Quantization and Classification of Sedimentation of a Coastal Hydraulic Model using Image Processing Technique

Saif Sayed
Department of Electronics and Telecommunication,
Pune Institute of Computer Technology, Pune
India
saifsayed@ieee.org

Prathamesh Prabhudesai
Department of Electronics and Telecommunication,
Pune Institute of Computer Technology, Pune
India
prathprabhudesai@gmail.com

M. Selva Balan
Senior Research Officer,
Central Water and Power Research Station, Pune
India
msels72@gmail.com

Mrs. Sushma Shelke
Associate Professor,
Pune Institute of Computer Technology, Pune
India
sush_aditi11@yahoo.com

Abstract

The water level and flow of hydraulic models has been successfully implemented. However, the estimation of sediment deposits for calm shallow water is still a manual operation. We propose an accurate estimation and classification method based on set of images bearing known quantity of the sediment proportion in a white rectangular box and then classifies a new image shot in the same scenario with the help of matching pixel counts of the new and the database images. The algorithm is also successfully implemented to a hydraulic model.

Keywords*: sediment concentration, statistics, image processing*

1.Introduction.

Sedimentation is a phenomena of the particles observed in a fluid. It is the tendency of the particles to settleon the surface and rest against the obstacle encountered. Forces like gravitation, centrifuge and electromagnetism, are responsible for the movement of the particles and when these forces tend to zero, they start to settle. Sedimentation is the conclusion of this process. Sedimentation in a reservoir is not a straight forward process. It mainly depends upon the watershed sediment production rate and deposition mode [1].

The classical method for quantization of the sediment deposits known as "dry weight"[2], which was based on sampling, drying and weighing, but this process has many disadvantages. Sampling requires a lot of manpower and it is a bit time consuming process. Technicians and researchers have been trying to measure it with technologies like electrical conductivity, ultrasound[3], photoelectric, LASER and isotopic techniques but temperature, photo-electric penetration, isotope security constraints and various factors in addition with the sensitivity limitation of the sensors, electric components, have made this method less accurate and reliable. Cost effectiveness is also less.

As a result of these problems, there is no good measurement method so far. Taking into consideration all these discrepancies, we have proposed a new technique using Image processing. Image processing provides an efficient and easy way to remove these shortcomings [4]. It provides a real-time and accurate channel to fulfill these needs. The procedure involves capturing set of images of water containing known concentration of sediments and storing the images in database and then capturing a different image in the same scenarios and comparing it with the previous set of images to calculate its sediment concentration.

The paper is divided into 4 sections. First section includes the introduction. Second section consist the methodology. Third section shows an application in a hydraulic model at Central Water and Power Research Station, India. Limitations and conclusion of the algorithm are mentioned in the fourth section.

2. Methodology.

The procedure includes the following steps:

- Creating a database of images with varying amount of sediment deposits.
- Capturing a new image in the same scenario
- Comparing it with the database images.

I.Database Creation.

Images are taken in an orderly manner with manually depositing sediments and capturing an image. The process is continued until the water gets fully saturated with sediments. The database images are classified into 5 classes.

(a) (b) (c) (d) (e)

Figure 1: Database Images

Figure 1(a), 1(b), 1(c), 1(d) and 1(e) are the captured images which clearly indicate orderly increase in the sediment quantity.

The five considered classes are

1. Very less sedimented water, figure(1(a))
2. Lightly sedimented water, figure(1(b))
3. Moderately sedimented water, figure(1(c))
4. Heavily sedimented water, figure(1(d))
5. Fully sedimented water, figure(1(e))

The number of classes can vary according to requirement. These classes can be seen physically but this needs it conversion to a mathematical model for easy comparison with a new image. So the image captured has to undergo many processes which include.

- Image pre-processing
- Image Binarization
- Statistical Calculations

1. Image Pre-processing.

In order to get sediment concentration, the image acquired should be pre-processed and the image quality that is signal to noise ratio (SNR) must also be improved [5]. Sometimes, the obtained image has less information in it, making the recognition of sediment deposits difficult. So as to remove this problem, the colored image, having red, blue and green components, have to be converted into Gray-scale.

The colored image, captured, is a 24 bit image having red, green and blue components 8 bits each. Computation of such images becomes difficult. So we convert it into gray-scale which is of the size 8 bits only.

