Remote Assessment Sensor Routing: An Application of Waste Management

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Extended abstract

Objectives and motivation

The urban waste management industry deals with the collection, transport, processing, recycling, disposal, and monitoring of waste materials. Although each aspect of the waste cycle is crucial, the collection process tends to be the most significant and costly portion of the entire activity. Therefore any cost savings that can be made in this area would potentially improve service in other areas and result in major budget savings. In the context of municipal solid waste collection, this involves the use of remote sensing technologies at garbage bins to relay information to a central server about bin fill-levels. The central server would then take into account each day’s bin fill levels and dispatch the appropriate number of vehicles on specific routes to the given pick up locations.

With the availability of each day’s bin fill-level information, the dispatcher still has to decide which bins to serve. One reasonable assumption would be to visit only those bins that are near capacity. This policy, however, is not necessarily optimal as it does not exploit the opportunity of visiting bins of lower fill-levels in an attempt to save future costs. In this paper, we propose an anticipative model, called the Remote Assessment Sensor Routing Problem, which would minimize each day’s costs while taking into account the implications of that day’s action on future costs. To model the problem, we use an approximate dynamic program where a continuous approximation model of vehicle routing is used to estimate the expected future routing costs. Use of the continuous approximation models is critical as it substantially reduces the search space of the optimization problem leading to reduction of computation time.

General description

The proposed model is compared to three benchmarks. The first benchmark, called periodic routing, represents contemporary waste management practice where bins are visited based on specific schedules. This benchmark helps evaluate whether the remote assessment technology can improve status quo. The second benchmark is called perfect hindsight as it assumes complete information about the waste production of each bin. This benchmark, although not realistic since complete production information is not available, is used as a lower bound to the minimization problem. The third benchmark, called the myopic model, is designed for the remote sensing technology but it is not predictive of future demand. This benchmark only considers each day’s costs and disregards future costs. A simple example of this benchmark is to visit only the bins that are near capacity. This benchmark helps evaluate whether more advanced decision-support models that consider future production patterns will increase the benefits of the technology.

Results and conclusions

Results show that the perfect hindsight model is the most optimal and the periodic routing model is the least. The performance of the approximate dynamic programming model is dependent on the variability in waste production. Under high variability, the proposed model can save up to 20% compared to the periodic routing model and is within 12% of the globally optimal solution.

References

Keywords: Vehicle Routing; Waste; Urban logistics; continuous approximation;