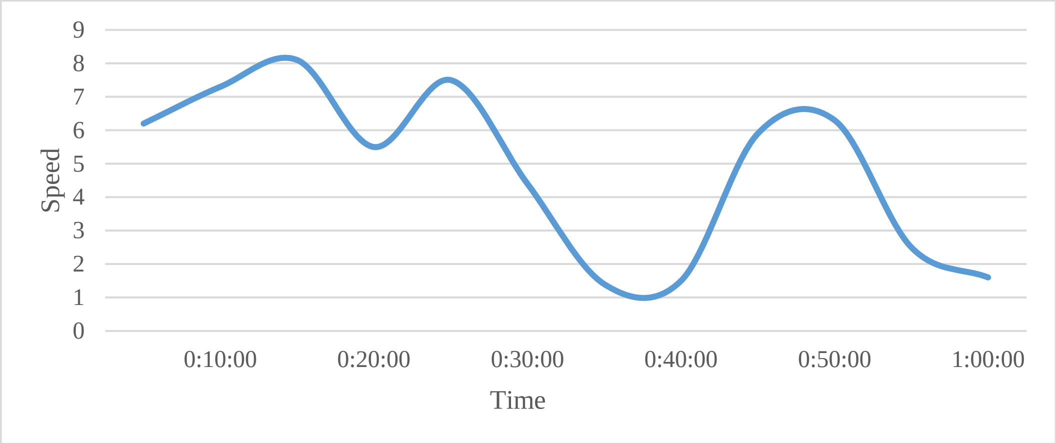
Figure 4: Changes in the athlete's body temperature

As shown in Figure 4, the athlete's body temperature remained between 36-37 degrees during exercise. At one point it hits 37 degrees due to vigorous exercise, but as the body adjusts itself, it steadily decreases to a constant 36-37 degrees.

At the same time, the average speed and maximum interval speed of the athlete are collected as shown in Figure 5.



(a) Average speed of the athlete



(b) Athlete's zone maximum speed

Figure 5: The athlete's average speed and maximum interval speed

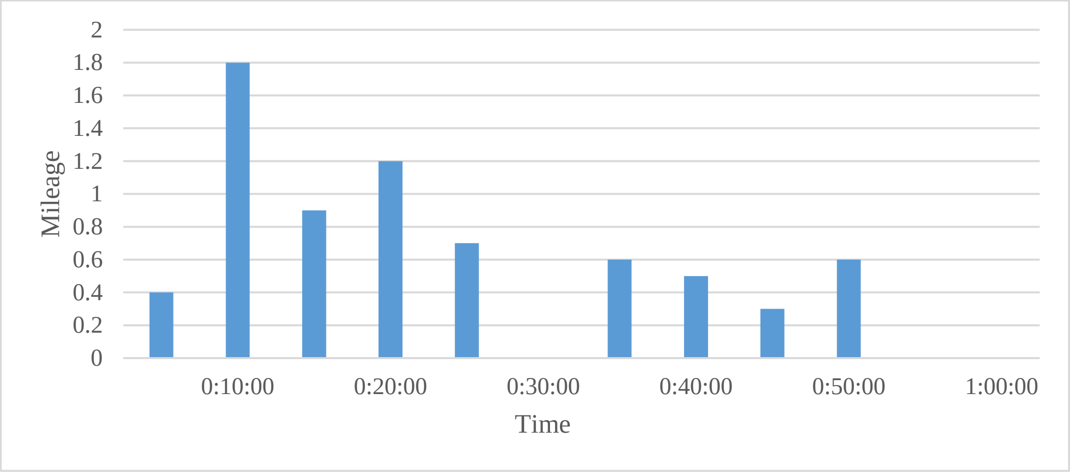
As shown in Figure 5(a), the average speed of the athlete has been rising during the first 20 minutes of exercise. After 20 minutes, there was a decline in physical condition. Until 30 to 40 minutes, the average speed during this time period was at its lowest. However, it also gradually regained strength. After 40 minutes, the sprint started to accelerate, and the speed was gradually slowed down due to physical reasons.

As shown in Figure 5(b), the athlete's interval speed changed from the fluctuation in the first half an hour to a gradual decrease, and reached the lowest level around 40 minutes. It can be seen from the Figure that the athlete had a small sprint at about 50 minutes, and then the interval speed gradually dropped.

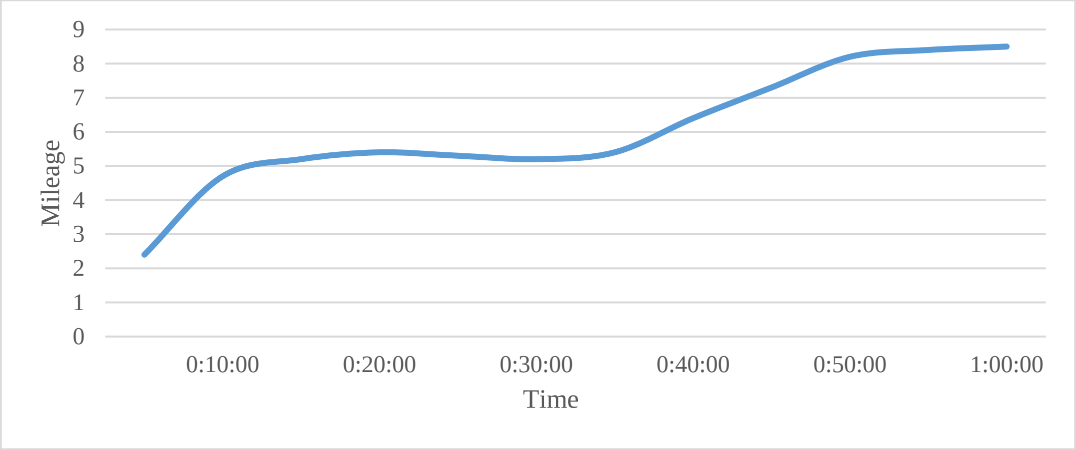
The collected running mileage and interval running mileage of the athlete are shown in Figure 6.

As shown in Figure 6(a), the athlete's interval running mileage reached the highest value in the first 10 minutes, and then gradually decreased. At about 30 minutes, the athlete's interval mileage was 0, and there was a slight increase between 30 and 50 minutes. However, after 50 minutes, the athlete's interval mileage dropped back to 0 here.

As shown in Figure 6(b), the athlete's running mileage generally showed an upward trend. In the first 10 minutes, the rising speed was the fastest, and it was relatively stable in the interval of 20-30 minutes without too much fluctuation. However, after 40 minutes, the athlete's mileage increased slightly again.



(a) The athlete's interval mileage



(b) the mileage of the athlete

Figure 6: The athlete's running mileage and interval running mileage

5. Conclusions

In this paper, the decision support layer of the comprehensive health management system is used to design the athlete's physical training assistant system to assist the athlete's physical training process. It includes judging athletes' individual game performance, analyzing athletes' personal training directions, comparing athletes horizontally, athlete selection and role adjustment, adjusting overall training plans, verifying personal training theories, judging local competition levels, and selecting athletes' talents. Moreover, this paper studies and constructs a collection terminal that can collect athletes' physical fitness data. The collection terminal DAT supports dynamic network configuration, business work instructions, data collection and uploading. The functions can be reused in many other research and industrial fields. They can be applied to other researches with a little modification, which is very versatile.

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