An Improved Image Feature Detection Algorithm Based on Oriented FAST and Rotated BRIEF for Nighttime Images

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***Abstract*-- This paper presents an improved feature detection and descriptor construction method for nighttime vehicle surrounding images. The proposed algorithm is based on the Oriented FAST and Rotated Brief (ORB) algorithms. In order to improve the accuracy of the proposed algorithm, the Contrast Limited Adaptive Histogram Equalization (CLAHE), feature detection, and descriptor construction were added. In addition, the proposed feature detection description method is realized by the Very Large-Scale Integration (VLSI) technique to meet the real-time application for vehicles. Compared with previous studies, the proposed design has better performance than previous methods of detecting features in nighttime for image stitching and recognition.**

Keywords—Oriented Rotated Brief, Description, Feature Detection, VLSI.

I. INTRODUCTION

The rapid growth of AI development, image processing technologies for self-driving cars and vehicles is a highly valued research topic in recent years. The feature detection is an important step in the geometric task based on computer vision, both for image stitching and image recognition. However, due to the dark light at night, traditional cameras usually perform poorly at night, which will cause difficulty in feature detection.

A system used light sources to feature mapping and positing is proposed in [1]. The deep learning model is used to detect and describe in [2]. In terms of VLSI technology, the ORB hardware proposed in [3] strikes a balance between performance and power consumption. The system of [4] proposed an improved hardware architecture of the Binary Robust Independent Elementary Features (BRIEF) in ORB to reduce hardware cost. Because the ORB algorithm has benefits of low power consumption and high speed, it is more suitable for application in high-speed vehicles than other mainstream feature detection methods.

II. METHOD

The purpose of this study is to improve the difficulty of nighttime image feature detection, and the proposed solution is that CLAHE can enhance the image contrast through the adjustment of the contrast of the night image. In addition, the proposed method also advances to enhance the features of night images, and with a fast and low hardware cost ORB to achieve the purpose of saving resources. The proposed algorithm mainly includes three steps: image preprocessing, feature detection, and descriptor construction, as shown in Fig. 1.

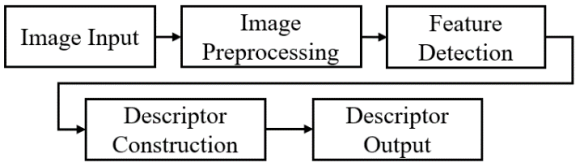


Fig. 1. Flowchart of the proposed algorithm.

A. Image Preprocessing

Since nighttime images are low in luminosity due to insufficient light, the proposed algorithm uses CLAHE, which is widely known for low-light image enhancement, to improve performance. The CLAHE divides the image into sub-regions, which can solve the problem of over-enhancement of large dark areas and bright areas better than Histogram Equalization (HE). Equ. (1) is used to calculate the Probability Density Function (PDF) of the pixel values of each sub-tile by the histogram.

$$p_x(i) = \frac{n_i}{n} \tag{1}$$

$$cdf_x(i) = \sum_{j=0}^{i} p_x(j) \tag{2}$$

where n_i indicates that the number of pixel values i appear, n is the total number of pixels. Thus, obtaining the Cumulative Distribution Function (CDF) is shown in Equ. (2).

Fig. 2 shows the interpolation of the pixels of the histogram by using bilinear interpolation to solve the problem of discontinuity in each sub-block. By limiting the slope of the CDF to limit the contrast, if it exceeds the threshold, the pixels in it will be evenly distributed to other PDFs to avoid image overexposure. Fig. 3 shows the hardware architecture of the linear interpolation simplified by factorization, followed by combining two linear interpolations to obtain bilinear interpolation.

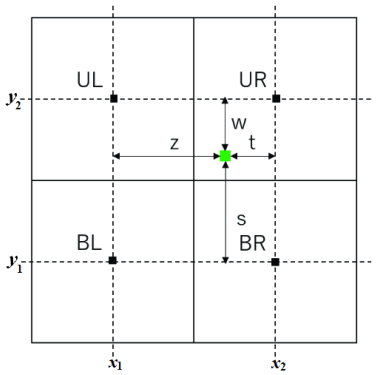


Fig. 2. Bilinear interpolation [5] .

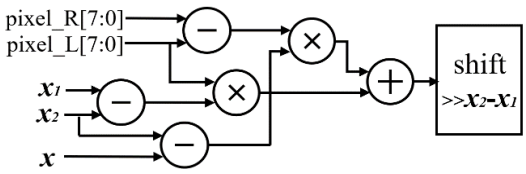


Fig. 3. Hardware architecture of the liner interpolation.

