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Braking distance application developed on Finnish D2I project

Introduction

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. The table on the right hand side presents the definition between friction coefficient and the state of the road.

The aim of the Data to Intelligence - D2I - program is to develop intelligent tools and methods for managing, refining and utilizing diverse data across a variety of sectors. Within the overall program, the D2I traffic project aims to create situation awareness for traffic circumstances in day-to-day life.

Friction	0.00 – 0.14	0.15 – 0.19	0.20 – 0.24	0.25 – 0.29	0.30 – 0.44	0.45 – 1.00
Description of the road surface	Wet ice	Icy	Packed snow	Rough ice/ packed snow	Clear and wet	Clear and dry
Slipperiness classification	Very slippery	Slippery	Fair winter condition	Good winter condition	Good road condition	Good road condition
Road weather index	Very bad road weather	Bad road weather			Normal road weather	

The definition between road condition and friction by Finnish Road Administration.

Braking distance

The developed braking distance application informs if a car is driving too close to another car driving ahead.

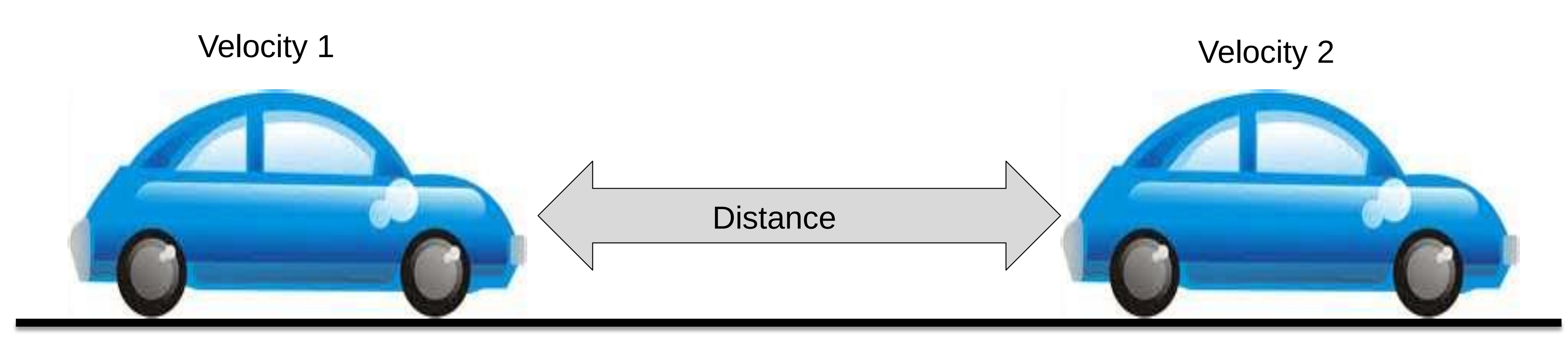
Local conditions, like vehicle's speed, distance between cars and slipperiness of the road surface, are taken into account in this application.

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

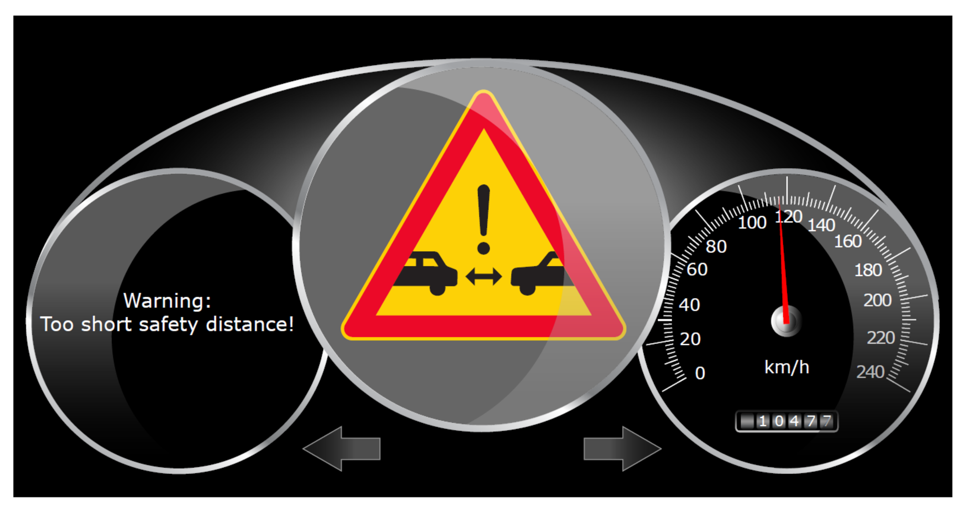
- perception time
- reaction time
- vehicle reaction time
- vehicle braking capability

This application has been designed in D2I project, Traffic ecosystem. The application is using Noptel's measurement data (velocity of a car and the distance between cars). Noptel's measurements, as well as friction, are stored into Noptel's database. Used road surface slipperiness (friction) can be a measurement or calculated by FMI's road weather model. The application gives a warning sign if the distance between cars is shorter than the estimated braking distance.

