New approach based on image processing techniques for water level measurements in the field and laboratory applications

〇Dina ELLEITHY, Sameh A. KANTOUSH, Tetsuya SUMI

1. Introduction and objectives:

Water level is crucial for observation and management of water resources and account as an essential part in any hydraulic study[1,2]. There are many conventional techniques used to measure the water level which require manual inspection for data collection where water level is directly measured[1]. Nowadays, New techniques emerged compatible with different situations which are based on remote measuring developed to improve the general performance through enhancing the accuracy, durability, and/or simplicity, etc[1]. However, there is some structural or financial disadvantages exist. For example, pressure and ultrasonic sensors are very accurate but they are often very costly to purchase and regularly to be renewed[2]. Image Processing Techniques *(IPT)* are very promising measuring techniques. Not so many applications have been studied to test the resulted accuracy and applicability of IPT for research purpose[1–5].

In this paper, two different applications for employing IPT in measuring water level using manual and automatic water level detection scheme will be studied, an in-situ and a laboratory application, to highlight their capabilities and limitations.

For the in-situ application, A series of scattered images were taken during estimated high flow periods at Arase dam removal site[6,7], fig.1, are collected before, during and after the weir removal with a total of 229 image. they were recorded using a fixed camera for the structure surveillance purposes. These images will be tested for the reliability to represent the actual water level and calculate the discharge hydrographs.

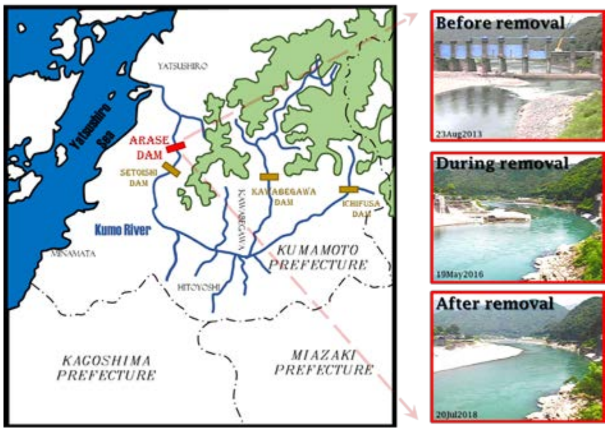

Fig.1 Arase dam before, during and after removal *(Right)*; and Location of Arase Dam inside Kuma River Basin *(Left)*

For the laboratory application, continuous images are collected from fixed camera recording the change in piezometer water level during the run of a physical model, fig.2. These images will be used for the calculating the water pressure inside the piezometer tubes.

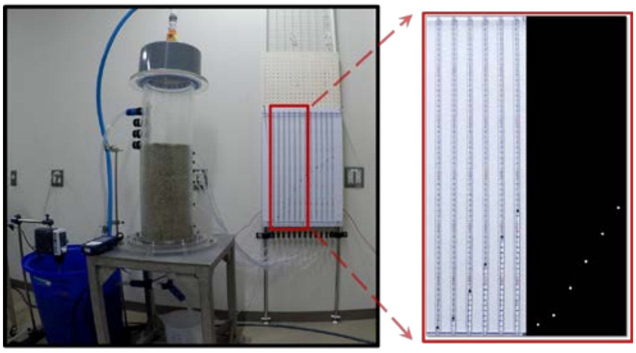

Fig.2 Piezometer tubes before and after IPT *(Right)*; and Location of chosen piezometer tubes on the physical model *(Left)*

The study objectives are: 1) evaluate the use of IPT for water level measuring in these two applications, 2) assess the capability to automatically track water surface, and 3) identifying the accuracy of the resulted water level data.

This paper utilizes water level measurement based on IPT using the ImageJ® open source software.

2. Methods and techniques:

To achieve these objectives, data collection and archiving is done by dividing all collected images and videos in two groups chronologically, one group for each application (Field & Lab.). For each group, One Image is chosen randomly and scaled according to the original as built drawings and the scale is calibrated and verified at different times.

For the in-situ, the right abutment of the structure was chosen to be the benchmark during the water level measuring process. Water level is measured at the benchmark location through all images. Water depth is deduced from the water level with respect to the original bed level. All the 229 collected images were combined in the form of an Audio Video Interleave (AVI) movie using the ImageJ® to facilitate the scaling and the data collection.

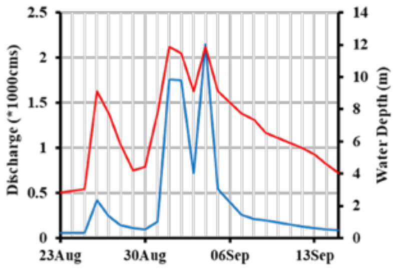

Fig.3 Detected water depth and Observed discharge at Arase dam in 2013, before dam removal

For the laboratory application, the video was converted from MP4 to AVI using Blender® open source software to be ready to be processed by ImageJ®.

Video converted to 8-bit color bands was adjusted and FFT filter was applied. The color threshold adjusted to separate the surface markers from the rest of the background as shown in *fig. 2*. Furthermore, automatic tracking was performed to detect the surface markers location at each frame. Water level is deduced with respect to the piezometer datum.

3. Results and discussion:

For the In-situ application, the resulted water depths showed same trends compared to the observed discharges measured at the dam location, *fig.3*. Additionally, rating curves resulted from plotting the water depth vs the observed discharge showing good trends, although the difference in the conditions of the riverbed and the low resolution of the surveillance image, which reflects the good accuracy and reliability of the outputs. However, separating the water surface automatically was very difficult and automatic tracking for the water level wasn't applicable.

On the other hand, regarding the laboratory application, after applying the surface markers, surface detection was doable, and automatic tracing with time was possible. Resulted water pressure heads from automatic tracking, *fig.4*, was precise and the resulted accuracy was ±0.005mm compared to accuracy of ±0.1mm for traditional measuring techniques.

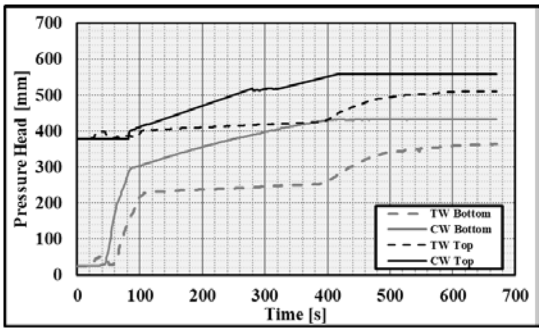

Fig.4 Change in Pressure Head During applying Clear and turbid water for both the Top and Bottom of the soil column.

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The work carried out through this paper is part of the PhD thesis research which aims: 1) to minimize the impacts of the physical clogging occurrence; due to the existence of suspended sediments in the harvested floodwater and 2) to hinder the change of the characteristics of the recharge basin.