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Camouflage model for human motion target based on bionics of marine plant leaf

Chunhong Xu, Siyu Yang, Haichi Wu, Ye Zhan*

College of Art, Hebei College of Science and Technology, Baoding 071000, China, email: zhanye98855@163.com

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ABSTRACT

Aiming at the problem that the current traditional methods can not effectively analyze the camouflage of human moving objects in real time, which leads to the poor accuracy of human motion prediction, this paper proposes an analysis method of camouflage model of human moving objects based on bionic leaves of marine plants, Firstly, establishing the index system of human motion target parameters. On this basis, the indexes of human motion objects were compared and the scores were given. According to the scores, the constitution parameter matrix was judged and the weight value of constitution index was calculated. Moreover, the reliability of constitution parameter and the body quality index were used to test the consistency, so that the combined weight of constitution was obtained. Furthermore, it was necessary to analyze and study the constitution elements of constitution health and the growth difference, and thus to complete the calculation of weight coefficient of constitution index. Finally, the change model of constitution parameters was built. Experimental results show that the results of proposed method are consistent with the actual results, so the proposed method has the advantages of high effectiveness.

Keywords: Bionics of marine plant blade; Human motion; Target camouflage model; Physical fitness; Weight coefficient of physical fitness

1. Introduction

As the normal background of camouflage target, the marine vegetation has become the focus of research on camouflage model of human motion target. Because the camouflage targets in marine vegetation environment are coated with green camouflage coatings, it is an important application to detect the targets coated with green camouflage coatings in marine vegetation environment. For the camouflage of basic green vegetation background, the advanced camouflage equipment has been able to achieve the "same color" with the environmental background, but it unable to achieve the "same spectrum" of fine spectral feature matching.

Hyperspectral imaging is a new concept of earth observing technology, which has a strong ability to identify target and background features, so it has become an important means of camouflage resistance and stealth resistance [1]. The traditional camouflage materials can only achieve "same color" with the green vegetation, but it is unable to achieve "same spectrum", so it is difficult to resist the fine spectrum reconnaissance. The key of resisting hyperspectral detection is to make the camouflage target and the environment background achieve the fine spectral feature matching. The effective way to achieve this goal is to carry out bionics research on plant leaves and prepare camouflage material with fine reflection spectrum characteristics.

Human physical quality is a special state of relatively stable structure, function and metabolism formed by individuals in the process of growth, development and aging on the basis of heredity and under the influence of environment [2]. Physical fitness is the basis of human organism activities. Human physical fitness is also a relatively balanced state formed by various biological factors in the conflict between heredity and variation. Therefore, it is the focus of

* Corresponding author.

research to construct the change model of human motion target parameters.

2. Material and methods

2.1. Index system of human motion target parameters

The tissue structure and material composition of leaves of marine plants are the main factors influencing the reflectance spectra. Generally, the physical quality is an important indicator of conditions of constitution, which refers to the external abilities when people participate in sports. Establishing a reasonable indicator system is the premise of comprehensive evaluation. In order to ensure that the comprehensive index can reflect the physical quality comprehensively and accurately, it is necessary to establish a constitution index system of human physical parameters [3]. The model of human physical parameter change is an important link in the analysis of physical quality [4]. It is able to analyze the specific physical index and influencing factors. This is conducive to the further study of constitution parameters.

2.1.1. Physical fitness index

Height and weight are two important indexes to evaluate the target parameters of human body motion. Only considering height and weight at the same time can clearly judge an individual. Therefore, BMI index calculated by height and weight is used as an important index to evaluate body shape [5]. BMI index (body mass index) is an index to measure the degree of fatness and thinness of human body and the condition of physical health [6]. It is a key index to evaluate the body constitution parameters. The equation is:

$$\mathrm{BMI} = \frac{T}{X} \tag{1}$$

where T denotes the weight. X denotes the height. The skin fold thickness of body is the sum of skin fold thickness of upper arm, skin fold thickness of shoulder spleen and skin fold thickness of abdomen. They are measured by skin fold calipers [7]. They are also important indexes to judge whether the whole body fat content is reasonable and whether the subcutaneous fat is normal. The bust index is to judge body shape by bust, which is similar to BMI index [8]. Because there is a positive correlation between bust and height, the bust of people with different height can't be directly compared. The height is introduced for conversion, and the conversion equation is as follows:

