DESIGN OF REAL-VIEW NAVIGATION SYSTEM WITH VIRTUAL PATH MAPPING TECHNIQUE

Chillo Ga, Doctor's course
Kiyun Yu, Professor
Department of Civil & Environmental Engineering
Seoul National University
crow75@snu.ac.kr
kiyun@snu.ac.kr

ABSTRACT

Currently, car navigation systems stand out with services such as telematics and ITS (Intelligent Transport System). Moreover, the demand for these services is rapidly increasing. Current widely used navigation systems are generally based on 2D or 3D graphics and provides route and guidance information services. However these navigation systems, are associated with compression and a loss of information during the process of modeling the complex real world into simple shapes and images. Hence, the real world is not fully reflected in the system, resulting in odd depictions of actual areas, and giving users difficulties in recognizing their driving status. Therefore, in this research, we designed a navigation system based on real-view image servicing route and various guide information, on top of real-time images obtained by a camera installed on the car. Also we proposed the system's core function; a technique creating and mapping virtual road objects and tested it.

Keywords : Navigation System, Real-View, Virtual-Path, Road Network Data

INTRODUCTION

Car navigation systems have been elevated to the status as a core service of telematics and LBS(Location based services) as a road and traffic information system that provides guidance along optimal routes considering the distance and traffic status from the current position to the destination(Cho, 2007). Navigation systems widely commercialized now are mainly based on 2D graphic service. Lately, a number of studies have been carried out on navigation systems based on 3D graphics from 3D models of buildings and topographic information of the real world. Some have already reached the commercialization stage. This research trend can be seen as a means of providing an accurate guide service with a higher level of reality to users. However, the existing system is incapable of reflecting the real world due to information loss that occurs during the process of modeling the complex real world into simple shapes and images. Moreover, as time passes, the constructed map data of the device cannot reflect the objects of the real world, as they change continuously. This increases the sense of distortion from reality. Due to these limitations, users may act out an incorrect judgment due to the difficulty in matching what the user sees and the information provided by the device. Recently, to overcome such a problem, research on navigation systems using real-view images or video is in progress. The real-view image navigation system is considered to be capable of greatly assisting users in recognizing their driving situations by mapping images obtained using a camera set on the car along with information related to the route and other types of information that is processed to display the maps(Chae, 2007). Following the current research trend, in this study, we designed real-view image navigation system based on the existing 2D navigation system with real-view image processing functions. And we also proposed the core function of the system; virtual object creation and mapping technique.

RELATED WORK

The technology related to navigation systems is developed from navigation systems based on 2D graphics that are typically spread to 3D graphic navigation systems to allow near real view cognitions through the construction of the topographical characteristics and objects around a road into three dimensional model. As the 2D navigation system incurs a loss of information while modeling the complex real world into two dimensional geometric objects,

it is difficult for users to perceive the driving condition accurately. The 3D navigation system, researched to overcome this shortcoming, provides information by constructing objects of the real world into three dimensional graphics and applying a perspective view to make this view similar to actual driving. However, a loss of information also occurs in 3D navigation systems during the process of modeling the real world. First of all, construction of 3D data requires enormous cost, and since it cannot reflect the constantly changing real life, the user can experience difficulty in perceiving the driving situation(Yamaguchi, 2007). To summarize, the problem is that, due to the discrepancy between the view the user sees and the information provided by the terminal, the user cannot perceive the accurate driving situation. In contrast to this, the recently researched real-view image navigation system increases the perception of reality by mapping and displaying routes and various guide information on top of images acquired through the camera installed in the vehicle. This improves user perceptivity. Additionally, navigation based on real-view image, when applied with HUD(Head Up Display) technology that displays information on the window of the vehicle, is thought to provide guide information that is more easily perceived as it minimizes decentralization of the driver's attention and allows for safe driving (Tonnis, 2005).

