Floating Car Data as Data Source for Modelling of Air and Noise Pollution in Regions with High Traffic Density

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1. Objectives

The state of the environment is normally assessed by environmental monitoring systems (e.g. air pollution monitoring, noise monitoring, water pollution monitoring). Logistic as well as financial limitations reduce the amount of actually available information to a number of sites that are then considered representative. Different modelling approaches have been developed to estimate the spatial distribution within the investigated areas. As the environment may be affected considerably by emissions (both noise and atmospheric pollutants) from the transport sector, frequently the emissions from these sector constitute an input to such models. Emissions from transport of passengers or goods are known to vary according to a number of traffic-related parameters such as traffic density, speed, weather situation and other vehicle-related properties (e.g. vehicle type, hubload). Currently many emission models are based on statistical or historical data (e.g. vehicle licences per area and average driving time, historical time series of traffic density) so that the modelling domain is only partly covered, and the uncertainty of results is rather high.
The information derived from Floating Car Data (FCD) has already been recognised as an important source for traffic related information (e.g. traffic density, speed, calculation of travel time). FCD technology has the potential to deliver near real-time data which can be applied for traffic control measures (e.g. line management on motorways(LCS), generation of traffic messages for drivers and other traffic participants).

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The aim of this paper is to demonstrate how existing FCD can be applied to assess the parameters required for traffic related environmental modelling. While no results from emission modelling are available at this stage, we can demonstrate which approaches are ready for application. Thus the described method is a further step towards integration of transport and environmental monitoring.

2. Detecting Floating Car Data and Generating Traffic Information

The detection of Floating Car Data (FCD) for the collection of traffic data could initiate a decisive turn in traffic monitoring. This method uses sensors integrated in vehicles to collect data mainly of position and speed, but also additional parameters (steering wheel angle, road slope, etc.). The metered values are sent to a traffic information sub-center with the help of the navigation unit via satellite or via GSM- or GPRS mobile phones.
There are three ways to locate a vehicle:
1) Satellite navigation (GPS/EGNOS/GALILEO) in combination with GSM/GPRS/UMTS data transfer
2) Celular tracking systems as systems used to run Location Based Services (LBS)
3) Long wave positioning using hyperbolic navigation methods
A realistic image of the current traffic situation can only be produced with a minimum of pursuant equipped vehicles in the investigated road network. Studies in the Netherlands and Scandinavia have calculated an average percentage about 2 to 20% of all cars. Due to the low level of pursuant equipped vehicles this traffic data metering method will only be applicable in a few years. The current architecture of a Traffic Information Center (TIC) should consider the implementation of new interfaces and algorithms to be able to use the new FCD technologies.
The single position values arriving from the FCD-vehicles have to be allocated to a virtual metering station in a digital road map stored in a Geographic Information System (GIS) before the integration of FCD-data into a traffic simulation. Unlike for stationary metering stations, whose data obtain to fixed road sections, there is the possibility to generate “dummy metering stations” with any desired distance in between according to the “traffic sensibility” of the road section. This permits a more differentiated view on the current traffic situation.
As the availability of FCD data depends on the presence of specially equipped vehicles a feasible vehicle density will first be reached in

urban areas whereas little information will be available in rural areas. As most environmental problems related to transport occur in urban areas or along routes with high traffic density (e.g. congestion, peeks of air pollution, high noise emissions) the method delivers data where it is necessary. For the calculation of emissions from the transport sector an estimation of traffic density on a specified road segment has to be available. As FCD mainly deliver position and speed of vehicles traffic density on a certain road segment has to be estimated from further information on the road segment (e.g. number of lanes, historical data) and speed.

3. Generating Information from Floating Car Data for Status and Impact of Transport Related Activities

3.1. Atmospheric pollutants

Current approaches to estimate emissions from road traffic all combine an emission factor with available information on vehicle mileage. This very simple approach is complicated by the necessity to separate different vehicle types and vehicle concepts (e.g. Diesel vs. gasoline driven car, with or without catalytic converter). Emission factors are also available for different driving conditions, ranging from stop-and-go traffic to highway speed traffic. Now the vehicle fleet may be determined from car registration numbers, or from occasional as well as from continuous traffic counts. Also, vehicle mileage as well as temporal distribution of emissions may be estimated from such traffic counts.

However, especially in cities the number of traffic count sites is relatively small in respect to total mileage and requires the use of outputs from sophisticated traffic models, if at all available. Additionally, speed distribution is very difficult to assess. Vehicle speed is not only required to apply the correct emission factor, but even the ratio between different pollutants. Emissions of Nitrogen oxides (NO_x) tend to be higher at higher motor temperatures and speeds, compounds emitted due to incomplete combustion (carbon monoxide (CO) and volatile organic compounds (VOC)) tend to be extremely high during stop-and-go traffic.

The application of FCD allows to obtain traffic flow throughout such a model area, including such important parameters as total mileage

driven and speed distribution or driving conditions at an adequate temporal resolution. Emissions even may be assessed real-time, a feature that is uncommon in standard emission inventories. Furthermore, the emission information can be used as input to photochemical models. As the chemical regime within city centres is generally VOC limited in terms of ozone formation (i.e. further VOC emissions will be critical for further photochemical activity) additional information on the stop-and-go traffic will help to strongly increase reliability of emission inventories used for atmospheric modelling or even atmospheric air quality forecasts.
If traffic density (i.e. vehicle density) can be estimated from FCD (which is not possible straight-forward) then it also possible to calculate noise emissions at any point of the investigated street or road network.

4. Integration of models into simulation software

The Floating Car Data method delivers basic dynamic information of the current traffic situation at different points of times. This method presupposes simulation tools using variable time steps instead of constant time steps like the programs offered today. Only online simulation can evaluate traffic data sent by moving vehicles at different times and positions.
The air pollution model developed by ARC Seibersdorf calculates emissions with time steps of about one hour. Therefore the results of an online traffic simulation have to be aggregated to the time steps used in the air pollution model in an interface software. An open architecture of this interface between simulation and pollution models will assure that changing or new parameters of the air pollution model (time steps, ...) can be regarded without any technical effort.
So the development of methods for the detection, storage and interpretation of FCD data has the potential of improving the information basis for modelling of traffic situation and air and noise pollution in regions with high traffic density.