REPRESENTATION OF NAVIGATION INFORMATION FOR VISUAL CAR NAVIGATION SYSTEM

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ABSTRACT: Car navigation system is one of the most important applications in telematics. A newest trend of car navigation system is using real video captured by camera equipped on the vehicle, because video can overcome the semantic gap between map and real world. In this paper, we suggest a visual car navigation system that visually represents navigation information or route guidance. It can improve drivers' understanding about real world by capturing real-time video and displaying navigation information overlaid on it. Main services of the visual car navigation system are graphical turn guidance and lane change guidance. We suggest the system architecture that implements the services by integrating conventional route finding and guidance, computer vision functions, and augmented reality display functions. What we designed as a core part of the system is visual navigation controller, which controls other modules and dynamically determines visual representation methods of navigation information according to a determination rule based on current location and driving circumstances. We briefly show the implementation of system.

KEY WORDS: CNS, Telematics, Video, Augmented reality, Route guidance

1. INTRODUCTION

In the geographic information system(GIS) and telematics, car navigation systems(CNS) have been developed as a key application. In the early developed 2D navigation systems, however, there are some semantic gaps between real world and displayed map. Therefore current navigation systems have begun to introduce elaborate 3D display features on crossroads, which is more perceptible than 2D map.

However, CNSs till now still have limited representation power for real world, especially in case of confusing crossroad or junction. Such defect may have drivers get lost or cause traffic accidents. In this reason, CNSs now aim at more realistic representation of real world. The most emerging and promising trend of CNS is to introduce real video captured by camera equipped on the vehicle. The examples of early video-based CNSs are INSTAR of Siemens(Narzt et al, 2003) and VICNAS of Kumamoto University(Zhencheng et al, 2004). Such systems capture real-time video and displaying navigation information (such as directed arrows, symbols, and icons) onto it. Because video is more perceptible than 2D map, such video-based CNSs are expected to reduce drivers' visual distraction while driving and to make navigation guidance easier.

In this paper, we suggest a new CNS that visually represents route guidance information overlaid with real-time video. Main approach of the system is to display guidance information by augmented reality (AR) scheme supported by computer vision features. Also suggested is visual navigation controller that determines and controls visual representation methods of navigation information dynamically according to current location and driving circumstances.

The remainder of this paper is organized as follows. Section 2 provides an overview on architecture of the system, and section 3 describes how the visual navigation controller controls visual representation of navigation information. In section 4, we present the implementation of the system, and section 5 concludes our suggestions.

2. ARCHITECTURE OF THE VISUAL CAR NAVIGATION SYSTEM

In this section, we suggest an architectural framework of the suggested visual navigation system. Main goal of the visual navigation system is to display navigation information directly onto the real video and thereby improve the drivers' understanding. In this paper, navigation information refers any form of information about route guidance, for example, "turn left after 500m," or "go straight till next guidance is notified." Guide point means a location where the navigation information is given, typically street intersection. We will first discuss about possible visual navigation services, and present system architecture to implement the services.

2.1 Services

Main features of our suggested video-based visual car navigation system are (1)to provide graphical turn guidance on reaching a guide point, and (2)to provide lane change guidance when the drivers need to change road lane in advance. The first service is a basic function of CNS, while the second service is a distinctive feature of CNS that uses real-time video. Note that, the determination of road lane change requires dynamic identification of current lane number. Following architecture and modules are designed to implement the given services.

2.2 Architecture

To implement the services, our visual CNS introduces computer vision functions and AR display functions, as well as real-time data acquisition and conventional route guidance functions. The architectural overview of suggested visual CNS is shown in Fig.1. The system is categorized into sub-modules: data acquisition module, navigation engine, object recognition module, AR rendering module, and visual navigation controller, which will be explained below.