Currently, research on the real-view navigation has led to the creation of the VICNAS (Vision-based Car Navigation System) system by Kumamoto University in Japan, the INSTAR (Information and Navigation Systems Through Augmented Reality) system as co-research by Siemens and Linz University in Germany, and a type of video-based navigation system carried out by ETRI (Electronics and Telecommunications Research Center) in Korea. VICNAS provides guide information on top of real-time images that are acquired using the three dimensional location and detailed information by a camera installed inside the vehicle. Using the information acquired through DGPS and a gyroscope sensor, the location of the vehicle is determined, and virtual image mapping technology is used to connect the road network data and the linear data of the road acquired from the image cognition operations(Hu, 2004). INSTAR provides guidance by combining the virtual path created from the 3D topography information with images. In contrast to VICNAS, as it does not carry out an image cognition process, it has the advantage of remaining unaffected by day and night or any type of weather. However, it requires expensive equipment and a precise electric map to combine the virtual path and the actual driving course accurately(Narzt, 2004). Finally, the video-based navigation developed in Korea perceives the various objects surrounding the road from acquired real-time images, maps a virtual path, and provides an additional warning service. However, this system is overly influenced by whether it is day or night and by different type of weather, as it mainly depends on computer vision technology(Kim, 2008).

DESIGN OF NAVIGATION SYSTEM BASED ON REAL-VIEW

The main goal of a real-view image navigation service is to allow the user to perceive the driving condition easily by eliminating the uncertainty generated by the discrepancy between the real world and the modeled information and to carry out appropriate decision making from this. In order to achieve this goal, in this research, we composed the modules in the an expanded form from the existing 2D navigation system to process the real-view information [Figure 1]. Path finding, guide generation, map matching and GPS module are used in real-view image navigation as the same necessary functions, and detailed functions combined with the use of the newly added modules provide a real-view based guide. The Video Module, the Traffic Light and Lane Cognition Module, the Virtual Path Creation Module, the Driving Context-Aware Module and the Display Module— are shown in Table 1.

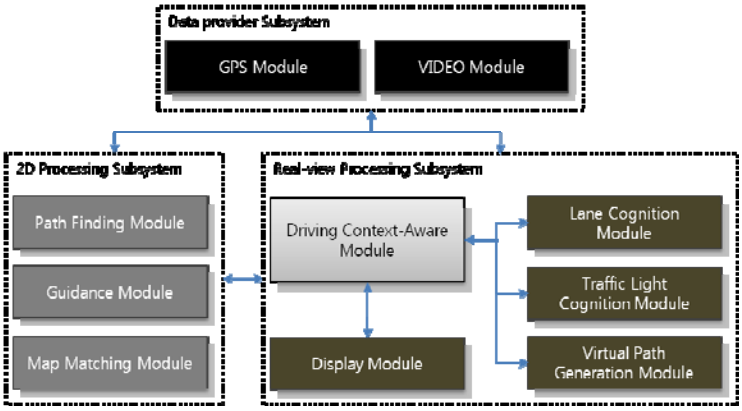

Figure 1. System Composition.

Table 1. Modules and their Description

Extension Module	Functional Description
Video Module	• Acquiring the real-time images synchronized with the current position • Transmission sequential frames as input data to the real-view processing subsystem
Lane Cognition Module	• Recognizing the road region and lane information from the current frame • Transmission recognized information to the driving context-aware module
Traffic Light Cognition Module	• Recognizing traffic light information from the current frame • Transmission recognized information in the driving context-aware module
Virtual Path Generation Module	• Generating the virtual path object for mapping on the top of real-time image
Driving Context-Aware Module	• Deriving the most appropriate information for the current driving situation by comprehensively considering various data • Controlling other modules
Display Module	• Displaying conventional 2D graphics and real-view information

The interface between modules and the system operation flow starts by acquiring and synchronizing the real-time images and location data from the Video Module and the GPS Module and then transmitting them as the input data for the 2D processing subsystem and the real-view processing subsystem. The current location of the path-finding stage is used as the input data for the Path Finding Module, along with the destination set by the user. The location information input is then transmitted to the Virtual Object Creating Module through the Map Matching Module. The image frame, which is the output information of the Video Module, becomes the input data to extract the specific cognition information in the Lane Cognition Module and the Traffic Light Cognition Module. The Lane Cognition Module and the Traffic Light Cognition Module respectively extract the lane and traffic light information based on the input image frame. The perceived information is then transmitted to the Driving Context-Aware Module. The Driving Context-Aware Module combines the conventional 2D-based path and guide data and the real-view based virtual path data and cognition data and carries out the role of creating the most appropriate guide information for the current driving condition. Finally, the guide and expression data created in the Driving Context-Aware Module are transmitted to the Display Module and are mapped in a real-view image.