$$l' = \frac{l}{X} \times 100 \tag{2}$$

where l' represents the bust size of human body. l represents the bust. The calculation ideas and methods of waistline index and hipline index are similar to bust index. The step index is calculated by the duration of step test of monitored object and the pulse at 1, 2 and 3 min after the step test. The equation is shown as follows:

$$\alpha = \frac{\left(h \times 100\right)}{\left(2 \times g\right)} \tag{3}$$

where α is the step index. h is the duration of step motion. g is the sum of three pulse measurements. Eq. (3) is an important index reflecting the cardiovascular function of human body. The bigger the index value is, the better the cardiovascular function is. Twenty-one indexes are measured [9], but each index can only evaluate one aspect of body constitution. If the index is used to measure the overall level of body constitution, it only takes a part for the whole, so it's necessary to integrate all indicators to construct comprehensive physical indicators according to the weight of comprehensive constitution level [10].

2.1.2. Influencing factors of physical fitness index

The factors influencing the level of body constitution are complex, including congenital heredity and acquired factors, but the congenital heredity factors are often fixed and unchangeable, so we mainly build the model of hypothesis analysis for the factors of acquired environment [11]. We analyze the information of education level, transportation mode, leisure activities and physical exercises, so as to explain and select the influencing factors.

Many practices and researches have proved that physical exercise can effectively improve the body constitution and reduce the modern civilization disease caused by various factors [12]. The physical exercise, traffic mode and leisure activities are included in model of body constitution parameter. The equation is shown as follows:

$$W = \left\{ \alpha + l' + \left(\frac{T}{X} \right) \right\} \times \beta \tag{4}$$

where β denotes the parameter affecting people's physique. From the hypothesis of physical fitness parameter model, this article analyzes the system of physical fitness parameters and influencing factors, which lays the foundation for subsequent identification and correction for the model of physical fitness parameters hypothesis, so as to build the final model of human motion target parameter change.

2.2. Calculation of weight coefficient of physical fitness index

On the basis of establishing the body mass index system, we compare the indexes and give the scores. And then, we establish the judgment matrix by scores, so as to calculate the weight of each index and test its consistency by the reliability of parameters and body mass index. Moreover, we calculate the combined weight and analyze the constituent elements of physique and health and the difference of morphological growth [13]. The highly significant relationship between the number of family children and height can be obtained. Thus, we complete the calculation of weight coefficient of physical index [14].

After the comparison of indexes, the scores are obtained. According to the scores, the judgment matrix is established and the weight of each index is calculated. The approximate weight is:

$$\bar{W}_i = m\sqrt{a_{i1}a_{i2}\ldots a_{ij}} \tag{5}$$

where a_{i1}, a_{i2}, …, a_{ij} represents the importance scale of physical quality in m-dimensional space of data. The approximate weight of each index is normalized by the following equation:

$$W_i = \frac{\bar{W}_i}{\sum_{i=1}^{m}\bar{W}_i} \tag{6}$$

Check the consistency of Eq. (6) as follows:

$$\text{CI} = \frac{\lambda_{\max} - m}{m-1} - \lambda_i \tag{7}$$

where $\lambda_{\max}$ denotes the reliability of body constitution parameters. $\lambda_i(I = 1, 2, \ldots, j)$ denotes body mass index. The combined weight of body constitution indicators is calculated. The combined weight is the coefficient obtained by multiplying the weight of body constitution indicators in different layers [15]. By using the reliability of body constitution parameters and body mass index, the components of physical health and the differences of growth are analyzed.

2.3. Model of parameter change of human motion target based on bionic blade of marine plant

Based on the establishment of index system of human movement and the calculation of weight, the changes of physical fitness parameters are analyzed. The tissue structure of leaves of marine plants is another important factor that determines the reflection spectrum properties in addition to the material composition. The loose and porous structure of mesophyll tissue is an important reason why the leaves have the reflectance spectral characteristics of "red edge" and "near-infrared plateau". The bionic method of marine plant blade is used to test the original data of physical fitness parameters and remove the abnormal data. If the risk rate of data error is S, when $S = 0.06$, the corresponding normality is calculated, and the equation is shown as follows:

$$D = \frac{\left|\bar{X}' - X'\right|}{S} \tag{8}$$

where $\bar{X}'$ and X' are the suspicious data in physical fitness parameters. The factor analysis for physical fitness parameter is to select a few comprehensive parameters from multiple physical parameters, so as to achieve the data simplification. When analyzing and dealing with the problem of physical fitness parameters, parameters are often closely related, which makes the information reflected by observation data overlapped. Therefore, it is necessary to find out less comprehensive physical fitness parameters which are not related to each other, so as to reflect the information of original parameters as much as possible. These unobservable comprehensive parameters are called public factors or potential factors of physical fitness.