The application is running on Centria's vehicle where the dashboard is extended by an Android tablet which visualizes the braking distance warning. The Android program gets the needed data from the database, does the calculation and shows the warning sign if needed.



Slipperiness, friction (μ) between road surface and tires



Braking distance as a function of slipperiness

Figure on the right hand side presents different braking distances as a function of car's velocity and road surface friction. Friction (μ) is a coefficient between 0 and 1 giving information about the grip between road surface and tires.

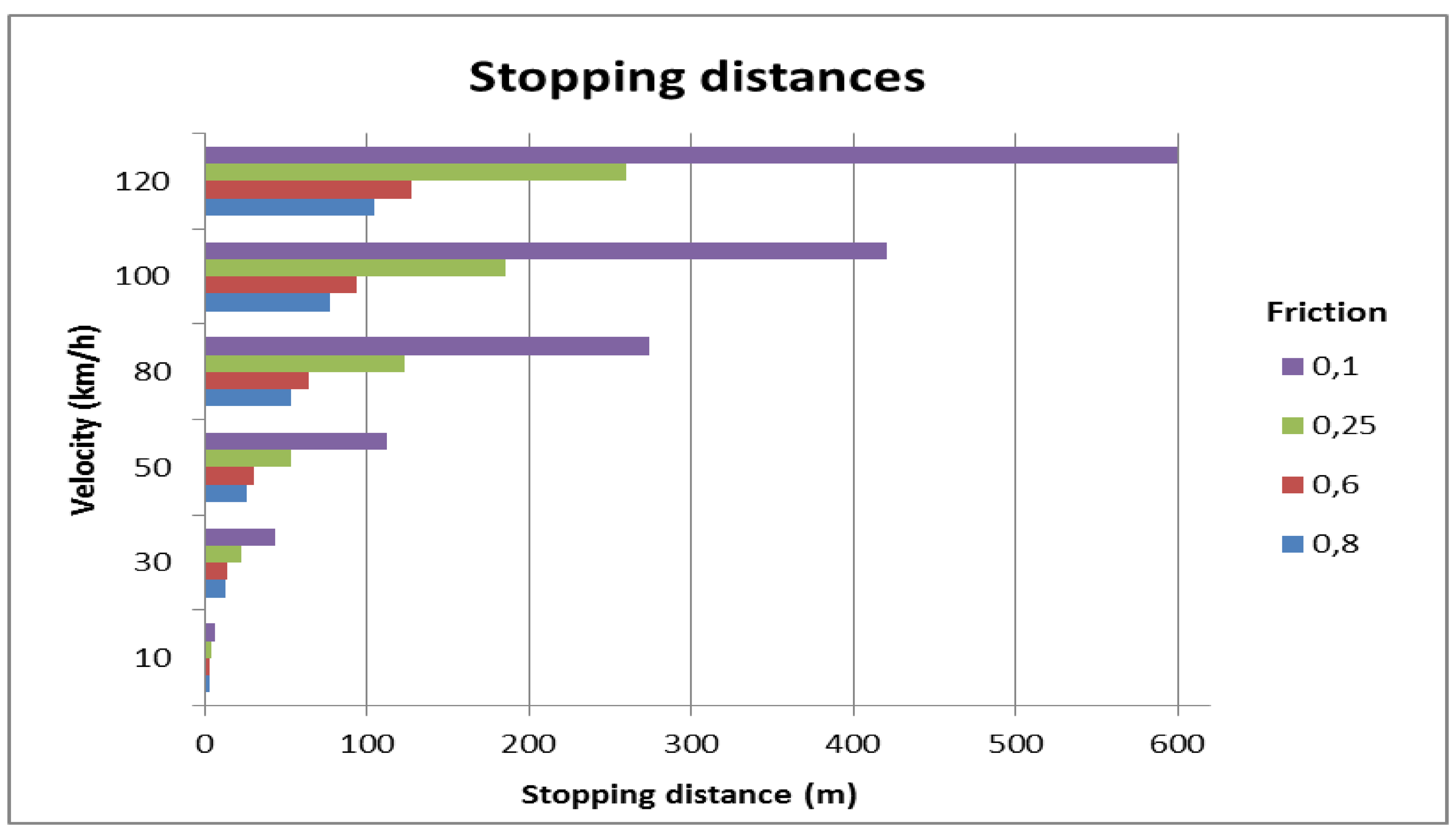
Examples for typical friction values:

- 0.8 bare and dry road surface,
- 0.6 wet surface,
- 0.25 snowy surface,
- 0.1 icy surface (with water layer on top).

The difference between various braking distances is huge when comparing different slipperiness (friction) values and speed. Braking distances don't differ very much in case of wet surface compared to bare and dry, but in case of snowy or especially icy surface the differences are dramatical. The braking distance is around 100 meters when driving 50 km/h and as much as 400 meters when driving 100 km/h. When the speed is doubled the total braking distance becomes four times longer as the formula below performs.

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

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



Stopping distances (including reaction distance when reaction time is 1 second and braking distance) as a function of different velocities and frictions.

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