ID: 0029

Braking distance application developed on Finnish D2I project

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ABSTRACT

Sometimes drivers are driving too close to another car driving ahead. Many drivers have a false belief that in case of the car in front starts to brake they can react, brake and come to a stop, still leaving enough distance between the two vehicles.

The distance between cars, called as a safe following distance, should be as long as the vehicle is possible to stop without collision in case of accident or other sudden braking. Suitable safe following distance improves the fluency and safety on the roads but the local weather and road condition should be taken into account, too. Car manufacturers have developed several systems to inform drivers if the distance between cars is too short. Also, there are systems that are automatically keeping the distance between cars long enough or braking also if needed. Those systems are called as autonomous or adaptive cruise control. However, most probably none of those systems take into account the prevailing road condition and weather.

Road surface slipperiness has a strong influence for the length of the braking distances. The braking distance can be several times longer if the road surface is icy compared to if the road surface is dry. Also, speed has a major role for the braking distances; when the speed is doubled the braking distance becomes four times longer.

On Finnish TEKES funded Data to Intelligence project (D2I) different traffic related data was combined to produce new innovative products and applications for traffic sector. One of the new applications is intelligent braking distance application that is presented here. The application informs driver if the safe following distance is too short. The prevailing friction is taken into account for the applications as well. The friction can be calculated by FMI's road weather model or it can be a measurement. This application has been created in a co-operation with different D2I partners. Noptel is the instrument company, Centria takes care of the data flow and implementation and Finnish Meteorological Institute has been creating the service and is delivering data for the application.

Keywords: slipperiness, friction, warning, road safety

1 INTRODUCTION

The distance between cars should be long enough to avoid collision in case of accident or other sudden braking ahead. Suitable safe following distance improves the fluency and safety on the roads but the local weather and road conditions should be taken into account, too.

This application informs driver if the safe following distance is too short. The application takes into account the velocity of the car(s), the distance between cars and the slipperiness of the road surface. The application has been done under Data to Intelligence project (D2I) in co-operation with several partners.

2 DEFINITION FOR THE STOPPING DISTANCE

The total stopping distance of a vehicle depends on four things:

- perception time
- reaction time
- vehicle reaction time
- vehicle braking capability

Reaction distance means the distance that car is moving before the drivers starts to press the braking pedal after noticing a need for stopping. Perception and reaction time is typically assumed to be around one second. After reaction driver starts the brake a braking pedal until the car is totally stopped. That distance is called as a braking distance. Stopping distance is a combination of reaction distance and braking distance. The faster you drive, the longer is the stopping distance. Also, a slippery road condition increases braking distances dramatically and the condition of tires has also influence for it.

Friction (µ) is a valueless coefficient between 0 and 1 giving information about the grip between tires and road surface. The bigger value means the better grip between road surface and tires. Water, snow and ice reduce the friction. The value of friction is around 0.8 in case of dry and bare surface. Water on the road surface reduced friction down to 0.5-0.6. Friction is typically under 0.3 if there is snow on the surface. Ice layer covered by water is the most slippery case and then friction can be as low as 0.1. The definition between road condition and friction is presented on figure 1.

Figure 1. The definition between road condition and friction by Finnish Road Administration [1].

Braking distance means the distance that a vehicle is moving from the moment when the driver starts to brake until the car has stopped. The braking distance is a function of initial velocity (v_0), friction between tires and road surface (µ) and the gravity of Earth (g). The braking distance increases exponentially as a function of initial velocity meaning that the braking distance is four times longer if velocity increases from 50km/h to 100 km/h.

The braking distance (s_b) can be calculated by this formula:

$$s_b = \frac{{v_0}^2}{2\mu g} \tag{1}$$

Reaction distance (s_r) can be calculated using this formula:

$$s_r = v_0 t_r \tag{2}$$

Reaction time (t_r) is typically 1 second.

The total stopping distance, including reaction distance and braking distance, can be defined as:

$$s_s = s_r + s_b \tag{3}$$

Figure 2 presents different stopping distances (including reaction distance and braking distance) as a function of car's velocity and road surface friction. Friction 0.8 represents typically friction between road surface and tires when road surface is bare and dry, value 0.6 presents wet surface, value 0.25 snowy and 0.1 icy with water representing the most slippery case. The differences between stopping distances are huge when comparing different slipperiness (friction values) and speed. Stopping distances doesn't differ very much in case of wet surface compared to dry and bare surface, but in case of snowy and especially icy with water on the top the differences are huge. Stopping distance is around 100 meters when driving 50 km/h and even 400 meters when driving 100 km/h.

