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Accelerating Moving Walkways: Optimization of an Innovative Transport System for Dense Urban Areas

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Extended Abstract

Pollution, congestion and urbanistic considerations are leading to a change in the use of private vehicles in dense city centers. More frequently, the *last-mile* is covered with systems such as public transport, car sharing and bike sharing as well as an increase in walking and cycling. Following this trend, we assume a hypothetical scenario where the use of private cars is strongly limited in dense urban areas, and a mix of traditional and innovative transport modes satisfies the need of mobility.

This project studies a system based on accelerating moving walkways (AMW) to facilitate movement of pedestrians in city centers. AMWs present an acceleration (deceleration) section at the embarking (disembarking) area that accelerates passengers to a speed close to 15 km/h. This speed is comparable with the commercial speed of bus and tram services, as well as private cars, which travel at an average speed of 18 km/h during peak hours. Although several installations of traditional moving walkways and few trials of AMWs exist, in particular in metro stations, airports and dense urban areas; this project investigates the possibility of implementing a network of interconnected AMWs. In the assumed scenario, the infrastructure previously used by private vehicles can be reused for the installation of AMWs on roads. This project designs and optimizes the network of this innovative transport system, identifying the optimal system characteristics that could best satisfy the demand of mobility given a budget constraint.

In order to investigate the best network design, we (i) define the system technological characteristics, (ii) make assumptions on possible junction designs, (iii) develop an appropriate optimization framework, and (iv) analyze a case study.

The first step is the definition of the system characteristics based on the currently available technologies and the already present installations. Analytical equations and parameter values define the main characteristics such as infrastructural aspects (e.g. acceleration, deceleration, speed, width, capacity), costs (e.g. construction and operational costs for the different sections per unit of walkway length and passengers), comfort (e.g. probability of falling and discomfort in the different sections), energy consumption (e.g. electricity consumption for the different sections per operational speed and passengers).

Given the system characteristics, additional information on the possible junction designs is needed. This is because AMWs have never been implemented in a network; therefore, assumptions on the junctions should be made. Considering as much as possible the characteristics previously defined, we design a series of junction types. For each design, we identify the transportation factors such as allowed directions, gain in travel time and maximum possible curvature. These *expressways* span over several roads without decelerating at intersections, allowing direct links between destinations with high demand.

Given the necessary technological characteristics and the junction designs, we define the optimization algorithm. Given a network of roads and an origin-destination (OD) demand, we are interested in determining the network of AMWs

that reduces the most the total travel time, given an operational budget. Following a review of *Public Urban Transit Network Design Problems* and the associated optimization algorithms, which encompasses all the problems related to network design in a urban environment; we identify our problem as a *minimum cost multimodal and multi-commodity directed network flow problem*. However, our problem slightly differs from conventional transit network problems due to specific system characteristics such as the presence of expressways. Therefore, we develop an *ad hoc* optimization algorithm. The algorithm is based on an iterative approach of traffic assignment and network optimization. In this approach, we start with an initial network equipped completely with AMWs, which we transform iteratively removing AMWs on selected roads until the budget constraint is reached. The OD matrix is reassigned on the updated network every fixed number of steps. We chose the frequency of the reassignment as a tradeoff between accuracy and computation time. The AMWs to be removed are selected following a greedy logic, removing the less beneficial ones, i.e. the AMWs leading to the smaller increase of total travel time. The number of parallel AMW lanes on each equipped link determines the capacity of the system, and the operational cost constrains it.

Finally, we test the optimization framework on synthetic scenarios and on a real case study. The synthetic scenarios are used to test the quality of the optimization algorithm and to identify the best framework variation for our specific problem. The city of Geneva, Switzerland, is used as a real case study. The current available infrastructure and OD demand are the input for the optimization framework, which provides as the result the optimal AMW network. The network of Geneva city center has a total road length of 70 km, 257 links, 186 intersections and a total demand of 1.5 million trip/day.

In summary, this project presents an innovative transport system based on accelerating moving walkways. The present research, after a review of existing installations to establish the system technological assumptions and possible junction designs, formulates an *ad hoc* optimization framework for identifying the best network configuration that minimize the total travel time given a budget constraint. We test the optimization algorithm on a real case study, and we evaluate the feasibility of the system.