According to the Glassman's law, the reaction of the color through vision depends upon the weighted algebraic sum of the three inputs red, green and blue,

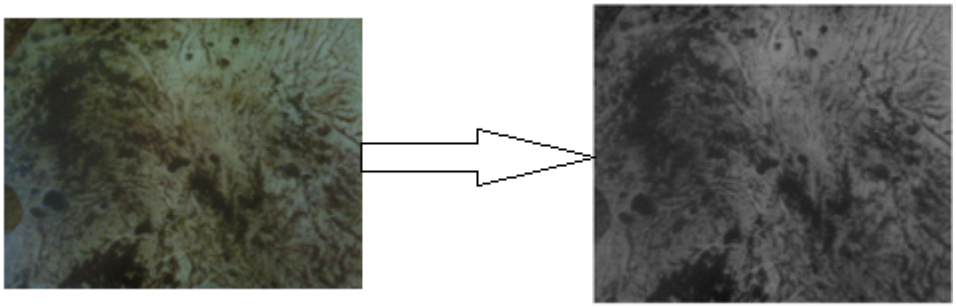
$$Y = aR(r) + bR(g) + cB(b) \ldots\ldots\ldots (1)$$

Where a, b and c are weighted algebraic coefficients.

Since we have to convert our true color images into grayscale, we have to add the brightness level of each pixel to the empty bit of the 4 bit image storage pixel in a computer. After averaging it, we will get a gray scale image

$$Y = 1/3(0.30R(r) + 0.59G(g) + 0.11B(b)) \ldots\ldots\ldots (2)$$

Then the image (figure 2(a)) is converted to gray-scale image (figure 2(b)). The gray–scale image will depict the brightness reaction of each pixel. The human eye perceives these brightness values easily and can differentiate between them. Hence, the weighted algebraic Coefficient before R, G, and B are different.



(a) (b)

Figure 2: Colored image to Gray-scale conversion

2. Image Binarization.

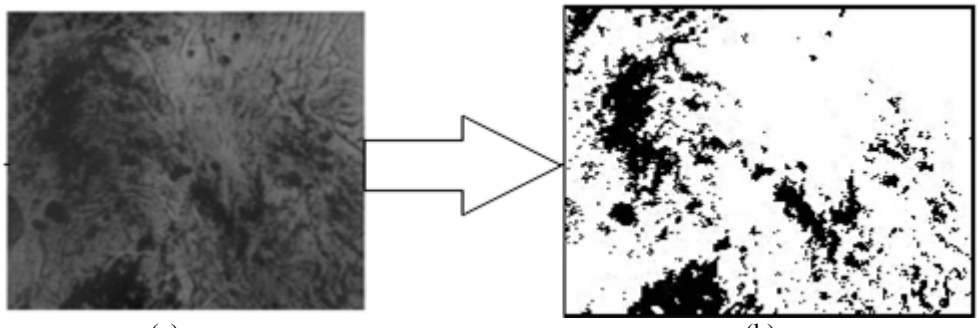
The binarized image is obtained by the following method

B(x, y) = 1 if grayimg(x, y) > T1
0 if grayimg(x,y) < T1

B(x, y) is the obtained binary image;
grayimg(x, y) is the obtained gray-scale image (figure(3(a));
T1 is the threshold.

The threshold is taken as gray-scale value 50 since the background is white. Keep this threshold constant for the images with same background. The threshold will mainly depend on the background of the image taken and can be variable according to different scenarios.

The dark spots indicate the sediment deposits. (Figure 3(b))



(a) (b)

Figure 3: Gray-scale image to Binary image conversion

3. Statistical/ Calculations.

The obtained binary image is then used for further statistical calculations.
Statistical calculations include the calculation of the pixels which are black. The binary image obtained is then used to calculate the number of black pixels.
The methodology is as follows:

A. Calculating Number of Black Pixels.

Pix=0;
loop
if (binimg(x, y) = = 0)
Pix=*Pix*+1;
end loop

Pix is a counter which will finally give the count of black pixels.
binimg(x, y) is the binary image obtained from step 3.
x and y are the row and column number of an image and will vary from 1 to maximum dimension of the image based on its pixel count.