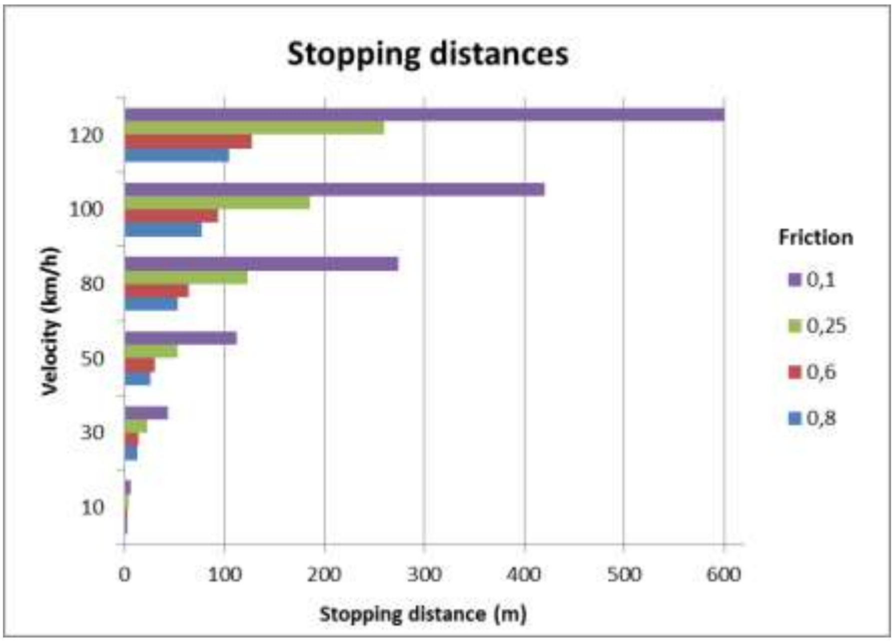

Figure 2. Stopping distances (including reaction distance and braking distance) as a function of different initial velocities and frictions.

Too short distances between cars have been noticed to be a problem quite often in traffic accidents. Slippery road condition due to ice and/or snow together with poor visibility reduces the road safety. Snowfall is one of the most challenging weather conditions for drivers because of slippery road surface and low visibility. Snow on the road surface reduce friction, part of the snow is packed into ice because of traffic leading even more slippery road condition. But also the blowing snow can very bad for drivers because reducing the visibility. In some chain accident cases in Finland the combination of slippery road condition and low visibility because of snowfall have happened at the same time [2]. In those cases visibility may be less than the approximated braking distance. The driver cannot see if there is a car stopped on the front of within a stopping distance. In those cases crash is expected unless the car can be steered past the stopped car.

3 DATA IN USE

This braking distance application has been done with several D2I project partners. The architecture of the pilot is presented on figure 3.

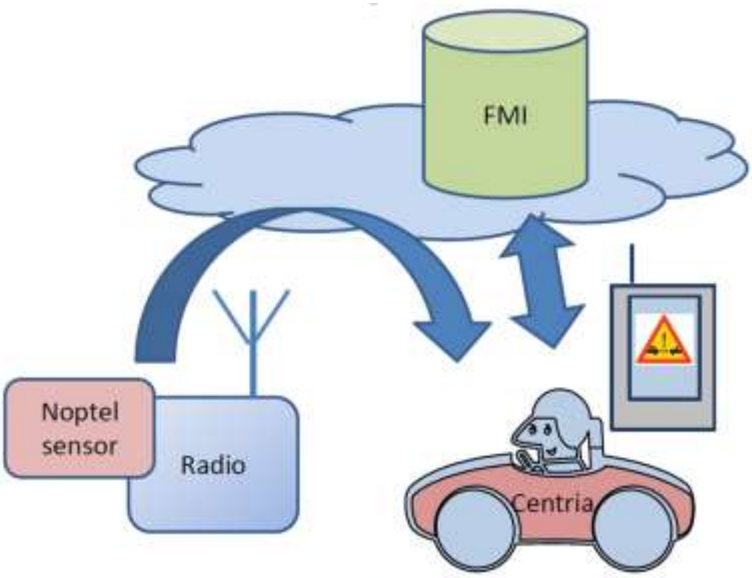

Figure 3. The architecture of the pilot.

In the first phase the braking distance warning information can be calculated for one pre-specified spot where the Noptel's instruments are installed. The place is called as Tuiran sillat, which locates on a bridge leading north from the city center of Oulu. The needed input data is velocity of the cars(s), distance between cars and the road surface friction. The estimated braking distance can be calculated if parameters mentioned above are available.

