In-vehicle Monitoring System

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In order to determine the conditions of occupants in vehicles and improve their safety and comfort, Mitsubishi Electric Corporation has been developing an in-vehicle monitoring system (IMS). This paper describes the characteristics, functions, and robustness of our IMS (Fig. 1).

1. Characteristics of IMS

Our IMS, with a wide-angle camera installed at the center of the dashboard as shown in Fig. 2, can monitor the driver and person in the passenger seat at the same time. In addition, since it captures images over a wide range in the vertical direction in addition to the horizontal direction, it can detect the shoulders and hands in addition to the face. Therefore, the IMS's functions can be easily expanded, unlike driver monitoring systems that only capture images of the driver's face with high accuracy for monitoring.

2. IMS's Functions

The IMS's functions are broadly divided into a sensing function that detects faces and outputs basic information such as head pose, eye opening rate, gaze direction, and shape of a hand, and an application function that uses the information detected by the sensing function to judge whether there is an occupant and to detect looking-aside, drowsiness, and gestures.

The two functions of the IMS are described in detail below.

Fig. 1 Sensing image

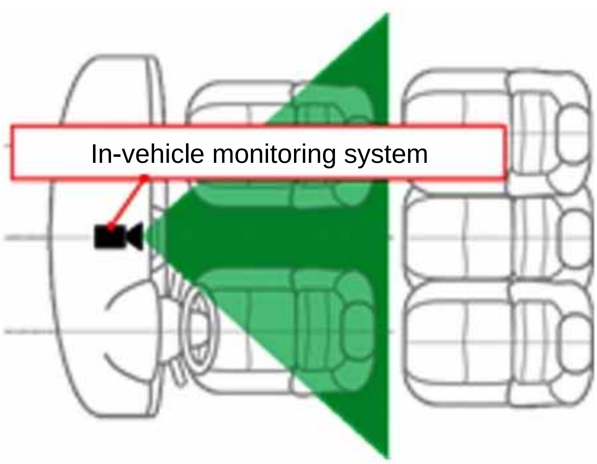

Fig. 2 Mounting position and imaging range

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2.1 Looking-aside detection function

Figure 3 illustrates the processing flow of the looking-aside detection function. Our IMS first detects the face and parts and uses the information to detect the head pose. The function determines that the driver is looking aside when the head pose exceeds the threshold, which can be changed based on vehicle information. This helps prevent misdetection of looking-aside when the vehicle is not traveling and when it is turning. The function also assists the driver by, for example, issuing a warning at a more appropriate time in more appropriate conditions when the effective field of view is narrower when driving at high speed.

To detect looking-aside, in addition to using head pose and vehicle information as shown in Fig. 3, our IMS can also use gaze direction and the results of monitoring the outside of the vehicle. For these additional factors, detection procedures need to be determined considering the increased risk of misdetection due to increased indexes, complexity of evaluation, and higher dependence on other systems.

2.2 Drowsiness detection function

Our IMS uses percent of eyelid closure (PERCLOS) to detect drowsiness. PERCLOS, which refers to the percent of closed eyes per unit time, is thought to correlate well with level of drowsiness and show little variation among individuals.(1)

To detect drowsiness, changes in expressions and posture, gestures, and other similar information may be used in addition to PERCLOS. Especially, our IMS is the only system that can detect drowsiness using changes in posture and gestures since its wide-angle camera can also monitor the trunk below the shoulders and a wide area to both sides.

3. Robustness

An onboard IMS for mass production must be robust and the limitations of its monitoring and application functions or performance should be understood, since it will be used by various users under diverse environments. For our IMS, we have selected four main perspectives for ensuring robustness and understanding performance limitations: environmental robustness, individual difference robustness, accessory robustness, and behavior robustness.

Environmental robustness refers to items of robustness to various types of onboard environments. Many of such items are related to light such as artificial light and sunlight (Fig. 4). Individual difference robustness refers to the robustness of the IMS to changes for each individual and among individuals. Accessory robustness refers to robustness to wearing articles such as glasses, sunglasses, and face masks as shown in Fig. 5 in the case of faces. Behavior robustness refers to robustness to the behavior of an occupant during driving, for example, covering part of the face with a hand and changes in expressions and posture.

In developing our IMS, we have listed detailed items for verifying robustness and have linked verification databases to the items. We are repeatedly conducting evaluations and improvements using the databases to improve the quality to a sufficient level for mass production and installation on vehicles.

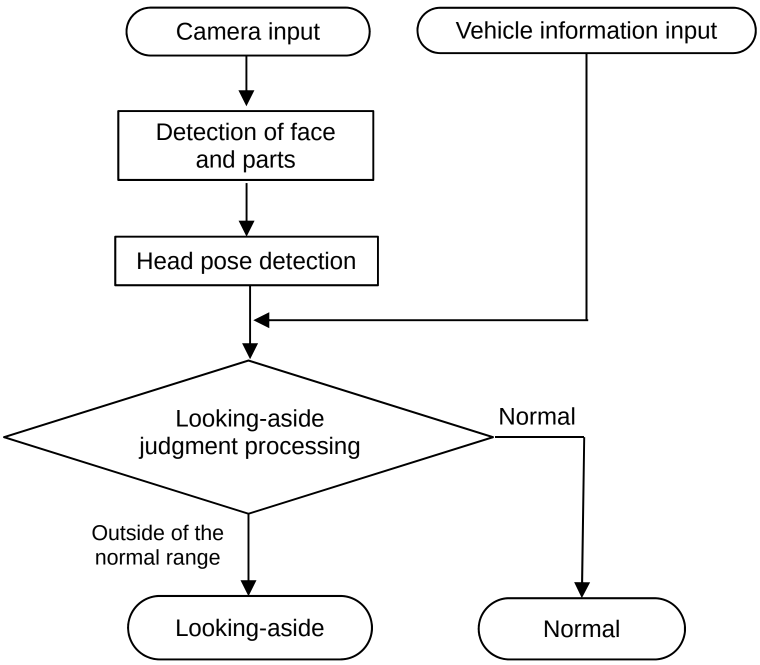

Fig. 3 Processing flow of looking-aside detection

Fig. 4 Example of external light contrast on the face

Fig. 5 Various accessories worn on the face

4. Conclusion

This paper described the characteristics of our IMS and the concepts of robustness. We will develop functions for the IMS that monitors occupants of seats other than the front seats to contribute to enhancing safety.

5. Reference

(1) R. Knipling, "Perclos: A valid psychophysiological measure of alertness as assessed by psychomotor vigilance", 1988.