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Danger zone allocation with vehicle-to-vehicle communication

The potential of the vehicle-to-vehicle communication (V2V) for mobile working machines and commercial vehicles has been studied at the Institute of Mobile Machines and Commercial Vehicles at the Technische Universität Braunschweig in cooperation with an automobile manufacturer. The goal of the study was to predict maneuvering areas for heavy commercial vehicles and block those areas dynamically for other road users. A tractor with an implement and a car have been used for validation and system functionality tests.

Keywords

Vehicle-to-Vehicle Communication, V2V, mobile machines, commercial vehicles, dynamic allocation of danger zones

Abstract

Landtechnik 67 (2012), no. 6, pp. 432–434, 3 figures, 7 references

Within the last four years the number of registered cars in Germany increased about 4 %, according to the Federal Motor Transport Authority. During that period the number of heavy duty vehicles grew even about 7 % [1]. This high traffic volume on the one side and the trend to bigger and faster mobile machines on the other lead to more critical situations, especially between cars and these large vehicles [2].

Traffic situations are sometimes misinterpreted by car drivers due to lack of knowledge about the behavior of large vehicles. Furthermore the dimensions of these vehicles and their implements can hardly be realized from the distance. Vehicle elements might swing out abruptly during a turning maneuver or the vehicle needs more space at an intersection to turn (**Figure 1**). For inexperienced car drivers these situations are sometimes confusing.

Solution

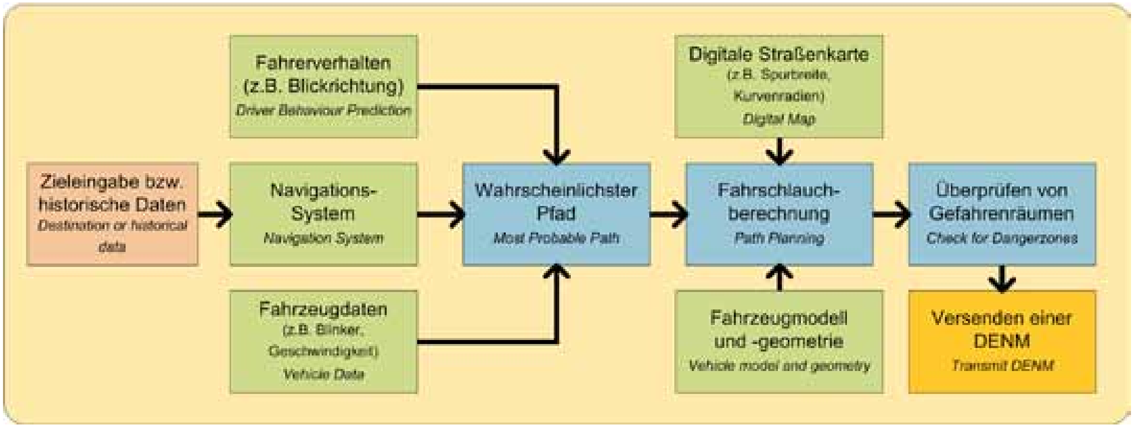
Blocking the occurring danger zones and maneuvering areas virtually for a short period of time is one approach to solve this problem and to detect critical situations from the very beginning to prevent accidents [3]. For that purpose the large vehicle reserves the required zones for its driving maneuver for a limited space of time. This information is transmitted via V2V communication to nearby cars afterwards. If one of this cars is going to cross the blocked area within the given time period a warning message will be generated.

To implement this system three essential types of information are necessary: a kinematic model of the vehicle combined with the vehicle's geometry, the planned route with the driving maneuvers and furthermore a digital map.

Fig. 1

Swinging out vehicle elements, e.g. a tractor with a cultivator (Photo: Robert)

Fig. 2



Flowchart showing the danger zone evaluation

Implementation

The kinematic behavior of a vehicle, e.g. truck-trailer combination, can be approximated with different complex models. For low speed and simple vehicle types a single track model is usually sufficient. It can be upgraded depending on the required model complexity. To represent the vehicle's volume it is extended with a 2D or 3D geometry, also depending on the required accuracy.

