

FUSION OF XFCD AND LOCAL ROAD WEATHER DATA FOR A RELIABLE DETERMINATION OF THE ROAD SURFACE CONDITION

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ABSTRACT

A high number of traffic accidents are caused by critical road surface conditions. In the course of the project "Reliable Determination of Weather-related Road Surface Condition", practical methods for increasing the traffic safety that will exceed the functionality of conventional traffic control systems will be developed. A major characteristic of traffic control algorithms in traffic control systems is the spatial extrapolation from locally detected road weather and road surface condition data to whole road stretches. The basic idea of the project is to aggregate locally detected road weather data and extended Floating Car Data (xFCD) towards more reliable and more accurate information about road condition on the stretch.

Objective of the project is the development of a concept for the fusion of xFCD and locally detected data. Using these data, adequate forecast models will be developed to gain optimized information on (critical) road surface and weather conditions and a sustainable reduction of traffic accidents.

Depending on the availability of different data types, applications for (1) traffic control and (2) winter maintenance will be developed. Traffic control and winter maintenance will benefit from more reliable information in terms of the ability of more efficient and timely disposition of winter maintenance service vehicles and a faster and more reliable warning of the drivers. Hence an increase in acceptance of traffic control methods by the drivers is expected.

Keywords: Road Weather Data, xFCD, Fusion of Data, Road Surface Condition, Traffic safety

1. INTRODUCTION

Results of different research projects make clear, that critical weather conditions affect traffic flow and traffic safety negatively [1]. This coherence is also reflected in actual accident statistics. For instance, in 2004 more than 12 % of all fatal accidents in the EU can be traced back to critical road surface conditions due to rain, snow or ice [2]. Prognoses state, that volume of vehicular traffic in Germany will increase further [3], such that measures for an increase in traffic safety are essential.

Actions of winter maintenance and section control systems on motorways counter the safety risk of critical caused by the weather road surface conditions.

Winter maintenance is concerned with protection from snow and snow removal as well as methods against slickness in winter and organisation of winter maintenance [4]. Against slick road surface conditions de-icing agents are deployed. Important factors of influence on the required amount of de-icing agents are slickness respectively precipitation as well as air- and road surface temperature, which are presently determined by stationary sensor systems.

Detector stations for traffic control algorithms of CCS are located every 2 to 4 kilometres. They establish the basis for the control algorithms that actuate variable message signs (VMS) and thus have an effect on traffic safety and traffic flow relevant parameters (e.g. speed, special attention in the case of potential risk situations). An important objective of CCS is the increase in traffic safety through a dynamic reaction to current traffic and

road weather and road surface conditions. Detecting road weather and road surface conditions and deriving corresponding suggestions for the VMS (warning signals, speed limits) are thus an important feature of CCS.

Within the framework of CCS environmental, data are input for situation adaptive control. Road users get warned of potentially critical meteorological conditions. For sustaining a high level of traffic safety for road users, traffic control algorithms rely on sufficient, precise and fast detection of meteorological data.

Traffic control based on critical road surface conditions, precipitation and reduced sight are elements of the automatic operation of section management systems. Wet or icy road surface conditions and / or precipitation affect traffic safety negatively in two ways:

- Wetness on the road reduces the traction between tyre and road surface. This leads to an extended stopping distance and a reduction of bearable radial forces in cornering.
- Water films cause spray that may limit driver's visibility.

2. MOTIVATION

Some facts about the currently acquisition and usage of environmental are listed below:

- Meteorological incidents are highly instationary and inhomogeneous.
- As weather and road surface condition data is acquired locally, there exists no knowledge about environmental conditions on road stretches (i.e. between the measurement locations).
- If one station breaks down, there is no information on environmental circumstances available for very long stretches (> 4 km even in densely equipped corridors)
- Presently, detection of environmental data is partially not precise enough and it is often not feasible to quality-check all data online using only local data.
- Road weather conditions have tremendous influence on traffic flow and traffic safety: Therefore, exact information about actual weather conditions should be available.
- Winter maintenance can only be carried out economical with exact knowledge about the amount of de-icing agents needed, a concerted deployment and spatio-temporal optimal machinery scheduling.
- The plausibility of the road weather and road surface condition based VMS control states is the basis for the drivers' acceptance [5]. Accurate detection of road weather and road surface conditions in the sphere of section control increases the acceptance/following of the signs and thus supports the reduction in risks of accidents and the rate of accidents aimed at [1].
- A high number of traffic accidents are caused by critical road surface conditions.

