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Evaluating the benefit of mixed fleet using agent-based modelling and simulation

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The aims of this paper is to evaluate the benefit of a mixed fleet for parcel delivery and pick-up operation in urban setting. This paper is a part of an ongoing project aimed at evaluating the feasibility and benefits of electrification (e.g., electric vans, trailers, e-bike, etc) in reducing greenhouse gas emissions, and analysing necessary reorganizations in the UK's logistics system through agent-based modelling and simulation.

Utomo et al. (2019) noted that until recently agent-based modelling is mainly used to model passenger EVs. In our previous study, we have evaluated the feasibility and benefits of electric vans for grocery delivery in urban area (Utomo et al., 2019). The novelty of this research is that we incorporate manual and electric bicycle for parcel pickup and delivery operation.

In this research we develop our agent-based model based on a data set provided by a real world parcel company. Our agent-based model considers parcel pickup and delivery by using vans and bicycle (manual and electric). The initial case study is done in the city of Munich.

The development of our model started by analysing the demand for parcel pickup and delivery, such as the geographical distribution of the customers, the average number of packages per customer, the size and the volume of the packages. We also carried out a series of discussion with the domain expert from the parcel company. The aim of these discussion is to understand their operation in the real world. We use this information to define the agents and their interaction in our model.

We develop our model using Anylogic software. The agents in our model comprise of, the distribution centre, consolidation hubs, vans, bikes and e-bikes. The position of all agents is initiated based on real data and are projected to a GIS layer obtained from OpenStreetMap in which the road network data is obtained from Geofabrik GmbH.

The model starts by generating a synthetic delivery and pickup orders. We then select the type of vehicle to serve the order. This selection is done based on the weight and size of the package, and the location of the customer. If a bicycle is selected to deliver an order, the parcels must first be delivered from the distribution centre to the consolidation hub where the bicycle is located using a van. The bicycle then continues the delivery from the consolidation hub to the customer. Similar process applies to pick up operation.

Finally we group these orders into several journeys. For this purpose we develop a routing algorithm that is based on nearest neighbour heuristics. Our routing algorithm considers constraints such as vehicle's capacity, delivery time window and the marginal cost of the delivery. Finally we compare the outputs of our simulation with the real data for validation.

Using this model we try to determine the cost and efficiency impact of incorporating multiple delivery modes like bikes and e-bikes in inner city delivery operations; the ideal combination of manual bikes, e-bikes, and EVs which has the minimum operating cost per package and stop without negatively impacting efficiency; and the reduction in emission and congestions by switching to EVs, bikes and e-bike from the current fleet.

Keywords: Agent-based modelling, mode choice and multimodal freight networks, electric vehicle

References

Utomo, D.S., Gripton, A., Greening, P., 2019. Modeling Home Grocery Delivery Using Electric Vehicles: Preliminary Results of an Agent-Based Simulation Study, *2019 Winter Simulation Conference (WSC)*. IEEE, pp. 1637-1648.