Wearable Sensor and Its Application in Urban Landscape Design

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In order to meet the needs of people for the environment, physical, and psychological needs and to improve the characteristics of local areas, this paper proposes an urban environment measurement method based on wearable sensors. This method mainly relies on previous questionnaires and tests the wearable sensor physiological data, subjective feelings, scoring tables, interviews, and other experimental methods in the psychological experimental environment. The recognition rate without adding association features was 93.3%, while the recognition rate of adding association features to individual test set verification reached 94.1%, an increase of about 1%. In this paper, naive Bayes and associated feature classification are used to effectively solve the influence of personal subjective factors and make up for the error of measurement data. The wearable sensor can achieve better results in the application of urban environmental measurement and can also be better applied in urban environmental landscape design, providing more effective data for urban landscape design.

1. Introduction

The rapid development of the socialization process has brought a series of problems, such as the deterioration of the ecological environment and urban pollution, people’s health has also been threatened, and psychological diseases and chronic diseases threaten mankind. It has become an urgent need for urban construction to implement public health into the landscape design of colleges and universities. Different regions and climates have different effects on life comfort, mental health feeling, outdoor participation, and environmental accessibility. People’s environmental feelings bring different audition feelings with climate change, temperature change, and seasonal change. Compared with other cities and regions, a certain region has higher latitude and cold climate [1].

The research shows that people in high-pressure environment are more likely to suffer from psychological diseases. The campus landscape should not only meet the physiological needs but also pay more attention to the psychological needs. With the improvement of the demand for the learning and living environment, the campus landscape design begins to pay more attention to the satisfaction of the space environment to the human spiritual needs.

Through the study of the campus landscape environment in a certain area, it is urgent to create a good campus landscape environment that combines the characteristics of a certain area, has a comfortable learning and living environment, has both campus culture, and adds luster to the city image. Starting from the feelings of campus landscape users, this paper studies the campus environment of colleges and universities in the area, analyzes the existing landscape problems of colleges and universities in the area, and provides certain reference significance for the landscape design of colleges and universities in a certain area in the future [2]. The workflow of sensation, perception, and cognition system is shown in Figure 1.

2. Literature Review

According to this problem, Raj and others can monitor skin sweating, skin temperature sensor for skin temperature regulation, ECG sensor for cardiovascular activity, EEG sensor for brain activity, respiratory sensor for respiratory activity, etc. [3]. Regulated by the hypothalamus, sympathetic nerve, parasympathetic nerve, and other nervous systems, emotional experience will show a series of physiological reactions. These physiological responses can form millisecond
responses to environmental stimuli, even including subdomain perception that is not fully conscious, and these physiological responses can be measured by biosensors more accurately and quickly. Ejaz-Ul-Haq and others used wearable devices to collect neurobioelectric reactions, so as to observe and record real-time environmental experience, which is a new technology for comprehensive environmental experience evaluation. Some pioneer scholars used skin and EEG technology to measure the experience during walking, identify emotional stressors, and analyze and evaluate the impact of the environment on people’s emotional experience and cognitive function [4]. Li and others collected the skin electrical response of pedestrians during walking in the real environment to analyze and identify the potential pressure in the traveling space. The skin electricity or skin resistance records the conductive characteristics of the skin. Because the skin electricity is affected by the sweat secretion of the skin, it is a physiological indicator that better reflects the emotional pressure [5]. Liu and others used real-time picoelectric data to identify potential space environmental pressure sources through synchronous analysis with space GPS data [6]. Korolkov and others found that when entering the natural environment with better greening from the urban block, pedestrians showed more calm mood, less frustration, anxiety, and active attention and showed more meditative thinking activities. This restorative receptivity caused by natural environment is in good agreement with the restorative nature theory of environmental psychologists [7]. Kpülü and others collected EEG data of walkers during real walking by using a portable EEG instrument with 14 electrodes and processed and analyzed their EEG data [8]. Compared with the EEG, the signal-to-noise ratio of EEG data is worse, but the data information that can be mined is much richer. In the experiment, the subjects wearing portable EEG walked through shopping blocks, green and natural areas, and busy commercial areas. The researcher used the EEG emotion analysis module based on machine learning developed by the instrument developer to analyze the collected EEG data and try to understand the pedestrian’s environmental experience at that time. In the current research on sensor-based behavior recognition, there are many types of sensors used to obtain behavior data, and the motion information obtained by different types of sensors is obviously different. There is no unified standard, and everyone just verifies unilaterally, which cannot guarantee the scalability of the proposed method.