These points are motivation for establishing a project aiming at a "reliable determination of weather-related road surface condition".

3. PROJECT DESCRIPTION "RELIABLE DETERMINATION OF WAETHER-RELATED ROAD SURFACE CONDITION"

The project "Reliable Determination of Weather-related Road Surface Condition" is funded by the German Federal Ministry for Transport (BMVBS) and its executive organ, the Federal Highway Research Institute (BAST). The project is carried out by Technische Universität München, Chair of Traffic Engineering and Control. The projected duration is from 10/2007 to 04/2009.

In a literature research the scope of current and finished projects and technologies was analyzed, some are mentioned below.

One approach for acquiring stretchwise road condition information is the thermal mapping procedure. By carrying out a few trips with additional infrared camera systems, information about characteristic profiles of road surface temperatures are acquired. It is also used for real-time detection of critical road surface conditions in many spreading machines in Germany. The temperature controls among others the amount of the de-icing agents during the spreading.

By mobile measurements accurate road condition forecasts for road stretches has been developed in the development project "Cold Spots" [6]. Vehicle Infrastructure Integration (VII) involving the two-way wireless transmission of data from vehicle-to-vehicle and vehicle-to-infrastructure is worked on in [7]. On-board measurement of friction and road slipperiness is done in [8] in order to enhance the performance of integrated and cooperative safety systems [9]. In REACT and COM2REACT the stretchwise friction is detected by additional sensors [10, 11]. The quality of information about road condition will be improved by the "Slippery Road Information System" using floating car data [12]. In [13] new systems for cooperative sensing and predicting flow, infrastructure and environmental conditions surrounding traffic, with a view to improve road transport operations safety and efficiency get developed.

In the course of the project "Reliable Determination of Weather-related Road Surface Condition", practical methods for increasing the traffic safety that will exceed the functionality of conventional data collection and traffic control systems will be developed. A major characteristic of traffic control algorithms in traffic control systems (e.g. reduced speed limit because of critical road surface condition such as ice or water) is the spatial

extrapolation from locally detected road weather and road surface condition data to whole road stretches. The basic idea of the project is to aggregate locally detected road weather data and extended Floating Car Data (xFCD) towards more reliable and more accurate information about road condition on the stretch. Objective of the project is the development of a concept for the fusion of xFCD and locally detected data. Using these data in the course of this project to be developed adequate forecast models shall lead to optimized information on (critical) road surface conditions and a sustainable reduction of traffic accidents.

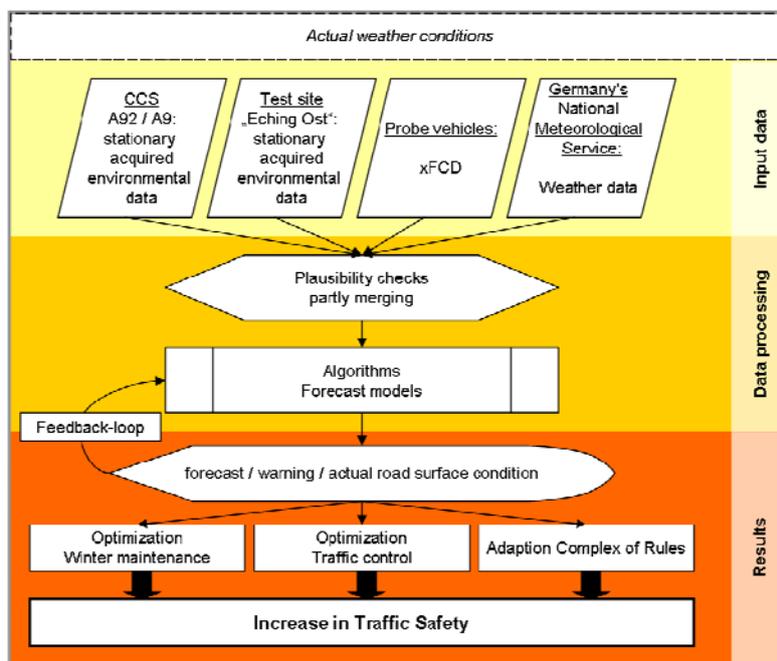


Fig. 1. Data processing in the project

For the development and verification of the forecast models an extensive database is built. Therefore, two dedicated probe vehicles (a passenger car (Audi A4) and a van (VW Caravelle)) are used to collect data in the Greater Munich area. Both vehicles are equipped with a data logger, which is connected to the CAN (Controller Area Network)-Bus. This way all vehicle information available is getting stored.

