

# Development of Lane-Level Guidance Service in Vehicle Augmented Reality System

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**Abstract**— A driver should always pay attention to various situations which he faces inside and outside the car while driving and always keep eyes forward for safe driving. A vehicle augmented reality system provides the driver with safe and convenience information which matched with the real world through HUD. It makes the driver keep eyes forward road and other cars. We have developed the vehicle augmented reality system and various services and tested them on an indoor testbed. This system provides driver with the forward situation awareness service, the lane change service, the lane departure service and so on displayed as the vehicle augmented reality. We describe the development contents and results of the developed vehicle augmented reality system focused on the lane-level guidance technology which determines the lane change or the lane departure using route information, road properties, the driving lane information, position, and so on.

**Keywords**— vehicle, augmented reality, lane change, lane departure, route guidance

## I. INTRODUCTION

A driver faces various situations inside and outside the car while driving and the driver should pay attention to all of them for safe driving. Especially, when the driver has to drive the destination where he hadn't been, he often has to see the navigation for checking route guidance and check the forward road signs and guide signs to follow the guided route. Moreover, the driver always has to keep the safe distance between his car and the forward car and be careful of the car cutting in and pedestrians to avoid an accident. Thus, the range of driver's vision is limited but he has to check the information on the dashboard or the navigation and pay attention not only to what's in the front but also to the rear while driving. The safe driving requires a lot of skill and if the driver takes his eyes off the surroundings of the vehicle, even for a fleeting moment, this might lead to a very serious accident. To assist and help these drivers, many systems have been developed for the driver's safety and convenience such as LDWS(Lane Departure Warning System) which informs the driver when the vehicle begins to move out of its lane, FCWS(Forward Collision Warning System) which recognizes the forward cars and warns of collision with the car ahead by measuring the distance and speed and so on[1]. These systems give the information or warning using image or sound through in-vehicle interface, but it may be rather to prevent the driver to keep eyes forward. Some systems support safe driving by

automatic control without the driver such as LKAS(Lane Keeping Assist System) which makes the vehicle keep the lane by controlling the steering without a driver, SPAS(Smart Parking Assistant System) which helps make parking easier by providing automatic steering assistance and so on. Before an autonomous vehicle[2] which it may take a long time yet to be commercialized is released, a vehicle augmented reality system is very effective to makes the driver keep eyes forward road and other cars because it presents the safe and convenience information which matched with real world information on the forward windshield through the HUD(Head-Up Display). In [3,10], they confirmed that a driver's forward-looking concentration and recognition are enhanced when the driver uses the HUD while driving through experiments. In this paper, we describe the development contents and results of the developed vehicle augmented reality system focused on the lane-level guidance technology and service.

## II. VEHICLE AR SERVICE

A vehicle augmented reality system aims at providing the vehicle, safety and route information which is fused with the real world and matched with the range of driver's vision for driver's safety and convenience[4]. Recently, mainly the high-end vehicles provide simple information such speed, RPM, navigation route, and so on through the HUD, but it is not matched with the real world.



Figure 1. A Vehicle Augmented Reality System

As shown in Figure 1[5,6], the vehicle augmented reality system gives the markings matched with the real car or road or lane and displays directly the related to information or warning signs in the area overlooking the forward vehicle. Also, in case of route guidance, it displays a direction which

the vehicle needs to move with an arrow matched on the road. Several car companies, universities, and labs are studying and developing an augmented reality system that shows the information matched with the real world[5-12]. However, only fragmentary services are provided and the BM model is not yet available commercially. The vehicle augmented reality technology needs the recognition technology which generates driving-related information based on information collected from various sensors, the decision technology which determines what information to guide for various driving situation based on the recognition information and the technology which represents the decision information as the augmented reality. For providing more accurate information, the highly precise map information and the continuous global position and attitude of the vehicle[13] may be used. The vehicle augmented reality system is currently being developed provides FSAS(Forward Situation Awareness Service) and LLNS(Lane-Level Navigator Service) based on the information gathered from a daytime static/dynamic object recognition module, a night time or bad weather dynamic object recognition module, and a high-precision three-dimensional map information and interworking technology. This system consists of 4 layers. First, the sensor layer collects data from each sensor module such as GPS, camera, radar, etc. and the sensor fusion layer recognizes and extracts the driving situation information from collected data. And then, the decision layer determines the forward car situation, the risk level of collision, the lane departure, the lane changing conditions and the results of decision are provided in accordance with the expression strategy through HUD in a display layer. Existing prototype[14,15] provided the vehicle augmented reality display information as a transparent LCD type. However, we have changed the display device to HUD due to the bifocal problem and the slow pace of development of the transparent display technology.