The best integration and simplification of plane data of multiple physique parameters is to reduce the dimension of high-dimensional physique parameters space after ensuring the least loss of data information. The matrix of relation number of people's physique indexes is built, and the matrix is expressed as:

$$R = [Ri'j] \tag{9}$$

where i' and j are the relationship coefficients of physique indexes. The main factor K is selected to calculate the factor load matrix or factor matrix. The equation is shown as follows:

$$A = [b_{\gamma\theta}]_{T\times K} \tag{10}$$

where $b_{\gamma\theta} = u_{\gamma\theta}$ denotes the feature value of physique parameters, $\gamma = 1, 2, 3 \ldots, T$, $\theta = 1, 2, 3, \ldots, K$. In the bionics of blade of marine plants, the first work of studying the structure and function of system is to analyze the relationship between various factors and find out the main characteristics and relationships of system, and thus to provide the necessary basis for the analysis and research. The basic idea of analyzing the correlation degree of physique parameters is to judge the correlation degree of parameters by the similarity degree of data series curves. In other words, the more similar the curve shape is, the greater the correlation degree is. Otherwise, the more similar the curve shape is, the smaller the correlation degree is. Taking physique parameters as the generating function and taking the indicators of special physical fitness as the sub function, we analyze the correlation degree and take average for the original data. The expression is:

$$X'\gamma = \frac{X'_0(K)}{X'_n} \tag{11}$$

where X'_0 denotes the generating function. X'_n denotes the sub-function of physical fitness index. X'_0 is the reference sequence. X'_0 is the comparison sequence. The absolute difference is calculated. The equation is:

$$\Delta_{\gamma(K)} = \left|X'_0(K) - X'_n(K)\right| \tag{12}$$

From Eq. (16), we can substitute Δmin and Δmax into the following formula to get $\Sigma^0{}_{\gamma(K)}$:

$$\sum 0_{\gamma(K)} = \frac{\Delta\min + S\Delta\max}{\Delta_{\gamma(K)} + S\Delta\max} \tag{13}$$

The equation for calculating the degree of association is:

$$r0_{\gamma(K)} = \frac{1}{T}\sum_{K=1}^{n}\varepsilon 0_{\gamma(K)} \tag{14}$$

ε represents the resolution coefficient of physique parameters.

By calculating the relationship matrix and factor matrix of physique indexes, the model of parameter change of human body motion target of bionic leaves of marine plants is built. The expression is shown as follows:

$$Y = B_1 + B_2 + B_3 + B_4 + B_5 + B_6 + B_7 \quad (15)$$

Respectively, B_1, B_2, B_3, B_4, B_5, B_6, and B_7 represent the standing start, rope skipping, standing broad jump, running, bench press, jump from standing position and somersault in the model of physical health parameters change. The change model of movement target parameters reflects people's physical quality. The higher the score, the better the physical quality.

3. Results

For the rationality and feasibility of design for camouflage model of bionic motion target of marine plant leaf, the principal verification experiment was carried out. The basic method is to test the reflection spectrum of paper after combining with PVC transparent film with rough surface, PVA film with chlorophyll, PVDC bag with water. Its marine plants are shown in Fig. 1.

The proposed method is widely adopted. According to different body constitution parameters, we can calculate body constitution indicators and physical factors to analyze the changes of physical parameters model. In order to verify the effectiveness of the proposed method, the computer with 3 G CPU, Windows XP and MATLAB was adopted for experiment. 15 experts and 120 students were selected to send out questionnaires. Firstly, the evaluation of physical health for experts and students was investigated. Through the feedback of questionnaire information, the mathematical statistical analysis is shown in Table 1.

From Table 1 we can see that the overall satisfaction of experts and students for current evaluation of physical health is not high, which is mainly concentrated in dissatisfaction. Ten experts have expressed dissatisfaction for current monitoring and evaluation of students' physical health. In addition, no expert is very satisfied with the current evaluation of physical health. Only ten students are very satisfied with evaluation of physical health. Forty respondents are very dissatisfied.

