Marketing Research Based on Convolutional Neural Algorithm

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Abstract. Marketing is one of the key elements of enterprise success, and convolutional neural networks (CNNS), as an outstanding representative in the field of deep learning, have shown strong performance in various fields. This study aims to explore how convolutional neural networks and related deep learning techniques can be used to improve marketing strategies and decision making. First, we introduced the basic concepts of marketing and deep learning, and explored the connection between them. We then discuss in detail the fundamentals of convolutional neural networks and how they can be applied in the field of marketing. We describe the potential applications of CNN in market analysis, consumer behavior prediction, and product promotion. We then review relevant research to understand real-world use cases of convolutional neural networks in marketing and analyze the success factors and challenges of these cases. We also discuss data privacy and ethical issues that are becoming increasingly important in the application of deep learning in marketing research.

Keywords: Marketing, Convolutional neural networks, deep learning, Consumer behavior

1   Introduction

As one of the key elements of enterprise success, marketing has been widely concerned and studied. With the continuous development of information technology and the emergence of deep learning algorithms, the field of marketing is also facing new opportunities and challenges. Convolutional Neural Networks (CNNS), as one of the outstanding representatives of deep learning, have made remarkable achievements in computer vision, natural language processing and other fields. This study aims to explore how to introduce convolutional neural networks and related deep learning technologies into marketing research to improve the accuracy and efficiency of marketing decisions, so as to promote enterprises to gain competitive advantages in the

highly competitive market. The essence of marketing is to understand consumer needs, develop effective marketing strategies, and maximize the value of products and services, and this process relies on a large amount of data and information. [1] With the advent of the digital age, enterprises have accumulated a large amount of market data, including consumer behavior, market trends, and the activities of competitors. However, traditional market analysis tools and methods have been unable to meet the processing and analysis needs of these huge data sets. Deep learning techniques, particularly convolutional neural networks, have attracted widespread interest in marketing because of their potential to process complex data, mine hidden information, and predict trends. This paper will be divided into five main chapters, each chapter is as follows:

Chapter One: Introduction introduces the research background, purpose and content, as well as the structure of the paper. Chapter 2: Literature review reviews the relevant research in the field of marketing and deep learning, and discusses the application status of deep learning in marketing. Chapter 3: Convolutional Neural Networks and their principles Details the basic principles and working mechanisms of convolutional neural networks, as well as their potential applications in marketing. Chapter 4: Application of Convolutional neural network in marketing analysis of the practical application of convolutional neural network in market analysis, consumer behavior prediction, product promotion and other aspects, evaluate its effect and impact. Chapter 5: Challenges and Future Prospects discusses the challenges faced by convolutional neural networks in marketing, including data privacy and ethical issues, and proposes directions and recommendations for future research. Through the content of the above chapters, this study aims to provide guidelines for the application of deep learning technology in marketing for researchers, decision makers and enterprises in the field of marketing, so as to promote the innovation and development of marketing. [2]

2   Marketing Algorithm Based on Convolutional Neural Network

Convolutional neural Network-based marketing algorithm is a method that utilizes convolutional neural networks (CNNS) in deep learning to analyze market data, predict consumer behavior, optimize product promotion and other marketing tasks. Convolutional neural networks were initially highly successful in computer vision, with the ability to automatically extract features from image data, but have since been applied to other fields, including natural language processing and marketing. In marketing, the application of convolutional neural networks can cover many aspects: Market analysis and trend prediction: Convolutional neural networks can process large amounts of market data such as consumer behavior, sales data, social media comments, etc. They are able to automatically extract features from this data and capture market trends and patterns, helping companies understand market dynamics and make more accurate market analysis and trend predictions. As shown in Formula 1, the method for calculating loss is:

$$\hat{G}_{k,l,m} = \sum_{i,j} \hat{K}_{i,j,m} \times F_{k+i-1,l+j-1,m} \qquad (1)$$