In order to verify the acquired xFCD and results of the models to be developed, every trip is recorded by webcam or video camera (see Fig. 2.). The driver's subjective impression of road surface is recorded by microphone.



Fig. 2. Picture of video camera / web cam / representative image

Figure 3 shows a sketch of a probe vehicle with available information sources.

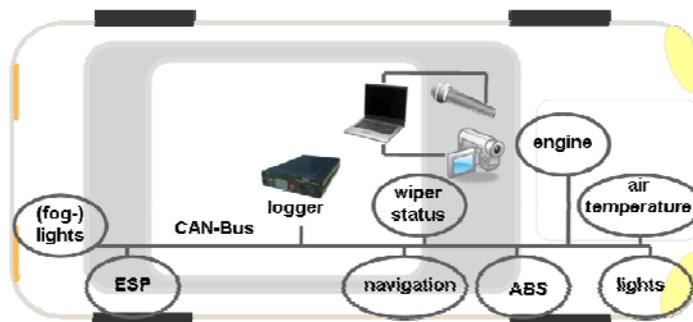


Fig. 3. Sketch of probe vehicle

No additional sensors have to be installed in the vehicles such that the algorithms will be designed and implemented to deal with normal “state-of-the-art vehicles”. This is a crucial point for near future practical deployment. The local road weather data are provided by the Bavarian Highway State Authority (ABDS) and will be collected by their standard data collection system in operation. Advantage of this approach is that the results can be transferred to real world applications easily. In Germany, acquisition, processing and usage of environmental data in section control systems is described and defined in “Merkblatt für die Ausstattung von Verkehrsrechnerzentralen und Unterzentralen” – MARZ [13] and “Technische Lieferbedingungen für Streckenstationen” – TLS [14].

Depending on the availability of different data types, applications for (1) traffic control and (2) winter maintenance will be developed.

For usage in to be developed algorithms it is planned to take into account – among others – the following vehicle data:

- Wiper status
The xFCD “wiper status” gets fused with stationary detected data of precipitation intensity, precipitation class and road surface condition. This will lead to an optimized information about precipitation and/or spray on a road stretch.
- Air temperature
The air temperature on a road stretch will be used for a better informed about the road surface temperature. Regarding the actual meteorological conditions, results of adequate models inform about the risk of an icy road surface on a road stretch.
- Safety Systems
Information about e.g. Antilock Breaking System (ABS) and Electronic Stabilization Program (ESP) is used as input for information about road surface condition on the road stretch. These systems operate just in case of emergency, so an improved result will be derived by considering the wheel rotation.

The XFCD are offline matched with the locally acquired environmental data and displayed in contour plots.

The trips are carried out according to a detailed scenario plan. They especially pass the test site “Eching Ost” (<http://www.vt.bv.tum.de/umfelddaten>). To improve reliability of sensor systems for environmental data under real conditions the test site “Eching Ost” has been established. The test site provides a comprehensive set of sensor equipment including cameras, various sensors and direct data links to the office. It is regularly monitored via cameras and visits. In coordination with manufacturers of road weather sensor systems, reference methods have been established to evaluate several environmental parameters [15]. Therefore knowledge about the applicability of environmental sensor systems is gained and just plausible data is used for merging.

In order to check and improve the quality of route based data, a special plausibility checking scheme will be established and used. First important criteria as well as a comprehensive architecture for checking the state of these criteria were defined in [16]. Experiences in operating the test site for road weather and road surface condition monitoring have shown that a continuous plausibility check of data shall be a core part of the project. Thus, plausibility (cross-)checks for locally detected road weather data are applied and developed for XFCD.

4. EXPECTED BENEFIT

Traffic control and winter maintenance are typical target applications for optimized road weather data by road surface condition monitoring. An optimized knowledge about road weather on the stretch will help finding (critical) positions for additional sensors.

Winter maintenance will benefit from more reliable information in terms of the ability of more efficient and timely disposition of winter maintenance service vehicles. Traffic control will be able to warn drivers faster and

more reliable. Hence an increase in acceptance of traffic control methods by the drivers is expected. This will lead to an increase in traffic safety.

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