

Stochastic Waste Collection Routing with Profit: A two-stage framework

This study addresses the Waste Collection Vehicle Routing Problem with Profit (WCVRP) while considering uncertainty in bin fill levels a critical challenge for municipalities and waste management providers aiming to enhance service efficiency. In real-world conditions, bins fill levels fluctuate unpredictably, leading to inefficient routing, unnecessary trips, or uncollected waste. To tackle these issues, we propose a Two-Stage WCVRP that incorporates uncertainty through a scenario-based approach. Scenarios are generated from residuals of predictive models, capturing realistic variations in bins waste usage.

The model employs a single recourse strategy: an overflow penalty is incurred when containers exceed their capacity and waste remains uncollected. This approach avoids the need for vehicle return trips and reflects practical constraints in urban collection systems. The objective is to maximize profits by balancing collection revenues, travel costs, and penalty costs. Formulated as a variant of the Capacitated Vehicle Routing Problem with Profit (CVRPP), the model performance is evaluated using indicators such as total profit, total distance traveled, and total waste collected.

Stochastic metrics, including the Expected Value of Perfect Information (EVPI) and the Value of the Stochastic Solution (VSS), are also calculated to assess the value of explicitly modeling uncertainty. A preliminary case study in Rio Maior, Portugal, demonstrates the applicability of the developed approach.

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