Study on Cold Chain Path Optimization Considering Traffic Flow and Dynamic Customer Demands

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Abstract

With the advancement of economic and societal development, there has been a growing demand for fresh food products, alongside the necessity for certain pharmaceuticals to be transported under low-temperature conditions. Consequently, cold chain transportation assumes an increasingly vital role within the logistics ecosystem. Given the perishable nature of cold chain products, customers exhibit a pronounced requirement for timeliness in their transportation. This study is grounded in an enterprise-centric perspective, seeking to address these challenges through the prism of total distribution cost optimization. It delves into two significant factors profoundly impacting the timeliness of cold chain transportation: the temporal and spatial variations in traffic flow and the dynamic nature of customer demands. Traffic flow conditions directly influence vehicle speed, thereby affecting the time taken for goods to reach customers. Meanwhile, the prevalence of dynamic customer demands within contemporary logistics systems poses novel challenges in promptly and accurately addressing evolving customer needs. To address these issues, this study proposes the utilization of graph neural network methodology to grid the geographical map and embed each designated point, thereby facilitating the prediction of road traffic flow across temporal and spatial dimensions. By incorporating a traffic prediction module, accurate traffic information can be provided to delivery vehicles, enabling them to select more time-sensitive delivery routes. In the process of solving vehicle routes, the study plans to employ the Deep Deterministic Policy Gradient (DDPG) framework, representing problem constraints in the freight process as rewards and losses, and the solution process as states and actions. Through the integration of the traffic prediction module and the route-solving module, the method proposed in this study provides a more realistic simulation of actual road network scenarios, optimizes vehicle pathways in cold chain transportation, reduces distribution costs at distribution centers, and offers novel insights and methodologies for the cold chain transportation industry.

Keywords

Vrp, Cold Chain Transportation, GNN, Reinforcement Learning