Study on Consumer Acceptance Evaluation Model of Ceramic Tea Set Based on Facial Emotion Recognition Technology

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Abstract—The purpose of this study is to explore a consumer acceptance evaluation model of ceramic tea sets based on facial emotion recognition and machine learning. Through the evaluation experiment of ceramic tea sets, we obtained the facial expression pictures of participants when observing tea sets and the questionnaire data of Self-assessment Manikin (SAM). Then the Microsoft facial emotion recognition API (Microsoft azure) was used to calculate the facial expressions of participants and form a data set of facial emotion characteristic variables. Finally, the models of consumer acceptance recognition were built by using random forest (RF) and neural network (NN) classifier. The results show that: 1) the accuracy of emotion value recognition using RF classifier was 82.26% and that of arousal is 74.7%. These two results are better than the model built by the NN classifier. This shows that the RF classifier model can meet the market acceptance evaluation of ceramic tea sets in practice, and contribute to the design and development of ceramic tea sets. 2) The participants in this experiment have a higher acceptance of delicate, shiny, and beautiful tea sets, while they gave a lower score for tea sets with primitive and crude style, rough texture, and heavy shape, which also confirms the general aesthetic taste of young people.

Keywords-ceramic tea sets, facial emotion recognition, classifiers, machine learning, features of tea sets

1 INTRODUCTION

Chinese tea culture has a long history. At present, tea drinking is popular, the market competition of ceramic tea sets is becoming more and more fierce. New products continue to

appear in the market, and the categories are also diverse. The ceramic tea set is not only a commodity with a useful function but also a decorative art with an aesthetic function. No matter the designer, producer, or operator of the tea set, they all hope to master the consumption orientation. Because consumers' evaluation of products is multifaceted, and it is difficult to obtain reliable evaluation results from a single aspect or several aspects of analysis. Therefore, this study comprehensively evaluates the psychological response to ceramic tea sets with the help of users' emotions. Compared with the questionnaire, it can obtain the information of people's emotional changes more objectively.

In the market, the questionnaire is generally used to obtain consumers' evaluation of these two aspects. However, this method has limited data and is not easy to operate. In this study, a ceramic tea set evaluation model based on facial emotion recognition and machine learning technology was established, which can support designers, producers, and operators to easily obtain consumers' acceptance of a ceramic tea set.

2 RELATED STUDIES

In recent years, some scholars evaluated consumers' satisfaction with products from consumers' perception. For example, M. S. Sohail analyzes the country-of-origin effect of products made in China through Malaysian consumers' evaluation of specific product dimensions [1]; Förster J. studied how physical feedback affected consumers' evaluation of products [2]. In addition, some scholars used the SD method to analyze consumers' acceptance of art products based on consumers' psychological needs and personal taste [3-6]. At the same time, some scholars conducted relevant research by using experimental methods, such as eye movement technology and convolutional neural network [7], but the research technology and results are still in a relatively preliminary stage, and only the introduction of experimental methods, and few results can be used in practice.

At present, there are relatively few studies on the consumer acceptance of tea set products by using facial emotion recognition [8, 9]. Based on previous studies, through quantitative and qualitative research methods, this study used the experimental method of facial emotion recognition to analyze the reasons for the differences in users' acceptance of ceramic tea set products, to construct the evaluation system model of consumers' acceptance of ceramic products, and reduce the errors caused by consumers' preference for product perceived attributes and individual differences, and finally improve the accuracy of evaluation results.

3 METHOD

3.1 Data acquisition

1) Tea set selection

On the online shopping network https://www.jd.com/, we selected ten ceramic tea sets. These tea sets belong to different price ranges, including five in the range of 50RMB-200RMB, five in the range of 201 RMB to 800 RMB, five in the range of 801 RMB to 1500 RMB, and five

above 1500RMB. The purpose of selecting samples in this way is to ensure the balance of sample distribution. At the same time, we randomly arrange the pictures of these tea sets to avoid arranging tea sets with similar styles and regions together, to improve the accuracy of the experiment. The twenty tea sets selected are shown in Table 1.

