Parking Assistance using Multi-Camera Infrastructure

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Abstract— **Parking assistance, one of ITS technologies, by various methods has been studied in various place. In the near future, as infrastructures are improving, we propose other ways of parking assistance in the HIR (Human-Oriented Information Restructuring) system we have proposed, which assists driver's visual sense by integrating and restructuring different kinds of information. Parking assist we propose use multi-camera infrastructure. At first, we actually experimented parking assist using a single camera infrastructure in actual world, and confirmed the effectiveness of it. so, We considered what type of information the system gives the driver to make it easy to park, and experimented, and we show some experimental result.**

I. Introduction

Nowaday, ITS technologies are studied widely. Parking assistance is also one of them. It is a system to support people who do a poor job of parking their car. At present, parking assistance using images of a rear view camera or the information on sensor, such as GPS have been studied[1]. In the technology of the rear view camera, automatic parking has already been realized[2].

We proposed a new concept system "HIR(Human-oriented Information Restructuring)"[3][4][5] which is different from automatic parking. HIR system assists drivers in recognizing road condition by showing images that are Easy-to-Understand. In this paper, as infrastructures are improving, we propose other ways of parking assistance using multi-camera infrastructure (In this paper, a camera infrastructure means a camera placed on the roadside) for surveillance or other purpose in car park as one of HIR system, then images are transmitted by road to vehicle communication and are displayed on an in-vehicle display. For a start, we have studied parking assistance using a single camera.

The outline of this paper is as follows. In Section 2, we introduce the outline of HIR system and the experimental environment. In Section 3, we confirm the effectiveness of parking assistance using a single camera infrastructure. In Section 4, we show the result of the experiment carried out to obtain overhead view images. In Section 5, we consider data transmission. Conclusion and future works comprise the final Section.

II. Our concept and experimental environment

A. HIR system

1) Outline: HIR(Human-Oriented Information Restructuring) is the system that assist drivers in recognizing road conditions by showing "images" which are Easy-to-Understand for humans. The flowchart of HIR is shown in Figure 1. The driver-assisting images are generated by integrating and restructuring information from road infrastructure or vehicles. These include GPS, VICS, sensors and multi-camera information. By watching the images, drivers can drive more safely. The judgement and recognition of driving are done by the driver, not by machines. We have proposed this new concept system "HIR" on the assumption that humans have the best recognition ability. Thus, in HIR, the main purpose of using images from cameras is showing them as "images" and are not using as "sensors".

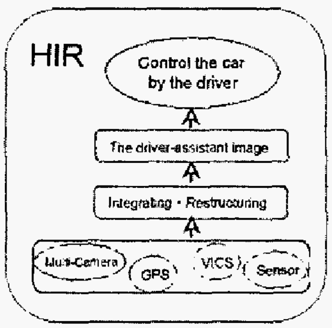

Fig. 1. The flowchart of HIR

2) Requierd accuracy for HIR: In HIR, the traffic condition is recognized by watching the assisting images, which are generated from multi-camera by Image Based Rendering(IBR). If the images are shifted or not clearly visible, it causes the driver to judge by delay, which leads to very dangerous situations. Therefore, we must consider the tolerance level of error, and required accuracy for HIR system. Driving a car consist of three actions called recognition, judgment, and operation as shown in Figure 2. The limit of human's reaction time is about 0.12 sec. But it is said that the average of reaction time

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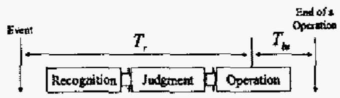
after human recognizes a condition until operating is about 1.0 sec. Therefore, 1.0 sec can be considered to be the standard human's reaction. So, we must build a system that consider this factor.



(T_r:Driver's Reaction Time, T_{bs}:Brake Stopping Time)

Fig. 2. Driver's action

B. Driving simulator

We built a driving simulator. This enable us to do experiments inside the laboratory. This consist of a cut-body, a radio controlled car and dioramas as shown in Figure 3. There are CCD cameras(TOSHIBA IDSM43H) on the radio controlled car. The driver in the cut-body operates, watching the screen in which those images of CCD cameras are reflected. The inside of the cut body is a duplicate of the inside of a normal car. If we operate it, the radio controlled car will move in connection with our operation.

