

Real time water surface elevation using video camera

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Abstract. In recent years, image processing has become a popular tool in wave flume experiments. In Indonesia, the use of image processing methods for measuring instruments in wave flume experiments has not been widely used. Therefore, in this study, an image processing method using image data from a digital camera was used in real time to measure the water surface elevation in the wave flume. Regular and irregular waves were measured with this image processing technique. The measurement results using this video camera were calibrated with wave gauges. The results showed that the measurement method using video images has a small difference less than 7% in wave height and wave period error. Therefore, this method can be a solution as a low cost measuring tool in wave flume or in field observations.

1 Introduction

The rapid development of remote sensing technology, especially image processing techniques, is currently very helpful for applications in various fields such as photography, medicine, engineering and other fields. One of them is the development of digital cameras as sensor tools in the field of photogrammetry. Photogrammetry can be defined as an art, knowledge and technology for obtaining data and information about an object and the conditions around it through a process of recording, measuring and interpreting photographic images (photograph results). Along with technological developments, photogrammetry applications are also growing rapidly. This is because data and information from photogrammetry is increasingly needed, so technology in the field of photogrammetry continues to be improved for ease of access and data processing. Especially the use of digital cameras for applications in the engineering field continues to grow because it is supported by developments in available software and the decreasing price of digital cameras that are not too expensive any more. Increasing developing digital camera technology makes the use of photogrammetry technology increasingly more popular.

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In its development, several researchers have attempted to use image analysis technology for various applications in the marine sector with various complicated methods [1]. For examples monitoring of swash zone hydrodynamics using video techniques [2]. Wave profile measurements using laser light, fluorescence dye or light slit based on image techniques [3-6]. Analysis on wave incident and reflected through submerged breakwater using a CCD video camera [7]. The investigation of sand bed evolution in flume laboratory by using video camera [8, 9, 10].

In wave flume laboratory, image processing from video camera is a challenging approach to apply in measuring wave properties such as wave profile, current or wave breaking. In laboratory experiments, commonly used wave meters such as capacitance, resistance and conductivity type are usually used to obtain such data. Added, in Indonesia, the use of image processing methods for measuring instruments in wave flume experiments has not been widely used. Therefore, this paper proposes image-processing method as an alternative technique to be used as a measurement tool in wave flume laboratory.

In this research, a digital video camera is applied to measure the elevation of water surface in the wave flume laboratory. Regular and irregular waves are measured with this image-processing technique in the experiment. The experimental setup and method of this study are explained in Section 2. In Section 3, the results of this study are presented. Then, summarizes of study are given in Section 4.

2 Material and Methods

2.1 Experimental Setup

In this study, the experiment was performed in a wave flume tank, 1.0 m wide and 20 m long at Ocean Engineering Department, University of Hasanuddin, Indonesia as shown in Figure 1. Table1 present specification of wave flume tank, which were used in this study. As shown in Figure 1, 3 wave probes was install in wave flume tank. A wave probe was install in front of camera to record the water fluctuation. 2 wave probes were install to measure the incoming wave. At least 10 experiments were carried on, and each experiment generated 3000 waves for more than 20 minutes.

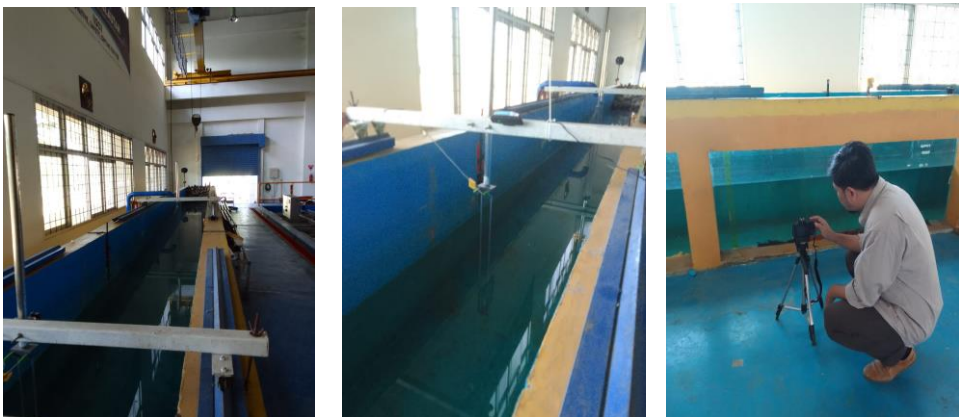


Fig. 1. View of wave flume

Table 1. Specification of wave flume.