Fig. 1. Schematic diagram of marine plants.

On this basis, take Chinese teenagers as an example to analyze the weight gain of adolescents in and out of school. The age range is between 14–19 y old, and the weight gain is between 2–14 g. Observe the weight change of two kinds of adolescents, as shown in Fig. 2.

It can be seen from Fig. 2 that the weight gain of teenagers in school is moderate, while the weight gain of teenagers out of school is very small, which indicates that the regular working and rest time of teenagers in school has good living habits, so their physical quality is good. Adolescence is a stage of long body, so good education and work and rest time are very important, will affect the physical quality of young people. After the analysis of the growth of height and weight of teenagers, analyze the vital capacity (ML) of teenagers, as shown in Table 2.

Table 2 shows that the lung capacity of 14-y-old boys is 45 mL higher than that of 14-y-old girls. The lung capacity of 15-y-old boys is 60 mL higher than that of 15-y-old girls. The lung capacity of 16-y-old boys is 170 mL higher than

Table 1
Evaluation survey on people's physical health by experts and students

Evaluation of physical health	Students	Experts
Very satisfied	10	0
Satisfied	25	2
Unsatisfied	75	10
Very unsatisfied	40	3

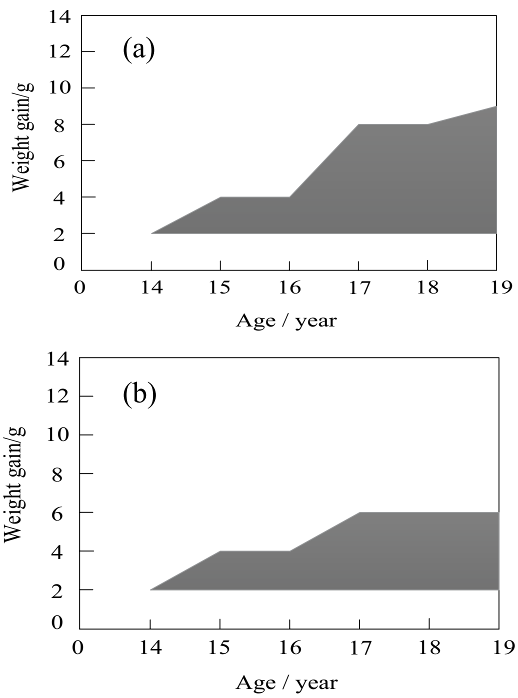

Fig. 2. (a) Height and (b) weight changes of adolescents in and outside of school.

Table 2
Comparison of vital capacity between boys and girls in adolescents

Age	Boy	Girl	Difference value
14	3,800	3,755	45
15	3,860	3,800	60
16	3,990	3,820	170
17	4,120	3,900	220
18	4,285	4,128	157
19	4,365	4,210	155

that of 16-y-old girls. The lung capacity of 18-y-old boys is 157 mL higher than that of 18-y-old girls. The lung capacity of 19-y-old boys is 155 mL higher than that of 19-y-old girls. The difference of vital capacity between boys and girls is obvious. The vital capacity reflects the volume of lung and the expansion ability of lung. It is an important index to judge the strength of respiratory function. Meanwhile, it is also a common functional index to evaluate the growth and development level and physical condition of adolescents. Thus, the spectral reflection characteristics are basically consistent with the vegetation background, and the effective countermeasure to hyperspectral detection is realized. The key technology of artificial military camouflage against hyperspectral detection is to prepare a new type of green camouflage material with porous matrix, rich water and plant pigment. These will bring great changes to the field of camouflage.

4. Conclusions

Based on the bionics of leaves of marine plants, the camouflage model of parameter change of human motion object was studied in depth. Then, the model was analyzed by physical fitness indicators of teenagers.

The bionic camouflage material of plant has unique structural characteristic and material composition. On the basis of its optical camouflage function, its bionic activity (transpiration) was improved. Introducing nano conductive material or nano absorbing material can increase the matching camouflage ability of ultraviolet/visible/near-infrared spectrum, unique thermal infrared shielding ability, electromagnetic shielding ability and radar wave stealth ability. If it can be combined with other camouflage materials such simulation soil, rocks into camouflage equipments, the wide-band and integrated camouflage will be realized, and the camouflage ability of human motion target in complex environment will be comprehensively improved.

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