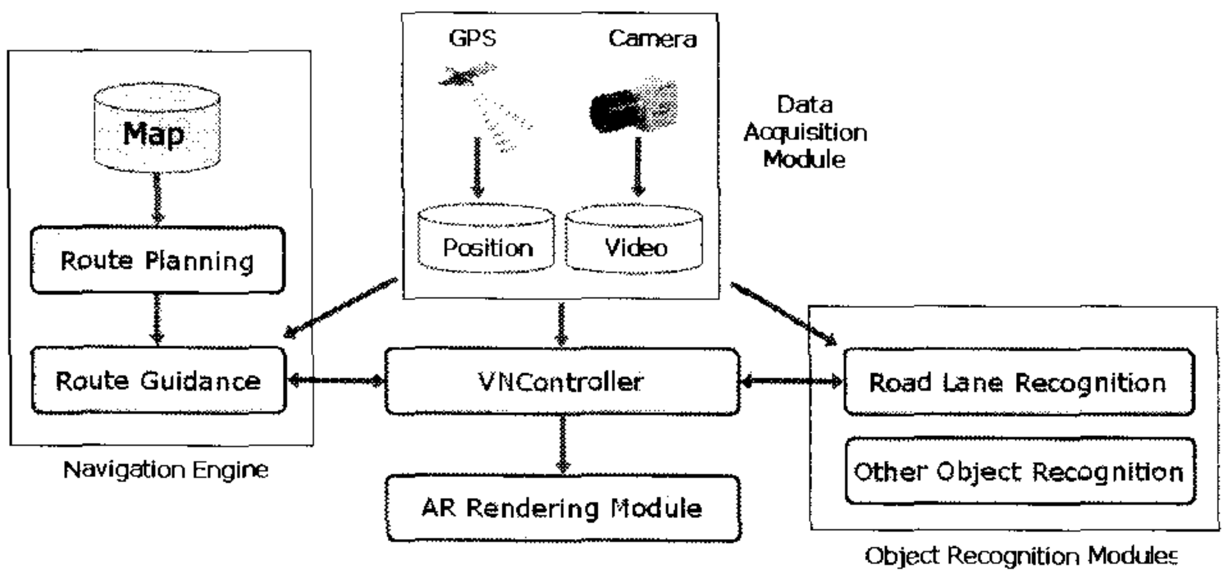


Figure 1. Architecture of suggested visual car navigation system

2.2.1 Visual navigation controller: The main part of the visual CNS is designed as a component called visual navigation controller (VNController hereafter). It determines visual representation methods according to current location and circumstance (such as GPS data, object recognition result, and navigation message) and controls other modules. How it controls visual representation will be described in section 3.

2.2.2 Data acquisition: location and video: In our system, the location data is acquired from GPS receiver with 1-sec interval, and video frame is captured by single forward-looking camera and frame grabber connected with it. The real-time video is sent to road lane recognition module and AR rendering module. The data acquisition module is designed to capture video into a file as well as process real-time video, in order that the video file can be also used in a simulation environment.

2.2.3 Navigation engine: This engine includes all functions of legacy CNS such as 2D map display, route finding, map matching, and route guidance. The way the navigation engine and VNController interact is designed to ensure interoperability with multiple navigation engines. The route data returned by navigation engine is a path from start point and destination point, described as an ordered list of coordinates of nodes and links. On the mid of driving, the VNController compares current location and next guide point, and decides when to request additional data to the navigation engine. The data are sent to and used for road lane recognition module and AR rendering module.

2.2.4 Road lane recognition module: It executes road lane recognition process from input video. The module gets a video frame, recognizes road lanes, and sends the result to VNController. The main goal of this module is to find current lane number on which the vehicle is going. The detailed explanation about identifying current lane number is beyond the scope of this paper, and is shown in (Bertozzi et al, 1996; Yim et al, 2003). The road lane recognition module returns current lane number and two lane-dividing lines represented in image coordinates to VNController. The road lane recognition processes may degrade the system performance, so they should be controlled to get a higher system performance. Because the visual guidance may be unnecessary when the car is going straight without need to turn, VNController runs the road lane recognition module only when necessary. For example, we can control the module like as: 'start the road lane recognition 200*m* before the guide point.'

2.2.5 AR rendering module. This module displays graphical navigation information overlaid on the video frame. The VNController controls the AR rendering module by sending messages for determined visual representation method. Also sent to the AR rendering module are parameters used for the rendering. The current location and road coordinates are sent to the rendering module for generating virtual objects (direction indicator) in 3D graphic space that will be overlaid on video. For example, the values of coordinates can determine the curvature and angle of arrow-shaped direction indicator (An example is shown in Fig. 2). Another important data for the AR rendering module is two lane-dividing lines recognized by road lane recognition module, which is used for estimation of vehicle heading.

3. VISUAL REPRESENTATIONS FOR NAVIGATION INFORMATION

In this section, we discuss how the visual representations are done based on the architecture shown in section 2. The actual visual representation methods should be selected according to current location and circumstance. For example, a condition may be 'how far is the next guidance point'. For each condition, the VNController apply a rule to determine visual representation method.