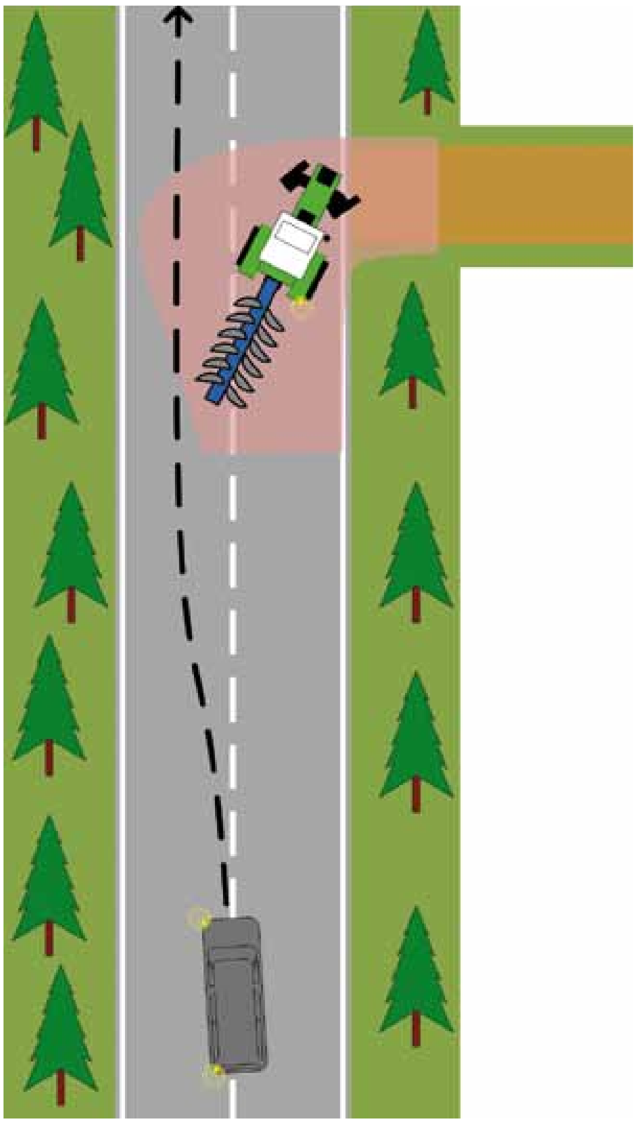
The most probable path (MPP) and the resulting driving maneuvers can be approximated. The primary source for the MPP is the navigation system if a destination is set. Furthermore a route prediction based on historical data, e.g. frequently used routes, is possible. Additionally machine parameters can be used for a higher approximation of the MPP, e.g. deceleration for turning maneuvers or the blinker. Also the driver behavior, e.g. changing the viewing direction, provides information about the possible maneuver and the MPP. Especially the analysis of the driver's intention for driving assistance functions is in focus of research for several years [4; 5].

If the vehicle model as well as the MPP are well known, an additional digital map is necessary, e.g. in the geographic data file format (GDF) [6]. It contains the GPS positions, the width and the shape of tracks or intersections nearby.

In the next step the model is driven virtually on the digital map following the MPP. During that time, special developed algorithms check permanently if parts of the vehicle's shape leave their own track. In such a case these zones will be temporally marked as danger zones. Finally the large vehicle transmits this information as a decentralized environmental notification message (DENM) via a communication module to the nearby vehicles [7].

Each of the nearby vehicles computes separately, whether the marked danger zone is relevant for it and, if applicable, displays a warning message (**Figure 2**). Vice versa also the driver of the heavy vehicle could get a warning.

Fig. 3



Turning tractor with swinging out implement, overtaking car and marked danger zone

System validation and tests

For the final verification of the concept a functional prototype has been set up and tested in a typical use case (**Figure 3)**. A tractor drives on a country road and activates the indicator to turn right onto a field path. Due to this maneuver the tractor implement is going to swing out on the neighboring lane. The driver of an approaching car interprets the indicator as a sign, that the tractor is slowing down and begins to overtake. At that moment a warning message informs the driver about the swinging out implement and the occurring danger zone, even if it is not obvious for him. The basic operational capability has been proven during a lot of tests and has met wide interest among the test persons.

Conclusion

The paper shows the potential of the vehicle-to-vehicle communication for a dynamic allocation of danger zones to increase traffic safety. A more reliable forecast of the planned driving maneuvers, more detailed vehicle models as well as an identification of different driver characteristics will be in focus of research in the near future. Additionally digital maps with higher accuracy are required to predict and locate the danger zones more precisely.

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