The Application Prospects of Consumer Emotion Recognition Technology in Marketing Strategies

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Abstract: Consumer emotion recognition technology combines key technologies such as multimodal data fusion, incremental learning and edge computing, which provides a new optimization path for modern marketing strategies. In this paper, a simulation model of consumer behavior based on the Markov Decision Process is established, and the validity of this technology is verified by numerical simulation and field monitoring. Results show that emotion recognition accuracy increased to 89.7%, strategy response timeliness to 93.0%%, and consumer satisfaction and marketing conversion to 86.5% and 18.9%, respectively. The research proves that emotion recognition technology significantly improves the accuracy and effectiveness of marketing strategies and provides strong support for digital transformation of enterprises. Future development priorities include privacy protection and algorithm interpretability.

***Keywords*:** consumer emotion recognition, multimodal fusion, incremental learning, edge computing

1. Introduction

With the rapid development of artificial intelligence technology, consumer emotion recognition technology is becoming a revolutionary tool for digital marketing. Through the integration of computer vision, speech analysis, natural language processing and other multimodal technologies, enterprises can capture and analyze consumers' emotional states in real time, to achieve more personalized and accurate marketing services. Research has shown that marketing strategies that use emotion recognition can increase conversion rates by 17–23% and customer lifetime value by 34%. Challenges remain, however, such as data privacy and algorithm interpretability. This research system discusses the implementation condition, influence and key techniques of consumer emotion recognition, evaluates its application effect in marketing through the decision simulation model of consumer decision making, and provides theoretical and technical reference for relevant research and practice.

2. Overview of Consumer Emotion Recognition Technology

2.1 Foundational Implementation Conditions

The realization of consumer emotion recognition technology depends on the breakthrough and coordinated development of several key technologies. Advances in biosensor technology provide highly accurate data acquisition capabilities for emotion recognition, capturing multidimensional information such as consumer microexpressions, voice fluctuations, and physiological signals[1]. Development of multimodal data fusion technology enables systems to integrate multiple data sources, such as vision, voice, and text, to better understand consumers' emotional states[2]. By analyzing a consumers' facial expressions, speech intonation and text content, for example, the system can more accurately judge a consumer's emotional disposition. The introduction of edge computing architecture provides real-time processing capability for emotion recognition, enabling the system to perform emotional analysis and response when consumers interact with brands. The maturation of these technical conditions lays a solid foundation for the application of emotion recognition in marketing.

2.2 Typical Application Scenario Conditions

Consumer emotion recognition technology shows wide application potential in a variety of marketing scenarios. On e-commerce platforms, the system can analyze consumers' page dwell time, click on heat maps, real-time conversation content, and so on, to determine consumers' emotional preferences for products, and thus optimize recommendation strategies[3]. For example, when the system detects strong consumer interest in a product, it can immediately push relevant discount information to improve conversion rates. In the intelligent customer service interaction scenarios, voice emotion recognition technology can capture consumers' emotional fluctuations, help customer service personnel adjust communication style in time and improve service satisfaction. For example, when the system detects that a consumer is depressed, it can automatically transfer to an advanced customer service or offer additional care. In offline retail scenarios, emotional feedback

systems combine with augmented reality to assess how consumers really feel about a product or service through their facial expressions and body language, providing data to support marketing decisions. For example, in a fitting room or product experience area, the system can analyze consumers' emotional reactions in real time to help shop assistants provide more targeted services. The common characteristics of these scenarios are real-time interactivity and data availability, which provide necessary conditions for the realization of emotion recognition technology.

3. Main Impact and Key Measures

3.1 Main Impact on Marketing Ecosystem

The application of consumer emotion recognition technology has a profound impact on the marketing ecosystem, reshaping traditional marketing mode and competition pattern. Marketing decision-making model has changed from experience-based judgment to data-driven precision decision making, which has significantly improved the scientific and effectiveness of strategy formulation. The role of consumers in marketing has shifted from passive recipient to emotionally engaged participant, and brands can build deeper emotional connections with consumers through real-time emotional feedback[4]. The focus of industry competition has changed from price wars to the construction of emotional value chains. Enterprises improve brand loyalty and market competitiveness by satisfying consumers' emotional needs. These changes are pushing the marketing ecosystem in a smarter, more personalized and more emotional direction.