The application is running on Centria's vehicle where the dashboard is extended by an Android tablet which visualizes the braking distance warning. Centria has developed the needed code for the application. The Android program gets the needed data from the database, does the calculation and shows the warning sign if needed. Different data sources needed for this application are presented on next sub-chapters.

3.1 Noptel's instrument and measurements

The application is exploiting the Noptel's instruments. Measurements are based on laser data information (figure 4). Laser radars are placed above the road for detecting passing vehicles and measuring their velocities (figure 5). The distances between the vehicles are calculated based on their velocities and accurate timestamps provided by laser radars when cars passing by.

The velocity of the vehicles and passing by timestamps are sent to Noptel's database. The distance between cars is calculated using the information stored in the database.

Figure 4. Noptel laser radar.

Figure 5. A laser radar affixed onto a gantry in the pilot site for measuring traffic and road data.

3.2 Friction

The application need information about road surface slipperiness (friction meaning the grip between tires and road surface) and it can be measured for example by Vaisala DSC111 instrument [3], µTec application developed by Tecomer [4] or it can be calculated by FMI's road weather model [5,6].

The calculated friction has been in use in the first pilot and up-to-date friction value has been stored into Noptel's database.

4 THE APPLICATION IN USE

The outputs (warning sign) of this braking distance application can be presented in car (mobile application) or the information can be given via road side sign tables. In this pilot the information is given via mobile application (tablet).

The application is running on Centria's pilot car where the dashboard is extended by a tablet where the braking distance application is running and presenting warning sign only then when needed, see figure 6. Centria has developed the code for the Android tablet that visualizes the dashboard and gives a warning sign in case of too short distance between cars on the pilot site.

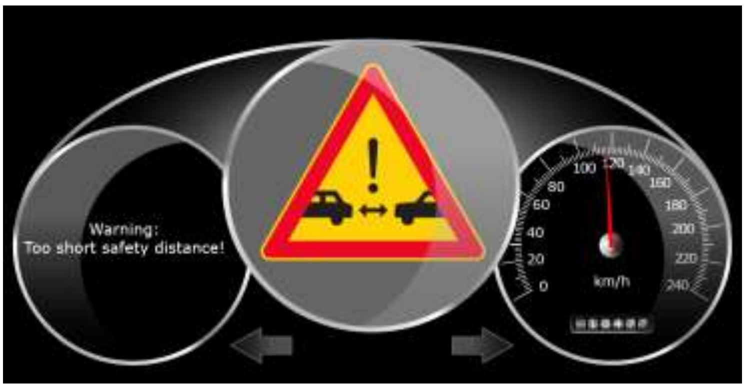

Figure 6. Screenshot of the car's dashboard in the pilot when the warning is given.

4.1 Future plans

The idea is to extend the pilot so that it could work in the larger area in the future. It would be possible to run the braking distance application everywhere, if friction available and the distance between cars could be defined by mobile application, for example using camera information as has been done already by now.

5 CONCLUSIONS

Road safety is a big topic now and in the future. It is important to develop products and applications to increase the safety on the roads. This pilot is a good example of innovative product that can be plan and carry out by combining different data sources.

Acknowledgements. This study has been done under TEKES funded project D2I.

6 REFERENCES

[1] Hippi M., Juga I. and Nurmi P. 2010. A statistical forecast model for road surface friction. *Proceedings of SIRWEC 15th International Road Weather Conference, Quebec City, Canada, 5-7 February 2010*. Available from http://www.sirwec.org/Papers/quebec/15.pdf

[2] Juga I., Hippi M., Moisseev D., Saltikoff E. Analysis of weather factors responsible for the traffic 'Black Day' in Helsinki, Finland, on 17 March 2005. Meteorological applications, vol. 19 p. 1-9.

[3] Remote Road Surface State Sensor DSC111. Technical report. Vaisala Ltd.

[4] T. Haavasoja and Y. Pilli-Sihvola, 2012. Friction as a Measure of Slippery Road Surfaces. *Proceedings of SIRWEC 15th International Road Weather Conference, Quebec City, Canada, 5-7 February 2010*. Available from http://www.sirwec.org/Papers/quebec/11.pdf

[5] Juga I, Nurmi P, Hippi M, 2012. Statistical modelling of wintertime road surface friction. *Meteorological Applications*, DOI: 10.1002/met.1285, 2012. Available from: http://onlinelibrary.wiley.com/doi/10.1002/met.1285/pdf.

[6] Kangas M, Hippi M, Ruotsalainen J, Näsman S, Ruuhela R, Venäläinen A, Heikinheimo M. 2006. *The FMI Road Weather Model*, HIRLAM Newsletter no. 51, October 2006. Available from: http://hirlam.org/index.php?option=com_docman&task=doc_details&gid=476&Itemid=70.