Research on Emotional Experience of Mobile Library App Users Based on Online Comment Mining

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***Abstract*—Mobile library app provides users with an effective way to obtain library digital resources and services anytime and anywhere, further deepens the concept of user-centred service. It is of great significance to accurately measure users' emotional experience when using mobile library apps to improve the quality of mobile library services. Based on the actual online reviews of mobile library app users, this paper uses the BERTopic model to extract the topic from online reviews. It constructs a user emotional experience measurement system containing four first-level indicators, including function, sensory, interaction and technology, and eight secondary indicators. According to PAD Emotion Scales, the paper measures the emotional experience of mobile library app users from the three emotional dimensions of pleasure(P), arousal(A) and dominance(D). It verifies the validity and accuracy of the results, providing an essential reference for the optimization of mobile library app user experience.**

Keywords—mobile library app, online comments, text mining, emotional experience, PAD emotion model

I INTRODUCTION

A mobile library app is one of the mainstream modes of mobile library services. It can provide users with rich information resources and various information services, meet users' mobile and personalized information needs, and promote the construction and development of smart libraries. User experience is an important index to measure the service level of a mobile library [1]. Mobile library apps not only establish a closer connection between libraries and readers, but also gradually become an important carrier for libraries to disseminate cultural knowledge and establish their brand image, but at the same time, they also lead to a series of problems such as serious homogenization, uneven service quality and lagging update of knowledge resources, which restrict the development of the library mobile service ecosystem. With the continuous growth of people's spiritual and cultural needs, users' experience demand for a mobile library gradually rises from functional satisfaction to emotional experience. Mobile library user experience is the perceptual psychological state and rational value cognition formed by users in the whole process of using mobile library, including the initial impression of mobile library, various emotional experiences during and after the use of mobile library. Therefore, it is important to accurately measure user emotional experience and put forward corresponding optimization countermeasures to improve mobile library app service level and user satisfaction. App online comments are an essential way for users to express their feelings about app use and an essential source of information to measure users' emotional experience [2]. With the increasing number of Mobile library apps in China, many user comment information has been accumulated on various mobile application download platforms. Fully mining and analyzing these comments can provide an essential basis for accurately evaluating users' emotional experience and effectively improving the service functions of apps [3].

Because of this, this paper takes China mobile library app as the research object, adopts text mining techniques such as feature extraction and emotion analysis to analyze the online comments of app users, constructs the measurement index system of user emotional experience, and measures the emotional experience of mobile library app users in combination with PAD emotion model. Thus, we can find out

the user pain points in the app and put forward corresponding improvement suggestions to provide useful reference for optimizing the mobile library apps development design and improving app service functions.

II RESEARCH FRAMEWORK

Based on user review data of mobile library app, this study uses the topic model and emotion analysis to mine online comments deeply. It quantifies user emotional experience in combination with PAD model. The specific research framework is shown in Fig. 1.

(1) Collect the online comment data of mobile library app users in the mainstream mobile application market, and perform data cleaning, word segmentation, stop words, keyword extraction and other preprocessing operations.

(2) Select high-frequency keywords to establish the initial feature set, and apply the BERTopic model to extract and classify the topics of comments containing keywords. Filter, merge and supplement the feature words under the topics, and construct a mobile library app user emotional experience metric system.

(3) Four apps with the highest user comments were selected as the affective experience measure research samples. Construct initial sentiment dictionaries based on HowNet and the Chinese sentiment ontology library of China Knowledge Network, and perform dependent syntactic analysis on online reviews. Extract indicator sentiment words combined with the user sentiment experience metric system constructed in (2).

(4) According to the PAD value of basic emotional words and the semantic similarity between emotional words, the PAD value of emotional words to be tested is calculated. The emotional experience of mobile library app users is measured from three dimensions of pleasure degree, arousal degree and dominance degree, and the results are analyzed.

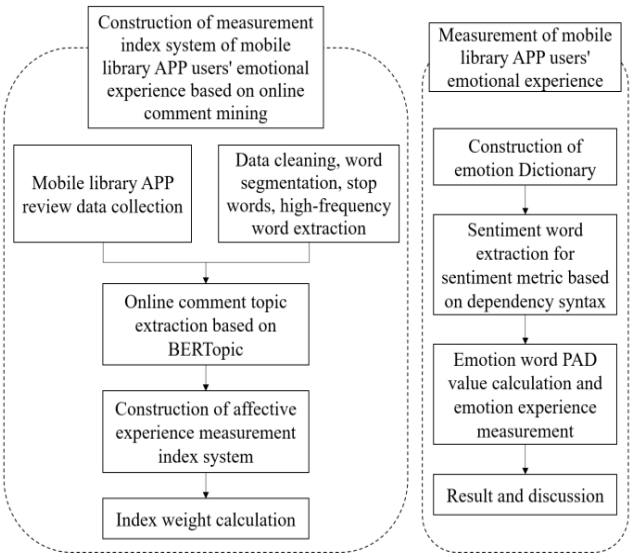

Fig. 1. Research framework.

