

Automatic Curve Deceleration System Using Enhanced ACC with Navigation System

Hiroshi Sakamoto, Masato Imai, Kazutoshi Tsuchiya and Tatsuya Yoshida
Hitachi, Ltd.

Masao Sakata
Xanavi Informatics Corporation

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ABSTRACT

We have developed a system for automatic deceleration upon entering curves to prevent collisions on tight curves on high-ways. The navigation system is used to determine safe speed negotiating the curve, defined as a speed that will keep lateral acceleration within a settled value. The navigation system sends the curve radius to a controller, which calculates the safe speed for the curve. The controller then sends the speed command to the ACC system, which adjusts the vehicle speed. One of the important features in this system is the estimation of the vehicle position, in terms of its distance from the curve entrance. Navigation systems have a certain amount of dispersion in positional accuracy. A front camera is used in our system to decrease this dispersion. This camera detects lane markers (white lines, raised pavement markers, etc.) using our line recognition technologies¹⁾. The change in the curve radius is detected by the lateral displacement of the markers to estimate the position of the curve entrance. The proposed technique in this estimation is to use a transient curve model. The lateral displacement of the markers changes according to the clothoid function in the curve entrance. By curve-fitting the data from the lateral displacement of the markers, which was obtained by the front camera, and by comparing the data with the clothoid function, the precise position of the curve entrance can be estimated. The developed system has been installed in a prototype vehicle. Safe deceleration upon entering curves has been demonstrated successfully. The demonstration video will be shown in the presentation.

1. INTRODUCTION

The number of traffic accidents in Japan is increasing, as shown in statistics released by the National Police Agency of Japan²⁾. An active safety system that could help decrease the number of such accidents is desired. A driving safety support system that utilizes an On-Board Camera, Radar, and the vehicle's navigation system could be effective in reducing those accidents such as rear-end collisions, head-on collisions, and single accidents (which is defined by a single vehicle running off the road or

crashing into a structure at the edge of the road), which account for half the number of casualties in automobile accidents²⁾. ACC (Adaptive Cruise Control), which automates the throttle and brake and safely maintain the headway distance between a vehicle and the preceding vehicle, is available for expressway driving³⁾⁻⁶⁾. However, the use of ACC is not yet wide spread, because the driver must still operate the brake before tight curves and tollgates. On the other hand, the rate of accidents in curves with a radius of 200m or less is about 2.6 times higher than the average on metropolitan expressways in Japan⁷⁾. The loss of these accidents is estimated to be 10 billion yen per year. Specifically, 21% of the accidents have taken place on frequent-occurrence curves (6% of all extensions) on Tokyo Metropolitan Expressway⁷⁾.

In response to this situation, we have been advancing the research and development of a driving support system which uses the navigation system to help reduce accidents caused by driving too fast through curves. The development of an enhanced ACC that works with the navigation system to control the speed according to the shape of the road by using map information is in progress. It is expected to allow the technological expansion of the driving support area of ACC.

2. OUTLINE OF SYSTEM

Figure 1 shows the outline of the new enhanced ACC with navigation system. This is a new driving support system which is a combination of ACC, which controls the speed by detecting the headway distance to the preceding vehicle with a forward-looking radar installed in the front of the vehicle, and a speed controller which automatically controls the speed before curves, exit ramps, and the tollgates using information from the navigation system.

Figure 2 illustrates the functioning of a conventional ACC. When there is no preceding vehicle, the vehicle with ACC cruises at a constant speed responding to the set speed (Cruise Control). If a low-speed vehicle ahead is detected by the radar, the ACC automatically decelerates by considering the detected distance, and it maintains an

appropriate headway distance which corresponds to the speed of the preceding vehicle (Following Control). In addition, the ACC automatically accelerates back up to the set speed when the preceding vehicle changes lanes or leaves the highway, and returns to the state of constant speed driving at the set speed.