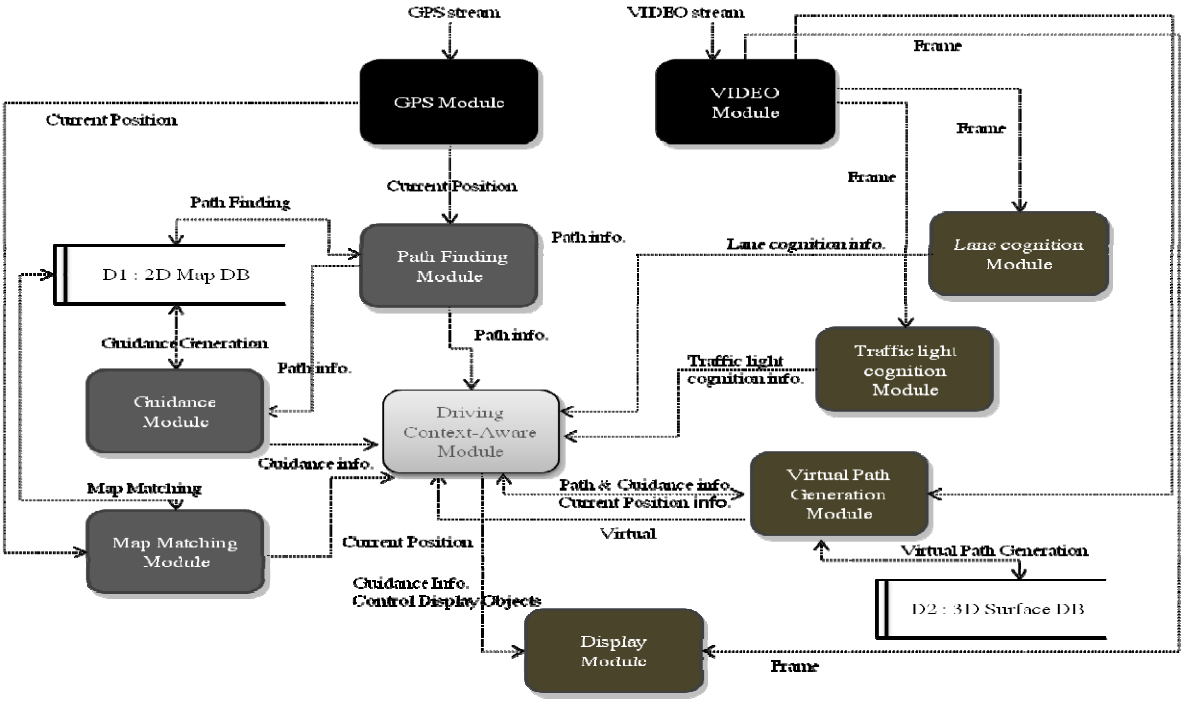

Figure 2. Interface & Process Flow Diagram.

VIRTUAL PATH GENERATION & MAPPING

The mapping technique that creates and overlays the virtual path on top of the real-time image, as it displays the driving information of the vehicle on the same display as the user sees, provides a more accurate and perceptive service to the user. This is a differentiated function from existing navigation systems and carries out a very important role in the real-view navigation system. Therefore, this section discusses the creation and mapping process of the virtual path. The most intuitive means of displaying the virtual path information on the image is a technique in which the road region and lane are recognized from a real-time image acquired from a camera while mapping the driving route and guide information based on that cognition information. However, techniques such as these are affected by the lighting and weather conditions and may not be feasible in conditions such as heavy traffic congestion (Kim, 2008). Thus, this research suggests a technique in which the geometry information of the search path and the topography information are used to create a virtual path and where road region cognition information is applied as acquired from imaging for mapping [Figure 3].