To solve the above problems, an effective association feature is proposed. At present, the features used in wearable sensor behavior recognition are mainly time-frequency domain features such as mean, variance, standard deviation, and spectrum, which are commonly used in digital signal processing. Sensor-based behavior recognition is a new field, which is still in the stage of rapid development. Many theoretical knowledge is used in similar fields. Due to the lack of targeted features, the paper proposes the correlation feature experiment according to the correlation between sensor data at different positions during human movement [9, 10]. The results show that this feature can effectively improve the efficiency of behavior recognition and improve the scalability of the method.

3. Method

3.1. Landscape Applicable Population. The applicable groups of urban landscape around colleges and universities include students, faculty members, dormitories, and family members of faculty members. However, the behavior and activities of faculty members, dormitories, and family members of faculty members are relatively single, and the proportion of the number of people is relatively small compared with that of students, so they have little impact on the landscape design of colleges and universities [11, 12]. Therefore, the subjects of the study and test are mainly college students. The reasons are as follows: the campus landscape mainly serves the students, whose study, life, and daily activities are closely related to the campus landscape; college students have obvious aesthetic consciousness and communication needs; college students’ behavior and environment interact with each other.

In this study, the preliminary questionnaire, E-Prime psychology experiment, wearable sensor physiological data measurement in real environment, subjective feeling rating scale, interview, and other experimental methods were used to analyze the measurement results, combined with the deviation distribution analysis method and the corresponding analysis and statistics method. Firstly, through the previous questionnaire survey, the landscape status and use preferences of three universities, namely, a technical university, a Forestry University, and a university, were determined, and the measured landscape spatial nodes of three universities were selected, respectively. Then, standardized tests are conducted through E-Prime psychological experiments to determine the physiological data under standard emotions. Then, wearable sensors are used for real-world measurement, and later landscape nodes are scored and interviewed. Finally, deviation distribution analysis and corresponding analysis statistics are used to analyze the real-world physiological data and subjective evaluation [12, 13]. Through the comparative analysis of objective physiological data measurement and subjective and objective evaluation of wearable
sensors in the whole stage, the emotional feelings under the campus landscape of colleges and universities, and the differences of individuals’ feelings towards the landscape are obtained. Based on this, the optimization strategies for the built landscape of colleges and universities and the future campus construction are carried out.

3.2. Field Investigation. Preliminary field investigation through the preliminary field investigation of a technical university, a Forestry University, and a university, a preliminary understanding of the current situation of the built campus landscape to be studied has been formed, and the existing behavior and use preference of users have been mastered through field observation. Based on the theoretical basis of the interaction between environment and behavior, and based on the environmental feelings, detailed observation and investigation are carried out from two aspects: subjective factors and objective factors. Integrate and summarize and take photo records and field measurements as the preparation basis of the later questionnaire survey.

Based on the previous theoretical guidance and real scene investigation, this paper discusses the influencing factors of university landscape, designs a questionnaire, and finally, determines the content of the questionnaire after many comparisons, corrections, and adjustments.

The questionnaire is divided into four parts:

(1) Research on the basic situation of university campus landscape users, including gender, age, major, grade, and other basic situations

(2) The investigation of campus landscape space activities, needs, preferences, and initial evaluation

(3) Investigation on the evaluation factors of landscape environment in colleges and universities

(4) Expectations and suggestions for the campus

The questionnaire is distributed in paper form and collected on the spot to ensure the effectiveness of the questionnaire. Real-time communication and effective records are achieved during the survey. After the questionnaire is collected, a second check will be carried out to locate the incomplete questionnaires and those that do not meet the survey scope as invalid questionnaires, so as to ensure the authenticity and reliability of the questionnaire information. The preliminary investigation stage will be conducted in August 2020, and the questionnaire will be distributed in July 2020 and July 2021 [14, 15].

The number and recovery of questionnaires from the three schools are as follows: a total of 300 questionnaires were distributed by the three universities, and 293 were recovered, with a recovery rate of 97.67%. Except for invalid questionnaires, there were 289 valid questionnaires, with a total effective rate of 98.63%. The effective rates of the questionnaires were more than 75%, which was consistent with the scientificity of the questionnaire survey.

