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Optimizing Supply Chain Management Through BO-CNN-LSTM for Demand Forecasting and Inventory Management

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ABSTRACT

This project addresses demand forecasting and inventory optimization in supply chain management. Traditional methods have limitations with complex demand patterns and large-scale data. Deep learning techniques are employed to enhance accuracy and efficiency. The project utilizes BO-CNN-LSTM, leveraging Bayesian optimization for hyperparameter tuning, Convolutional Neural Networks (CNNs) for spatiotemporal feature extraction, and Long Short-Term Memory Networks (LSTMs) for modeling sequential data. Experimental results validate the effectiveness of the approach, outperforming traditional methods. Practical implementation in supply chain management improves operational efficiency and cost control.

KEYWORDS

BO-CNN-LSTM, demand forecast, inventory optimization, supply chain management

1. INTRODUCTION

Supply chain management is a crucial aspect of modern enterprise operations, and demand forecasting and inventory optimization are key issues within this domain. Accurate demand forecasting can help businesses plan production and inventory more effectively, avoiding situations of stockouts or excess inventory, thus improving customer satisfaction and operational efficiency(Sharma, 2020). However, traditional statistical methods have limitations in demand forecasting and inventory optimization due to the complexity of demand patterns and the challenges posed by large-scale data. Therefore, the application of deep learning and machine learning models is highly significant in addressing these problems.

The application of deep learning and machine learning models in supply chain management contributes to improving the accuracy of demand forecasting and the effectiveness of inventory optimization. By leveraging large-scale data and complex models, these methods can capture demand patterns, trends, and nonlinear relationships, thereby providing more precise predictions and optimized inventory management strategies. This is of great importance to businesses as it can reduce costs, enhance operational efficiency, and provide reliable decision-making support.

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In the field of supply chain management, various deep learning and machine learning models are widely employed. Here are five common models and their advantages and disadvantages: Recurrent Neural Networks (RNN) are models suitable for sequence data modeling, capable of capturing temporal dependencies(Bandara, 2019). However, RNNs suffer from the problem of vanishing or exploding gradients when dealing with long-term dependencies and memory. Long Short-Term Memory (LSTM) is an improved variant of RNN that addresses the issues of vanishing and exploding gradients by introducing gate mechanisms(Bandara, 2019). It performs well in handling long-term dependencies and memory, but it has higher computational complexity when dealing with large-scale data. Convolutional Neural Networks (CNN) are primarily used for image processing and are effective in extracting spatial features. In demand forecasting, CNN can be used to extract spatiotemporal features from demand data(Name, 1996). However, CNN's modeling capability for sequence data is relatively weak. Self-Attention Mechanism is a model that captures dependencies at different positions in a sequence. It can effectively learn important information in the sequence for demand forecasting, but it has higher computational complexity when dealing with long sequences. Random Forest is an ensemble learning method that makes predictions by combining multiple decision trees. It performs well in handling large-scale data, but its modeling capability for complex nonlinear relationships is relatively weak.

This study aims to enhance the effectiveness of demand forecasting and inventory optimization in supply chain management. Traditional methods have limitations when dealing with complex demand patterns and large-scale data, so the introduction of deep learning models is highly significant in addressing these issues. Additionally, the combination of Bayesian optimization, CNN, and LSTM can fully leverage large-scale data and powerful modeling capabilities to improve the accuracy and efficiency of demand forecasting and inventory optimization. This study proposes a method based on BO-CNN-LSTM to enhance the effectiveness of demand forecasting and inventory optimization in supply chain management(Kiuchi, 2020). The main principles of this method are as follows:

Firstly, Bayesian optimization is employed to automatically tune the hyperparameters of the model to achieve optimal performance. Bayesian optimization progressively optimizes the selection of hyperparameters by continually exploring and exploiting model performance feedback, thereby improving the model's performance and generalization ability.

Secondly, CNN is introduced to extract spatiotemporal features from demand data. CNN, through the use of convolutional layers and pooling layers, effectively captures local and global features of demand. This enables a better understanding of demand patterns and trends, providing accurate feature representations for subsequent prediction and optimization.

Lastly, LSTM is used to model sequence data to handle long-term dependencies in demand. LSTM, through the introduction of gate mechanisms, effectively retains and updates sequence information, thereby capturing the temporal features of demand more effectively. This improves prediction accuracy and provides more reasonable strategies for inventory optimization. Through training and testing on experimental data, this study validates the effectiveness of the BO-CNN-LSTM-based method in demand forecasting and inventory optimization(Oyewola, 2022). The experimental results demonstrate that this method has higher accuracy and efficiency compared to traditional methods. Furthermore, this method has been successfully applied in practical supply chain management, achieving significant results in improving operational efficiency and cost control capabilities.

The proposed BO-CNN-LSTM-based method has significant practical value in supply chain management. By combining Bayesian optimization, CNN, and LSTM, this method can better address the challenges of demand forecasting and inventory optimization, thereby improving supply chain efficiency and cost control capabilities, and providing accurate prediction results for business decision-making.

Introducing the BO-CNN-LSTM method: This study proposes a method based on BO-CNN-LSTM, which combines Bayesian Optimization, convolutional neural network (CNN) and long short-term memory network (LSTM), used to solve demand forecasting and inventory optimization problems