

Image Processing Method for Speed Perception with Side View Camera

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ABSTRACT

This paper presents a verification of the effectiveness of an image processing method, used to reduce the inconsistent speed perception caused by using the camera images in conjunction with side-view mirrors. Vision assistance technology using cameras is widely used in practical applications today. However, speed and distance perceived with camera images may differ from those viewed directly or viewed with conventional side-view mirrors. That is particularly evident in wide-angle camera images, and can easily cause a sense of discomfort experienced by the driver. A Side View Camera (SVC) shows images rearward and to the side that include the blind spots of side-view mirrors on an onboard display. It is a system to compensate side-view mirrors, broadening the driver's field of view to eliminate blind spots. SVC is used in conjunction with the side-view mirrors. In order to reduce sense of discomfort experienced by the driver, it is important to reduce the inconsistent speed perception caused by using the side-view mirrors and SVC. During 2010 SAE World Congress, we proposed an image processing method that can be used to reduce this inconsistent speed perception. In this paper, subject tests were conducted to compare the speed perception on side-view mirrors, original camera images and processed camera images. As a result, it is observed that by using the proposed image processing method, the inconsistent speed perception can be reduced.

1. INTRODUCTION

Vision assistance technology using cameras such as rear view cameras, front side view cameras, and front cameras is widely used in practical applications today [1-2]. Those systems compensate the driver's field of view by shooting the driver's blind spot with a camera and showing the camera

images on an onboard display. While those systems broaden the driver's field of view, speed and distance perceived through camera images differ from those viewed directly or viewed with conventional side-view mirrors [3]. That can cause a sense of discomfort experienced by driver. Such an effect is particularly evident in systems that use wide-angle cameras. To correct distance perception, a method in practical use today involves drawing reference lines and displaying the distance for the driver on the screen [4]. That is equipped to rear-view cameras and similar applications. Speed perception correction, however, has not yet been put into practical use.

A Side View Camera (SVC) covered in this paper shows images rearward and to the side including the blind spots of side-view mirrors on an onboard display. It is a system to compensate side-view mirrors, broadening the driver's field of view to eliminate blind spots, used in conjunction with the side-view mirrors. Vision assistance technology using cameras in practical use today mainly supports parking and pulling over, and thus assumes use in low-speed situations for observing static objects. On the other hand, SVC is a system to support lane changing in all speed ranges. Compared to systems for parking and pulling over, it is thus even more important for SVC to allow the driver to perceive the speed of approaching vehicles without a sense of discomfort. For that purpose, we proposed an image processing method that can be used to reduce this inconsistent speed perception [5]. In this paper, subject tests are performed, in order to verify the effectiveness of the proposed image processing method.

2. IMAGE PROCESSING METHOD

2.1. POINT OF GAZE MOVEMENT ON THE IMAGING PLANE

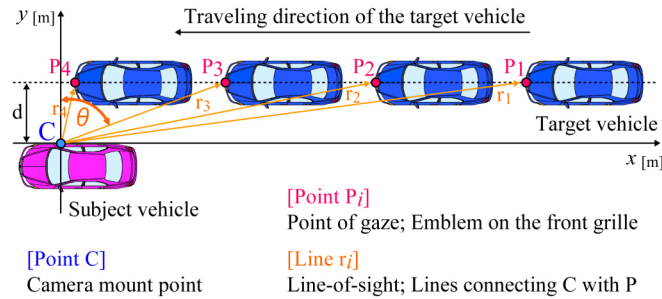


Figure 1. Point of gaze movement and difference in line-of-sight angle as target vehicle approaches

Figure 1 shows a target vehicle approaching in the adjacent lane on the passenger side of the subject vehicle, at a fixed speed. Point P is defined as the point of gaze; in this paper, it is the emblem on the front grille of the target vehicle. Point C is defined as the camera mount point. Line r that joins point C with point P is defined as the line-of-sight. It forms angle θ with y-axis. In this instance, angle θ can be expressed as $\theta = \arctan(x/d)$. As point P gets closer to point C, θ gets rapidly smaller.

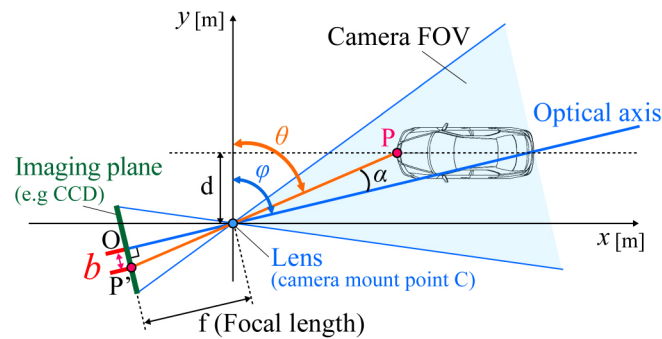


Figure 2. Relation of point P and point P' projected on the camera imaging plane

Figure 2 shows the relation of point P and point P' that is projected on camera imaging plane. The angle formed by the optical axis of the camera and the y axis is ϕ , that is, the camera is rotated by ϕ in the horizontal direction from the y-axis. The imaging plane is perpendicular to the optical axis, and the intersection is at O. Also, f is the focal length of the camera. Point P is projected on the imaging plane as point P'. If it is assumed that the lateral distance from O to P' to be b, then the distance b will be:

$$\begin{aligned} b &= f \cdot \tan \alpha \\ &= f \cdot \tan(\theta - \phi) \\ &= f \cdot \tan(\arctan(x/d) - \phi) \end{aligned} \quad (1)$$

When $\phi \neq 0$, as the angular velocity increases, the speed of movement of the point P' on the imaging plane also increases. In other words, speed of movement of the target vehicle situated rearward and to the side, which should be approaching at a fixed speed, is shown as appearing to increase in speed as it approaches subject vehicle in the imaging plane.

2.2. CAMERA AND MIRROR FIELD OF VIEW

Events in this imaging plane are not specific to the camera, but rather should show, just as when viewed directly or when seen in a side-view mirror, that the target vehicle situated rearward and to the side appears to accelerate as it approaches subject vehicle. However, the angular field of view in the side-view mirror is only about 27 degrees at maximum. Therefore, when the target vehicle is close to the subject vehicle where the angular velocity of θ increases, the target vehicle is already outside the field of view of the side-view mirror. In other words, it is not reflected in the side-view mirror, so that the target vehicle as reflected in the side-view mirror does not appear to have accelerated. However, the images from a wide angle camera does show the target vehicle even in the area close to the subject vehicle where the angular velocity of θ increases, so that the images of the target vehicle in the screen does appear to have accelerated, and when that view is compared with the view in the side-view mirror, there will be a difference in vision.

Next, a method will be shown for compressing the area in the camera images that shows the area at issue in the vicinity of the vehicle. Its purpose is to convey the same sense of the speed with which the target vehicle is approaching, whether it is seen in the side-view mirror or in the camera images. Attention will be focused on the angular velocity of θ within the range reflected in the side-view mirror, and on the angular velocity of θ within the range shown by the wide angle camera.