III EMPIRICAL RESEARCH

A. Data acquisition and preprocessing

This study firstly searches related apps in App Store and Android mobile App market with the keyword "library". It selects 66 mobile library apps that meet the requirements according to specific application information and function description. "Qimai Data" brings together the App information of App Store, Google Play and 9 major Android application markets in 155 countries/regions around the world, covering the basic introduction, real-time ranking, rating, comments, downloads and other data of 13 million App applications. We collected online comments from users of 66 apps in major mobile application markets through the Qimai data platform and obtained 37,198 comments data in total (as of December 31, 2021). Since the online reviews of apps have obvious short textual and colloquial characteristics, which contain a lot of low-value or even non-value information, it is necessary to pre-process the collected review data to improve the accuracy of review topic mining. In this study, the data is cleaned by compressing repetitive words, removing repetitive comments and phrases that do not contain substantive comments, and building a custom deactivation word list based on the deactivation word list of HIT, adding indicative words such as "software" and "app". The deactivated words were filtered, and 30,433 comments were retained as the study sample.

B. Construction of user emotional experience measurement index system

This study uses BERTopic model to efficiently identify and extract topics from online reviews. This technology, combined with BERT pre-training language model, can better link the correlation between different words, effectively cope with the sparse short text data and difficult to identify ambiguous words. Firstly, the sample of comment data is processed by using the stubbing word segmentation tool to classify and label part of speech. After removing the stop words, 5,639 nouns, 739 adjectives, 4,132 verbs and 455

adverbs are obtained. The words with the top 20% of word frequency and no less than 5% are selected as feature words to form the initial feature word set of app online comments.Then, the initial feature word set is matched with the online comment dataset, the comments containing the feature words are input into the BERTopic model, the BERT pre-training model is used to generate text word vectors, and 28 categories are obtained by UMAP dimensionality reduction and HDBSCAN clustering. Then, by calculating the cosine similarity of the c-TF-IDF vectors between the topics, the number of topics is reduced and 10 topics are obtained.

To evaluate the effect of BERTopic model in theme extraction, this paper compares it with LDA theme model and Biterm theme model for short text, and uses three evaluation indexes, Normalized Pointwise Mutual Information (NPMI), Topic Diversity and Topic Quality, to measure the performance of each theme model [4] results, Normalized point-by-point mutual information (NPMI) is a standardized metric extended from point-by-point mutual information (PMI) that reflects the degree of association between words and is mainly used to measure topic consistency. In addition, redundant words characterizing multiple topics may occur in topic modeling, so the diversity of the generated topics needs to be assessed. Topic extraction quality is determined by both topic consistency and diversity, and is calculated by the product of Normalized Point-by-Point Mutual Information (NPMI) and Topic Diversity. The results are shown in Table I. Among them, the App online review topics generated using the BERTopic model outperformed the results generated by the other two models in terms of consistency, diversity and quality, thus verifying the accuracy and validity of the App online review topic mining results based on BERTopic.

On this basis, based on the theories related to emotional experience and the principle of index system construction, this study defines and classifies the topics extracted from users' online comments from the instinctive layer, behavioral layer and reflective layer of users' emotional experience, and establishes the measurement index of users' emotional experience of mobile library app, as shown in Table II.

TABLE I. COMPARISON OF MODEL PERFORMANCE

Model	NPMI	Topic Diversity	Topic Quality
BERTopic	0.068	0.78	0.053
LDA	-0.021	0.67	-0.014
Biterm	0.052	0.54	0.028

D. Discussion

According to the measurement results of users' emotional experience of mobile library app, users' emotional experience of app's "function" dimension is the best, with the highest degree of pleasure (0.41). It indicates that various functions of the mobile library app can basically meet users' needs and stimulate users' excitement to a certain extent, but there are still some problems such as inconvenient operation, which leads to low user dominance and a certain learning cost.

C. User emotional experience metric

In this study, we sorted the number of user reviews of collected mobile library apps and selected apps with more than 1,000 reviews as the samples of user affective experience metrics, and finally selected four apps, namely, Super Star Mobile Library App, National Digital Library App, Literary Suzhou App and Book Collection App.

On this basis, we firstly extracted the emotional words under the user emotional experience metric of mobile library app by constructing an emotional lexicon and subordinate syntactic analysis; then, we used the PAD emotional model to refine and quantitatively analyze the complex emotions generated by users in the process of using mobile library app, and further obtained the users' emotional experience evaluation of app. Specifically, we take the Chinese version of the simplified PAD emotion scale established by the Institute of Psychology of the Chinese Academy of Sciences on the basis of the PAD emotion scale developed by Mehrabian et al. as the measurement basis (5). As the measurement basis, the meaning similarity between the extracted emotion words and the 14 basic emotion words in the PAD scale is calculated separately by HanLP to obtain the evaluation of users' emotion experience under each level of the index system in the mobile library app The pleasure (P), arouse (A) and dominance (D) values of users in each level of the emotion experience index system in the mobile library app are obtained. On this basis, the user's emotional experience measurement results under each level index are further calculated by weighted merging, as shown in Fig. 2.

