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An Image Processing-Based Motorcycle Detection System with InfraRed Markers and an Onboard InfraRed Camera

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In this paper, we assume a system for detecting motorcycles by attaching several infrared LEDs as markers to a motorcycle and a commercially available infrared camera attached to an oncoming vehicle. The system will detect the motorcycle mechanically from the capturing images to inform its existence to the vehicle driver at an early stage. We propose and evaluate two detection methods: marker placement pattern matching and flashing pattern recognition.

In order to distinguish infrared markers from exterior lights and lights of other vehicles, which can be noisy, this method detects motorcycles by recognizing the flashing patterns assigned to the markers. We developed a program that tracks light points in a time series and recognizes flashing patterns using feature point extraction and optical flow calculation in the OpenCV[(1)] open source library. Table 1 shows the results of the evaluation of the performance of the flashing pattern-based motorcycle detection method while varying the placement and distance between the automobile and the motorcycle. The results show that the camera detects the target from a distance of 90 meters in twilight to night.

Template matching is a method that prepares an image of an object to be detected as a template, shifts the template to the target image one pixel at a time, calculates the similarity of the areas, and detects the areas with high similarity as objects. In this verification, we developed a placement template matching program using OpenCV, as in the case of flashing pattern recognition. Since the size of the target motorcycle in each image varies with its distance, we prepared ten templates with different sizes corresponding to 10 to 100m distance. Table 2 shows the results of motorcycle detection by marker placement template matching. As a criterion, we used the normalized squared difference from the template, and we confirmed that the method could detect motorcycles at a detection distance of more than 90 meters. However, the precision decreases significantly in bad weather conditions such as fog and backlighting. We have confirmed that the precision can be improved to some extent by binarizing the 256 levels of luminance of the target image in a threshold-based manner and making the contrast clearer.

The validation results show that these methods perform exceptionally well at night when it is not easy for ordinary visible light cameras to detect physical obstacles on the road. The methods can detect a motorcycle from approximately 100m away in the experiment.

Table. 1 Results for Each Shooting Compositions in Flashing Pattern Recognition

	Flashing Pattern Length: 5bit		
Shooting Composition	Max Detection Distance	Marker Recall	Marker Precision
Opposite (Original)	>100m	83%	31%
From left (Original)	>100m	97%	51%
From left (Backlighting)	>100m	92%	39%
From left (Foggy)	31m	97%	15%

Table. 2 Results in Placement Template Matching

Target Layout	Detection Distance	Recall Rate	Precision Rate
(1) From the right	>90m	62.3%	65.2%
(2) Foggy (original)	30m	13.0%	0.385%
(3) Foggy (Th = 50)	36m	24.7%	69.7%
(4) Foggy (Th = 100)	36m	10.1%	47.0%

Th means the binarization threshold for luminosity value (0–255).

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References:

(1) OpenCV: `https://opencv.org/` (2022.7.15).