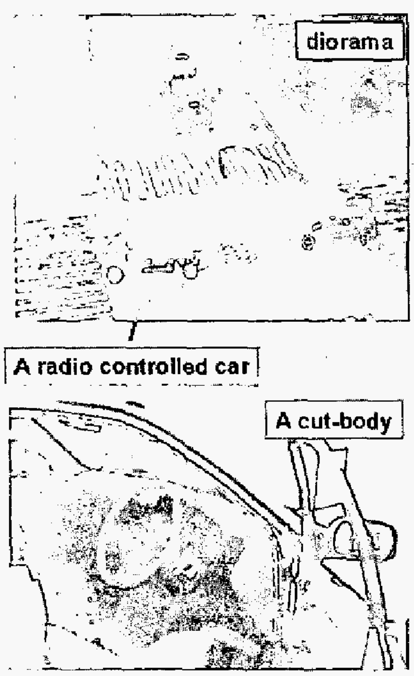


Fig. 3. Driving simulator

C. Equipment of an experimental car

We built the in-vehicle system to experiment in actual environment. Position information is acquired from RTK-GPS (TOPCON LEGACY-E,output:maximum 10Hz,accuracy:3cm). Direction information is from 3 axis angle sensor (DATATEC GU-3024,output:60Hz,roll and pitch accuracy : 0.5 deg, yaw accuracy : 1combined the oscillating gyroscope and the acceleration sensor. Geomagnetic sensor(MicroStrain 3DM, output : 30Hz, roll accuracy : 0.33 deg, pitch accuracy : 0.93 deg, yaw accuracy : 1.0 deg) is also used. The wireless LAN of the IEEE802.11g standard (BAFFALO WLA-G54 frequency band : 2.4 GHz, access spead : 15Mbps, electric wave attainment range : 150 m) is used for getting data of infrastructure of vehicles. The wireless LAN van transmit about 7 to 8 frames/sec of the non compressed picture of 320x240 size.Camera is CCD (TOSHIBA IDSM43H). The data is controlled by one server PC (CPU : PentiumIV processor 2.8 GHz, Memory : 1 GHz, OS : Linux). Experimental car is Estima Hybrid(TOYOTA) because of its power supply. We show system architecture of it in Figure 4.

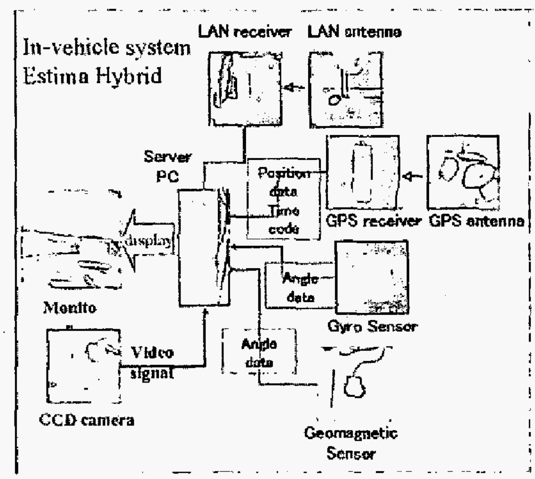


Fig. 4. System architecture

III. PARKING ASSISTANCE USING SINGEL CAMERA INFRASTRUCTURE

A. Decision of camera position

Before experimentation with multi-camera infrastructure, we carried out a study on a single camera infrastructure. Before we experiment, we decided a position where the camera for parking assistance is to be set up. Ideally, we had better look over parking space in the image without interruption. The camera should be therefore set up above the position where the car parks. But as the camera can't be set there in the open air and area in the image become narrower, we decided to look for other good camera position. As a result of evaluation of images taken at the various places, we found it the best to set up the camera at the rear of the position where the car parks.