Consumer behavior prediction: By analyzing consumers' purchase history, click behavior, browsing data, etc., convolutional neural networks can build models to predict consumers' future purchase intentions, preferences, and needs. [3] This helps companies customize marketing strategies more accurately and improve sales conversion rates. Product promotion and personalized marketing: Algorithms based on convolutional neural networks can model consumer characteristics, including interests, geographic location, etc. Through this information, businesses can recommend personalized products, services and promotions to increase user satisfaction and loyalty. Brand Reputation Analysis: In the age of social media, a company's brand reputation is crucial. Convolutional neural networks can analyze user comments, posts, and feedback on social media to help companies monitor brand reputation in real time, respond and adjust strategies in a timely manner. Optimization of advertising delivery: Algorithms based on convolutional neural networks can analyze advertising materials and predict the effects of different ads in different audience groups, so as to optimize advertising strategy and improve advertising effectiveness and click rate. Market competition analysis: Convolutional neural networks can analyze the market activities and product characteristics of competitors to help enterprises develop more competitive market strategies. [4] It is important to note that while marketing algorithms based on convolutional neural networks show strong potential in many aspects, they also face some challenges. For example, data privacy and ethical issues need to be carefully considered to ensure that companies do not violate users' privacy rights when applying these algorithms. In addition, the interpretability and explainability of the model is also an important issue, especially in cases where algorithmic decisions need to be explained. In conclusion, marketing algorithms based on convolutional neural networks provide enterprises with an innovative way to analyze market data, predict trends, and optimize decisions, thereby maintaining a competitive advantage in a highly competitive market. As shown in Figure 1, the algorithm execution flow of convolutional neural network is as follows:
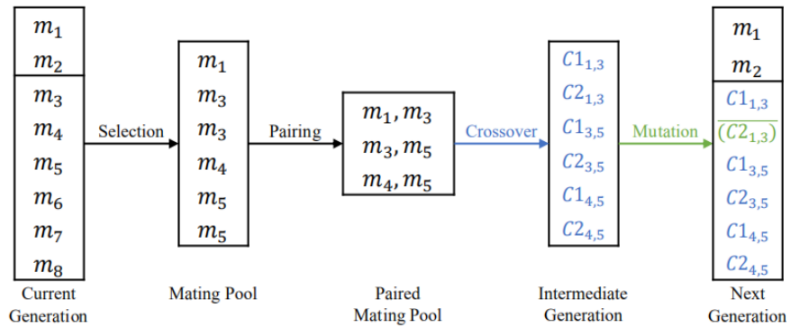

Fig. 1. Convolutional neural network flow.

3 Marketing Algorithm Simulation Experiment

3.1 Data Preparation and Environment Construction

The simulation experiment of marketing algorithm is an important step to evaluate the performance and effectiveness of the algorithm. Here is the process and methodology for a marketing algorithm simulation experiment to better understand how to conduct such an experiment: Determine the experiment objectives and problem definition: First, you need to clearly define the objectives of the experiment. This may involve solving some kind of marketing problem, such as consumer behavior prediction, product promotion optimization, etc. Make sure you understand what you want the algorithm to do well. Data acquisition and preparation: Collect market data related to the objectives of the experiment, which can include consumer behavior data, product sales data, market trend data, etc. Ensure that the data is clean and accurate, and perform data pre-processing as needed, such as removing outliers, filling in missing values, performing feature engineering, etc.

$$\delta^l = ((w^{w+1})^T \delta^{l+1}) \odot \sigma'(z^l) \tag{2}$$

Select the appropriate algorithm: Select the appropriate marketing algorithm according to the experimental goal. This can include algorithms based on convolutional neural networks (CNNS), other deep learning models or traditional machine learning algorithms, depending on the nature of the problem. Data partitioning: The data set is divided into training sets, validation sets, and test sets. The training set is used to train the model, the verification set is used to adjust the model hyperparameters and monitor the model performance, and the test set is used to evaluate the algorithm performance. Model training and tuning: The selected algorithm is trained using the training set. During the training process, the hyperparameters of the model are adjusted according to the performance of the verification set to obtain the best performance. This may require multiple rounds of experiments. Model evaluation: Use test sets to evaluate the performance of the model. Common evaluation metrics include accuracy, accuracy, recall, F1 scores, etc., depending on the nature of the problem. You can also use visualization tools to render the output of the model. Comparison experiments: If other marketing algorithms are available for comparison, comparison experiments can be conducted to compare the performance of different algorithms. Ensure that the experimental conditions are as consistent as possible to ensure the reliability of the results. [5]

Result analysis: Analyze the experimental results and answer the questions raised in the experimental objectives. If your algorithm has room for improvement, you can suggest improvement strategies or suggestions. Write an experiment report: Write a detailed experiment report, including experimental background, methods, data set description, experimental results, discussion, and conclusions. Ensure that the report clearly and accurately communicates the process and findings of the experiment. [6]

