

Image Processing Method for Perception of Status of Approaching Vehicles Using a Camera System

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ABSTRACT

This paper proposes an image processing method for easier perception of speed from a camera image. Vision assistance technology employing cameras is presently being put to widespread practical use. In some cases, however, the speed that is perceived from a camera image differs from that perceived from conventional side-view mirrors and the like. This is particularly apparent in the case of images taken by wide angle cameras, and it tends to cause drivers to feel a sense of incongruity. In order to reduce this sense of incongruity associated with perceiving vehicle movement in the camera image, therefore, the speed of movement of the object vehicle reflected in a conventional side-view mirror was compared with the speed of movement of the object vehicle shown in the camera image, and portions of the camera image were selectively processed to make them larger or smaller accordingly.

1. INTRODUCTION

Technology that employs cameras to compensate for driver blind-spots and provide an expanded field of view has become increasingly widespread in recent years. Installation of cameras for practical use includes rear-view cameras to show the blind spot close behind the vehicle from the early 1990s, front side-view cameras for the front wheels when pulling off the road, front-view cameras mounted in the front grill area that show vehicles approaching from the sides at intersections where visibility is poor, and so on. In 2007, a system that uses four cameras to obtain images covering a 360 degrees area immediately surrounding the vehicle in order to facilitate tight maneuvers and parking was also implemented as a practical application.

When these technologies employing cameras to see blind-spots were initially made available for practical use, they

consisted of systems that simply displayed the camera image just as it was. More recently, however, systems that employ distortion correction or image composition to combine images from multiple cameras, and so on, performing image processing to provide drivers with camera images in more readily viewable ways, have also become available [1-2].

Even when distortion correction and other such technologies are employed, however, there is sometimes a sense of incongruity associated with perceiving the speed and distance of objects by viewing camera images as indicated, in comparison with the speed with which objects are perceived when viewing them directly or in mirrors [3]. The distance to the object is most important when the area to be checked in the camera image is in the immediate vicinity of the test vehicle and when the object is a wall, a pole, a parked vehicle, or some other static object. Methods for distance perception in which reference lines are drawn on the screen to cause the driver to perceive distances correctly have entered practical use and have been installed in rear-view cameras and similar applications [4]. However, there are not as yet any practical applications of technology to reduce the sense of incongruity associated with perceiving speed.

This paper describes research conducted on a Blind Spot Monitor system (BSM) that seeks to prevent other vehicles from being overlooked during lane changes by taking camera images rearward and to the side of the test vehicle, to include areas that are in blind-spots in the side-view mirrors, and displaying that imagery. The research concentrated on the speed of movement of points shown on the screen, and an image processing method intended to reduce the sense of incongruity associated with perception of speed when using this system is proposed.

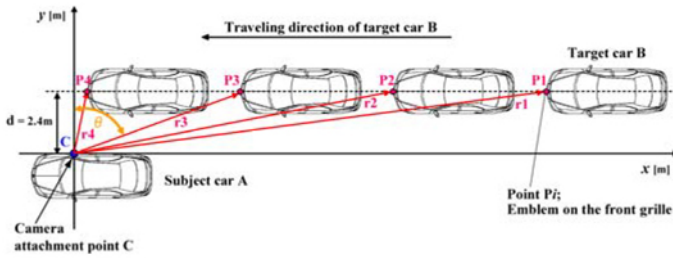


Figure 1. Location of a subject car, a target car, and a camera. Point P_i indicates location of the emblem on the front grille of the target car B. The camera attachment point C is same position as mirror plane. Lines-of-sight r_i are lines connecting points C and P_i . θ is defined as the angle between y-axis and r_i .

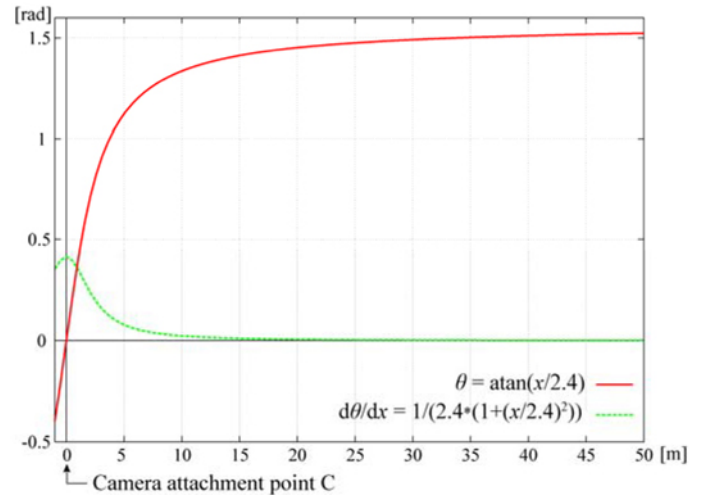


Figure 2. The value of θ with respect to distance x , and its first derivative.

2. CONCEPT OF IMAGE PROCESSING

2.1. RELATIONSHIP BETWEEN DISTANCE TO THE OBJECT AND THE LINE-OF-SIGHT ANGLE

Figure 1 shows a target car B traveling at a fixed speed rearward and to the side of a subject car A, in the next lane, and approaching the subject car A. There is a straight line r_i that joins fixed point P_i (in the figure, this is the emblem on the front grille of the car) on the target car B, which is approaching from rearward and to the side, with the camera attachment point C. This line forms angle θ with y-axis. In this instance, the target car B is approaching the subject car from 50 m to its rear, and the changing value of θ until the target car B passes subject car A is shown in graph form in Fig. 2. When the horizontal axis is the distance from the camera attachment point C and the vertical axis is θ , this angle can be expressed as $\theta = \arctan(x/d)$. Here, d is the distance on the y axis direction from the camera attachment point C to point P on the target car B, and is defined as $d = 2.4$ m. The first derivative of the function shown in Fig. 2 is $d\theta(x)/dx$, which reaches a maximum when $x = 0$ and becomes zero when $x \rightarrow \infty$. In other words, the amount of change in θ per unit distance increases as the camera attachment point is approached.

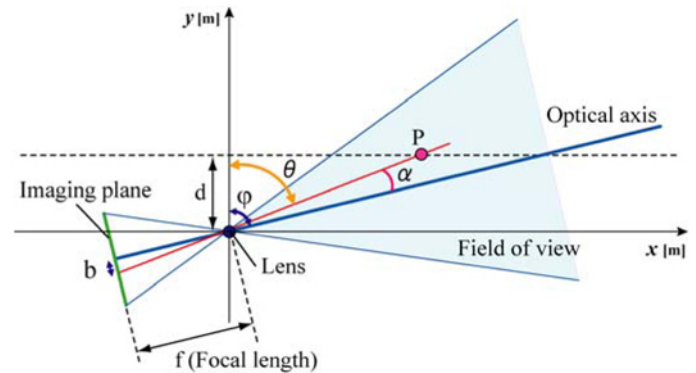


Figure 3. The relationship between the camera imaging plane, lens, direction of optical axis and point P. b is the distance in the lateral direction from the center of the imaging plane to projected point.

Figure 3 shows the relationship between the camera imaging plane and point P on the target car B situated rearward and to the side. When the angle formed by the optical axis of the camera and the y axis is ϕ , then the distance b of the projected image in the lateral direction from the center of the imaging plane of the camera will be:

$$b = f \cdot \tan \alpha$$

$$= f \cdot \tan(\arctan(x/d) - \phi)$$