The Netherlands Research School for Transport, Infrastructure and Logistics

TRAIL

OPTIMIZATION OF EXTERNALITIES USING DTM MEASURES

A Pareto optimal multi objective optimization using the evolutionary algorithm SPEA2+

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Traditionally, the **Network Design Problem** (NDP) focuses on **accessibility**. Yet, the quality of traffic systems is not only a matter of accessibility, but also of externalities such as **traffic safety** and **air quality**. This research is about solving the multi objective NDP in which minimizing the externalities of road traffic using **Dynamic Traffic Management** (DTM) measures are the objectives.

Aim of the research

- Optimization DTM measures on a strategic level
- Extending NDP with externalities as objectives
- Performing a Pareto optimal multi-objective optimization
- Reduction of Pareto optimal set

Optimization problem

$$\min_{S \in F} \begin{pmatrix} z_1(S) \\ z_2(S) \\ \vdots \\ z_I(S) \end{pmatrix}, \text{ subject to } \left(q(S), v(S), k(S)\right) \in \Gamma^{DTA}\left(G(N, A, S), D\right),$$

in which S is a set of applications of strategic DTM measures to be selected from a set of feasible applications F, and $z_i(S)$, is a different objective function of the link flows $q(S)$, the link speeds $v(S)$, and the link densities, $k(S)$, expressed as $z_i(S) = f_i\left(q(S), v(S), k(S)\right)$. Furthermore, the link flows, speeds, and densities are assumed to follow from solving a DUE problem, indicated by for which the supply of infrastructure is given by G with nodes N and links A and the DTM measures defined in S, and the travel demand D.

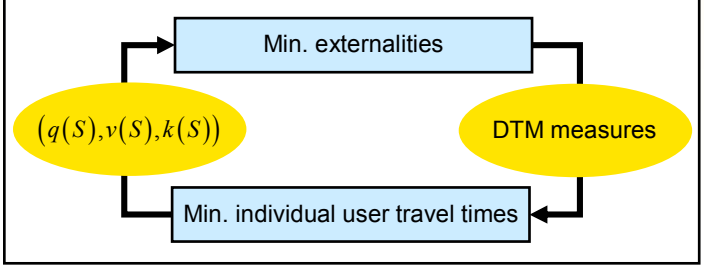
Objectives

- Congestion – Total travel time
- Climate – Total amount of CO_2 emissions
- Air quality – Total weighted emissions of PM_{10} (or NO_x)
- Noise – Weighted average sound power level at the source
- Traffic safety – Total number of injuries

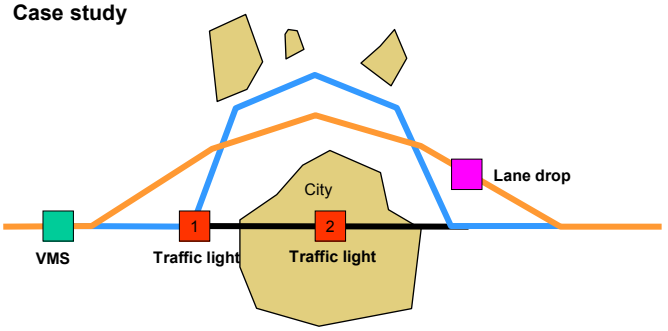
Emissions are based on the ARTEMIS emission model, noise on the RMV noise model, traffic safety on an accident risk based model.

Framework

- Bi-level optimization
  - Lower level solved using the Streamline DTA model
  - Upper level solved using the SPEA2+ algorithm
- Convergence check by S-metric and C-metric
- Reduction of Pareto optimal set by convex hull method

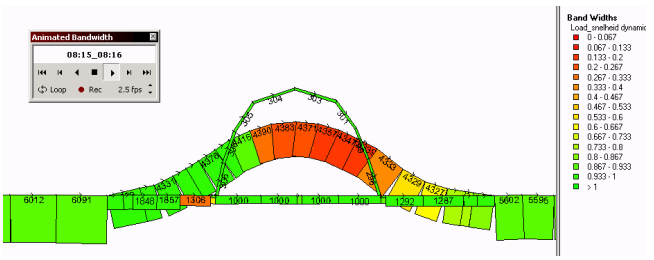


Case study



3 measures, 6 time periods, 4.05×10^{21} possible solutions S

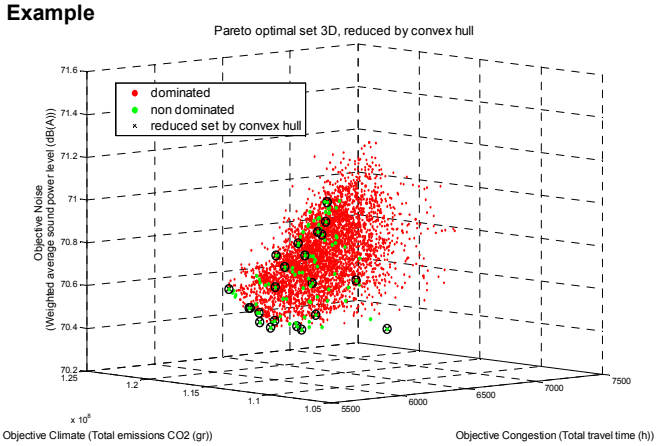
Reference



Results

- Climate and congestion objectives are aligned and these objectives are opposed to noise, air quality and traffic safety.
- Pareto optimal solutions show large diversity of settings DTM, which means the Pareto optimal set can not easily be characterized using simple rules of thumb
- Usage of convex hull when three objectives are simultaneously optimized, reduced the Pareto optimal set effectively to less than 25% of original size

Example



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