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Deep Learning-based Intelligent Marketing System Application Analysis

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Abstract: With the development of artificial intelligence and big data technology, an intelligent marketing system that responds to customers' shopping needs by analyzing user behavior data has emerged. The system can formulate more accurate and personalized marketing strategies, thus significantly improving customers' shopping efficiency and satisfaction. This paper focuses on the core technical architecture of the deep learning-based intelligent marketing system, including the information collection system, the data algorithm system, the dialog system and its related technologies. In this paper, it is concluded that the intelligent marketing system achieves personalized product recommendation by collecting user activity information on multiple platforms, constructing real-time user-profiles and extracting social image information, as well as using matrix decomposition and collaborative filtering algorithms for data analysis. Meanwhile, natural language processing technologies such as convolutional neural networks, recurrent neural network and attention mechanisms are used to enhance the interactive capability of the dialog system. However, Intelligent marketing systems face challenges such as data privacy and security, implementation of personalized and customized push, and neutrality of push content. This paper suggests continuous optimization of related technologies and the development of new functions during the implementation of the system, such as the introduction of multimodal interaction technology and attention to collecting after-sales user feedback, optimizing the database and algorithms, which will help solve the problems to a certain extent.

Keywords: Deep learning, big data, natural language processing, intelligent marketing system.

1. Introduction

With the development of information technology, digital transformation has become an important trend in various industries. In the field of shopping, online shopping has gradually become an important way for people to buy goods, with the advantages of convenience, timesaving, low price and a variety of choices, which greatly improves shopping efficiency and experience. A large part of online sales performance depends on the effect of effectiveness of e-marketing and publicity, and in e-marketing, interaction, and communication with customers are crucial. Intelligent marketing system not only accurately captures customer needs and enhance customer experience, but also builds customer trust in the brand and deepens customer relationships. This interaction promotes sales conversion and enhances customer stickiness, which is the key to increasing brand influence and market share. The traditional e-marketing tools often focus on one-way information transfer, lack of

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deep interaction with customers and emotional exchange, and a wide range of redundant, dazzling array of goods can not quickly and accurately achieve the needs of customers, leading to a significant decrease in customer buying desire. In addition, in traditional marketing, enterprises often use massive information bombardment for marketing, believing that the wider the coverage of the advertisement, the better the effect. However, with the information overload, the audience gradually feels impatient or even disgusted. In the era of big data, enterprises can restore consumer profiles through data correlation, gain precise insights into customer preferences and needs, and discover potential business opportunities, so as to formulate personalized services, achieve precise positioning, and improve marketing effectiveness [1].

However, with the development of AI technology, especially the advancement of deep learning and Natural Language Processing (NLP), computers can better understand and process human natural language, which provides the possibility of constructing an e-marketing dialog system capable of understanding and responding to customers' emotional needs. In addition, big data technology continues to mature, and its application in the marketing field is becoming increasingly widespread. Through the collection and analysis of user behavioral data and the integration of information resources from multiple platforms and channels, corporations can gain a deeper understanding of user needs, behavioral patterns, and preferences, Thus, developing more accurate and personalized marketing strategies, to achieve a natural, smooth and emotional communication with customers at the same time, more appropriate to give its urgent need for the goods, thus improving customer shopping efficiency, satisfaction, to achieve the purpose of product marketing. Chen Dongxu's research shows that in 2018, a provincial telecom operator used the K-Means algorithm personalized marketing model to design different grades of package products according to the user's real needs, making it easier for the user to make a choice, with a significant increase in the volume of package sales and the page sales conversion rate, market unlimited packages more effectively and quickly to target users, forming a win-win situation for the enterprise and the user [2]. Wang Ya's research shows that data-driven precision marketing has become a key factor for enterprises to improve market competitiveness, and can improve marketing efficiency, reduce marketing costs, and enhance customer satisfaction and loyalty [3].