3.1 Visual Representations for Navigation Information

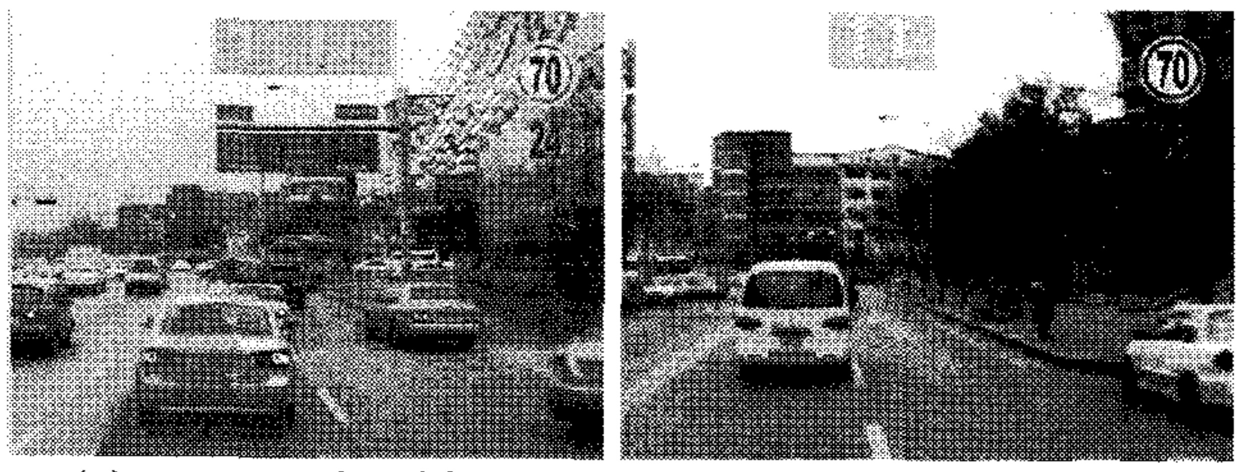
For implementing the visual navigation services (section 2), we designed visual representation methods for navigation information as follows. However, the schemes are extensible; further types can be also considered. The specific design for each representation method is supported by user experiments and analyses conducted in (Park et al, 2007).

Crossroad guidance. We can represent navigation information by creating a virtual object and overlaying it on the video frame. In our system, the shape of the virtual object is a curved direction indicator, whose pictorial example is shown in Fig. 2(a). To make the virtual indicator match the road in video as exact as possible, we use current position, road coordinates, and vehicle heading estimated from recognized lane-dividing lines.

Lane change guidance. We represent a graphical guide for lane change when required on reaching the guide point in order not to miss the turn. Such guidance is provided for crossroads, overpasses, underpasses, and tunnels. A pictorial example is shown in Fig. 2(b). Such type of guidance is realized by identified current lane number, as well as turn information at next crossroad for each lane of current road.

Text and icon display. In this type of guidance, we just represent simple information such as guide type and remaining distance for the next guide point as a form of text, icon, or symbol. The display is similar to that of 2D CNS except that it is displayed on video frame. In Fig. 2, some informative icons are also displayed on video frame.

Sometimes it is preferable to display no navigation information on video. The typical case is long straight way where no guide is necessary. By pausing displaying guidance information, the system can do other process with the system resource.



(a) crossroad guidance (b) lane change guidance

Figure 2. Visual representation methods

3.2 Determination Rule of Visual Representation

This section describes how the visual representation methods above are applied according to current location and circumstance. A determination rule suggested in this paper is based on distance and current lane number, as described below. The determination rule is established in order that the methods can be applied in combination rather than they are executed exclusively. For example, the route guidance is represented as a curved direction indicator in crossroad as well as the navigation information displayed as text and symbols. A suggested determination rule is shown in Tab. 1.

Table 1. Determination of visual representation methods

```
set mode_CrossRoad OFF
set mode_LaneChange OFF
set mode_TextIcon OFF
set distL ← 300m
set distC ← 200m
set distLE ← 100m
set distR ← 100m
set laneChange← 0
for each time unit, repeat
   set dist ← location~nextGuide
   set back ← location~prevGuide
   if(dist<distL)
      set mode_TextIcon ON
      set laneNum ← TotalLane(currentRoad)
      set currentLane ← LaneRecognition(laneNum)
      set tLane ← TargetLane(nextGuide)
      if(currentLane ≠ tLane) set mode_LaneChange ON
      else if(dist<distC) set mode_CrossRoad ON
   if(dist<distLE) set mode_LaneChange OFF
   if(back<distR) set mode_CrossRoad OFF
   set mode_LaneChange OFF
   set mode_TextIcon OFF
until end of video or end of route
```

In the rule, we should predefine values of parameters `distL`, `distC`, `distLE`, `distR`, that mean distance for activating `mode_LaneChange` before guide point, distance for activating `mode_CrossRoad` before guide point, distance for deactivating `mode_LaneChange` before guide point, and distance for no display after guide point, respectively. The values of parameters can be tuned according to road conditions, characteristics, and human factors. Note that, the rule in Tab. 1 is not uniquely established; similar variations of the rule can also be managed and applied in the same manner.

