Onboard Surveillance System for Automobiles Using Image Processing LSI

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We demonstrate an obstacle detection system using three cameras mounted on a vehicle. The three onboard cameras were positioned to observe the front, the right rear side, and the left rear side of the vehicle, respectively (see Figure 1). Three image sequences captured by the three cameras were inputted into the image processing board via the three video input channels. Obstacles in each image sequence were detected based on our obstacle detection method[1] using the newly developed image processor. Our obstacle detection method, which is briefly described later, is capable of detecting obstacles using a single camera and is robust in the face of various real road scene conditions. For the purposes of demonstration, the obstacle detection results were superimposed on original image sequences. A long red horizontal line indicates the border line between the detected obstacle and the road. The distance between the observer and the obstacle was estimated based on the detected position of the border line, and our system displays the top view of the obstacle positions around the observer.

Our system is capable of detecting various types of vehicles in various scenes with poor lighting conditions and with disturbances such as raindrops or wipers on the windshield as shown in Figures 2(a)-(f) that indicate the results of the preceding vehicle detection in various scenes.

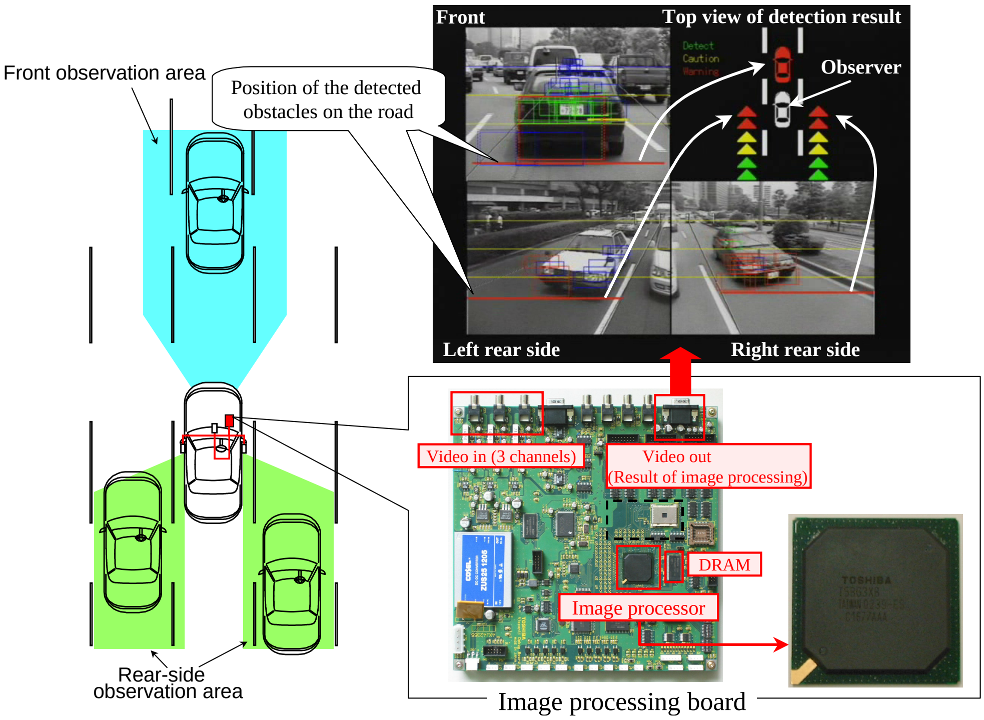

Figure 1. Overview of our obstacle detection system.

[1]Our obstacle detection method will be presented in the International Conference on Computer Vision 2003. The title of our paper is “Obstacle Detection Using Projective Invariant and Vanishing Lines”.

(a) Truck and cross walk. (b) Pick-up truck with black tarp covering. (c) Vehicle cutting in.

(d) Trailer. (e) Night scene. (f) Rainy scene.

Figure 2. Detection of various types of vehicles in various conditions.

Our high-performance onboard image processor enables us to simultaneously detect obstacles in the front, the left rear side, and the right rear side because the image processor has three arithmetic and logical units, and is therefore capable of executing the three obstacle detection algorithms in parallel at about 10 – 50 ms/frame. Note that, in the left and right rear side, we detected the vehicles approaching the observer as obstacles.

The following is a brief description of our obstacle detection method and the onboard image processor.

Obstacle detection method

Assuming that the road is a plane and that an obstacle is approximated by a fronto-parallel plane perpendicular to the road plane, we derive the motion constraint of each plane from the projective invariant combined with the vanishing line of the plane that is a prior knowledge of road scenes. The system detects obstacles based on the motion constraints as follows:

1. extract horizontal line segments, assuming that they exist on the obstacles,
2. track them in an image sequence for observing their motions,
3. test whether the motion of a set of three horizontal line segments satisfies the motion constraint of the road plane or that of the surface plane of the obstacles, and
4. detect the obstacle as a set of horizontal line segments satisfying the motion constraint of the surface plane of the obstacles.

Onboard Image processor

Our image processor has high image-processing performance and fulfills the specifications for onboard devices. Our LSI works at temperatures between -40°C and 85°C with a power consumption of less than 1 W at an operation frequency of 150 MHz. This LSI is capable of executing various types of image processing by replacing the software.

Our LSI has three processing units and a data conversion unit. Each processing unit consists of a RISC processor core and a VLIW coprocessor that is capable of executing several types of SIMD operations. For the obstacle detection system, each processing unit executes our obstacle detection algorithm. The data conversion unit converts a data set such as an image according to a conversion table that defines the conversion of each datum. Typical types of conversion include affine transformations of an image.