The purpose of this paper is to analyze the core technical architecture of the intelligent marketing system by bibliographic review, followed by demonstrating its specific application functions in this system through an in-depth study of its technical principles, and finally, by analyzing the challenges of the development of this system, aiming to provide useful guidance and suggestions for the development prospects of this system. Through the research in this paper, I hope to organize the technical composition of the intelligent marketing system clearly and provide constructive guidelines for related practitioners.

2. Core technology

With the user as the core, the intelligent marketing system first obtains information about the user's activities on various Internet platforms and deposits useful information into the database through real-time user profile modeling and social image extraction technology. When the user puts forward preliminary product requirements, the dialogue system uses three major technologies, namely convolutional neural network, recurrent neural network, and attention mechanism, for natural language processing, so as to efficiently and accurately understand the customer's needs. Subsequently, the system transmits the instructions to the database, which calculates through the matrix decomposition algorithm and collaborative filtering algorithm, arrives at the recommended products, and pushes them to the user, completing the personalized recommendation. The schematic diagram is shown in Figure 1.

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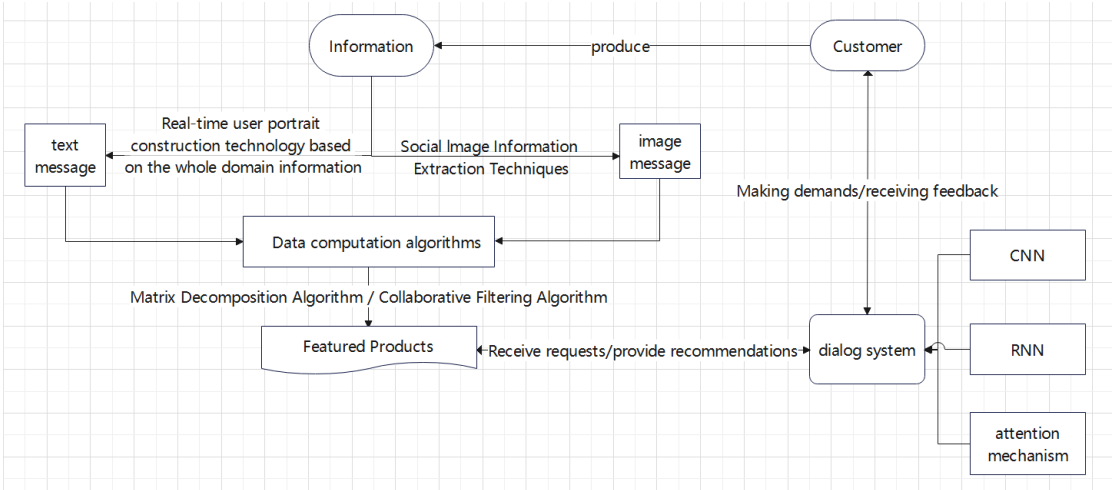

Figure 1 : Schematic diagram of the workflow of intelligent marketing system application

Compared with the traditional marketing model, the personalized intelligent marketing system aims to build a more humane and accurate interactive experience, which relies on big data analysis and machine learning technology to continuously optimize the recommendation algorithm to better meet the personalized needs of users. In personalized marketing, users are no longer passive recipients of information, but active participants in decision-making, because the content and products they see are highly relevant to their personal interests and needs. Among them, data-driven is the cornerstone of personalized marketing, according to the accumulated data to optimize the recommendation strategy, so that the e-commerce platform can provide users with more accurate and more personalized services.

Information Extraction and Analysis and Natural Language Processing (NLP) are the two major components of the Intelligent marketing system, which together form a smooth and intelligent system. The natural language processing system is the communication channel between the user and the system, which is the external presentation of the system; while the information extraction and analysis system is the important tool for the system to collect user information and process the computation, which is the internal drive of the system. The following section highlights the technologies related to information extraction and analysis and natural language processing.