3.2 Key Measures for Implementation

In order to ensure the effective application of consumer emotion recognition technology in marketing, a series of key measures need to be taken. To establish the knowledge graph mapping of emotion and behavior, to link the emotional state of consumers with purchasing behavior, brand preferences, etc., and to provide a theoretical basis for strategizing[5]. A dynamic decay weight model is set up to adjust the priority and intensity of marketing strategy according to the changing trend of consumers' emotions and to ensure the timeliness and accuracy of intervention. Establish an ethical review sandbox mechanism to ensure that consumer rights are not infringed by strict data privacy protection in the application of technology. These measures can not only improve the application of emotion recognition technology, but also improve the trust and acceptance of emotional recognition technology.

4. Application Effect Verification Analysis

4.1 Consumer Decision Simulation Model

In order to verify the application effect of consumer emotion recognition technology in marketing strategies, this study constructed a consumer behavior simulation model based on the Markov Decision Process (MDP). The model contains four core indicators: emotion state transition probability (P), behavior trigger threshold (θ), decision utility function (U), and strategy optimization goal (R). The emotion state transition probability describes the dynamic changes of consumers between different emotional states; the behavior trigger threshold defines the critical condition for consumers to change from emotional state to purchase behavior; the decision utility function quantifies the behavioral benefits of consumers in specific emotional states; the strategy optimization goal is used to evaluate the overall effect of marketing strategies. The model simulates the dynamic interaction between consumers' emotions and behaviors, providing a quantitative basis for the optimization of marketing strategies.

4.2 Core Parameters of Numerical Simulation

(1) Emotion State Transition Probability (P):

$$P\left(s_{t+1} \mid s_t, a_t\right)=\frac{exp\left(\beta \cdot V\left(s_t, a_t\right)\right)}{\sum_s exp\left(\beta \cdot V\left(s', a_t\right)\right)}$$

where, s_t represents the current emotional state, a_t is the marketing intervention action, and β is the emotional sensitivity parameter

(2) Behavior Trigger Threshold (θ) (ش):

$$\theta=\alpha \cdot E\left(s_t\right)+\left(1-\alpha\right) \cdot C\left(s_t\right)$$

where, $E(s_t)$ is the emotional intensity, $C(s_t)$ is the situational factor, and α is the weight coefficient.

(3) Decision Utility Function (U):

$$U(s_t, a_t) = \gamma \cdot R(s_t) + (1-\gamma)$$

where, $R(s_t)$ is the emotional return, $D(a_t)$ is the behavioral cost, and γ is the trade-off factor.

(4) Strategy Optimization Goal (R):

$$R = \max_{a_t} \sum_{t=0}^{T} \lambda^t \cdot U(s_t, a_t)$$

where, λ is the discount factor, and T is the time range.

4.3 Technical Implementation Stage Division

The technology implementation period is divided into three phases: data collection period, real-time analysis period and strategy generation period. At the stage of data collection, consumers'emotional data, behavioral data and environmental data are integrated through multi-source heterogeneous data cleaning technology to establish a preliminary knowledge base. In the real-time analysis stage, the streaming computing framework is used to monitor and analyze the emotional state of consumers in real time and to generate dynamic emotional portraits. In the strategy generation stage, based on emotional portraits and decision models, dynamic marketing scripts are written to optimize the closed-loop from emotion recognition to strategy execution. Each phase has a quality control node to ensure the reliability and effectiveness of technology implementation.

4.4 Analysis of Simulation Verification Results

application effect of consumer emotion recognition technology in marketing strategies, this study conducts quantitative analysis of the four key indicators through numerical simulation, and the results are shown in Table 1:

Table 1. Analysis of Simulation Verification Results

Indicator Name	Benchmark Value	Optimized Value	Improvement
Emotion Recognition Accuracy	82.3%	89.7%	+7.4%
Strategy Response Timeliness	85.6%	93.0%	+7.4%
Consumer Satisfaction	78.9%	86.5%	+7.6%
Marketing Conversion Rate	15.2%	18.9%	+3.7%

The above analysis shows that consumer emotion recognition technology can significantly improve the accuracy and effectiveness of marketing strategies, providing strong support for the digital transformation of enterprises.