B. *Feature Detection*

The proposed algorithm uses the Features from Accelerated Segment Test (FAST) algorithm based on corner detection and implements by hardware design to improve performance and reduce resource consumption to meet the requirements of throughput and performance for real-time applications. Fig. 4 shows Bresenham's circle which is a circle with *P* as the center and a radius of 3 pixels, and 16 values are extracted on the circle to determine whether the intensity between the pixel and the P pixel exceeds the threshold. As shown in Equ. (3), *N* is used to determine whether point *P* is a corner point. It is used to calculate whether the 16 points greater than the threshold by means of counters and the hardware architecture shows in Fig. 5.

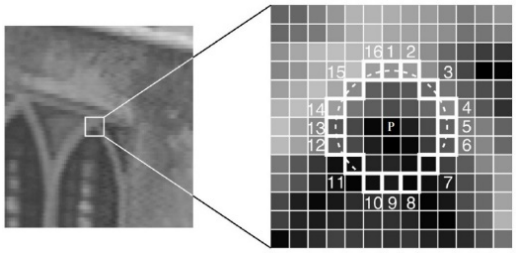


Fig. 4. Bresenham's circle [6].

$$N = \sum_{\forall x \in P} | I_x - I_p | > \varepsilon_d \qquad (3)$$

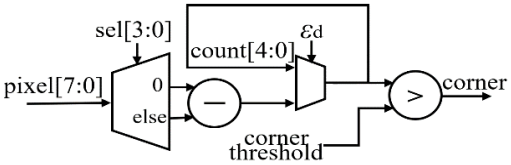


Fig. 5. Hardware architecture of FAST algorithm.

C. *Descriptor construction*

The descriptor construction part of the BRIEF algorithm is fast. However, the problem is that a random sampling model is required, which is difficult to implement in hardware. Hence, a fixed sampling model is used based on Gaussian distribution as shown in Fig. 6. The sampling point pairs are compared after Equ. (4) to generate the descriptor.

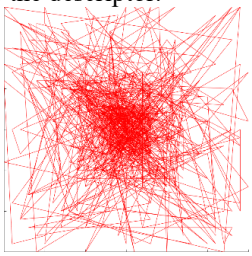
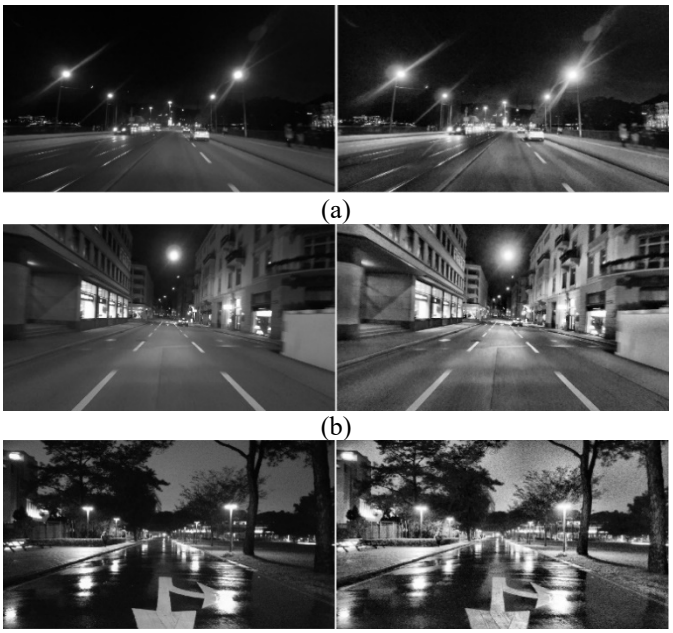


Fig. 6. BRIEF random sampling model.

$$\tau(p;x,y) = \begin{cases} 1 & if\ p(x) < q(y) \\ 0 & otherwise \end{cases} \qquad (4)$$

III. Conclusion

The proposed CLAHE algorithm is realized by three sets of images, namely road, campus, and building, as shown in Fig. 7, in which the original images show in the left and processed images show in the right. Table 1 lists the features and time spent comparisons of the ORB method and the proposed algorithm. As results shown, the proposed ORB algorithm of CLAHE finds more features and only takes a small amount of extra time.



(a) (b) (c)

Fig. 7. Comparison before and after the CLAHE (a) Road (b) Building (c) Campus [7].

Table I
Features and Time Spent for The ORB and This Work

	Features		Spend time	
	ORB [3]	This work	ORB [3]	This work
Road	11	29	0.405s	0.529s
Building	12	73	0.385s	0.528s
Campus	7	90	0.303s	0.466s

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