3. Information extraction and analysis

Information extraction is the process of automatically extracting structured information from unstructured or semi-structured data; information analysis is the in-depth processing of this information to discover hidden patterns, associations, or trends. Real-time user profile construction technology improves real-time data processing and realizes precision marketing through Global Information Fusion and Stream Computing. Social image information extraction technology combines deep learning and social network analysis to improve recommendation accuracy. Data analysis algorithms such as matrix decomposition and collaborative filtering process information in different ways to optimize the recommendation effect. Together, they serve the system so as to enhance the efficiency and accuracy of data processing and provide support for decision-making, market forecasting, personalized recommendations, etc.

3.1. Real-time user portrait construction technology based on the whole domain information

The real-time user portrait construction technique is a key component in the intelligent marketing dialogue system, which supports personalized service and precise marketing by accurately portraying

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user characteristics. In this section, the technology used in this system and its innovative application in marketing systems are described in detail.

The model is based on the combination of searching the information on multiple platforms of this user (e.g., social media, other e-commerce platforms, search engines) and analyzing it, and integrates stream computing technology to generate a multi-dimensional user profile. Unlike traditional browser/server mode architecture, the existing research technology achieves dynamic modeling by collecting and updating flow information in real-time, thus significantly improving the real-time and accuracy of data processing. With stream computing technology, the system is able to realize real-time collection and updating of user profiles, shortening the data processing cycle from the daily level to the minute level. This rapid response capability provides strong support for accurate market promotion. The automatic update and iteration system is able to automatically acquire users' high-frequency keywords and utilize the vocabulary-based vector model learning technology to realize the mastery of new vocabulary and real-time updating of labels. This enables the system to continuously and accurately characterize users [4].

The system also has the function of customer group selection, which can categorize and manage users from multiple perspectives, quickly identify new user groups, and grasp the interests and preferences of users in a timely manner. This not only improves the efficiency of the marketing process but also makes marketing more accurate. The system can mine users in multiple dimensions according to different business models, identifying valuable high-end customers and customers that need to be focused on maintenance. By combining with the customer's own characteristics, the system can provide personalized services for customers and achieve targeted and precise marketing [4].

3.2. Social Image Information Extraction Techniques

Social images are difficult to describe and categorize directly by simple features due to the diversity of their contents (e.g., landscapes, people, events, etc.) and complexity (e.g., multiple objects in the image, background interference, etc.). As a result, traditional recommendation methods are often ineffective when dealing with this type of data. Instead, this approach is a personalized recommendation strategy that combines deep learning and social network analysis, specifically designed to improve the accuracy and personalization of social image recommendations.

In order to capture the user's interests, the method first builds a "user interest tree". This tree structure is constructed using the user's historical behaviors (e.g., likes, shares, comments, etc.) and can reflect the user's interest preferences at different levels. This structure not only considers the user's direct interests (e.g., favorite image types) but also implicitly expresses broader or more specific interest areas through hierarchical relationships. Meanwhile, in order to utilize the tag information in social images more effectively, the method constructs a "tag tree" by rearranging and organizing tags. The tag tree can reveal the hierarchical or associative relationships between tags, which helps the system better understand the image content and make recommendations accordingly. In order to represent the image content compactly and efficiently, the method employs deep learning networks to train image features such as Alex Net. Convolutional neural networks such as Alex Net are able to automatically learn hierarchical feature representations from raw image data that capture the complexity and diversity of images better than hand-designed features [5].

This method outperforms the latest method in terms of accuracy and recall of personalized recommendations because it integrates the user's interests, the image's labels, and deep features. It is not only capable of recommending images that may be of interest to the user but also of providing a more accurate and personalized recommendation experience through deep learning and social network analysis.

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3.3. Data analysis algorithms

Currently, there are two mainstream data analysis algorithms, Matrix Decomposition Algorithm and Collaborative Filtering Algorithm, which process known information in different ways in order to give the best answer to the user.

