Assessment of The Effects of Single Vehicle Data for Traffic Flow Harmonization in The Scope of V2X Systems

Master‘s Thesis of Anas Denno

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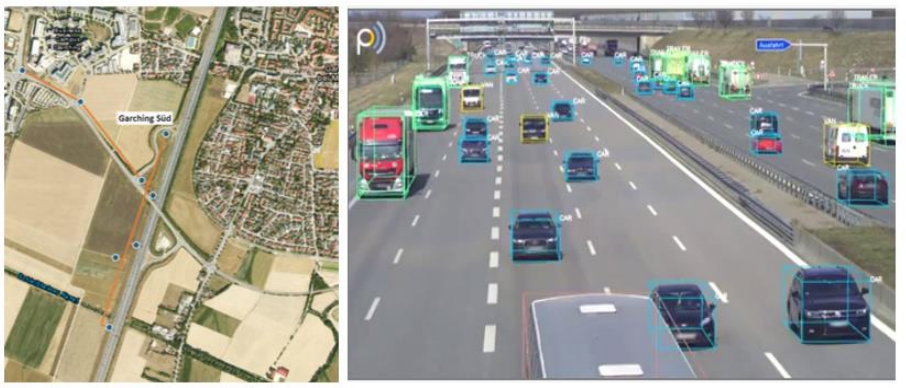
Traffic congestion is characterized by slower speeds and longer travel times accompanied with huge negative impacts on the environment as well as the economy. Therefore, by implementing smart solutions of traffic control that react productively and effectively on traffic situation aimed at harmonizing the traffic, the congestion could be reduced or even avoided, and the flow would be homogenized. One of the smart solutions is using single vehicle data in traffic harmonization algorithm in cooperation with different proportions of cooperative vehicles inserted in the traffic relying virtual variable message signs using V2X system to communicate and receive the new implemented speed limit. Cooperative vehicles are distinguished that they receive the speed limit and implement it 100 % so the human behavior by following the speed limit is excluded. The study area is the section of Motorway A9 connecting between Intersection Neufahrn and Intersection München Nord. The motivation behind this study area is that 47.8 % of employees in Munich are commuters as well as that Munich was identified as the German Capital of Traffic Jam for the year 2022, this had resulted in 74 hours delay per driver.

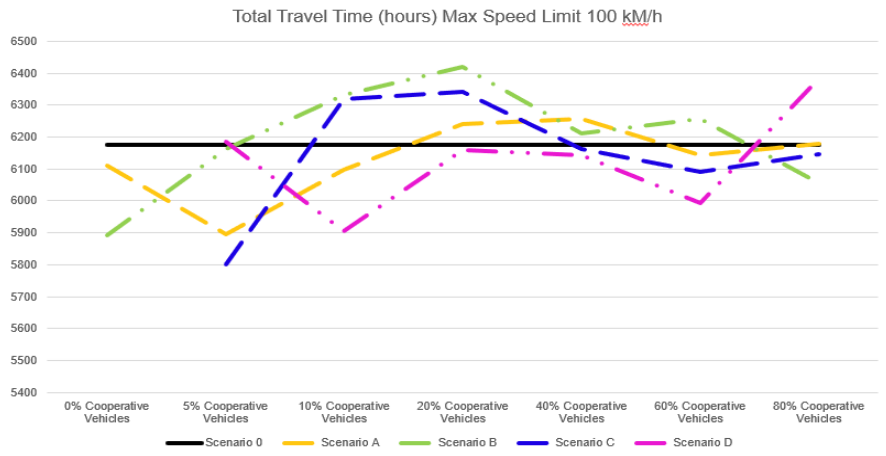
Single vehicle data provide extensive and comprehensive information not only regarding the vehicle itself, but also regarding the prevailing traffic conditions. The information that are acquired from the single vehicle data are speed of the vehicle, trajectory, distance to the vehicle in front, spatially and temporally. The approach to use single vehicle data in the traffic harmonization on the A9 is based on the existence of the Provedentia++ project. The project consists of seven sensor stations and more than 60 sensors to observe a 3.5 kM long section of the A9. The observation is conducted nonstop using cameras, lidars and radars. This high-sophisticated equipment provides information in a frequency of 25 Hz. The provided data from such a state-of-the-art observation are sequences and frames of the vehicles as well as specific scenarios regarding congestions, lane changing maneuvers and the travel behavior of the vehicle. The algorithm is based on single vehicle data as input in addition to Time to collision (TTC) as additional parameter. TTC is the time that remains until the rear vehicle driving in speed of vi collides with the vehicle travelling ahead at distance d at speed vi+1, assuming that both vehicles maintain their speed constant

Providentia++ Data on the Motorway A9



Source: TUMTraf Dataset: Frames und Sequenzen vom Testfeld A9 (innovation-mobility.com)

Traffic Demand from 6:00 AM to 9:00 AM: 28016 Cars + 2358 Trucks= 30374 Vehicles



Scenario 0 presents the total travel time without any intervention. Scenario A shows the results after implementing the algorithm whereas Scenario B is for the algorithm with TTC as an additional parameter. Scenarios C and D are the same as A and B but virtual VMSs are added. The results show that adding TTC as a parameter makes the Algorithm more sensitive and provides quick reactions (Scenario B0) Moreover, the System in all of its scenarios leads to improvement and reduced total travel time at the beginning. The increase of cooperative vehicles proportion leads to increased total travel time until they are the majority of the traffic vehicles (> 40 % of the traffic) then the total travel time in the network starts to decrease. This is justified to the configuration of cooperative vehicles that they follow the speed limit 100 %. Virtual variable message signs for the cooperative vehicles cooperate strongly in producing improvement (Scenario D) throughout the whole scenarios except when cooperative vehicles are 80%. Furthermore, adding TTC in combination with virtual VMSs lead to improvement with low proportion of cooperative vehicles.