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Bump/Hump detection using CNN with stereo camera road height profile as input

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We developed a method to detect bumps/Humps, which are small bumps placed on the road, using an in-vehicle stereo camera. Therefore, we developed a CNN discriminator that uses depth-height waveforms obtained from 3D shape measurements as input. We investigated the performance and processing time of a configuration that can be scaled to the processing capacity of an embedded device.

In order to realize safe and comfortable automobile driving assistance and automation, it is necessary to detect and control automobiles over not only pedestrians and vehicles, but also small bumps on the road. Speed breakers, bumps, and humps (hereafter referred to as "bumps" on behalf of the following) are set up on roads to encourage speed suppression, and entering these structures at high speeds is dangerous due to the large impact.

There are many types of bumps, with differences in height and depth, as well as differences in installation methods, such as multiple consecutive levels, etc. In order to locate bumps, the challenge is to measure the shape of the road surface and to accommodate many types of bumps. In this report, we developed a bump detection method using images from a stereo camera installed on the front windshield of a car, as shown in Fig 1.

A 3D point cloud is obtained from a stereo camera, and a cross-sectional view of the road is generated from the 3D point cloud. In order to adapt to bumps of various shapes, we developed a CNN-based judgment technique using the road surface height waveforms as input. The network consists of 8 layers and can process the input data in parallel. By increasing the number of parallels, the discrimination performance can be improved, and this configuration enables adjustment of the processing cost and performance, which is a trade-off when the system is integrated into an automotive system.

Fig 2 shows an example of CNN input data (top), grand trueth (middle), and inference results (bottom). It can be seen that Bump locations can be extracted even when the input data contains noise.

Figure 3 shows the detection performance in the number of parallel CNN networks. The evaluation method used is an index of how well the inference results match the grand trueth(mIoU). It can be seen that the performance improves with each increase in the number of parallels.

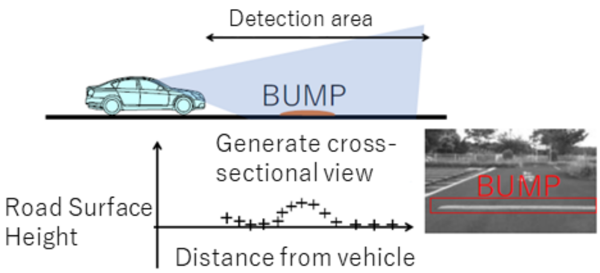

Fig.1 Overall view of Bump Detection System

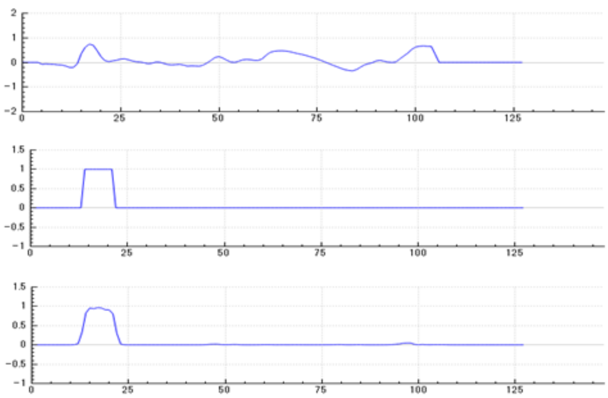

Fig.2 Example of Bump Detection Result by CNN

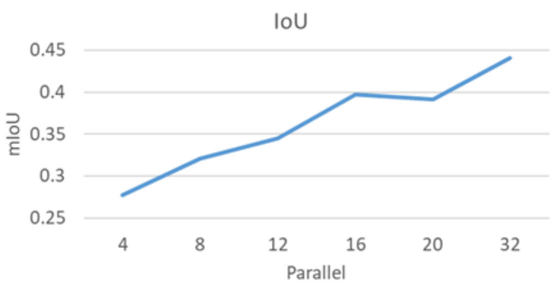

Fig.3 Comparison results of number of parallels and detection performance