The matrix decomposition algorithm predicts the user's rating or level of interest in an unknown product by analyzing the user-product rating matrix (or interaction matrix), decomposing it into two low-rank matrices (user feature matrix and product feature matrix), and performing matrix decomposition using methods such as singular value decomposition or non-negative matrix decomposition. Generate a list of recommendations based on the decomposition results [6].

Collaborative filtering algorithms predict the products that users may be interested in by analyzing their historical behaviors (e.g., purchasing, browsing, evaluating, etc.) and the behaviors of similar users or similar products. User-based collaborative filtering: first find other users similar to the target user, and then recommend products for the target user based on the behavior of these similar users. Item-based collaborative filtering: analyzes the products that users have purchased or evaluated, find other products that are similar to these products, and then recommend them to users [6].

Matrix decomposition algorithms and collaborative filtering algorithms have their own merits. Matrix decomposition reveals potential relationships through mathematical decomposition, with high prediction accuracy, and is suitable for scenarios with rich rating data. However, it relies on a large amount of rating data and does not handle the cold start problem well. Collaborative filtering, on the other hand, utilizes the similarity between users or products to make recommendations, which is simple to implement and captures changes in user interests but may be affected by data sparsity. In terms of applicable scenarios, matrix decomposition is more suitable for rating prediction, while collaborative filtering is more flexible and applicable to recommendation scenarios with multiple user behavior data.

4. Natural Language Dialog

The natural language dialogue system is realized based on three major techniques :convolutional neural network, recurrent neural network and attention mechanism, which divide the work so that it can communicate smoothly with the user, quickly obtain the user's needs and respond to them [7].

4.1. CNN-based dialog system

Convolutional Neural Networks (CNN) is a deep feed-forward neural network and a deep learning model inspired by biological visual processing mechanisms. It achieves learning and recognition of complex patterns by combining multiple layers of neural networks. In CNN, the core components include a convolutional layer, pooling layer and fully connected layer. The convolutional layer extracts spatial features, such as edges and textures, from the input data through convolutional operations; the pooling layer is used to reduce the spatial size of the feature map, reduce the computational complexity and enhance the translational invariance; and the fully connected layer integrates the extracted features for the final classification or recognition task.

It has many advantages in natural language processing. CNN can automatically extract effective feature representations from raw data without the need to manually design complex feature engineering, which greatly improves the efficiency and accuracy of intelligent marketing systems. In addition, CNN can be well adapted to large-scale data processing with low computational complexity and spatial complexity, which is suitable for processing large-scale datasets and meets the requirements of real-time and high efficiency of intelligent marketing systems.

CNN not only excels in the field of natural language processing but is also widely used in image processing. This gives it a multifaceted advantage in intelligent marketing systems. Especially in

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pushing image advertisements, CNN can automatically extract key features from image advertisements to achieve classification and labeling of advertisements. At the same time, combining user profiles and ad features, it can recommend more accurate and personalized ad content for users. Secondly, when talking to users, CNN has powerful feature extraction ability in the image processing field. CNN can be used to process image data related to conversations, such as product images uploaded by users. By extracting features from these images, the system can better understand the user's points of interest and needs, thus providing more personalized recommendations and services.

4.2. RNN-based dialog system

Recurrent Neural Networks (RNN) is a recurrent neural network that takes sequence data as input, recurses in the evolutionary direction of the sequence and all recurrent units are connected together in a chain fashion. RNN are more recurrent than conventional feed-forward neural networks such as CNN. RNN is designed for processing sequence data. It excels in processing time-dependent data by introducing cyclic connections in the hidden layer, which allows the network to preserve and utilize information from previous time steps. In intelligent marketing systems, information about user behavior, preferences, etc. is often in the form of sequences, making RNN an ideal tool for processing this data and predicting user behavior.