Table 1 Twenty ceramic tea sets selected

O1	O2	O3	O4	O5
O6	O6	O8	O9	O10
O11	O12	O13	O14	O15
O16	O17	O18	O19	O20

2) Experiment

The participants were randomly selected 20 graduate students, with an average age of 24.7 years. The experiment was conducted in an undisturbed laboratory. Each participant sat in front of the experimental table. A picture of the ceramic tea set appeared on the computer screen on the table every three seconds. Each picture stayed for five seconds. In the middle of these five seconds, a high-definition camera was used to take a picture of the participant's face. The participants browsed all 20 tea set photos in this way (Figre 1). Then, participants immediately filled in the SAM scale concerning the pictures in the browsing order just now. So, we got 20 * 20 = 400 face photos (Figure 2) and the user's emotional valence and arousal for each ceramic tea set.
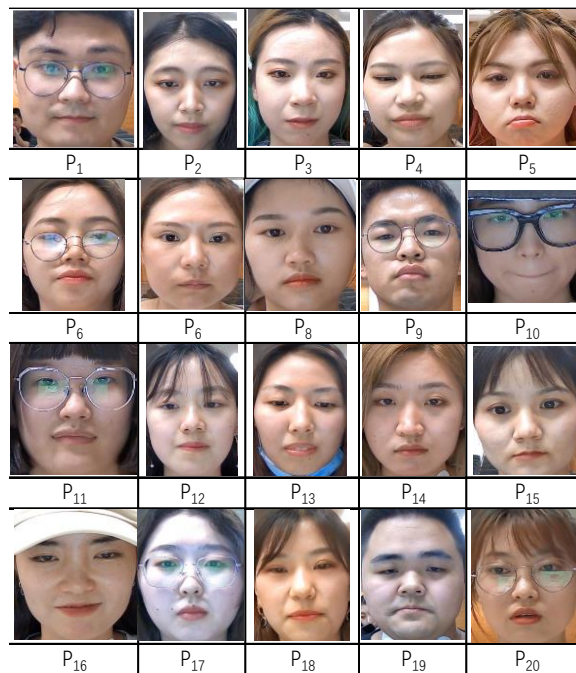
Figure 1 Experimental data acquisition

Figure 2 Facial expressions of 20 participants in the experiment

3.2 Data analysis

1) Facial emotion recognition

Firstly, the participants' face images were screened. We deleted the unclear photos and the photos with the participants' eyes closed. At the same time, to classify emotional valence and

arousal, the samples of "valence = 0" and "arousal = 0" in the SAM scale were deleted. Finally, 206 valid photos were obtained.

We use Microsoft facial emotion recognition API (Microsoft azure) to classify facial emotions. Microsoft Azure uses face rectangular coordinates to collect 26 facial feature points and output the proportion of eight emotions: happiness, sadness, surprise, anger, fear, contempt, disgust, and neutral. Then, the SAM questionnaire filled in by the participants was counted to obtain the value and arousal value of each participant's emotional response to each tea set photo.

2) Tea set feature extraction

According to the photos of each ceramic tea set, we extracted the basic features of the tea set, and describe its features with seven pairs of antisense adjectives. By counting the characteristics of each tea set, we obtained the characteristic data sets of all ceramic tea sets.

3) Building evaluation model

Taking the emotional valence and arousal of each participant to each tea set as the target variable, and the facial emotion recognition and tea set characteristics of the participants as the independent variables, the emotion evaluation model was established by the SPSS modeler. The model used neural network (NN) and random forest (RF) as classifiers respectively. The established model data flow is shown in Figure 3 below. After running, the model output the evaluation results of the ceramic tea sets based on emotion classification.
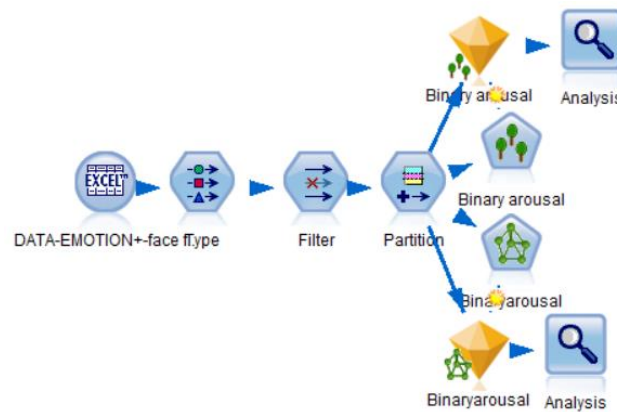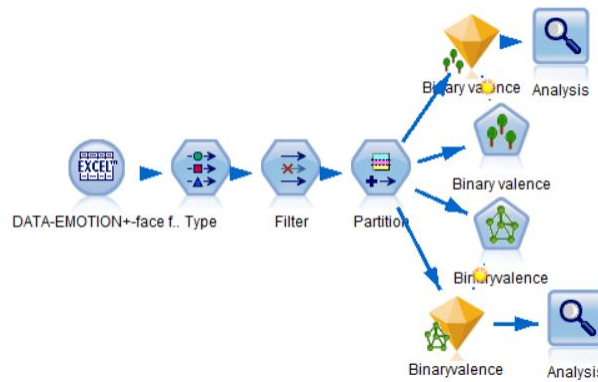
Figure 3 The binary classification model flow for valence and arousal

4 RESULTS

4.1 The accuracy of the models

We divided the data sets of emotional value, facial emotional features, and tea set features into a training set and verification set according to 8:2, and then input them into the SPSS modeler data stream after specified type and filtering. After running, we got the recognition accuracy of the RF classifier model and NN classifier models. The results as shown in Table 2, the accuracy of emotion valence recognition of random forest classifier model is 82.26%, the accuracy of emotion arousal recognition is 74.7%, the accuracy of emotion valence recognition of neural network classifier model is 70.97%, and the accuracy of emotion arousal recognition is 56.06%.

