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A HYBRID ARTIFICIAL INTELLIGENCE AND MATHEMATIC OPTIMIZATION APPROACH FOR TRANSPORTATION OPTIMIZATION IN SUPPLY CHAIN MANAGEMENT

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ABSRACT

Transport is one of the key elements of SCM that impacts logistics cost, time of delivery, customer satisfaction, and overall efficiency of operations. Classical approaches to modeling of transportation processes mostly concentrated on minimization of transportation cost under supply and demand restrictions. The problem of varying customer demand, cost of transportation, traffic flow, and uncertainty of delivery makes classical approaches of optimization less efficient. At the same time, Artificial Intelligence (AI) opens up new opportunities in transportation decision making through demand prediction, cost calculation, route choice, and intelligent optimization.

An AI-based mathematical approach is introduced for transportation optimization in Supply Chain Management in this paper. The classic transportation problem is built by defining decision variables, objective function, and supply-demand constraints. Artificial Intelligence is added to the formulation in order to make future demand predictions for better transportation decisions. A numerical case study considering 3 warehouses and 4 destinations is illustrated to explain the proposed approach. It is concluded that using the AI approach along with the mathematical modeling technique makes the transportation more efficient and unnecessary transportation is minimized.

Key Words: Artificial Intelligence, Transportation Optimization, Supply Chain Management, Mathematical Optimization, Demand Forecasting, Logistics, Transportation Cost.

INTRODUCTION

Suppl Chain Management (SCM) includes the efficient transfer of goods, information, and resources from suppliers to consumers. Transportation is an important aspect of SCM, which requires the consideration of factors like supply, demand, cost, capacity, and time to deliver.

Mathematical modeling, especially the transportation problem and linear programming, reduces the cost of transportation and resource allocation. But the supply chain is dynamic, with changes in demand, cost of fuel, traffic, and climate.

Artificial Intelligence (AI) enables the prediction of demand, cost, time to deliver, and the optimal route through the use of past and present data. Thus, the combination of AI and mathematical modeling leads to an intelligent solution for transportation problems.

The prime objective of this paper is to come up with an AI-driven transportation optimization model for efficient Suppl Chain Management.

1.Objectives of the Study

The main objectives of this research are:

- Application of AI in the field of transportation management.
- Creating the optimum mathematical model for transportation.
- Minimizing cost of transportation subject to supply and demand requirements.
- Implementing AI-based prediction for demand forecasting to support decision making.
- Analyzing the efficiency of the combination of AI and mathematical optimization.
- Proposing a simple technique for transportation planning in Supply Chain Management.

2. Literature Review

Transportation problems are one of the vital applications of linear programming which focuses on reducing costs involved in transporting from one place to another. There are classical approaches like the North-West Corner, Least Cost Method, and Vogel's Approximation Method.

With the development of Artificial Intelligence (AI), the prediction of demand, traffic, delivery times, and routes is possible using machine learning. But, just using AI predictions will not ensure optimized use of resources.

Thus, AI and mathematical optimization can be combined; where AI will provide accurate predictions, and optimization will give the best decisions in terms of transportation.

3. Problem Statement

The supply chain has warehouses providing items to various destinations. The problem involves determining how much should be moved from each warehouse to each destination at the minimum total transportation cost.

As the future demand might be unknown, AI determines the future demand based on historical data. The calculated demand becomes an input for the transportation optimization problem.

Two stages:

1. AI-based demand prediction
2. Mathematical transportation optimization

Flow:

Historical data → AI → Demand prediction → Optimization → Optimal transportation plan

4. Role of AI in Transportation Optimization

There are a number of ways in which AI can be used for improving transportation management.

4.1 Demand Prediction

AI algorithms can use previous sales and customer behavior data in order to predict future demand. Correct demand prediction will help organizations in not having too much or too little stock.

4.2 Route Optimization

AI can use traffic data, distance, travel time and other factors in order to find an optimal route.

4.3 Costs Prediction

Depending on fuel price, traffic, distance, availability of vehicles, costs for transportation might be different. AI can be used in order to estimate costs.

4.4 Delivery Time Prediction

AI can estimate average delivery time based on transportation data and current circumstances.

4.5 Dynamic Decision Making

Contrary to static transportation model, dynamic transportation decisions can be made by using AI.

5. Proposed AI-Optimization Approach

The following is the process involved in the proposed AI-optimization approach.

Step 1: Data Gathering

Gather data in the form of past information like sales, demand, cost of transport, delivery times, and routing data.

Step 2: Demand Prediction Using AI

Appropriately use AI or machine learning algorithms to make predictions regarding future demands.

Step 3: Formulate Mathematical Models

Use predictions of demand, supply, and transport cost into the formulation of the mathematical model for transport optimization.

Step 4: Optimize

Find solutions to the mathematical model that give the optimal number of transports from the warehouses to the destinations.

Step 5: Making Decisions

The optimized transportation plan may then be adopted by the supply chain manager.

6. Results and Discussion

It is clear from the above approach that it is important to integrate AI with mathematical optimization where AI forecasts future demand, and the mathematical transportation model schedules products under supply and demand restrictions.

From the above numerical example, we see that systematic planning of transportation is possible in order to optimize the cost and fulfill demand. Further development of the above model could incorporate the vehicle capacity, delivery time, fuel consumption, warehousing capacity, and route availability.

7.Advantages of the Proposed Approach

The proposed AI-based transportation optimization model provides several advantages:

Reduction in transportation cost: Optimal allocation can reduce unnecessary transportation expenditure.

Improved demand planning: AI-based prediction helps estimate future customer requirements.

Better resource utilization: Available warehouse supply and transportation capacity can be utilized efficiently.

Improved decision-making: Managers can make decisions based on data and mathematical analysis.

Flexibility: The model can be updated when new demand or cost information becomes available.

Improved customer satisfaction: Better transportation planning cancontribute to timely product delivery.

Scalability: The mathematical model can be extended to larger numbers of warehouses and destinations.

8.Limitations

1. Although the proposed approach provides several benefits, some limitations should be considered.
2. First, the accuracy of the transportation plan depends on the quality of AI-based demand predictions. Incorrect or incomplete historical data may result in inaccurate predictions.
3. Second, transportation costs and supply conditions may change rapidly in real-world environments. Therefore, the model may need to be updated regularly.
4. Third, implementing an AI-based optimization system may require suitable software, computing resources, and skilled personnel.
5. Future research can address these limitations by integrating real-time transportation data, advanced Machine Learning techniques, traffic information, vehicle capacity, and environmental considerations.

9. Future Scope

The proposed model can be improved by implementing more advanced AI and ML approaches to achieve higher accuracy in demand prediction. In addition, multiple objectives can be incorporated into the model, like minimizing the transportation cost, time, fuel usage, emissions, and increasing customer satisfaction.

Real-time optimization of transportation processes based on traffic and vehicle location information is another direction for future research. Other application domains of the proposed approach include e-commerce, retail, manufacturing, healthcare, and food industries.

10. Conclusion

Optimization of transportation in Supply Chain Management is very essential since it influences cost, logistics, resource utilization, and customer satisfaction. Mathematical models can be used to determine the most optimal allocation of products considering the supply, demand, and cost of transportation.

AI models can analyze the data from the past to forecast the future demand and logistics conditions. The aim of this research is to combine an AI model to predict demand and a mathematical model for transportation optimization to reduce transportation cost while meeting the supply and demand constraints.

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