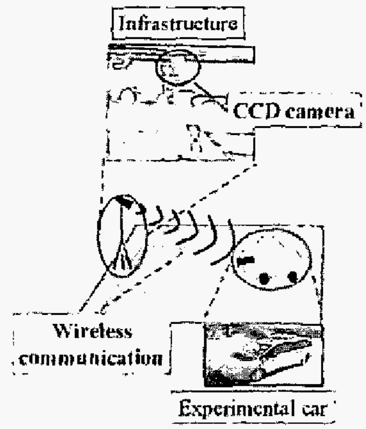


Fig. 5. The situation of the experiment

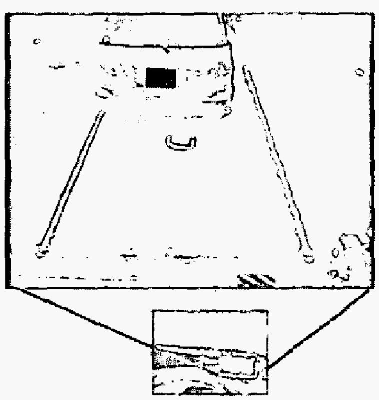


Fig. 6. Image of parking assist using single camera infrastructure

B. Evaluation of images for parking from a single camera

To evaluate images for parking assistance from a single camera infrastructure, we used a CCD camera (TOSHIBA IDSM43H) and put it on a tripod stand which is about 2.5 meter high, and it was placed at the rear of a parking place. Images are transmitted by wireless communication from the infrastructure to our car, and are displayed on the in-vehicle display. Figure 5 describes the situation of the experiment.
We didn't process images as the purpose of this experiment was only evaluation of images from a single camera infrastructure. The displayed images were shown in Figure 6.
Then we considered techniques for parking assistance. So, as one of them, we show how to detect white line by image processing below.

- Detection of white lines by image processing

We consider that this technique can be used as alarm when parking as an example. We explain how we detect white lines in following sentence. The character of this image processing is that we use Hough transformation. The Hough tansformation is a technique which can be used to isolate features of a particular shape within an image. Because it requires the desired features to be specified in some parametric form, the classical Hough transformation is most commonly used for the detection of regular curves such as lines, circles, ellipses, etc. A generalized Hough transformaition can be employed in applications where a simple analytic description of a feature is not possible. Due to the computational complexity of the generalized Hough algorithm, we restrict the main focus of this discussion to the classical Hough transformation. Despite its domain restrictions, the classical Hough transform retains many applications, as most manufactured parts contain feature boundaries which can be described by regular curves. The main advantage of the Hough transform technique is that it is tolerant for gaps in feature boundary descriptions and is relatively unaffected by image noise. Hough transformation carry out to filter out after binarization. Figure 7 gives sign of filtering out. When we detect white lines, we can obtain parameters used for parking assistance.

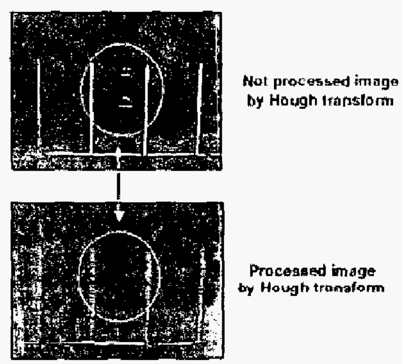


Fig. 7. Filtering out after binarization

Currently, parking assist system using an in-vehicle rear camera is widely used. The position of the camera changes with movement of the car, which also changes the direction of the image, so it may be difficult for drivers who are bad at direction to use this system. As for the feature of the system we propose, it makes it easy for drivers to gain a sense of direction because it uses fixed camera's images.
We demonstrated this experiment at the 11th ITS world congress of ITS Nagoya, Aichi in October 2004 to ask how drivers like to use this system. We gained a high reputation as useful system from almost all guests. We consider that parking assistance system is made easier to park by changing camera viewpoint into overhead view of vehicle in addition to using fixed camera's images. The image processing technology to generate such a view from images

got by rear view camera have already made[6]. So we also decided to show drivers overhead view images when assisting.

