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Development of Visibility Estimation Model on Winter Road Conditions using Image-based Driver's Visibility Index by On-Board Video Camera

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In winter, motor vehicle transportation systems in Hokkaido, where is northernmost prefecture of Japan, are affected frequently by poor visibility conditions due to snowstorms in winter. The visibility is sensitive to changes in weather conditions and topography because of snowfall and ground blizzards. In a short period of time, the visibility varies greatly. Poor visibility induces road accidents involving several vehicles crashing into each other. Timely visibility information along the road allows for safe driving. Thus, it is required to develop a smart system to monitor changes of the visibility along the highway widely because poor visibility makes vehicle handling more difficult and threatens road safety.

In this study, we developed road visibility inspection system (RVIS) using images taken by on-board camera. We evaluated visibility conditions along the road by RVIS. The results showed that RVIS captured the visibility changes road ahead due to the road environment and meteorological conditions. Values of the WIPS calculated from images taken by on-board camera are preferable as an index of the driver's visibility road ahead.

Based on the results of this study, the connected vehicles on the road could provide visibility information using on-board cameras by the image processing technology automatically (RVIS). It is possible to evaluate visibility conditions at the current time through whole road sections. Also, it is possible to see visibility problems occurred on the road quickly. In addition, we could estimate visibility conditions using meteorological conditions several hours later according to the estimation model proposed by the present study. The RVIS could support decision-making regarding travel on the road. Also, the RVIS could support preparation of the road maintenance management to the future occurrence of poor visibility conditions on the road by the visibility estimation model. It is supposed that we should advance the prospects for image processing technology using on-board cameras.

In the present study, the model to estimate value of the WIPS during poor visibility using a general linear model was developed. The estimating model was able to capture the visibility conditions during poor visibility approximately. When the visibility conditions were slightly poor, prediction accuracy of the estimating model might be good, and the estimated and observed values of the WIPS were almost the same at many locations. However, the observed values of WIPS under poor visibility conditions were relatively large due to the objects in the image. Objects such as roadside forests, snow fences and power poles in urban area in the image had a large influence on increasing a gap between observed and estimated values of the WIPS. Also, the estimation model often could not capture the increase of transport rate of drifting snow on the ground. It is necessary to improve the accuracy of prediction under poor visibility conditions especially by increasing number of observed data.

Fig. 1 Devices of the advanced RVIS.

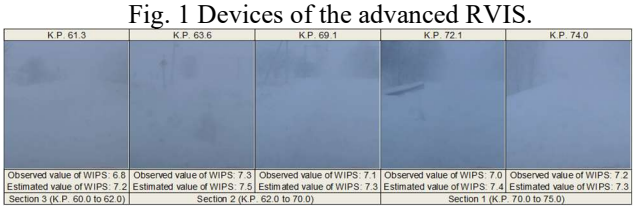

Fig. 2 Five cropped images of Run-2B on Mar. 5th, 2020

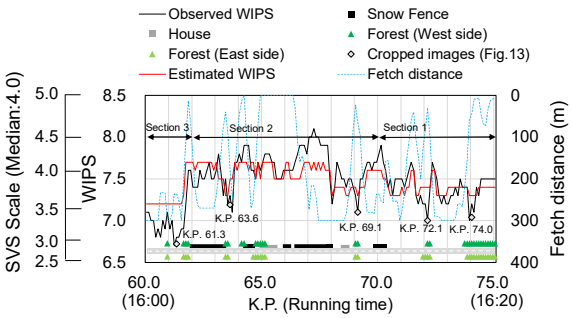

Fig. 3 Changes of observed and estimated values of WIPS, fetch distance and roadside environments [Run-2B].