Wide Angle Stereo Camera with Monocular Vision using Camera Posture Estimation and Correction

Felipe GOMEZ-CABALLERO [1)], Masayuki KOBAYASHI [1)], Kazuyoshi YAMAZAKI [1)], Takuma OSATO [1)], Takeshi ENDO [1)], Masayuki TAKEMURA [1)], Takeshi NAGASAKI [2)] and Takeshi SHIMA [2)]

1) Hitachi Ltd. Research & Development group
7-1-1 Omika-cho, Hitachi-shi, Ibaraki, Japan
2) Hitachi Astemo Ltd.
2520 Takaba, Hitachinaka-shi, Ibaraki, Japan

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Stereo cameras have been used to effectively avoid traffic accidents, but limited peripheral vision of current systems may be insufficient for full safety coverage at road intersections, where most accidents involving pedestrians occur. Also, problems related to detection distance performance degradation and image distortion remain when simply increasing the system field of view (FOV). In response, we developed a stereo camera employing a multi-shift approach where CMOS sensors are shifted with respect to the lenses optical axis center. An example FOV for a stereo camera using the multi-shift method is shown in Fig. 1,where the FOV for each camera is extended to the outer side, with respect to the center of the stereo camera system. In this configuration, the center area of the system FOV becomes stereo vision while the right and left areas of the FOV are monocular vision. Also, both lenses optical axis centers are aimed towards the vanishing point to reduce distortion and achieve high accuracy distance measurement. In this way, we are able to preserve far object detection performance and obtain wider FOV without using expensive image sensors.

We also developed a monocular detection process using a top view image subtraction method along with camera posture estimation by road disparity obtained from the stereo vision. The top view image subtraction method follows the assumption that the road position with respect to the camera system is known and hence data correspondent to the road can be separated. By using such kind of approach, we can avoid the need to create model patterns for each possible target object. Therefore, we are able to preserve a low computation cost as strong assumptions related to the camera placement and flat-world / ground-plane position are used as prior information to prepare the image data for further processing and to restrict the search space. That is, captured images of current and previous time frames are affine-transformed to create top view images, which are translated in a way that the road on both images overlap, and then subtracted to obtain a differential top view image. The result is an image where only the differentials of moving three-dimensional objects standing on the road surface remain, making detection possible for vehicle mounted systems as the point of view moves along with the own vehicle. In this way, pedestrian and cyclist detection in the monocular region created at the outer region of the stereo camera FOV becomes possible.

Furthermore, we can achieve high accuracy for detection and distance measurement at the monocular region by using the disparity information from the central region to estimate the camera posture.We focus on decreasing deviations caused by the camera extrinsic parameter errors that directly affect the top view imagetransformations and distance calculations.

For this purpose we employ an approach based on road estimatio where the disparity data available in the stereo region is used to estimate the shape of the road surface in front of the vehicle as a linear model approximated using the cross-section points as input. The obtained road shape is used to estimate camera posture with respect to the road and calculate the necessary extrinsic parameters (i.e. camera height, tilt and roll angles) which are used as feedback to correct the orientation of the vehicle mounted camera. In this way, it is possible to create appropriate top view images to perform object detection and preserve distance measurement accuracy for the monocular region even when camera posture changes dynamically. The evaluation conducted for the present work is mainly intended to serve as performance measurement of the camera posture estimation, especially on the distance measurement accuracy where its effect can be easily perceived.

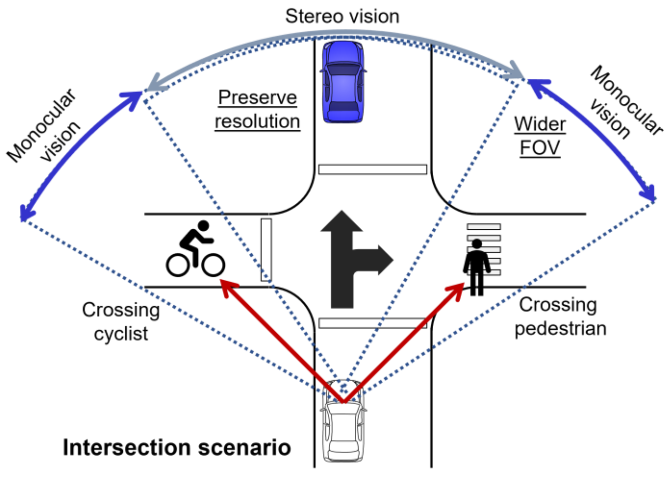

Fig.1 Stereo camera FOV when using a multi-shift approach.