An optimal configuration for the Micro-hubs and Cargo bikes for last mile freight delivery:
Results from the comparative analysis of the developed model

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Introduction

Share of urban freight transport in overall urban transport in Europe

<table>
<thead>
<tr>
<th>Share</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of trips of urban freight transport</td>
<td>15% (10-20%)</td>
</tr>
<tr>
<td>Share of km of urban freight transport</td>
<td>20% (15-25%)</td>
</tr>
<tr>
<td>Share of fuel consumption and emissions of urban freight transport</td>
<td>30% (20-40%)</td>
</tr>
</tbody>
</table>

Source: Cycle Logistics Report (Europe), 2019

Source: Maes et al., 2017

Source: World Economic forum Report, 2020

Less traffic, noise and GHG emissions
More public space
Last Mile Freight Transport

CEP (Courier, Express and Parcel) services

Source: Maes J. (2011)
## State of Art

<table>
<thead>
<tr>
<th>Study</th>
<th>Scope</th>
<th>Results</th>
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</thead>
</table>
| Verlinde et al. (2014) | **Pilot Study**: 1 Mobile depot + 4 electric cargo bikes | 24% reduction in CO2 emission (kg)  
59% reduction in PM2.5 emission (gm)  
72% reduction in Spatial consumption on road  
Transport cost **doubled** |
| Navarro et al. (2014)  | **Pilot Study**: 1 micro-hubs+ 2 freight cycles | Saving in fuel consumption: 400 l/month  
Reduction in distance travelled : 64 km/month |
| Neils et al. (2018)    | **Pilot Study**: Truck trailer + cargo bike | Saving of CO2 emission: 7.5 tons per year  
Reduction in distance travelled: 135 km/day |
| Nürnberg et al. (2019) | Cargo bikes                                | Lack of suitable bicycle infrastructure hinders the advantage of cargo bikes                                                        |
| Allen et al. (2000)    | Cargo bikes                                | 87% of the total time of delivery of goods is spent in search of parking space for long distance delivery without consolidation points |
| Brown et al. (2011)    | **Pilot Study**: Micro-hubs+ 6 e-cargo tricycle and 3 e-vans | Reduction in CO2 emission (kg): 54%  
Spatial consumption on road reduced by 56% |
| Arvidsson et al. (2018)| **Trial Study**: Freight Bus+ electric cargo bikes | **24% increase** in transport cost |
| Arnold et.al (2018)    | Distribution points + cargo bikes          | **134% increase** in delivery time  
**9% increase** in operational cost  
40% decrease in external cost |
| Gruber et al. (2014)   | Cargo bikes                                | 48% of trips by motorised vans can be substituted by cargo bikes                                                                      |
Motivation, Research Gap and Questions

**Motivation**
- Potential to be an economically and environmentally feasible and viable in last mile freight delivery

**Research mostly focused on trials/ pilot studies**
- Trials not applicable in generalized scenario
- Random selection of location for micro-hubs
- Lack of proper configurations of vehicles used
- Uncertain economic viability
- Lack of proper Implementation Framework for LSPs/ City Planners

**Research Questions?**
- How can the logistics setting using cargo bikes and micro-hubs be framed in an existing scenario?
**Problem Formulation**

**Optimal Network Configuration**

- Optimal location of micro-hubs
- Optimal number of micro-hubs

**Location Model for micro-hubs**

- Optimal number of cargo bikes
- Routing configuration

**Vehicle Routing Model**

**Location- Routing problem (LRP)**

**Objective Function:**

\[
\sum_{j \in J} f_j \cdot X_j + \sum_{j \in J} \sum_{i \in I} \sum_{k \in K} c_{ij} \cdot Y_{ijk}
\]

facility cost  Transport cost
Proposed Greedy Search Heuristics Algorithm for LRP

1. **Data Preparation and Parameterisation**
   - Initial Solution
   - Improvement of initial solution

2. **Stage 1: Clustering of Customers and Location allocation**
   - Clustering of customers with Greedy Search Algorithm
   - Assignment of clusters to micro-hubs based on Gravitational centres
   - Removal of unopened UCCs

3. **Stage 2: Vehicle Routing Problem in Jsprit**
   - Solving VRP in Jsprit

4. **Stage 3: Minimizing the Objective Function**
   - The parameters and constraints are varied wr.t to different scenario
   - Iterated until the cost functions are minimized

**Objective Function:**

\[
\sum_{j \in J} f_j \cdot X_j + \sum_{j \in J} \sum_{i \in I} \sum_{k \in K} c_{ij} \cdot Y_{ijk}
\]
Proposed Greedy Search Heuristics Algorithm for LRP

Cluster of demand points

Potential micro.hubs
Proposed Greedy Search Heuristics Algorithm for LRP

\[
(X,Y) = \left( \frac{\sum_{i \in I} x_i}{n_I}, \frac{\sum_{i \in I} y_i i}{n_I} \right)
\]

- **Assigned micro-hubs**
- **Unassigned micro-hubs**
Proposed Greedy Search Heuristics Algorithm for LRP
### Comparative Results with others algorithms in Literature

<table>
<thead>
<tr>
<th>Instances: no. cust X no. Dept</th>
<th>GRASP (Prins et al. 2006)</th>
<th>LRGTS (Prins et al. 2007)</th>
<th>CH (Barreto et al. 2007)</th>
<th>Proposed algorithm</th>
<th>Min. no. Of vehicles</th>
<th>Min. no. of depots</th>
</tr>
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<tbody>
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<td>Christ89–50×5</td>
<td>599.1</td>
<td>586.4</td>
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<td>5</td>
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<td>–</td>
<td>6238</td>
<td>5118.219</td>
<td>11</td>
<td>8</td>
</tr>
</tbody>
</table>

**Fig:** Result of initial solution

**Source:** own
Conclusion and remarks

- Micro-hubs together with smaller vehicles, such as cargo-bikes could be a feasible solution to last-mile delivery, when the configuration of their network is optimal.

- The developed model results for optimal solution when compared with previous known literatures of LRP

- Initial results from the developed model shows optimal results but can be improved further

- However, the developed model needs to be assured for larger instances of data
**Problem Size for the study**

**Potential location:** 2,020, capacititated, opening cost $f_j$

**Customers:** over 220,000 demand $h_i$

**Vehicles:** infinite fleet, capacity $u$, total transport cost as $c_{ij}$ (fixed+variable)

**Available data:**
- Customer georeferenced points
- Potential UCC georeferenced points
- Generation of demand randomly for a given day
- Fleet characteristics in xml

Source: own
Thank you for your attention!

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