No	Details	Specification
1	Width of wave flume	1.0 m
2	Length of wave flume	20 m
3	Depth of wave flume	1.8 m
4	Bed flume material	Concrete
5	Side flume material	Acrylic sheet
6	Wave generator type	Flap type
7	Wave condition	Regular & Irregular wave

2.2 Experimental Method

The methodology of this research is to apply a single camera as a wave measurement tool in wave flume experiments. The type of camera used in this experiment is a digital camera. Camera calibration is carried out through calibration based on experimental data in the laboratory using a wave gauge-measuring instrument installed right in front of the camera.

The video camera is installed at a distance adjusted to the data resolution and boundary conditions of the desired image, including the scale markings placed on the wave flume acrylic glass. To produce a clear image between the water and the background, the other side of the wave flume is coloured dark blue. In addition, lighting around the laboratory area needs to be managed to minimize noise in the image data, including blocking reflections of object shadows. This is because the quality of the recorded image is an important factor in image processing. In this research, the algorithm of edge detection is used to detect the water surface elevation in images. The example results of image processing analysis using the edge detection algorithm is shown in Figure 3



Figure 2. Image processing analysis results

3 Results

To analyze the height of the water surface elevation obtained from video camera recordings, an edge detection algorithm is used. From the output results, the water surface elevation continuously at certain time intervals is then analyzed to determine the wave characteristics, both wave height and wave period, using zero up-crossing analysis (Holthuijsen, 2007).

The results of the experiments obtained in 10 tests of regular waves and irregular waves in the wave flume are shown in Table 2. Observations of the water surface elevation measured from the digital camera were compared with those measured from the capacitance wave-measuring device.

Table 2. Specification of wave flume.

No	Case Study	Wave height (cm)	Wave period (s)	Wave height (cm)	Wave period (s)	Difference	Difference
		Wave gauge		Video Camera		Wave height (%)	Wave period (%)
1	Regular wave	2.59	1.351	2.43	1.355	6.17	0.30
2	Irregular wave 01	5.53	1.357	5.35	1.361	6.18	0.29
3	Irregular wave 02	5.81	1.358	5.77	1.354	3.25	0.29
4	Irregular wave 03	6.76	1.340	6.74	1.342	0.69	0.29
5	Irregular wave 04	8.26	1.348	8.21	1.350	0.30	0.15

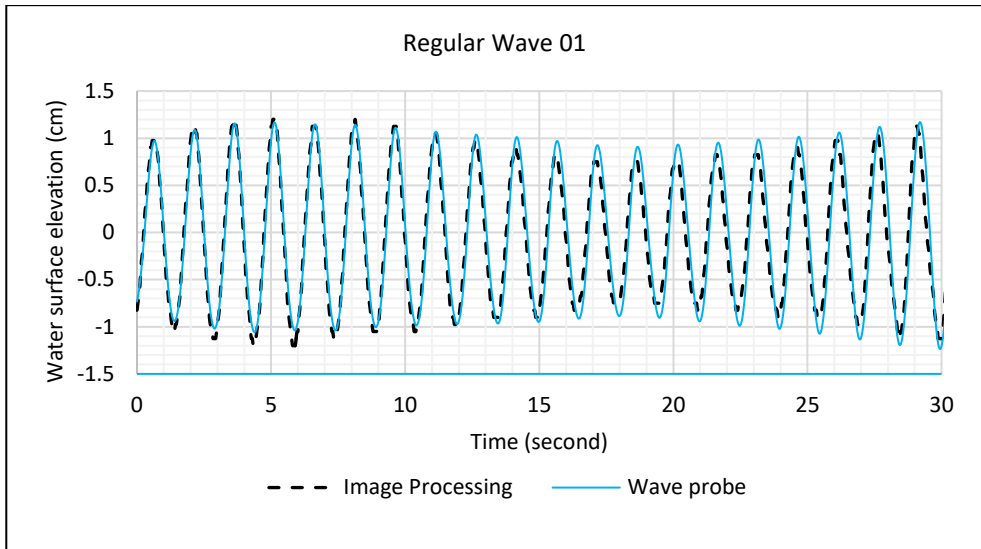


Fig. 3. The measurement comparison between image processing method and wave probe for regular wave

In the case of the first experiment, the wave flume was generated using regular waves. A comparison of the water surface elevation in the two measurement methods is shown in Figure 3. Figure 3 shows that both measurements have a similar trend with a difference in wave height of 6.17% and wave period of 0.30%. The differences in the two measurement methods can be caused by differences in frequency: differences in the frequency rate of data observation between the digital camera (30 Hz) and the capacitance wave meter (50 Hz). Therefore, the data obtained has different time intervals during which the experiment was carried out.