TABLE II. METRICS OF MOBILE LIBRARY APP USERS' EMOTIONAL EXPERIENCE

First-level Indicators	Secondary Indicators	Subject
Sensory Dimension	Visual Design	Subject 6
	Interface Layout	Subject 1
Functional Dimension	system function	Subject 0, Subject 8
	Resource Content	Subject 4, Subject 5
Interaction Dimension	Service Response	Subject 7
	Interactive sharing	Subject 3
Technical Dimension	system performance	Subject 9
	network environment	Subject 2

Therefore, it is necessary to constantly improve the usability of app functions. On the one hand, libraries should optimize and innovate traditional library services according to the functional attributes of the App, and form differentiated advantages with service platforms such as library WeChat public number, small programs and Web sites; on the other hand, they should fully explore readers' needs, combine the library's collection and special collection resources, improve the quality and characteristics of App resources, create a matrix of knowledge content, and increase readers' interest in

reading and enthusiasm in using the App.

Users' pleasure, arousal and dominance of the "sensory" dimension of mobile library app are positive, positive and negative respectively, indicating that mobile library app also needs to improve the simplicity and consistency of interface layout and module setting, so that users can quickly adapt to the interface, so as to reduce users' use cost and improve users' dominance. Mobile libraries should bring users a comfortable and beautiful sensory experience through clear and beautiful interface layout, color matching and icon design in the App interface design according to the visual processing mechanism of users, and highlight the regional and cultural characteristics of libraries to shape a good brand image and stimulate users' interest in continuous browsing and exploration.

Users' emotional experience of "interaction" dimension is not only low in dominance, but also low in arousal, indicating that mobile library app should pay attention to the fun of interaction and stimulate users' willingness to use while improving the usability of interaction.The library can actively build the App user data intelligent analysis system through self-built or cooperation with third parties, track the trajectory of user interaction behavior in real time, effectively analyze user browsing interest and intention degree, build accurate user portrait, and provide users with high-quality personalized knowledge services; and set reasonable information architecture levels according to the characteristics of user interaction behavior, optimize the path of user interaction behavior, and improve operation efficiency.

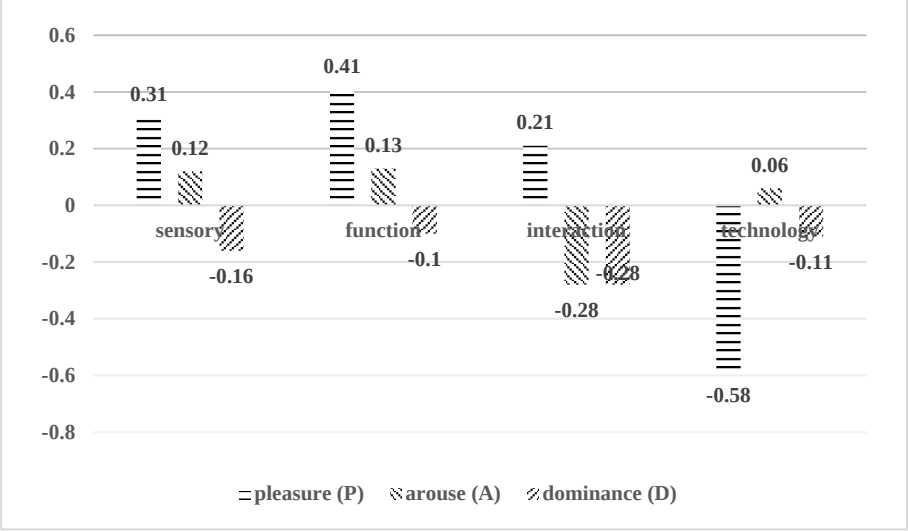

Fig. 2. Measurement results of user emotional experience

Among the four dimensions, users have the worst emotional experience for the dimension of "technology", and the lowest degree of pleasure is -0.58. Technology is the basis of various service functions provided by mobile library app, which has an important impact on users' emotional experience. Therefore, mobile library APP developers and operators should apply advanced technical architecture in the App development process to reduce the dependence of the system on network configuration, physical environment and equipment performance, and improve the ease of use and usability of the App. In addition, the system should be iteratively updated according to the dynamic changes of user needs in a timely manner, and the product performance should be continuously improved through technical upgrades.

IV CONCLUSION

User emotional experience evaluation is a necessary basis for optimizing and improving mobile library App services. APP online reviews contain a large amount of user emotional information, which can accurately reflect user satisfaction with the app from different dimensions and is becoming an important basis for measuring user emotional experience. This study measures and analyzes the users' emotional experience of mobile library app from the perspective of online comment text mining, extracts the theme of online comments by using BERTopic model, constructs the measurement index system of users' emotional experience, and takes four mobile library apps as research samples to measure the users' emotional experience in fine-grained combined with PAD model. The experimental results show that the measurement results obtained by the method in this paper are consistent with the actual results of users, which has good universality and promotion value. The research results enrich the research achievements in the field of mobile library users' emotional experience and have important theoretical significance and practical value.

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