Since emotion is difficult to measure and no standard can be established, the psychological E-Prime program is used to conduct the experiment of “arrangement and presentation of experimental stimuli,” and the Chinese emotion system video is used to conduct the emotional stimulus experiment. At the same time, wearable sensors are used to record heart rate, skin electricity, blood oxygen, EEG, mental stress, fatigue index, cardiac compressive capacity, autonomic nerve balance, and other related physiological data. The measured standardized emotional physiological data are analyzed for similarity and correlation with the emotional physiological data in the real scene to determine the objective landscape evaluation of colleges and universities, as shown in Figure 2.

In the perceptual restorative scale in order to more accurately reflect the actual feeling of each campus space and facilitate the analysis and comparison with objective physiological data, a 1-5-level segmented quantitative description is set, 1 (none at all), 2 (relatively few), 3 (general), 4 (relatively many), and 5 (very many).

Corresponding to PRS question: I can have a good rest in this place. This place makes me feel interesting. I want to stay a little longer and have a look. There is some confusion here, which distracts me. I can do anything here. I enjoy it very much. I feel like I belong here to score. Combined with the real scene interview and evaluation score results, this paper summarizes the use evaluation and landscape preference of university campus landscape.

KMO (Kaiser-Meyer-Olkin) and Bartlett spherical tests were used in this experiment, and Table 1 was obtained through SPSS monitoring. It is concluded from the table that KMO statistic is 0.972 > 0.8, P < 0.05. The closer the appropriate amount of KMO sampling is to 1, the stronger the validity of the questionnaire. KMO and Bartlett spherical tests are shown in Table 1.

3.3. Reliability Analysis. According to Table 2, Cronbach’s $\alpha > 0.7$, showing a positive correlation, and the questionnaire has a strong correlation. The correlation statistics are shown in Table 2.

To sum up, the questionnaire in the experiment was input into SPSS for analysis and presented visually in the form of charts. The validity and reliability of the questionnaire are in line with the requirements of the questionnaire, indicating that the questionnaire has accuracy and relevance.

(1) Plant seasonal evaluation

At present, among the existing seasonal landscape of plants in colleges and universities, a university has the highest evaluation. The campus of a university has good greening and rich vegetation. Among the surveyed people, 56% think that a university has flowers in the seasons, the seasons are always green, and the seasonal landscape is good, 41% think that it is average, and the remaining 3% think that the seasonal change is not obvious. The university with the lowest evaluation is a technical university. Although the campus area of a technical university is large, the landscape environment space of the university is relatively small. 73% of the people think that the seasonal landscape is average, 19% of the people hold a good attitude towards the seasonal
landscape, and the remaining 8% think that the seasonal change is not obvious. In a forestry university, 41% of the respondents thought that the season was good, 54% thought that the season changed generally, and the remaining 5% thought that the change was not obvious. In the three schools as a whole, 55.67% of the respondents thought that the seasonal changes of campus landscape were average, 39% thought highly of them, and the remaining 5.33% thought that the seasonal changes of campus landscape were not obvious. In the landscape design of colleges and universities, the creation of seasonal landscape can enrich the landscape space, and the space created with seasonal landscape has more atmosphere.

(2) Evaluation of shade degree of plants

Among the three universities, only 5% of the respondents from a university think that the shading effect is very good, while the other two universities, a technical university and a forestry university, think that the shading effect is very good. On the whole, a university has a high degree of shading evaluation, and the school with the lowest degree of evaluation is a technical university. In general, 45% and 41.66% of the respondents, respectively, believe that the campus landscape has a small amount of shade and a part of shade. The shade degree of the campus landscape in summer affects the feeling of landscape use. In a certain area, the sun is strong in summer, and reasonable shade can meet the site activities of the landscape space, affecting the use preference, frequency, and frequency [16, 17].

