Planning of bike-lane networks

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Outline

- Motivation
- Types of Bike Lanes
- Problem Formulation
- Conclusion and Further Steps
Motivation

- Bike Lane: Cycle Friendly, Safety, and sustainability
- The Albert Street bicycle lanes
  
  “The new lane is confusing to motorists and cyclists and it is obvious the council has not thought through the implications of such a scheme,” RACV General Manager for Public Policy, Brian Negus.
Motivation

- Link Level Approach
Network Level Approach

- Origin
- Destination
- Bike lanes

Network diagrams showing links with a bike lane and ordinary links.
Research Aims

- Identification of the best set of bike lanes in the network.
  - Optimum Combination of bike Lanes.
- Application of a mathematically efficient method
- Consideration of interest of bike users
- Consideration of effect on other road users such as traffic congestion
## Types of Bike Lanes

<table>
<thead>
<tr>
<th>Type of Facility</th>
<th>Description</th>
<th>Degree of Separation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exclusive Bicycle Lane</td>
<td>A separate lane that can only be used by bicycles</td>
<td>High</td>
</tr>
<tr>
<td>Shared Parking and Bicycle Lane</td>
<td>A separate bicycle lane in which motor vehicles can also park</td>
<td>Medium to High</td>
</tr>
<tr>
<td>Wide Kerbside Lane</td>
<td>A wide left lane that is shared by bicycles and motor vehicles</td>
<td>Low</td>
</tr>
<tr>
<td>Off-road Path</td>
<td>A path located adjacent to a carriageway</td>
<td>High</td>
</tr>
</tbody>
</table>
Nine Ways to Create Bike Lanes

1. Reduce width of traffic lanes
2. Seal shoulders
3. Indent car parking
4. Prohibit car parking
5. Use existing service roads
6. Widen road into the median
7. Widen road into the nature strip
8. Remove traffic lane
9. High standard off-road path
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Problem Formulation

- **Upper Level**

<table>
<thead>
<tr>
<th>Objective Function</th>
<th>( \text{MaxZ} = \sum_{(i,j)\in A} l_{ij} x_{ij}^c \Phi_{ij} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.t.</td>
<td>( \sum_{(i,j)\in A} l_{ij} (\sum_{m} \phi_{ijm} e_{ijm}) \leq Bdg )</td>
</tr>
<tr>
<td>Budget</td>
<td>( \sum_{(i,j)\in A} l_{ij} (\sum_{m} \phi_{ijm} e_{ijm}) \leq Bdg )</td>
</tr>
<tr>
<td>Only one type of bike lane on each link</td>
<td>( \Phi_{ij} = \sum_{m} \phi_{ijm} \leq 1 \quad \forall(i,j) \in A )</td>
</tr>
<tr>
<td>Auto flow constraint</td>
<td>( x_{ij}^{a} / c_{ij}^{a} \leq \rho \quad \forall(i,j) \in A )</td>
</tr>
<tr>
<td>Min cyclist flow</td>
<td>( x_{ij}^{c} - x_{\text{min}}^{c} \leq M \Phi_{ij} \quad \forall(i,j) \in A )</td>
</tr>
<tr>
<td>Continuity</td>
<td>( \sum_{h} \Phi_{hi} l_{hi} + \Phi_{ij} l_{ij} + \sum_{k} \Phi_{jk} l_{jk} \geq \Phi_{ij} l_{ij} \quad \forall(i,j) \in A )</td>
</tr>
</tbody>
</table>

- **Lower Level**
  - Traffic Assignment model
  - Bike Assignment model

A heuristic solution algorithm based on ant colony
Traffic Assignment

- **Static User Equilibrium**

\[
\text{Min} Y = \sum_{(i, j) \in A} \int_{0}^{x_{ij}} t_{ij}^{c}(\omega) d\omega
\]

\[
\text{S.t.}
\]

\[
\sum_{k} f_{rs}^{k} = q_{rs} \quad \forall r, s
\]

\[
f_{rs}^{k} \geq 0 \quad \forall k, r, s
\]

\[
x_{ij} = \sum_{rs} \sum_{k} f_{rs}^{k} \delta_{k,ij} \quad \forall (i, j)
\]

- \(x\): link flow
- \(t\): travel time
- \(q_{rs}\): OD demand
Bike Demand Assignment

- All or nothing assignment
  - Shortest distance
  - Shortest time
  - Maximum grade
  - Safety and convenience

- Assignment based on discrete choice logit models
Challenges

- Bike zone definition
- Bike demand estimation
- Quantification of safety and health value of a bike lane
- Cost estimation of bike lane implementation
Conclusion

- A planning method should be developed to optimize a bike-lane network
- Methods to implement a bike lane were identified
- A bi-level optimization formulation is proposed for reallocation of the road space
- Route choice models for car and cyclists are considered
- An efficient heuristic algorithm is applicable to analyze large scale road networks