The route information is determined based on the road network data that models real world roads; hence, it provides the linear information related to the path to the destination. In other words, using this, the road shape in the forward direction can be inferred from the current location. A virtual path object is created from the application of a distance threshold of a buffer to this linear road information, the transformation of it into planar form, and then execution of the projection at the same visual angle of the users. By extracting only the road region from this projected image, mapping is carried out on the image synchronized to the current location. However, the linear road information is two dimensional information and does not account for the undulating information of the geography of a given area; moreover, the data used in the process of creating the virtual path, such as the current location and the road network data, include various errors that can generate discrepancies when used with the image. To solve this problem, we put the rise and the fall information of the line of the path using the three dimensional topography information and used the correction technique from the vanishing point and the road boundary information provided by the lane cognition module. [Figure 4] shows the process of creating and mapping the virtual path object.

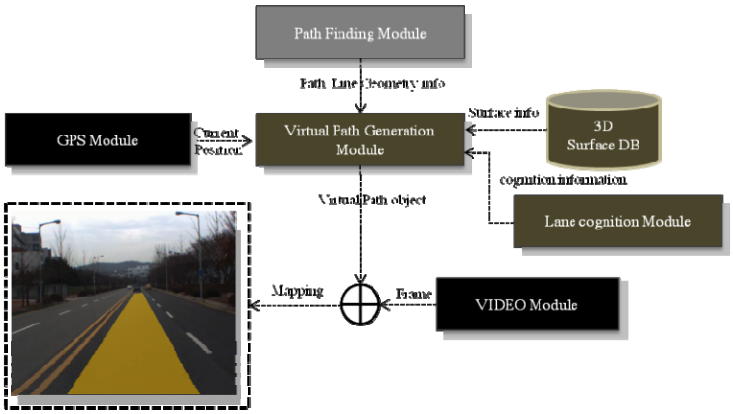

Figure 3. Virtual path generation process.

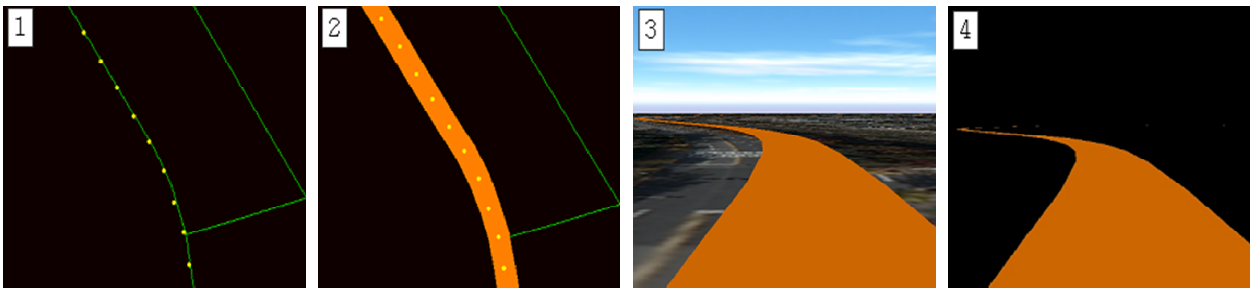

Figure 4. Process of mapping the virtual path object.

RESULT & FUTURE WORK

Conventional navigation systems based on 2D and 3D graphics currently involve the compression and loss of data during the process of modeling the real world. In addition, because they cannot continuously reflect the constantly changing real world, they can confuse the user. These factors obstruct safe driving. Recently, research on

the subject of real-view based navigation technology that expresses the path and guide information on top of a real time image has been conducted to overcome these problems. According to such a research trend, in this study, a real-view image navigation system is designed that expands the real-view processing functions of the existing 2D-based navigation systems. A prototype was constructed and tested centering on the creation and mapping of virtual objects.

Figure 5. Test Scenes, crossroads(left), straight road(middle), curved road(right).

Through the test, it was confirmed that mapping a real-view image is possible by extracting the forward road geometry from the current location in a manner that is not affected lighting or weather conditions. However, as the data used within the process of creating the virtual path includes many errors, additional research should be carried out to map virtual paths accurately for any driving situation. Therefore, a future research subject would be to increase the mapping accuracy by using the cognition data of the objects in the vicinity of the road that contain location information, such as traffic lights, crosswalks and buildings. In addition, because the information acquirable during driving, including cognition data, can vary greatly in the real-view image navigation system compared to existing navigation systems, an in-depth study of the Driving Context-Aware Module that generates high-quality guide information most appropriate for the current driving condition, through comprehensive determinations of the various data, should be conducted.

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