There are many kinds of plants in a university; a technical university has the least plant species and the least richness. 43% of the respondents in a technical university think that a technical university has more plants and fewer species. Clove is the main tree species in the campus of a technical university, supplemented by other poplar and willow trees; 26% of the respondents of a forestry university think that a forestry university has a small number of plants and a large number of species, which is deeply related to the fact that a forestry university is an agricultural and forestry university. There are several teaching and learning parks in the Donglin campus, which are rich in plant species for plant identification and investigation. In general, 43% of the respondents believed that the three universities had a large number of plants and a variety of species, and 26.67% of the respondents believed that there were a large number of plants and a few species. According to the comprehensive analysis of the three universities, the university with the best plant construction and the highest evaluation is a university. In terms of plant season, plant species, and shading degree, the existing plant landscape of a university is reasonably constructed and feels good.

After comprehensive consideration, 9 people were selected, including 4 boys, 5 girls, 5 design related majors, and 4 nondesign-related majors. From July 10, 2019, to August 12, 2019, real-life physiological data monitoring experiments of wearable sensors were carried out in the selected landscape spaces of a technical university, a forestry university, and a university. Through E-Prime in the early stage, subjectivePRS scoring and real scene interview records in the later stage, the landscape environment of the university campus is comprehensively described.

3.4. E-Prime Standardization Experiment. As it is difficult to formulate the standardization of feelings and emotions, the E-Prime program of psychology is used to form a stimulation test. Physiological data are recorded when watching the standardized emotional video, and each experimental video is scored with a pleasure degree of 1-7 points. 1 means none at all, 4 means medium, and 7 means very strong, as shown in Figure 3. After the experiment, the similarity analysis between the measured data of the standardized experiment and the measured data in the real scene is carried out to determine the emotional state in the real scene environment. The final results of the landscape environment evaluation experiment are analyzed together with subjective evaluation and objective measurement. The pleasure level options are shown in Figure 3.

The deviation distribution between the actual measurement data collected in the whole experiment and the standard experiment measurement data is analyzed, and the resulting quartile bitmap compares the data information from two aspects: the smaller the median deviation is, the closer it is to the standard experiment; the more concentrated the distribution is, the closer it is to the standard experiment. Take the no. 1 experimenter as an example to draw the following conclusions. Next, take the no. 1 experimenter as an example to analyze the measurement process of his objective physiological data. In the five experimental spaces of a university, the Grove (space 2) is close to positive emotion, and the playground (space 1), library (space 5), small pool (space 3), and Yanyuan (space 4) are close to neutral emotion.

The wearable sensor experiment can analyze the university landscape space that is closest to the standard experimental mood in the real landscape environment. The experiment is carried out in the real landscape environment,
which is affected by uncertain factors, resulting in some errors in the measurement results. It needs to be analyzed in combination with subjective preferences to improve the accuracy of the evaluation of the university landscape environment space feeling.

3.5. Naïve Bayesian Method. Naïve Bayesian model is one of the most widely used classification models. The Bayesian theory proposed many years ago is the solid mathematical foundation of the model. Bayesian model has the advantages of stable classification efficiency, few parameters, insensitive to missing data, and simple and fast algorithm. The algorithm is based on probability and assumes that each attribute is independent. Its classification principle is to obtain the postexperiment probability by using Bayesian theorem according to the prior probability of the object and select the category with the largest postexperiment probability as the classification result. However, in practice, it is difficult to ensure that attributes are independent of each other. When the correlation between the attributes is large, the classification efficiency of the model is poor. Only when the attribute correlation is small, the model can perform well.

The working process of naïve Bayesian classification is as follows:

(a) Let \( X = \{x_1, x_2, \ldots, x_n\} \) be an item to be classified, and each is a characteristic attribute of \( X \)

(b) There are \( m \) categories in total, forming a category set. \( C = \{c_1, c_2, \ldots, c_m\} \) gives an unknown data

Sample \( X \): the classification method will predict the class with the highest a posteriori probability, that is, naïve Bayes classification will assign the sample data without class label to the class if and only if

\[
P(c_i | X) > P(c_j | X) \quad 1 \leq j \leq m \# i. \tag{1}
\]

Formula (2) can be obtained according to Bayesian theorem:

\[
P(c_i | X) = \frac{P(X | c_i)P(c_i)}{P(X)}. \tag{2}
\]

Given a dataset with many attributes, the calculation cost is large. In order to reduce the calculation cost, the attributes are assumed to be independent. Given the sample label, assuming that the attribute value conditions are independent of each other, that is, there is no dependency between attributes, formula (3) can be obtained:

\[
P(X | c_i)P(c_i) = P(x_1 | c_i)P(x_2 | c_i) \cdots P(x_n | c_i) = P(c_i) \prod_{j=1}^{n} P(x_j | c_i). \tag{3}
\]

Among them, \( P(x_1 | c_i)c_p(x_2 | c_i) \cdots P(x_n | c_i) \) can be estimated by training samples.

