ITS improves cycling in Copenhagen

The City of Copenhagen has been successful in creating a physical infrastructure that makes cycling the most efficient mode of transport for commuting in the city. The City of Copenhagen is developing and implementing ITS solutions that promote cycling and thereby the quality of life of citizens in general. By adding a digital layer on the existing cycling infrastructure, we continue to increase cyclists' mobility and road safety, as well as improve the city's daily traffic management.

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Through ongoing development of the physical infrastructure as well as development in ITS technologies, cyclists' conditions are to be improved. The driving ambition is to become the first carbon-neutral city by 2025.

In 2016, 63% of citizens in the City of Copenhagen use the bike daily to and from work and education and 41% of all trips to education and work took place by bike. The goal is to reach 50% by 2025.

Variable Message Signs for Cyclists

The variable message signs for cyclists are based on technology known from e.g. highways. They consist of a screen that can display diverse information in a simple and easy-to-understand way, thus giving cyclists warnings and information about the trip ahead.

Although the technology is similar to that from highways, it has been scaled and adapted to the conditions and demands of cycling, such as lower speeds, better visibility and improved manoeuvrability, compared to cars. Though smaller, the signs have screens of a higher resolution, with varying brightness and more colours than variable message signs on highways.

The signs are connected to the City Traffic Management System – MobiMaestro – which provides information based on collected data about bike track congestion, digging, slippery roads, events, alternative routes, travel times, etc. Basically, there is no limit to what the signs can display. The only limitation is set by the data available and whether the information can be conveyed simply and easily understandable.

Since Copenhagen is the first city to install such variable message signs, there is no experience in providing this type of information to cyclists. Therefore, the signs have also been installed to investigate their behavioural impact on bicycle traffic, especially with regards to dispersing cyclists along less used routes and corridors, leading to a more efficient use of the bike

Figure 1: Afternoon rush hour in Copenhagen. Photo: Troels Heien, City of Copenhagen.

track capacity. A socio-economic analysis that was prepared during the project, concluded that the signs would lead to a socio-economic gain of € 765.100 in a period of 15 years if the signs managed to change 5% of the cyclists' route selection at a particular location.

The technology chosen to measure behavioural change, was unfortunately not accurate enough to give a valid result. In general finding technology which can accurately count cyclists – especially bigger groups of cyclists – has been a challenge for traffic management in Copenhagen.

Cyclist attitudes towards the signs were, on the other hand, quite positive. In a questionnaire survey, 67 of the 280 surveyed cyclists stated that the signs made it easier to avoid congestion. 113 of 280 were of the opinion that the signs showed commitment by the City of Copenhagen towards cyclists. While 87 of the 280 asked believed that the safety tips displayed on the signs made cyclists behave better.

> The City of Copenhagen has always strived to protect citizen privacy and anonymity. For this reason, the cameras are not used for surveillance, the feed is not stored and is only accessible for calibration purposes. The city traffic management system simply receives the counts as analysed by the on-location counting software connected to the cameras.

Figure 2: Variable Message Sign for cyclists. Photo: Troels Heien, City of Copenhagen.

Bicycle data and simulation

An unforeseen result of the exposed inaccuracy of the counting equipment was that the City of Copenhagen, together with our main ITS supplier, began to explore alternative equipment for accurate cyclists counting.

The City tested cameras and automatic image recognition software which showed to have an accuracy of about 98%.

This system even counts large crowds of cyclists accurately, which is a necessity for a cyclist's city like Copenhagen. The new bike counting cameras have been deployed in 18 locations in Copenhagen and are used for daily traffic management as well as for evaluation and planning of signalling changes, roadwork and more. The cameras will also allow the City of Copenhagen to repeat the behavioural evaluation of the variable message signs, to measure the effect and compliance of cyclists to the warnings and messages shown.

But the city requires other data than simply counts – data on the current travel times on individual corridor sections in the cycle network. This data is not available from representative sources and in the quantities and quality required for daily traffic management.

For this reason, the City of Copenhagen has developed the BikeSim module for MobiMaestro.

Usually, travel times for cyclists is mainly determined by the cyclists' individual speeds, as well as the traffic signals and signal programs. By using a Monte Carlo simulation based on the location of the traffic signals, the current active signal programs and generic cyclists' speed values, BikeSim can provide a good estimate of the average travel time on a particular corridor.

Via the counting cameras, real-time data about the number of cyclists in some intersections is also used to improve the estimate.

