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Usage of Road Weather Sensors for automatic traffic control on motorways

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Abstract

Within section control systems on motorways drivers get information about adequate speed limits during adverse weather situations. Therefore road weather data are necessary. To detect the danger of aqua-planning measurements of precipitation intensity and waterfilm thickness as well as the status of the road surface are needed. To detect these atmospheric data different weather sensors are located near the motorway. There are two different sensor systems available which detect these measurements at the moment. For the detection of the status of the road surface, like dry, moist or wet, the sensor is embedded directly in the road surface in most cases. The other sensor system is non-invasive which can be installed next to or over the road. Nowadays more and more open-pored asphalt is used because of its advantage to be less noisy and its property to drain off water better than normal asphalt. But this kind of asphalt cannot be cut to install a road sensor therefore the usage of non-invasive sensors will increase in the future. This may also lead to different thresholds in automatic traffic control during adverse weather situations.

The measurements of waterfilm thickness, road surface and road temperature are very important for automatic traffic control algorithms [2] as a speed limit caused by rain is derived and shown on variable message signs. In the German Technical Bulletin [2] a matrix with the two measurements precipitation intensity and waterfilm thickness define which wetness-level is detected. There are 5 wetness-levels which cause different speed limits. For the first supply thresholds are given based on the experiences with road sensors. For the newer non-invasive sensors other thresholds may be necessary. This paper will show some possible thresholds for the precipitation/waterfilm thickness matrix and their effects on the speed limits shown on the variable message signs.

Within the German Test Site for Road Weather Stations [1] various road sensors as well as various non-invasive sensors are installed. The data for both detection technologies has been collected for the last 2 years and allows a statistically valid comparison of them. In this paper the advantage and disadvantage of the two sensor technologies will be shown for the measurements waterfilm thickness, road surface and road temperature. In order to describe the behavior of the sensors, the available data will be analyzed concerning the availability of valid datasets and the accuracy.

Keywords: road weather data, automatic traffic control algorithms, precipitation/waterfilm thickness matrix

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1 Introduction

Weather sensors are used within the automatic traffic control to warn the driver of adverse weather situations. In the test site “Eching Ost” three embedded and three non-invasive sensors are installed. Both sensors determine plausible values and the overall results look similar but there are slightly different trends and values, which need to be analyzed to examine if the performance is the same and if there are any limitations for the usage of those types in traffic control systems on motorways. The ground truth is not always evident as there is no reference or the reference is very complex to include e.g. webcam pictures for every minute. Therefore most of the analysis is done by comparing the different sensor types to identify specific trends.

2 Sensor Types and Requirements

For detecting road temperature, waterfilm thickness and condition of the road surface the sensors can be divided into two types. There are non-invasive sensors which are either installed on poles or gantries next to or above the road. They are easy to install as the road does not need to be cut. Their usage is also possible on bridges and road surfaces that cannot be cut, e.g. open porous asphalt.

The measuring method used in these sensors is an optical spectroscopy which is either laser or infrared based. The road temperature is measured using a pyrometer. (www.lufft.de, 2015) (www.vaisala.com, 2015). For this study the non-invasive Sensors Lufft NIRS31, Vaisala DSC111 and Vaisala DST111 are used.

Embedded road sensors are located in the road either in the middle of a lane or underneath the tires on the left lane. They can additionally measure the temperature in different depths. The measuring method is either radar absorption based or thermic passive. (www.lufft.de, 2015) (www.vaisala.com, 2015) Used in this study are the sensors Lufft IRS31 and Vaisala DRS511. Both of them are located in the middle of the lane.

To ensure an adequate display there are requirements the sensors have to meet. Among the location which has to be homogeneous the sensors have to transmit a measured value every minute. Depending on the parameter there are specific requirements which are explained in the next section.

Sensors for road weather data should be located every 2-5 km. Variable message signs however are located closer. That is why the data needs to be very accurate as it is the input for more than one sign.

3 Usage in Traffic Control Systems

According to the TLS (2012) the sensors have to meet certain requirements to be used in automatic control algorithms for traffic management.

3.1 Condition of the Road Surface

The status of the road defines the qualitative coverage of the road surface. The sensors need to be able to distinguish the status “dry” and “not dry” which includes moist and wet. Additionally the status “frozen” has to be detected as well. The status of the road is mainly used to detect the danger of sleekness. The model uses the status of the road, the road temperature, dewing temperature and air temperature.