IV. GENERATING OVERHEAD VIEW OF VEHICLE

As a camera is fixed in this system, we can use a camera that has already been calibrated. So, we processed images by using camera parameters. We obtained transformation matrix from the camera's coordinate to the world coordinate and camera parameters by calibration, and solved a relation of the world coordinates $M = (x, y, z, 1)^t$ to the image coordinate $m = (x, y, 1)^t$ in advance. Equation to transform is expressed as follows. And the relation among these coordinate systems is shown in Figure 8.

$$s * m = A * (R\ t) * M$$

(A : Camera Parameter Matrix, R : Rotation Matrix, t : Translation vector)

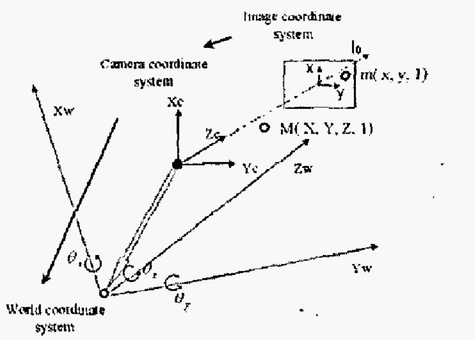


Fig. 8. The relation among coordinate systems

When we assume the ground to be the z-coordinate plane at zero in the world coordinate, all points in the image are projected on the x-y plane with the z-coordinate at zero. If there is no object in the image, images are correctly projected. But if there are some objects like a car, area of the object in an image can't be projected onto the right position because of neglecting information of car's height. Therefore we described objects as boxes as shown in Figure 9.

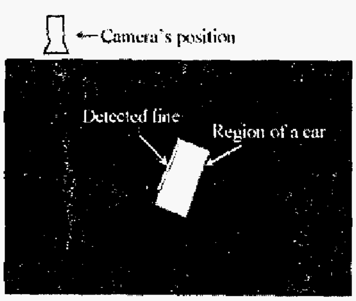


Fig. 9. Display method

When described by a box, it is necessary for parking assistance to calculate the accuracy position of a car. We explain how to calculate it in the next subsection.

A. Calculation of car's position

We use both inter-frame difference and background difference by mixture to extract area of a car in an image. At the beginning, it is extracted by inter-frame difference and is divided from other area. And a binary image is made by this data. By comparison of it with image made by background difference, area of a car is extracted again. And then a position and direction of a car is decided by coordinates which the extracted area projects on the world coordinate. As a base on side of a car near camera's position is correctly projected in the world coordinate. The box is placed along the line, based on size of a car measured.

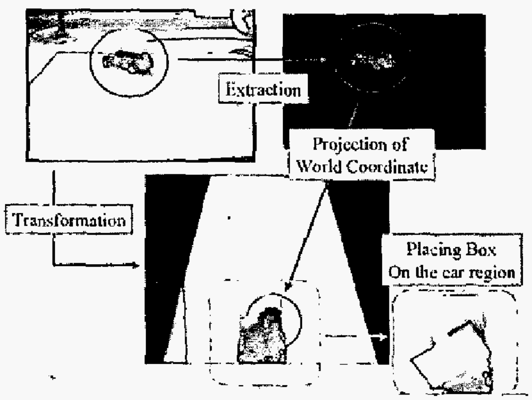


Fig. 10. The flowchart of processing method

We add processes such as prediction by preframe to improve the accuracy of the position and the direction. However, in our opinion, their accuracy of them is insufficient for parking assistance. When assisting parking by using a fixed camera as infrastructure, more information should be given such as data of a gyro sensor and a geomagnetic sensor. As it is not always true that all cars are equipped with these sensors, we consider that the data used for the process had better be given on the infrastructure. So, we will use multi-camera infrastructure.

V. THE CONSIDERATION OF DATA TRANSMISSION

The system we propose transmits processed data to cars and displays it on the in-vehicle camera. As it is necessary for parking assistance to display in real time, we considered how long it takes to transmit data. When data for generation of each image, as shown in Figure 11, is transmitted in our research about visual assist system for the situation of turning right[5], each processing time is shown in Figure 12. And the specification of the wireless LAN used in this experiment is shown in Table 1.