Unfortunately, it is still difficult to find commercial players who can provide representative real-time data on cyclist travel times in sufficient quality and quantity. The available data sources are often too small or come from certain apps targeted at particular user groups, which means data is not representative enough of the whole cyclist population.

Through estimation, BikeSim can provide a current picture of the travel time on the relevant corridor until better sources are identified or developed.
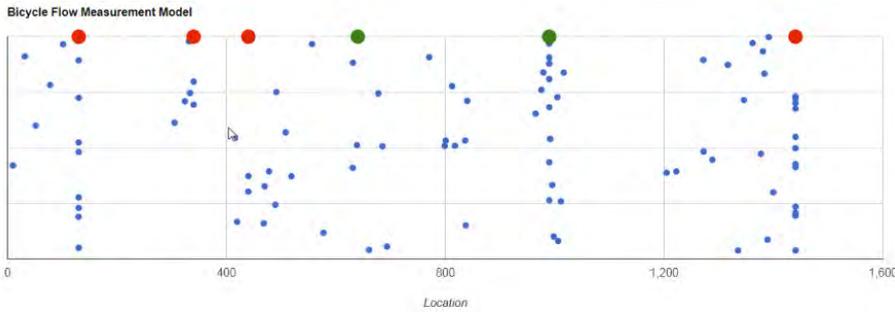
Figure 3: Example of BikeSim's graphical interface. The red and green dots at the top represent traffic signals along a corridor. Each of the little blue dots represent a cyclist, which moves from left to right. The "cyclists" move at different speeds with a normal distribution around a generic average speed and with predetermined variance.

Intelligent street lighting

In December 2017, the City Council of Copenhagen decided to work towards reducing the number of killed and seriously injured in traffic to zero. Behind the ambitious goal lies a sad statistic from 2016, where 13 were killed and 177 serious injured in traffic in Copenhagen. An increase of 20% compared to 2015.

55% of all accidents in the City of Copenhagen occur in the city's intersections. In most other road sections traffic is segregated by modes. In intersections, on the other hand, all modes are on the same level and potential for conflict is as a result higher. Furthermore, even though there are fewer road users, a third of all accidents happen at night.

For these reasons, the City of Copenhagen has launched an innovation project, where street lighting is brightened for a period of time when sensors in intersections detect cyclists and pedestrians.

The purpose of this initiative is thus to create additional awareness of vulnerable road users in the intersections at night and thereby reducing the risk of collisions. Initially, the system has been installed in 5 intersections in Copenhagen.

Signal optimization and traffic management

The City of Copenhagen has service levels for all modes of transport. For cyclists, we are striving towards a 10% reduction in travel time and the number of stops on selected routes in the city. In this way, the mobility of cyclists has been prioritized on particularly important corridors. Traffic signals have been optimized and set to ensure the best possible flow without unnecessary stops.

Through MobiMaestro it is possible to monitor the traffic signals and ensure that they work optimally. Additionally, it is possible to automatically and manually intervene in the signal programs based on certain traffic data input. MobiMaestro is acquired with the mobility and safety of cyclists in mind. It is a Dutch traffic management system, which has been built modularly, so that new functions can be added as needed. For example, BikeSim has been developed specifically for Copenhagen's need to estimate cyclists' travel times. In addition, most data sources can be integrated into the system and provide the basis for the system's automatic actions as well as decisions of the traffic managers.

The features that have already been incorporated into MobiMaestro will be expanded and additional features can be added in the future to ensure that the system is kept up to date and meets the demands of citizens and cyclists.

Conclusion

Convenience is the key to promoting cycling in any city.

To improve convenience, road authorities, transport planners, and transport solution developers need to focus at least as much on creating efficient cyclists' infrastructure as they do on creating infrastructure for motorised vehicles.

In sustaining a prolonged cycling culture, it is necessary to make cycling more convenient than the other modes of transportation.

The end-goal of this work should not be forgotten. The purpose of creating and improving cycling infrastructure is to make cycling more efficient, quicker, safer and a more reliable mode of transportation compared to the others. Hereby creating a modal shift towards cycling which decreases emissions, improves health and road capacity, promotes social and gender equality in transportation, as well as increases overall quality of life in a city.

Figure 4: Notice the smaller signal head for cyclists. This turns green in advance of the one for cars allowing cyclists to pass before right turning vehicles. Photo: Troels Heien, City of Copenhagen.