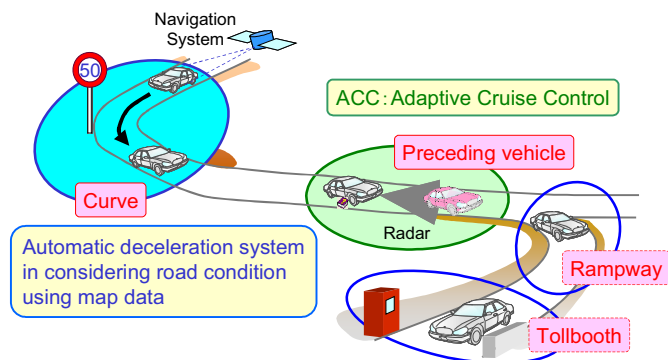


Figure 1: Enhanced ACC with navigation system

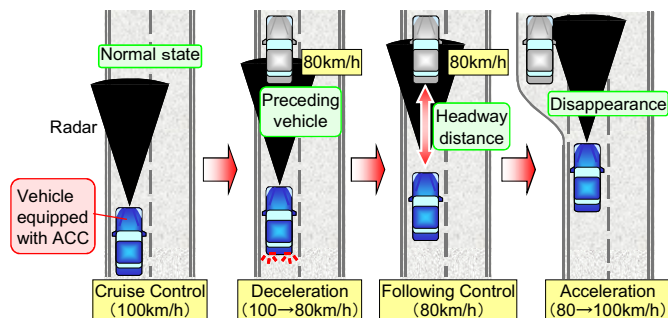


Figure 2: The function of conventional ACC

Thus, a conventional ACC has a function that reduces the driver's load by automating part of the accelerator and brake operation according to the headway distance detected by the radar. Thus, the driver does not need to operate the accelerator and brakes on straight sections of road. However, deceleration before a curve is not supported in conventional ACCs. In addition, since the ACC is cancelled once the driver operates the brake pedal, the driver then needs to reactivate the ACC and reset the speed by operating the drive switch. The ability to provide automatic speed control based on the shape of the curve will be a key functions in the more sophisticated, next-generation ACC. To achieve that demanded function we developed an enhanced ACC, which is a combination of a conventional ACC and a speed control linked to the navigation system that uses the map database to control the speed according to the road shape.

Figure 3 shows the enhanced ACC system configuration. The system is based on the conventional ACC. The ACC and navigation systems exchange the various types of information through a CAN (Controller Area Network). The navigation computes the vehicle position according to latitude and longitude information acquired from GPS (Global Positioning System) and the map database, and calculates the radius of the curve on road ahead of the

vehicle. The enhanced ACC calculates the target speed from the following three factors: the headway distance to preceding vehicles detected by the radar, the speed which has been set by the driver, and data from the navigation system. The ACC then utilizes the engine, the transmission, and the brake to control vehicle speed. This system configuration allows for speed control based on the shape of the road and expands the driving support area of the ACC system.

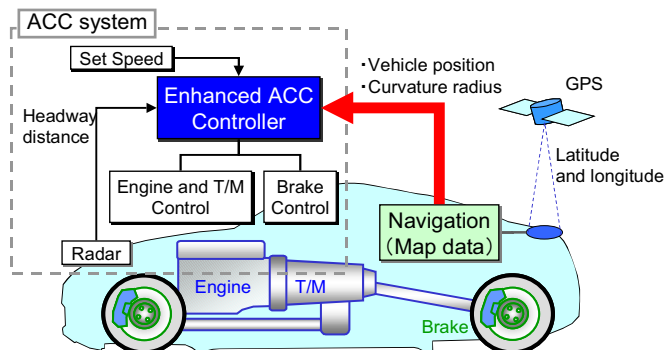


Figure 3: System configuration

3. DECREASING DISPERSION IN POSITIONAL ACCURACY

3.1. CONTROL METHOD

Figure 4 shows the block diagram of the automatic curve deceleration control.

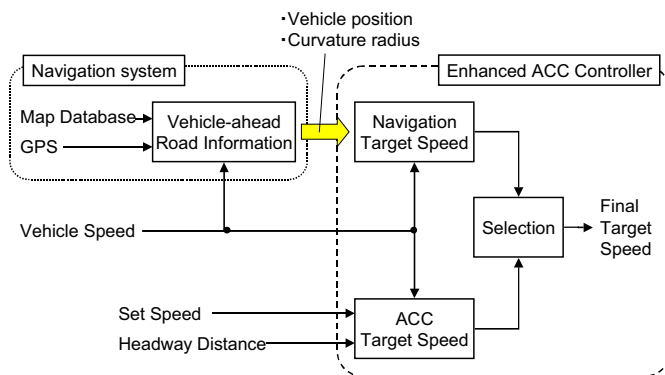


Figure 4: Control block diagram

First, in the Vehicle-ahead Road Information Extraction Part, the information required for the control (the map database at latitude and the longitude obtained from GPS, and the vehicle speed) is extracted. Once a curve is detected the curvature radius and the vehicle position (concretely, the distance to the curve entrance) are calculated. Next, in the Navigation Target Speed Operation part, the safe target speed for the curve is calculated from the curvature radius, and a deceleration pattern is calculated such that a deceleration will end at the entrance to the curve. In the ACC Target Speed Operation part the ACC target speed is calculated from the speed set by the driver and the headway distance to the preceding vehicle. In the Target Speed Selection part the