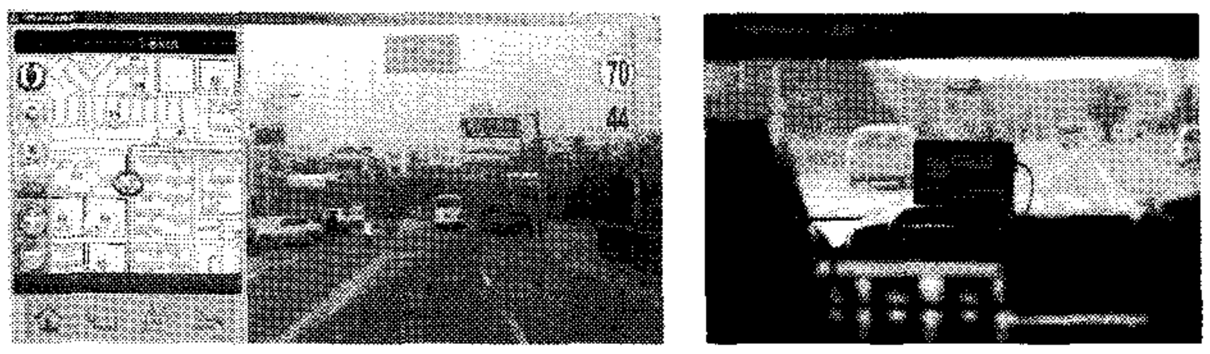
4. IMPLEMENTATION OF A VISUAL NAVIGATION SYSTEM

We have been implemented the suggested visual CNS as a prototype system operated on a vehicle equipped with a PC, a forward-looking camera and frame grabber, a GPS receiver, and a terminal of 7" wide screen(1024*600 resolution). Video is captured by camera in 640*480 size and 30fps, and GPS data is received in 1-sec interval.

The navigation engine is developed by updating and customizing that of a currently used CNS. The VNController is developed as a dll with the designed interfaces implemented. The object recognition module is developed for road lane; but our system supports further extension to other object recognition modules for sign lamps, road signs, and buildings which will give further features. In the developed system, we also have a 2D map displayer like that of conventional 2D CNS, where the display and guidance on the 2D map are synchronized with visual representation on video.

Rendering module is developed as an ocx component with OpenGL functions. It plays input video on screen and displays virtual guidance objects onto the video frame. The rendering is executed by AR technology with coordinates of current position, road data, and estimated vehicle heading. For directed arrows and icons/symbols that will be displayed on video frame, we designed 2D and 3D representation models and constructed them as a graphic library database.

Fig. 3(a) shows an example of execution screen of the system, where 3D virtual curved direction indicator representing right turn and lane change to right is displayed to provide visual and realistic route guidance. In this figure, `mode_CrossRoad` and `mode_TextIcon` are applied. We can see that, the turning angle of path on crossroad is used for the rendering to make the guidance more realistic. Fig. 3(b) shows actual execution of the system installed on vehicle.



(a) execution screen of system (b) running system

Figure 3. Execution of the system

5. CONCLUSION

In this paper, we suggested a new visual car navigation system that uses real video captured by camera equipped on the vehicle to represent navigation information, and introduced the implemented prototype system. By capturing real-time video and displaying graphical navigation information on it, the system is expected to enhance drivers' understanding about route. We designed architecture for the system and suggested kinds of visual representation methods. What we designed as a core part of the system is visual navigation controller, which dynamically determines visual representation methods for route guidance according to current location, guidance information, and road lane recognition results from the video frame.

As the future works, we are going to implement a fully operational system that is stable for many conditions of driving. Further, the VNController can be extended to manage much more visual representation methods and more complicated determination rules. Also, because the visual navigation is highly related with human factor, some issues of this visual navigation system should be approached and more studied from the view of HMI(Human-Machine Interaction).

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