Image processing algorithm for robot tracking in reactor vessel

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1. Introduction

In this paper, we proposed an image processing algorithm to find the position of an underwater robot in the reactor vessel. Proposed algorithm is composed of Modified SURF(Speeded Up Robust Feature) based on Mean-Shift and CAMSHIFT(Continuously Adaptive Mean Shift Algorithm) based on color tracking algorithm. Noise filtering using luminosity blend method and color clipping are preprocessed. Initial tracking area for the CAMSHIFT is determined by using modified SURF. And then extracting the contour and corner points in the area of target tracked by CAMSHIFT method. Experiments are performed at the reactor vessel mockup and verified to use in the control of robot by visual tracking.

2. Method

In this section overall flowchart of the algorithms and some of image processing techniques used to filter noise and color clip and to detect robot are described.

2.1. Algorithm overview

SURF algorithm which based on the extraction of feature have an advantage of high accuracy, however it takes a lot of computing time[1]. In the contrary, CAMSHIFT has an advantages of computing time but has a problem to assign an initial tracking area and weak to noise[2]. In this paper, we solved color noise problem in the low light conditions by eliminating color noise using luminosity blend method and clipping colors except for the robot color. Then CAMSHIFT is apllied to the base image acquired above. Whence initial tracking area is acquired automatically by the proposed SURF algorithm. Fig. 1 shows system block diagram of proposed algorithm. First, base image is acquired using noise filter and color clipping filter, then initial tracking area is acquired from proposed SURF. Second, CAMSHIFT is used for continuous tracking and finally, find contour and 4 corner points of the robot[3].

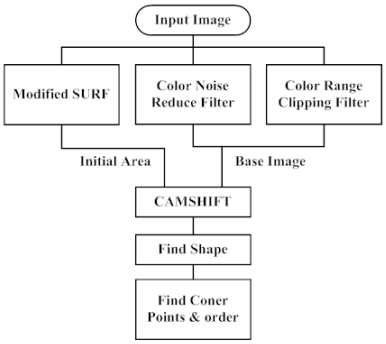
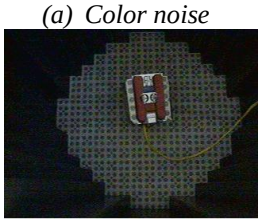


Fig. 1. System block diagram.

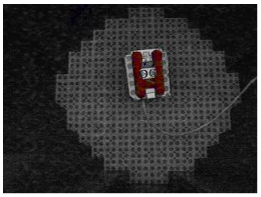
2.2. Noise reduction and Color clipping filtering

Fig. 2(a) shows color noise caused by low light intensity. In these noise conditions, CAMSHIFT method has a problem which tracking area is divergent to whole area. Proposed algorithm is as follows : first, convert RGB image to HSV color space, second clip a hue range of robot and saturate high saturation area by using adaptive thresholding. Then noise is reduced by eliminating small area with morpology filtering and labeling at saturated S region. Fig. 2(b) shows an noisy image before processed and Fig. 2.(c) shows result image. The result image shows saturation of background color noise is reduced and saturation of robot is reinforced.

(a) Color noise



(b) Noised image



(c) Result iImage

Fig. 2. Noise and color clipping filter result

2.3. Modified SURF

The area of SURF is moved to the center of the feature points which is acquired by Mean-Shift method, and calculate matching points. When the number of current matching points have more than previous points, the size of search window is reduced to diverge and decide to robot searching area [1,4]. Fig. 3 shows search window of SURF is converge.

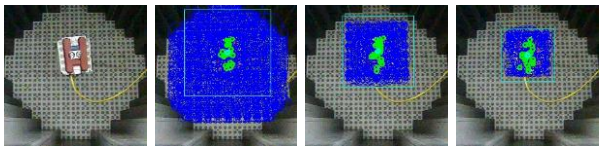


Fig. 3. Result of Modified SURF

2.4. CAMSHIFT

CAMSHIFT algorithm uses base image from section 2.2 and initial area of robot from section, Fig. 4 shows the ROI(region of interest) using the result of CAMSHIFT.

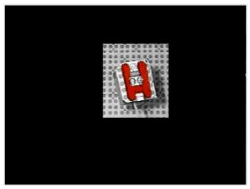


Fig. 4. Result of CAMSHIFT

2.5. Find shape and corner points and ordering

Find 4 corner points of robot using contour and convex hull in the ROI which is resulted from CAMSHIFT[5]. Whence the sequence of acquiring each point is showed at Fig. 5. The sequence of the points is as follows : First, acquire a line through a middle point of contour and center of bottom points, and then calculate a line perpendicular to above line and pass through the center of contour, finally, divide into 4 areas using the line and ordering into clockwise direction started at the top left position.

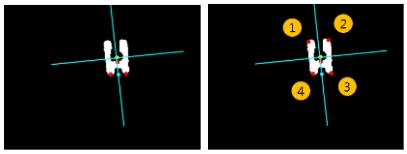
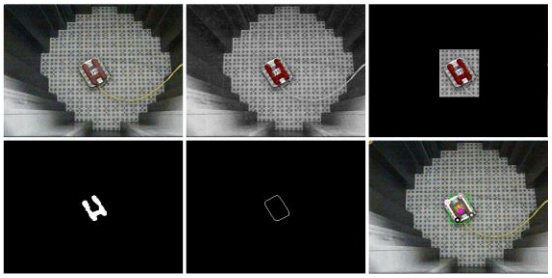


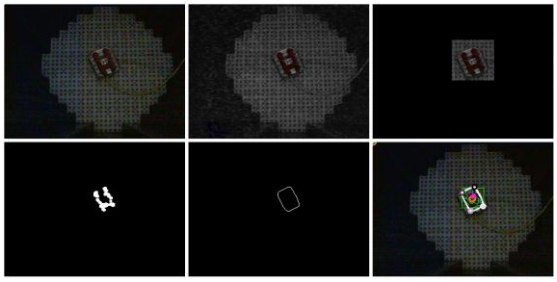
Fig. 5. Find contour and points ordering

3. Result and Conclusions

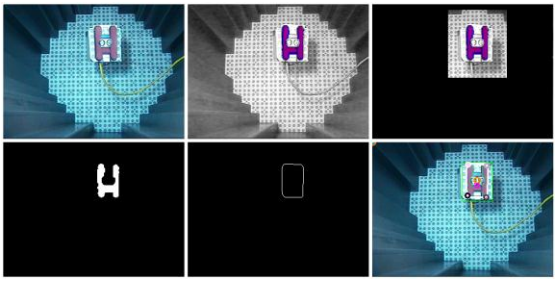
Fig. 6 shows the tracking result. The image shows input image, base image, CAMSHIFT result, contour, convex hull, detection of corner coordinate from the top left. The condition of light is as follows : Fig. 6.(a) is general light condition, Fig. 6(b)is low light condition, Fig. 6.(c) is blue light condition.



(a) Normal condition



(b) Low intensity condition (Noise)



(c) Blue intensity condition

Fig. 6. Result of intensity condition

This experiment is performed on the RV(reactor vessel) mockup which scaled down by 6. The image used in this experiment is 320x240 pixel with a 24 bit color, and the consuming time of algorithm is about 80ms. In this experiment, we verified proposed algorithm and the performance of the algorithm is applicable to the visual servoing of underwater robot in the reactor vessel.

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