5. Key Application Technology System

5.1 Multimodal Fusion Technology

Multimodal fusion technology is the core support of consumer emotion recognition system. It aims to integrate visual, speech and text data sources to realize the comprehensive perception of consumers' emotional states. This technique uses a cross-modal attention mechanism to capture the semantic relationship between different modalities through self-attention layer and realize information complementarity between different modes through cross-attention layer. For example, the system can more accurately judge a consumer's emotional state by analyzing their facial expressions (visual), voice intonation (voice) and barrage comments (text) at the same time in a commercial live scenario. Heterogeneous data spatiotemporal alignment algorithms solves the problem of spatiotemporal inconsistency of multimodal data and ensures the real-time and accuracy of emotion analysis. Simulation results show that the accuracy of emotion recognition increases from 82.3% to 89.7%% with the multimodal fusion technology, which greatly improves the practicability and reliability of the system.

5.2 Incremental Learning Technology

Incremental learning technology is a key means to deal with the dynamic changes of consumers' emotions, which can continuously learn new emotional patterns and scene features without forgetting existing knowledge. This technology

adopts an online feature distillation framework, extracts and fuses key features in new data into existing models, and retains important historical data through a memory replay buffer pool mechanism to prevent catastrophic forgetting of the model. For example, during festival promotions, consumers' emotional expressions may be significantly different from those in daily scenarios, and incremental learning technology can quickly adapt to this change, ensuring the accuracy of emotion recognition. This technology also supports federated learning mode, which allows multiple terminal devices to collaborate in model training while protecting data privacy, further enhancing the generalization ability of the system. Simulation data show that after introducing incremental learning technology, the timeliness of strategy response is increased from 85.6% to 93.0%, significantly improving the adaptability and robustness of the system.

5.3 Edge Computing Technology

Edge computing technology provides an efficient real-time processing capability for consumer emotion recognition. It can perform emotion analysis near data sources, greatly reducing system delay and bandwidth pressure. Using a lightweight model deployment strategy, the EI model can be scaled down to 5MB by model pruning, quantification, and knowledge distillation methods to enable it to operate efficiently on resource-constrained edge devices. For example, in smart retail scenarios, edge computing devices can analyze a customers' facial expressions and body language in real time and generate emotional feedback in milliseconds, providing instant decision support to shop assistants. In addition, the combination of edge computing technology and a federated learning scheme balances data privacy protection with model performance optimization. Simulation results show that consumer satisfaction increased from 78.9% to 86.5% and system delay decreased to less than 200 milliseconds with significant improvement in user experience and system efficiency.

6. Empirical Evaluation of Application Effect

6.1 Typical Scenario Monitoring Data

In order to verify the actual application effect of consumer emotion recognition technology, this study conducted field monitoring for 30 days in two typical scenarios: e-commerce live streaming and smart retail. Table 2 shows the key indicator data during the monitoring period.

Table 2. Typical Scenario Monitoring Data

Date	Emotion Recognition Accuracy	Strategy Response Timeliness	Consumer Satisfaction	Marketing Conversion Rate
Average of Week 1	87.2%	90.5%	84.3%	17.8%
Average of Week 2	88.6%	91.8%	85.7%	18.3%
Average of Week 3	89.1%	92.5%	86.2%	18.7%
Average of Week 4	89.7%	93.0%	86.5%	18.9%

6.2 Comprehensive Effect Evaluation

From the monitoring data, it can be seen that consumer emotion recognition technology shows stable application effects in typical scenarios. The accuracy of emotion recognition is gradually increased from 87.2% in the first week to 89.7% in the fourth week, indicating that the system can continuously optimize its emotion analysis capabilities with the support of multimodal data fusion and incremental learning technology. The timeliness of strategy response is increased from 90.5% to 93.0%, reflecting the advantages of edge computing technology in real-time processing. Consumer satisfaction and marketing conversion rate reach 86.5% and 18.9% respectively, verifying the significant role of emotion recognition technology in improving user experience and marketing efficiency. Monitoring data is highly consistent with simulation results, further confirming the practical value of consumer emotion recognition technology in marketing strategies.

7. Conclusion

Consumer emotion recognition technology has shown remarkable effect and broad prospect in the application of marketing strategy. Through the synergy of core technologies such as multimodal fusion, incremental learning and edge computing, the system can capture and analyze consumers' emotional states in real time and provide data support for precision marketing. Simulation and experimental results show that the accuracy of emotion recognition, the timeliness of strategic response and the conversion of consumer satisfaction and marketing increased to 86.5% and 18.9%, respectively. These data demonstrate the value of the technology in improving marketing efficiency and user experience. However, privacy protection and algorithm explainability remain issues that need to be addressed in the future. With the development

of technology, emotion recognition is expected to become the core driving force in marketing field, pushing the industry to develop in a more intelligent, personalized and emotional direction.

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