It also has many advantages in natural language processing. First is the sequence modeling ability, RNN can capture the temporal dependencies in the data and effectively model the user's successive behaviors, so as to more accurately predict the user's future behavior. Secondly, RNN has good long-term memory capability, which can be passed through the state of the hidden layer, RNN can retain information over a longer period of time, which is crucial for understanding the long-term preferences and trends of users. In addition, RNN has a strong generalization ability, using the same weights for each element in the sequence data reduces the number of parameters and improves the generalization ability of the model, allowing it to adapt to input sequences of different lengths.

In the intelligent marketing system, RNN is specifically applied to the following aspects. First of all, RNN can predict user behavior, by analyzing the user's browsing history, clicking behavior and other sequence data, to predict the user's next possible behavior, such as clicking on a certain advertisement, purchasing a certain product and so on. This is of great significance for intelligent recommendation systems, advertisement placement optimization and other scenarios. In addition, RNN can be used for customer service optimization to provide more attentive and personalized services by analyzing the user's conversation history and mood changes. For example, recognizing a user's emotional state based on his or her tone of voice and keywords, and adjusting the tone and content of replies to better meet user needs. At the macro level, RNN can also be used in areas such as economic analysis and social media trend prediction, where it can process a large amount of time-series data to reveal the patterns and trends of market changes and provide powerful support for corporate strategic decision-making.

4.3. Dialog system based on attention mechanism

The attention mechanism is a technique that allows the model to focus on the important parts of the input data, mimicking the human attentional process and enabling the model to concentrate on the key information in the input data while ignoring the less relevant parts. By assigning different weights (or attention scores) to different parts of the input data, the model is able to recognize the most important information, thereby improving overall performance and efficiency. [8]

Attention mechanism is not only widely used in natural language processing, computer vision and other fields, but also plays an important role in intelligent marketing systems. In terms of user behavior analysis, the attention mechanism can be used to analyze the user's browsing, clicking,

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purchasing and other behavioral sequences to identify the user's interest preferences and purchase intentions. Combined with the user's historical behavior and current contextual information, it predicts the user's future behavioral trends and provides a basis for personalized recommendations and marketing strategy. In addition, the attention mechanism can enhance the overall performance of the model, which is used in combination with models such as CNN and RNN to guide them to focus more on key parts of the input data, such as important events in the user's behavioral sequences or salient attributes in the product features, and this focusing makes the model more efficient and accurate in extracting the features, which improves the comprehension of the user's preferences and the recommendation result's accuracy. By using these three techniques in combination, the intelligent marketing system can analyze user behavior more accurately, achieve personalized recommendations, and improve user experience and marketing results.

5. Challenges and prospects

Intelligent marketing system also faces many challenges in future development. First of all, data privacy and security are two of the main challenges. As more and more personal information is involved in the dialog system, if the platform fails to protect the user data better, data leakage may occur, resulting in the leakage of the user's private information. This will not only damage users' trust in the platform but may also cause serious damage to the platform's reputation. This requires researchers and developers to focus on improving data security-related work to ensure the safe use of the software [9]. In addition, the system also faces the challenge of data quality and diversity, data quality is uneven, need to fine cleaning to improve the accuracy of the model, the data may be more single insufficient to affect the model generalization ability, need to broaden the data sources and types, to ensure that the system operates efficiently and accurately. Another marketing system problem is the cold start problem, especially for new users and new products. New users have not yet generated enough behavioral data to obtain personalized recommendations. Similarly, new products don't have enough historical user data to make accurate recommendations. This may result in new users not being satisfied with their first experience on the platform, or new products having difficulty gaining exposure [9]. Maintaining push neutrality is also a big challenge, this system is designed to allow customers to get the most suitable products quickly, if the application has some improper cooperation with some brands, or if some companies falsify data to attract users, so that the system pushes the brand's products more, the fairness of the push will be lost, breaking the original design intention of this system.