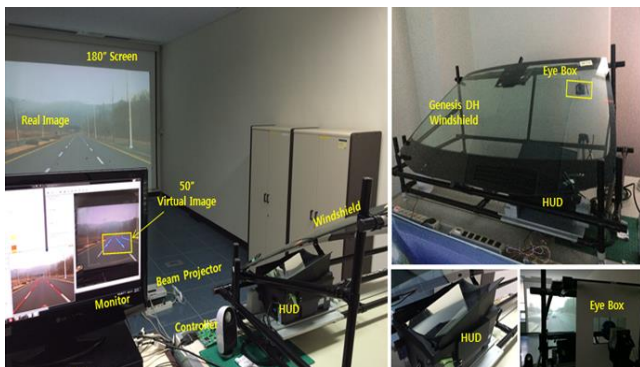


Figure 2. Indoor Testbed

As shown in Figure 2, we have built an indoor testbed which is similar environments as applied to the vehicle prior to applying the vehicle augmented reality system to the real vehicle and tested the developed system using the sensor data collected during the real vehicle driving on the indoor testbed.

### III. LANE-LEVEL GUIDANCE SERVICE IN VEHICLE AR SYSTEM

#### A. Lane-Level Guidance Service

The lane-level guidance service provides the lane-level guidance information which is determined by a decision layer using the lane information recognized by the camera, route information and road properties from the navigation map and the position information through the vehicle augmented reality system. The representative services are a lane change service which guides to change the current lane if the car unable to drive as guides on current lane and a lane departure service. This service also provides suitable services for a variety of road types and shapes, such as underpass, overpass, crossing road.

#### B. Information optimization

The Information optimization technique is a technique that processed by a decision layer for a method of determining whether to provide the service information and time and providing a driver with the information effectively based on the data acquired from the sub-system. The Information optimization technique of the lane-level guidance service determines whether the driver has to change the lane and whether the car deviates from its lane for the lane departure service. Besides, it determines whether to provide the information in any form at any point in time. And then, the results of decision are determined by the information optimization are transferred to the upper HUD display layer and are shown as an expression that can provide most effective information to the driver on the vehicle augmented reality.

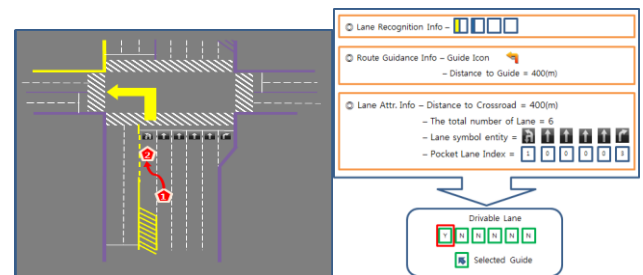


Figure 3. Lane Change Decision

As shown on the left in Figure 3, the vehicle is driving in the second lane (position 1), then if the driver receives a left turn route guidance at the forward intersection, the decision layer recognizes that the first lane is the lane which the vehicle can turn left at the forward intersection from the intersection lane attributes. And it checks that the current driving lane is the second lane from the result which the camera recognizes the forward lane and determines that current driving lane is not possible for the vehicle to turn left. From these results of decision, this system provides the guidance to move the vehicle from the second lane to the first lane(position 2) through the vehicle augmented reality. As shown on the right in Figure 3, this system receives the lane recognition result (centerline, current driving lane), route guidance information(guide icon, distance to guidance, etc.), and the lane attribute information(distance to crossroad, the total number of lane, lane symbol entity, etc.) and determines that

the lane change is required and the vehicle must be moved to the first lane by matching all information and selecting the guide. In the case of lane departure, the decision layer determines the warning level as two stages depending on the distance between a lane and a vehicle.

#### IV. DEVELOPMENT AND RESULTS

The lane-level guidance service was designed based on the previous study[1] and implemented in the integrated S/W. We have been developed the lane change guidance services are suitable to various road types with basic lane change decision algorithm. Also, the guidance service for lane departure and sharp curve section was developed. The developed system was tested on an indoor testbed based on the data collected through the real vehicle. The vehicle augmented reality system on the indoor testbed determines whether to provide the information for each service through the integrated S/W which is installed on the PC based on the recognition result of collected data from various sensors. And it shows the image which is represented as the augmented reality based on the results of decision through the HUD connected to the PC and is matched with the driver's eye point. In case of the lane-level guidance service, also, the integrated S/W containing the decision layer generates the results of decision about various driving situation using the recognition results generated by the lane recognition module and the map information collected at the same time as the input data. The appropriate expression model is selected by using these results of decision and a display module on the controller draws the image or figure such as the line, arrow, icon, etc. which is matched with the original image on the HUD. As a result of this process, the lane-level guidance services are shown as the driver's field of vision on the indoor testbed are as follows:

##### A. Lane Change Guidance Service

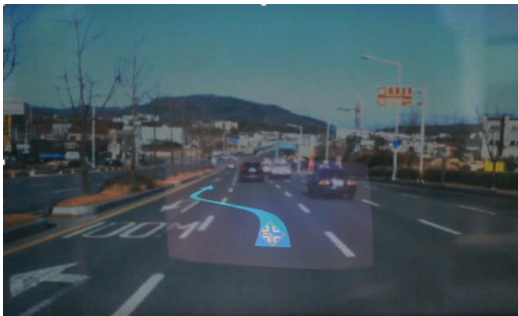


Figure 4. Lane Change Guidance on the Intersection

If the driver needs to turn left at an intersection ahead as Figure 2, this system recognizes that this vehicle need to move from the current lane to the left lane possible to turn left and provides the augmented reality information as shown in Figure 4. First, the decision layer checks the route guidance information which the vehicle need to turn left at the forward intersection and the remaining distance to the forward intersection received from the map and the display layer displays the remaining distance to the intersection with the

intersection icon on the HUD. And, the decision layer makes sure that current driving lane is not possible for the vehicle to turn left and makes the display layer display an arrow indication pointing to the first lane possible to turn left.



Figure 5. Lane Change Guidance on the Highway

Figure 5 shows the guidance information displayed as the augmented reality about the driving situation that the vehicle drives on the highway and then exit to the IC by using the current driving information and IC-related information. First, the decision layer recognizes that the vehicle has to get out of the forward IC on the route from the map information and makes display layer display the remaining distance with the highway exit icon (top left). It also makes sure that the vehicle can't enter the highway exit IC in current lane from recognition results and guides it to move to the second lane (top right). After moving into the second lane guided, the remaining distance is displayed with the highway exit icon (bottom left). When the pocket lane for exiting the highway IC is appeared, it checks that it is not able to enter the exit IC on the current lane and guides that the vehicle moves to the newly opened pocket lane (bottom right).

##### B. Lane Departure Warning Service

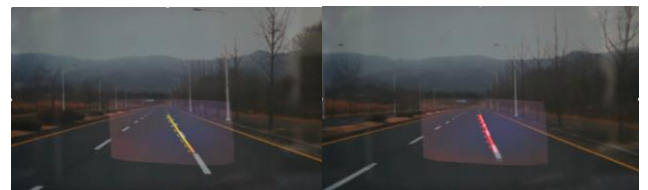


Figure 6. Lane Departure Warning

The lane departure warning service detects whether the vehicle is departing from the current lane and notifies the driver of it. The optimization technique of this service determines whether or not the lane departure of the vehicle using a distance between the driving lane and the vehicle. As shown in Figure 6, if the vehicle reaches close to the lane, this system shows a yellow and sawtooth-shaped line matched with the lane for giving the first warning. If it crossed the lane, it shows a red and sawtooth-shaped line matched with the crossed lane. Thus, this service may reduce the risk of

accidents caused when the driver gets out of the lane due to drowsiness, etc.

### C. Other Services

As other services, if the slope of the recognized lane is over a certain size in a curve section, this system recognizes it as a sharp curve section and displays the forward road in red in order to induce keeping the lane. Figure 7 shows the result of this service.

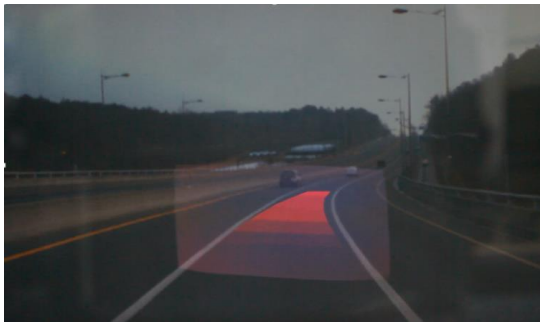


Figure 7. Curved Lane Guidance

## V. CONCLUDE

So far, we have shown the developed contents focused on the decision layer which determines the lane change and lane departure and results displayed as various lane-level guidance services in the vehicle augmented reality system. In the current developed system, each module recognizes forward vehicle, pedestrian and lane respectively and also determines what information to guide for the driving situations and displays respectively. But, in this year, we will integrate these modules for expressing a convergence result in the vehicle augmented reality. In the future, it is also worthwhile to consider applying the driving workload[16] to select and determine the information represented by the vehicle augmented reality. It is also necessary to test this system in a more wide range of driving conditions in order to apply the present system to the vehicle. If the vehicle augmented reality system is installed on the vehicle, it will help the driver to drive more safely.

## ACKNOWLEDGMENT

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