Situation classification for a traffic situation and road infrastructure adaptive ACC-system

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Due to increasing traffic volume and growing complexity of the driving task, advanced driver assistance systems (ADAS) have been developed to support the driver and relieve him of some of these tasks. So-called ACC-systems (adaptive cruise control) combine information about the current vehicle state with data from a distance sensor respective the distance and the relative velocity of a preceding vehicle. An automatic intervention into the engine management and the brake system adapts the vehicle velocity and acceleration depending on the current traffic situation. Today's main field of application for such ACC-systems are motorways and rural roads with low traffic density [1].

At the Institut für Kraftfahwesen Aachen (ika) a traffic situation and road infrastructure adaptive ACC-system is being developed. The idea is to increase the performance and the comfort of existing ACC-systems by taking information about surrounding road infrastructure such as velocity limitations, curvature or positions of intersections into account. Adaptation of the system to individual driving situations on motorways, rural or urban roads results in adapted and comfortable acceleration and deceleration procedures. The vehicle velocity is also adapted to the infrastructure and therefore the driver is relieved of further adjustments.

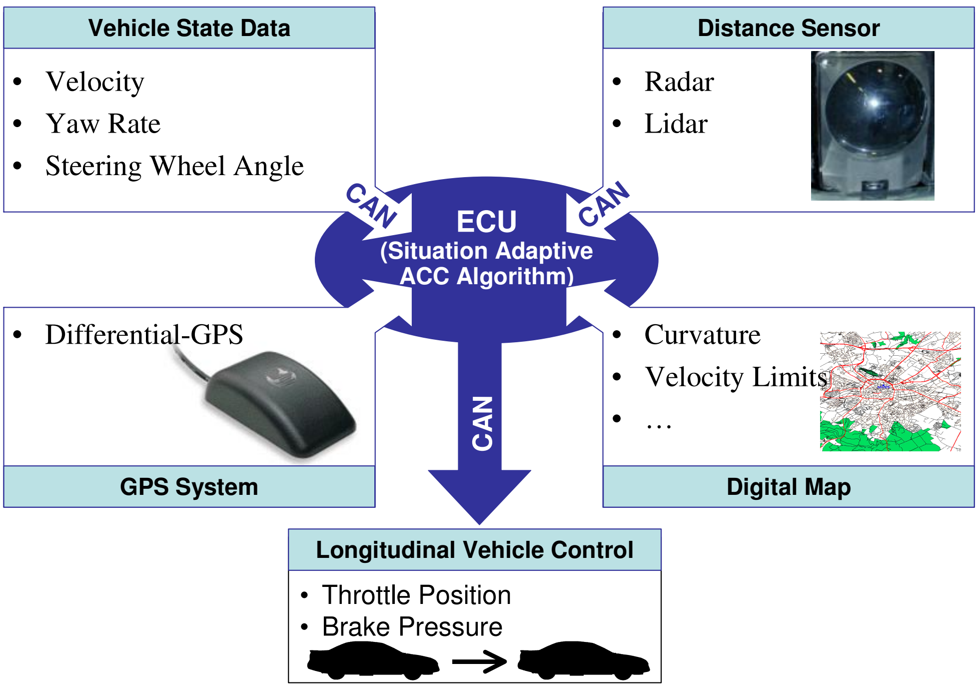

Fig. 1: Overall system set up for position classification

Digital maps are being used for route planning and increase the traffic safety by supporting the driver in the navigation task today. Information about surrounding topology can be obtained with the help of digital maps. Digital maps of the first generation do not provide information about velocity limitation, curve radii, traffic signs etc. Digital maps of the next generation will provide more detailed information. An introduction of the second generation of digital maps is to be expected in the near future. Those attributes are implemented into a digital map of the first generation for a test track in the region of Aachen. The position of the vehicle is determined with the usage of a modern GPS-system.

The overall system set-up for the adaptive ACC-system is shown in Fig. 1. The four main components are the environmental sensors (a 77 GHz radar sensor for the far-field and two 24 GHz radar sensors for the near-field), the vehicle state data such as velocity, acceleration, steering wheel angle, yaw rate etc., the second-generation digital map for the test track and the GPS receiver. The situation classification, the calculation of the desired control values and the ACC-control algorithm are implemented into a computer-processing unit. The overall system is integrated in a BMW 728i test vehicle. The vehicle is controlled in longitudinal direction by adjusting the desired throttle position and the desired brake pressure. The communication of the components is based on the CAN-bus.

Within this paper the situation determination and the situation classification especially for urban traffic are presented. On basis of this classification process the situation adaptive desired acceleration values and the maximum possible driving velocity of the vehicle are determined by the ACC-controller.

In a first step driving tests were conducted in the region of Aachen. 20 driver of both genders and three different age categories were following a given test track in a test vehicle, which was equipped with the sensors described above and a video camera. The tests persons were encouraged to describe their driving operations and the driving situations. During all test drives the data of the vehicle sensors and the environmental sensors (radar sensors) were recorded. At the same time a moderator was recoding the verbal description of each driver of the subjective classification of the driving situations. Therefore 41 different driving situations were identified by the test persons.

In a second step the recorded data was analysed in great detail. A total of 935 driving manoeuvres were filtered out of the overall test drives. Driving situations, which could be summarized, were reduced and parameters, which allow a distinct classification of the driving situations were identified. As a result of this classification process a logical distinction between different driving situations on the motorway and in the city are available and can be processed by the ECU of the adaptive ACC-system.

On basis of these driving situations an algorithm, which is based on [2], for the automated situation classification is developed. Within this algorithm the data about the boundary conditions of the infrastructure (curve radius, velocity limitations) on basis of the digital map and the data of the vehicle and environmental sensors are combined. The algorithm determines the current driving situation. Therefore the parameters for the control of the ACC-system can be adjusted depending on the identified driving situation.

The overall classification system is implemented into an ika test vehicle and tested on the test track around the region of Aachen.

References:

[1] Wallentowitz, H.: Vorlesungsumdruck Fahrzeugtechnik III, Aachen, 2004

[2] Sandkühler, D.: Verkehrssituationserkennung: Entwicklung und Anwendung in Fahrerassistenzsystemen, 13. Aachener Kolloquium, Aachen, 2004