Table 2 the Recognition accuracy of two classifier models

		RF classifier	**NN classifier**
Recognition Accuracy	Valence	82.26%	70.97%
	Arousal	74.70%	56.06%

4.2 The corresponding relationship between emotion and features

By calculating the average value of 20 participants' emotional value for each tea set, we obtained the average ranking of the emotional value of 20 tea sets in the experiment. The seven characteristics of tea sets were refined to form the corresponding relationship between the mean of valence and characteristics of the top five and the bottom five listed in Table 3.

Table 3 The tea set characteristics with the value ranking in the top 5 and the last 5

Features	Top 5 valence value					Last 5 valence value				
	O_{16}	O_{10}	O_9	O_2	O_{17}	O_3	O_7	O_8	O_{15}	O_{20}
modern (1) / traditional (-1)	-1	-1	-1	-1	1	-1	1	-1	-1	-1
sophisticated (1)/ quaint (-1)	1	1	1	1	1	1	1	-1	-1	-1
shiny (1) / matte (-1)	1	1	1	1	1	1	1	-1	-1	1
smooth (1) / rough (-1)	1	1	1	1	1	1	1	-1	-1	-1
light (1) / heavy (-1)	1	1	1	1	1	1	1	-1	-1	-1
textured (1) / non textured (-1)	1	1	1	-1	-1	1	-1	1	-1	-1
easy to use (1)/ not easy to use (-1)	1	1	1	1	1	1	1	1	-1	1

5 DISCUSSION

1) From the results of the emotion recognition model aiming at emotion value and arousal, the accuracy of emotion value recognition of the RF classifier model is 82.26%, which can meet the requirements of actual tea set evaluation. The recognition accuracy of the NN classifier (70.97%) is relatively low. At the same time, the classification results of arousal degree by the two classifiers cannot meet the actual needs (74.7% and 56.06% respectively). This shows that the ensemble classifier RF is more suitable for the recognition of objects with low complexity. At the same time, the recognition rates of emotional arousal were low because it is difficult for objects such as tea sets to cause strong emotional arousal of participants, resulting in the low correlation between the change of arousal value and the tea set.

2) From the analysis of the correlation between emotional valence and tea set features as shown in Table 3, it can be found that participants have a more pleasant psychological response to refined, shiny, smooth, and light tea sets, that is, they have better acceptance; The other three features, traditional or modern, whether textured, easy or difficult to use, have no direct correlation with an emotional response. This may be related to the age, culture, and background of the participants. Twenty participants are college students, so they are more sensitive to appearance and quality, but less sensitive to the shape and details of tea sets. This result is also consistent with the general aesthetic preferences of contemporary young people.

6 CONCLUSION

This paper takes the acceptability of tea set users as the research content. Through the evaluation experiment of the ceramic tea sets and the application of facial emotion recognition technology, we obtained the facial expression pictures and SAM emotion evaluation questionnaire data of participants during the observation of tea set were obtained, and obtained the data set of facial emotion characteristic variables of participants. Then the random forest and neural network classifiers are used to establish consumer acceptance recognition models respectively. Finally, the model established by the random forest classifier is superior to that established by the neural network classifier. At the same time, it was found that participants had a higher degree of acceptance for the tea set products with fine texture, luster, and

beautiful shape, while they had a lower score for the tea set products with a dull appearance, rough texture, and thick shape. The results show that the random forest classifier model can meet the market acceptance evaluation of ceramic tea sets in practice, and contribute to the design and development of ceramic tea set products. In addition, as the participants in the experiment were postgraduates with an average age of 24.7, the results of the experiment also confirmed the general aesthetic taste of young people.

Through the experiment and application of facial emotion recognition technology this study found that participants consumer preferences for a ceramic tea set, and further to establish the evaluation model of tea set of user acceptance, the model can be used to the new tea product market acceptance evaluation, for ceramic tea set designers, producers, and business operators to provide decision-making basis.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and the standards of the Ethics Committee of School of Art and Design, Dalian Polytechnic University.

Conflicts of interest: The authors declare no conflict of interest.

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