Considering the advantages of naïve Bayes classification method, such as easy implementation, stable classification efficiency, and fast execution speed, this method is added to the experimental performance evaluation.

4. Results and Analysis

This chapter conducts research in combination with the landscape environment, analyzes the existing problems through the questionnaire, and concludes that the existing urban university campus environment is a dynamic process. The quality of an environmental space is not a single evaluation, but a time-varying process determined by the influencing factors [18, 19]. Regional characteristics make the urban campus landscape inherit the historical foundation of local context. Using the test method in Section 3, each time, select volunteer data as the test set and other volunteers as the training set, and carry out individual independent leave one verification. As shown in Table 3, the behavior recognition rate is 94.1%, which is about 1% higher than the recognition rate of 93.3% without adding associated features, which verifies the effectiveness of this feature [20].

Generally, researchers prefer to make one-time feature selection for the stored data, that is, all the data used for recognition are stored in one feature quantity, but the feature selection method selects the features. Each feature has a feature weight value. A new feature vector is composed of \( N \) features with large sampling weight and finally transformed into multitask model logarithm, such as classification or recognition. However, this method has two important problems.

First, the direct difference of behavior indexing between sensor data at different locations is not fully considered, that is, the feature weights of feature vectors obtained from sensor node data at the same location are different; second, the traditional method needs to transmit the data of each sensor node to the background data mining processing
not at all  
4 intermediate  
7 very strong  

Figure 3: Pleasure level options.

Table 3: Analysis of objective feelings.

| Test number | A forestry university | A technical university | A university |
|-------------|-----------------------|------------------------|--------------|
| 1           | Spaces 1 and 3 > 4 > 2 and 5 | Space 3 > 2, 4 > 1 | Space 2 > 1, 3, 4, 4 |
| 2           | Space 1 > space 2, space 4, space 5 > space 3 | Space 2 > 1, 3 and 4 | Spaces 2, 3, and 4 > spaces 1 and 5 |
| 3           | Spaces 1 and 4 > 5, 3 > 2 | Space 3 > space 2 > 4, space 1 | Spaces 1, 2 and 4 > 3 > 5 |
| 4           | Space 2 > 1, 3, 4 > 5 | Spaces 1 and 3 > 4 > 2 | Spaces 2 and 4 > 1 > 5 |
| 5           | Space 1 > space 5 > space 2, space 3 and 4 | Space 2 > 4 > 1 | Space 3 > 1, 2 > 4 > 5 |
| 6           | Spaces 3, 4 and 5 > 1 > 2 | Spaces 2, 3 and 4 > 1 | Spaces 1, 3 and 4 > spaces 2 and 5 |
| 7           | Space 1 > 2, 3 > 4 > 5 | Space 4 > 3 > 2 | Spaces 2 and 3 > 5 > 1 and 4 |
| 8           | Spaces 3 and 4 > 1 > 2 and 5 | Space 1 > 2 > 3 > 4 | Spaces 4 and 5 > 3 > 1 and 2 |
| 9           | Spaces 1, 2, 4 and 5 > 3, | Space 4 > 2 > 3 > 1 | Space 3 > space 2 > space 1, 4 and 5 |

5. Conclusion

In this paper, the author proposes a correlation method, which measures the changes of each person’s psychological situation and personal feelings at individual different positions through sensors. Specifically, it is expressed by the change of heartbeat emotion and the questionnaire. According to the results of the observation questionnaire and the calculation of naive Bayes formula, we can draw a conclusion: the factors of urban environment have a great impact on individual psychology and physiological behavior. Therefore, we can use wearable sensors in urban landscape design to carry out portable measurement of the impact of the surrounding environment on us, so that we can timely transform the surrounding urban environment, meet our needs for learning and living environment, and meet the spiritual needs of human beings, and improve the different requirements of different regions, different climates, and different people for life comfort, mental health feelings, outdoor participation environment, etc.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

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