(a) the image that displays only area of a car
(b) the image that displays a full image
(c) the image that displays area of a car and a box enclosing it
(d) the image that displays a box enclosing area of a car
(e) the image that describes area of a car as silhouette
(f) the image that displays the bird's-eye view image made by information of car's position

And each sent data by communication is mentioned below.

(a) the image data and parameters
(b) the image data and parameters
(c) the image data, parameters and infomation of distance to a car in world coordinate
(d) parameters and information of distance to a car in world coordinate
(e) silhouette image data and parameters
(f) information of distance to a car in world coordinate

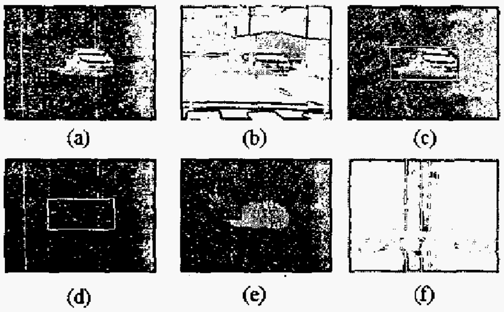


Fig. 11. Transmitted Images

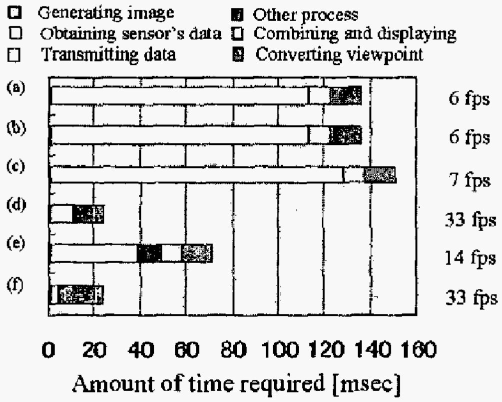


Fig. 12. The graph of processing time

TABLE I
THE SPECIFICATION OF THE WIRELESS LAN

Frequency Band	2.4 GHz
Transmission Speed	54 Mbps (about 18 Mbps in practice)
Range of Access of electric wave	about 150 m

As shown in Figure 12, The larger amount of data is, the longer time it takes to transmit data. So if transmitting data is large, frame rate is not enough to assist parking. It is not therefore possible to assist parking safely in the case that uncompressed image data is transmitted in our communication system described above. To obtain sufficient frame rate for parking assistance, it is necessary to reduce amount of data or to quicken transmission speed.

VI. CONCLUSION

In this paper, firstly we explained about the concept of "HIR" system we propose, and showed our equipment to experiment. Next we evaluated parking assistance by images from a camera infrastructure and generated overhead view of a car to make it easy to gain a sense of distance and direction. But information from a fixed camera was unsufficient for accurate assistance. So, some additional information such as a gyro sensor and a geomagnetic sensor should be given for it, or we should increase the number of cameras. In addition, we investigated time it took to transmit data. The result showed that transmitted data had to be reduced or transmission speed had to be quickened.
In our future research, we will build a system to assist parking by multi-camera infrastructure as shown in Figure 13. It will realize high accurate parking assistance.

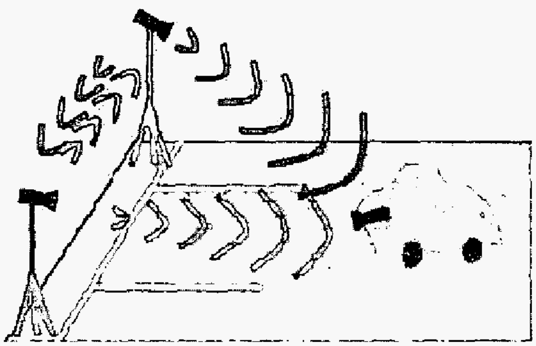


Fig. 13. Parking assistance using multi-camera infrastructure

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