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Short Paper

Detection and Removal of Jellyfish Using Underwater Image Analysis

Matsuura, F.*[1], Fujisawa, N.*[1] and Ishikawa, S.*[2]

*1 Visualization Research Center, Niigata University, 8050 Ikarashi-2, Niigata, 950-2181, Japan.
E-mail: fujisawa@eng,niigata-u.ac.jp
*2 Higashi-Niigata Thermal Power Station, Tohoku Electric Power Co., Inc., 957-0101, Japan.

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1. Introduction

The invasion of sea obstacles, such as jellyfish, into the thermal power plant is one of dangerous problems for sustaining the stable electric generation in the thermal power station. Thus, the detection and removal of jellyfishes at the power station are topics of interests for many years. They have been carried out using the manual detection method, mechanical filter and so on (ex. Ishikawa and Ikeda, 2006).

Moon jellyfish is most popular one among the jellyfish detected near the seashore in Japan. They are semitransparent, so that they cannot be detected easily by the observation from CCD camera placed on the ground. Moreover, such captured image suffers from the reflection of sun light on the wavy sea-surface. This is why the detection of jellyfish has not been done successfully in comparison with the other research subjects by image analysis (ex. Foster et al., 1995; Tillett et al., 1999; Fresno et al., 2005). The underwater observation of jellyfish by CCD camera is one of important techniques for the development of automatic detection and removal system of jellyfish.

The purpose of this paper is to examine the performance of detecting algorithm of jellyfish using underwater image analysis technique for application to automatic detection and removal of jellyfish.

2. Detection and Removal of Jellyfish

Figure 1 shows an illustration of detection and removal system of jellyfish in the present study. This system detects jellyfish by the underwater observation from CCD camera having spatial resolution of 512x512 pixels with 8 bits. When the acquisition and image analysis system detects the jellyfish, the system removes the jellyfish by operating the pump. According to the preliminary study, the intensity difference between the jellyfish and the background is increased 3 to 4 times larger for the bottom observation in comparison with the top observation through the sea surface, which is due to the difference in optical characteristics of the jellyfish under consideration. An example of jellyfish observed by the underwater CCD camera from the bottom is shown in Fig. 2. There are many small fish around the moon jellyfish and they act as image noise. Note that the underwater CCD camera is located 1.5 m below the sea surface and the jellyfish is observed near the sea surface in this experiment.

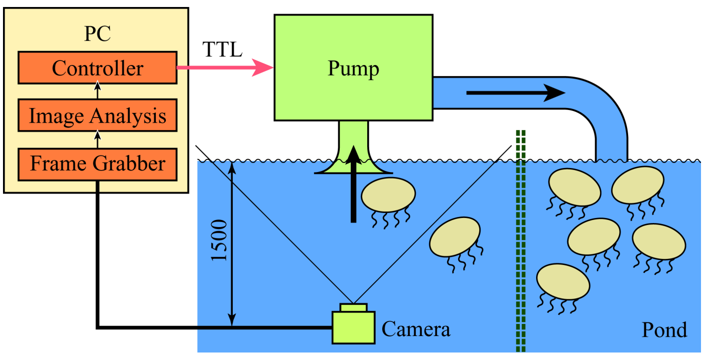

Fig. 1. Detection and removal system.

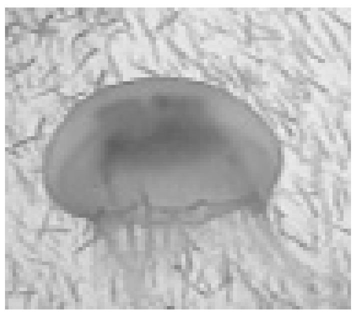

Fig. 2. Example of jellyfish.

3. Image Analysis

The flow chart of image analysis for the detection of jellyfish is described in Fig. 3. The development of the algorithm was conducted both from the point of accuracy in jellyfish counting and the real time operation capability using a standard personal computer. The latter requires the image detection at every 10 to 20 seconds in the actual experiment. The detection process consists of the image acquisition, the removal of image noise, the jellyfish detection by thresholding, the confirmation by image tracking, the histogram analysis and the digital control of pump. For this purpose, ten sequential images are acquired at every 1 seconds by the frame grabber board installed to the computer. The removal of image noise is carried out using the averaging procedure and median filter, where the filter size is set to 25 x 25 pixels. After the thresholding, the detected areas are labeled to count the number of jellyfish. In order to confirm the number of detected jellyfish, the tracking algorithm is introduced into the sequential three frames of the images. This algorithm allows the discrimination of the jellyfish from the stationary image noise. In this algorithm, the position of the jellyfish is evaluated from the first two images and is compared with the third image. When the expected image position agrees closely with that of the jellyfish in the third image, the detected image is considered to be a true jellyfish. This algorithm was applied to the number of jellyfish less than 3, because the number of jellyfish more than 4 has rarely been observed in the actual environment.

4. Performance of Image Detection System

The performance of the image detection system was tested using artificially generated gray images of jellyfish (Kiuchi et al., 2005). The assumption for generating the artificial image was as follows: (1) The shape of the jellyfish is oval with various aspect ratios. (2) The position and the size of jellyfish are randomly distributed in space. (3) The intensity distribution of jellyfish is uniform and is obtained from the experimental observation. (4) The background of the image is taken from the experimental image, which has non-uniform intensity distributions. (5) The target area of the CCD camera and the size of jellyfish are assumed as 1.2 x 1.2 m^2 and 0.15 m, respectively. (6) The algorithm does not discriminate the overlapped image of jellyfish, because the influence of the overlapping is small.

Numerical simulation was carried out by generating 100 sets of artificial images. The detection rate of jellyfish using the present algorithm is summarized in Table 1. Although the correct detection rate of the jellyfish decreases by increasing the number of jellyfish, the detection rate is more than 94 % for all cases of jellyfish less than 3. Note that the correct detection rate without tracking is much lower than that with tracking for the images without jellyfish, which indicates that the tracking algorithm is very effective for removing the noise for the images without moving targets. These results demonstrate that the present system works well for detection and counting of the number of jellyfish with a reasonable detection interval.

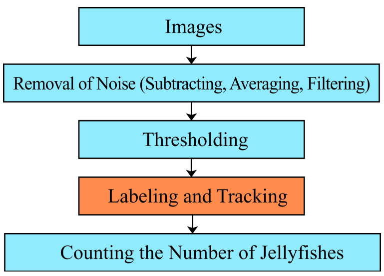

Fig. 3. Flow chart of image analysis.

Table 1. Detection rate of jellyfish.

Number of jellyfish	Detection rate without tracking (%)	Detection rate with tracking (%)
0	37	94
1	100	100
2	100	99
3	100	96

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