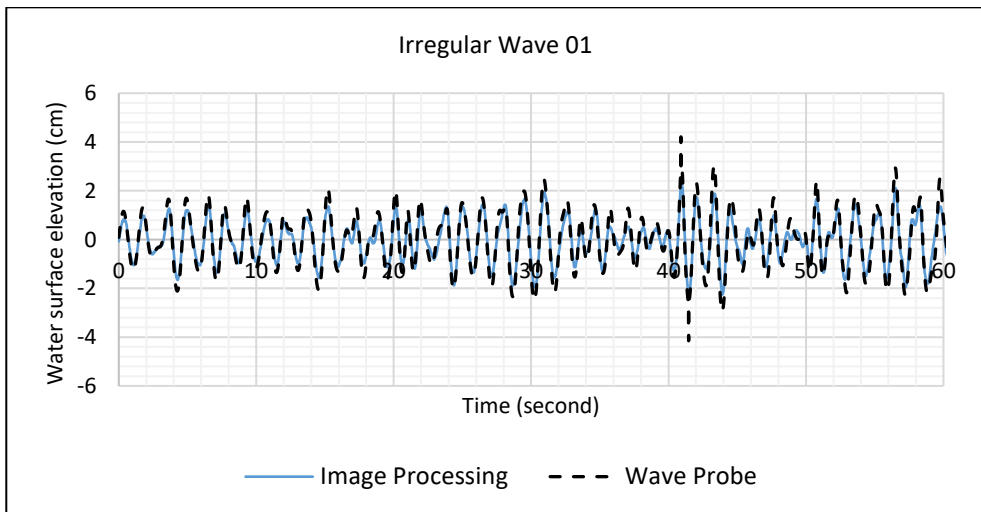


Fig. 4. The measurement comparison between image processing method and wave probe for irregular wave 02

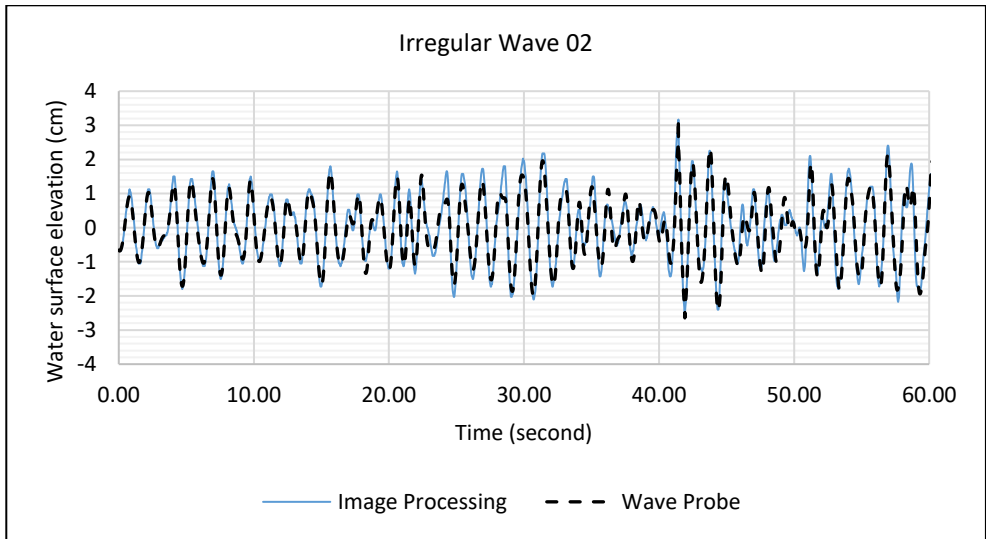


Fig. 5. The measurement comparison between image processing method and wave probe for irregular wave 03