In addition, the fulfillment and distortion of users' individuality is one of the drawbacks of the system itself. Personalized marketing satisfies the unique needs of users by accurately distinguishing between groups or individuals of users, so that the individuality of each user is valued and protected. However, this type of marketing also runs the risk of distorting users' individuality. On the one hand, individuality may be over-enhanced, making it difficult for users to try new and different expressions of individuality, e.g., e-commerce platforms continue to recommend goods that match users' past preferences, limiting users' exploration of individuality. On the other hand, individuality may gradually disappear due to excessive marketing, users' consumption patterns and purchasing behaviors are controlled or shaped by merchants, potential demands are not released, and consumption patterns become rigid. To balance personalization and personalization distortion, e-commerce platforms should integrate personalization and humanization. For example, by asking users about their satisfaction with the display page, it can quickly update the user database and adjust the recommendation strategy based on the feedback. When the recommended products are not clicked or purchased many times, recalculate the top display products. This "personalization + humanization" approach helps to promote the healthy development of user personality and enhance user satisfaction [10].

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In the future, with the development of technology, such as the continued advancement of natural language processing technology, it will be possible to more accurately understand the user's intent, provide more precise and personalized services, and provide a more coherent and natural dialogue experience. Ulti-modal interaction (e.g., voice, image, video, etc.) can also be introduced and will further enrich the form of interaction of the dialog system and enhance user experience and satisfaction. In addition, it is possible to combine pre-sale and after-sale, extend the service of this system to after-sale service, and continuously optimize the algorithm and adjust the weighted value based on the user's purchase record and user feedback suggestions, compared with the first recommended product, to make the push more personalized. At the same time, the product evaluation is incorporated into the big data, which is referred to in the push of other users, constantly improving the data ecology and continuously improving user satisfaction.

6. Conclusion

In this paper, we have discussed in depth the intelligent marketing system based on deep learning, which realizes highly personalized product recommendations by integrating multi-source data, constructing accurate user profiles, and adopting advanced data analysis algorithms. The introduction of the dialog system, with the help of advanced natural language processing technology, further enhances the user experience and enables the system to more accurately understand user needs and provide corresponding services. However, with the wide application of the system, issues such as data privacy and security, accuracy, and neutrality of personalized recommendations have become increasingly prominent. In the future, with the continuous advancement of technology, the intelligent marketing system is expected to achieve more flexible customized services while protecting user privacy and improving the accuracy of recommendations. In addition, the combination of pre-sales consultation and after-sales service to form a closed-loop marketing system will also become an important direction for the development of intelligent marketing systems.

References

[1] *Fang, Y. (2024). Marketing intelligence analysis in the era of big data. International Conference on Psychology.*
[2] *Chen, D. (2019). Research and implementation of internet product marketing model based on big data. China New Communication, 21(12), 140-142.*
[3] *Wang, Y. (2024). Exploration of data-driven precision marketing model construction. Old Brand Marketing, (05), 13-15.*
[4] *Wang, Y., & Ming, Y. (2023). Application of enterprise intelligent big data analysis and marketing system based on full domain user portrait. Software, 44(10), 137-139.*
[5] *Beijing Institute of Technology. (2018). A construction method of visual attention-tag-user interest tree for personalized social image recommendation: CN105045907B.*
[6] *Sun, J. (2020). Research and application of user profiling in recommender system. North University of Technology.*
[7] *Xing, C., & Ren, X. (2024). A review of research on deep neural network-based dialog system]. Software Guide, 1-11. Retrieved from http://kns.cnki.net/kcms/detail/42.1671.TP.20240704.1132.034.html*
[8] *Yao, Z. (2022). Research on commodity recommendation algorithm based on deep learning and attention mechanism. Nanjing University of Posts and Telecommunications, Jiangsu.*
[9] *Zhang, L. (2023). Research on personalized marketing strategy of e-commerce platform. Financial Guest, (11), 34-36.*
[10] *Wang, H. (2016). Research on the application of big data in e-commerce personalized marketing: Taking Taobao as an example. Hebei University, Hebei.*