# Self-localization with Omnidirectional Camera using RGB-D Map

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In recent years, multiple sensors installed in advanced automated driving systems, which has been introduced in stages from luxury cars to affordable cars. Therefore, it is important to reduce sensor costs by minimizing the sensor configuration to the minimum necessary to realize automated driving systems in price ranges where widespread adoption is possible, such as in senior cars.

LiDAR is a sensor used for SLAM and object recognition, which simultaneously perform self-localization and mapping. However, LiDAR has the problem of high cost, and its replacement with other inexpensive sensors has been proposed as a solution. In this research, LiDAR is used only for mapping in advance and color information is added to the map. Then, the authors propose a method for self-localization using only an omnidirectional camera and RGB-D maps. The self-localization is performed by matching the color information of the map and the image and using the distance information of the RGB-D map. A schematic diagram of this method is shown in Figure 1 below.

It also assumes that the vehicle is traveling on the same plane when driving and that the color information matching results are correct. The specific method for self-localization is to first calculate the elevation and azimuth angles of the matching point from the image. The self-position is estimated using the calculation results and the 3D information of the matching map.

Since this method is applied to an omnidirectional camera, there was a problem that the value of color information changed with changes in brightness. Therefore, we attempted to improve this problem by using Retinex theory, which models the color constancy of human vision. In Single Scale Retinex (SSR), a conventional application of Retinex theory, a Gaussian filter is used to estimate the illumination component. The author used a moving average filter, which is relatively light in computational cost.

In the first experiment the experiment confirmed the effect of Retinex. The images used for comparison were taken at three different locations on the Omiya campus of the Shibaura Institute of Technology: an image taken in daylight, an image with gamma correction to reduce contrast, and an image taken at night. In addition, "the difference in intensity values between an image taken during the day and an image with reduced contrast by gamma correction or an image taken at night," "the difference in intensity values between an image taken during the day and an image with reduced contrast by gamma correction or an image taken at night and processed with Retinex," and "the difference in intensity values between an image taken during the day and an image with reduced contrast by gamma correction or an image taken at night and processed with Retinex. The difference in intensity values between an image taken during the day and an image with reduced contrast due to gamma correction or an image taken at night and processed with Retinex" were evaluated using heat maps, respectively. As an example, Figure 2 shows the image used for evaluation. The heatmap is also shown in Figure 3 with the results of Retinex processing on both images with the best results.

The results of the experiment on self-localization are shown in Table 1. In the experiment, colored paper was attached to the wall as a landmark in advance, and the map was created, and images were captured by an omnidirectional camera. The coordinates and color information of the color paper in the RGB-D map were obtained in advance because the matching results of the color information were assumed to be correct. And as the true value, the result of self-position estimation by NDT matching using LiDAR was used.

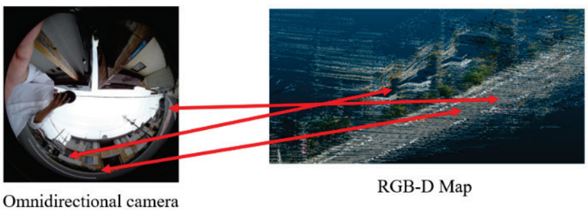


Fig.1 Summary figure of proposal method

Fig.2 Experiment location 1
(left: taken at noon, middle: low contrast, right: taken at night)

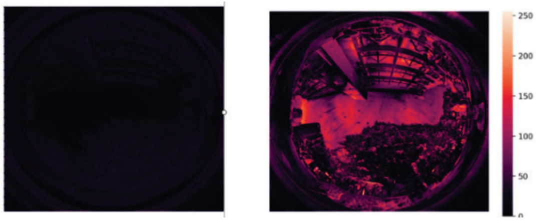


Fig.3 Heatmap of differential values between when Retinex is applied to both

Table1 Result experiment of Self-localization [m]

| | x | y |
|---|---|---|
| Correct Position | 6.08 | 0.01 |
| Estimate Position | 6.75 | 1.8 |
| Error | +0.67 | +1.79 |