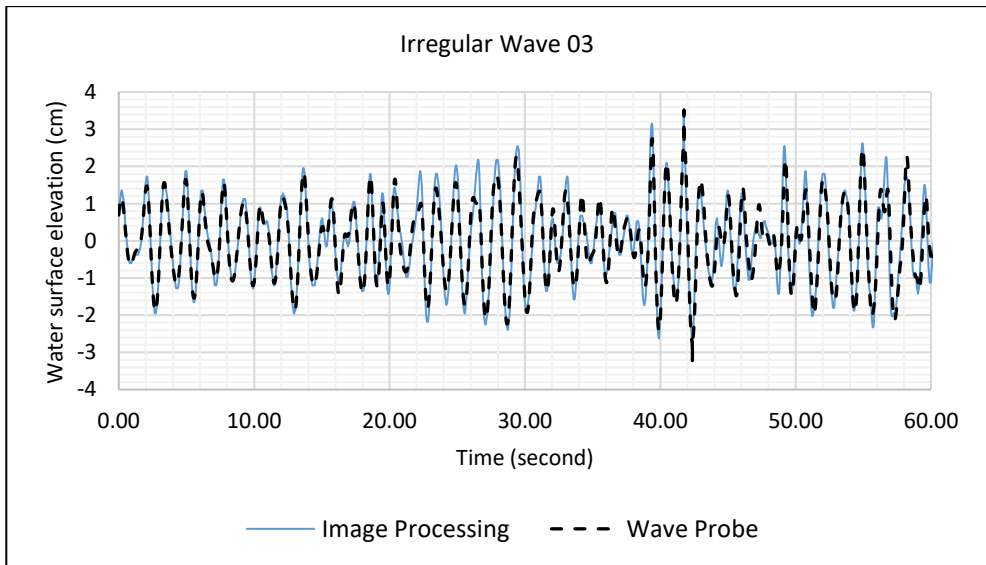


Fig. 6. The measurement comparison between image processing method and wave probe for irregular wave 04

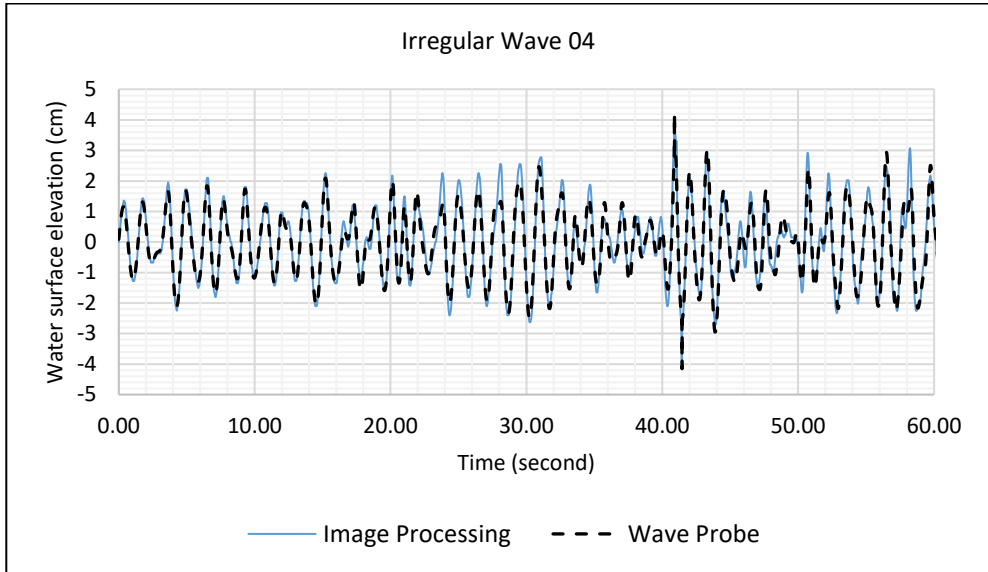


Fig. 7. The measurement comparison between image processing method and wave probe for irregular wave 05

After the first experiment showed promising results with a small error rate, the next test experiment was carried out on irregular waves produced in the wave flume to simulate a scenario of real sea conditions. The algorithm of edge detection is used to monitor the elevation of water surface, similar way as in the first experiment of regular waves. The monitoring point is also located right where the wave gauge is placed. The wave height scenario representing the irregular wave case is tabulated in Table 3. The results of water surface elevation measurements for the scenario of irregular waves obtained experimentally and image processing are shown respectively in Figure 5 to Figure 7. From each measurement result both image processing and wave gauge in Figures 5 to 7 shows that all graphs have the similar trend. The results of the level of difference for wave height ranged from 0.3% – 6.18%, while the level of difference for wave period ranged from 0.15% – 0.30%. These results show that there is good agreement between measurements using cameras and wave probe data.

4 Conclusions

In this study, real time water surface elevation detection system in the wave flume has been analyzed using image processing method using image data from a digital video camera. Regular and irregular waves were measured and recorded using a digital video camera. The measurement results using this video camera were calibrated with wave gauges. The experimental results showed that the measurement method using video images has a small difference both regular and irregular waves. For regular wave, the difference was 6.17% in wave height and 0.3% in wave period. Meanwhile, for irregular waves the averaged of difference was 2.6% in wave height and 0.25% in wave period. The results indicated that there were good agreement between the image processing and camera data with wave probe data. Therefore, this method can be an alternative solution as a low cost measuring tool in wave flume or in field observations in the future.

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