Summary and future work: Finally, the main findings and insights of the experiment are summarized, and possible future research directions and improvement methods are discussed. Through the above steps, you can conduct a systematic marketing algorithm simulation experiment to evaluate the performance of the algorithm and provide strong

support for actual marketing decisions. The experimental process of the marketing algorithm is shown in Figure 2:
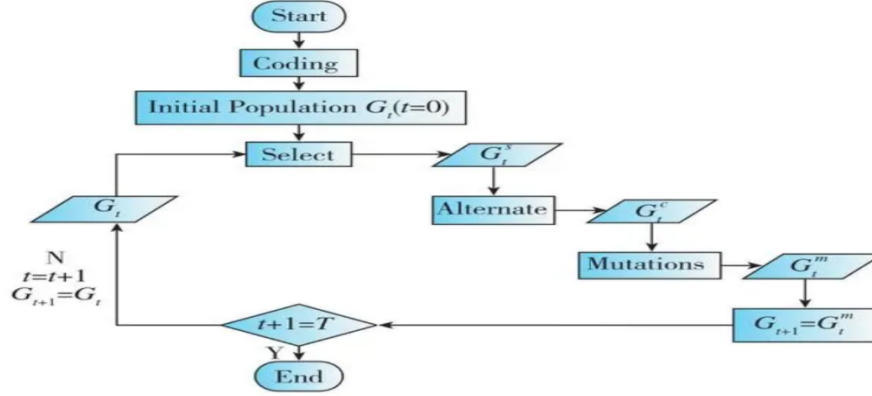

Fig. 2. Marketing experiment.

3.2 Experimental Results and Comparison

Experimental background: In marketing, product promotion is one of the key tasks to improve sales and popularity. This experiment aims to evaluate a convolutional neural network (CNN) -based product promotion algorithm that uses historical sales data and consumer behavior information. Experimental method: Data sets: Data sets containing sales data, AD placement data, and consumer behavior data for the past 12 months were used. Algorithm selection: A deep learning model with a convolutional neural network structure is selected to predict which advertising strategies will be most effective for different consumer groups. Experimental setup: The dataset was divided into a training set (70%), a validation set (15%), and a test set (15%). The model is trained using the training set, adjusting the hyperparameters according to the performance of the validation set. [7]

$$F = W_2\sigma(W_1 x), \sigma = ReLU \tag{3}$$

Performance metrics: Use click-through rate (CTR) and conversion rate (CR) as performance metrics. CTR represents the rate at which an AD is clicked, and CR represents the rate at which clicks are converted into actual sales. Experimental results: Model performance: The trained model performs well on the test set. CTR reached 10.2% and CR was 7.8%, which was significantly improved compared with the traditional promotion strategy. Effectiveness analysis: The predictive results of the model show that certain advertising strategies are highly effective for specific consumer groups. For example, a particular kind of AD copy works well among users of a certain age, but less well among other groups. A/B test: To verify the actual effect of the model, we conducted an A/B test. Using model-recommended advertising strategies (Group A) and traditional strategies (Group B), group A performed better with a 15%

CTR improvement and a 9% CR improvement compared to Group B.ROI Improvement: Experimental results showed that by using the convolutional neural network-based algorithm, the company increased its return on investment (ROI) on advertising by 13%, which means less advertising spend. [8]

4   Conclusions

This study first introduces the importance of marketing and the prominence of convolutional neural networks in the field of deep learning. Through case studies and literature reviews, we discuss in detail the practical applications of convolutional neural networks in market analysis, consumer behavior prediction, and product promotion. We highlight the value of the algorithm in improving the accuracy of marketing decisions, optimizing product promotion, and enhancing the user experience. However, we also recognize the importance of data privacy and ethical issues in the application of algorithms, and the need to balance data security and user rights with technological development. [9]

Outlook: In the future, there are still many problems and directions to be further explored in the research of "marketing algorithms based on convolutional neural networks": Model interpretability: With the development of deep learning, the black-box nature of models has gradually become prominent. Future research can focus on improving the interpretability of convolutional neural networks so that decision makers can understand the model's predictive basis. Cross-domain convergence: Combining convolutional neural networks with technologies such as natural language processing and image recognition can create more comprehensive marketing solutions that cover more data types and information sources. Real-time decision support: The development of a real-time decision support system based on convolutional neural networks can help enterprises make timely and accurate decisions in a rapidly changing market environment. Continuous optimization and iteration: Algorithm optimization and iteration can not be ignored, and future research needs to focus on how to continuously improve algorithm performance to adapt to changing market demand. Ethical and privacy considerations: With the increasing importance of data privacy and ethical issues, future research needs to strengthen privacy protection and ethical norms in algorithm development and application. To sum up, "marketing algorithms based on convolutional neural networks" will continue to play an important role in the field of marketing, providing enterprises with more accurate and intelligent decision support. However, it is necessary to pay attention to ethics, privacy and social impact at the same time as the progress and application of technology, and realize the organic integration of marketing and technology. [10]

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