B. Calculating the percentage of Black Pixels.

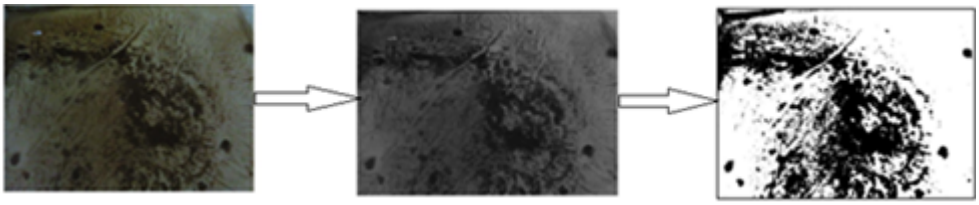
$$\text{Percent} = \frac{Pix}{x*y} * 100 \quad \ldots\ldots\ldots (3)$$

Percent is the percentage of black pixels.
Pix is final number of black pixels.
x and y are the maximum number of rows and columns of the image.
Based on the percentage of black pixels the database images can be statistically classified into following groups

1. Very less sedimented water(0-20% Black pixels)
2. Lightly sedimented water(20-40% Black pixels)
3. Moderately sedimented water(40-60% Black pixels)
4. Heavily sedimented water(60-80% Black pixels)
5. Fully sedimented water(80-100% Black pixels)

II. Capturing and processing a new image

The new image obtained also has to undergo the procedures involved for database images.
Figure(4(a)) represents the new test image while Figure4((b)) is the image obtained after gray-scale conversion and Figure(4(c)) is the final image obtained after binarization with its threshold value same as that of the test images.



(a) (b) (c)

Figure 4: Capturing a new image and processing

After Binarization the percentage of black pixels is calculated.

III. Comparing with Database and classifying.

The percentage obtained is then compared with the database percentage range. This percentage is linked to the 5 classes and the suitable class is selected based upon the range. (Figure5)

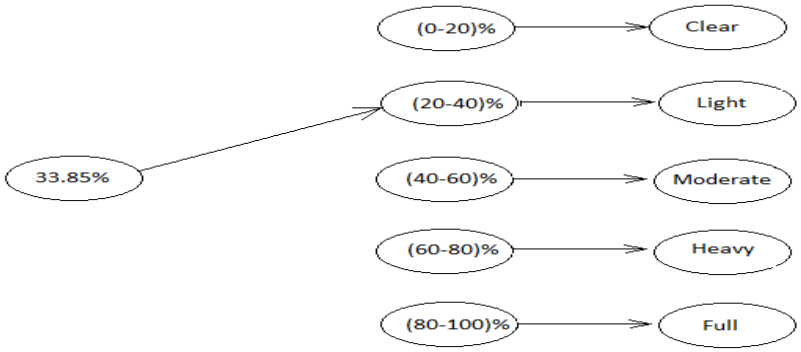


Figure 5: Linking the Result to database

3. Application.

The same algorithm was applied in a physical hydraulic model in Central Water Power and Research Station, India (figure 6). Images were shot and the algorithm successfully classified the images according to the sediment deposition.

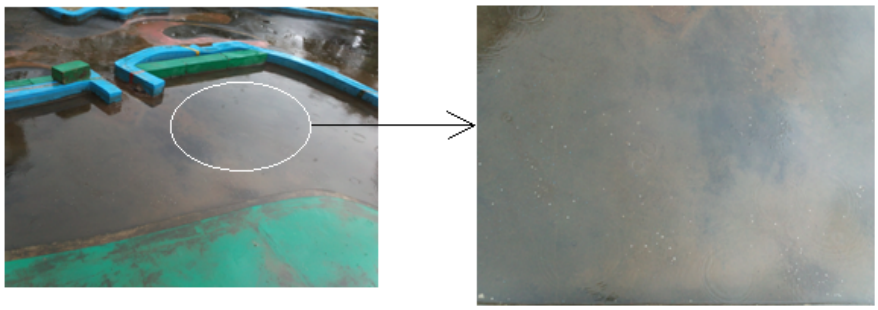


Figure 6: Application in a hydraulic model (CWPRS)

4. Limitations and Conclusion.

Thus, the study has made a great contribution in categorization of reservoir according to the sediment deposits; but the application is limited. The images which are obtained should not contain light reflections and there should be a sufficient contrast in order to successfully threshold the image. Same database images cannot be used for classification of images with different backgrounds. The algorithm will work only for shallow reservoir with still water.

5. References.

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Authors Profile.

Saif Sayed,an IEEE member, is pursuing his BE degree in Electronics and Telecommunication Engineering at Pune Institute of Computer Technology under University of Pune, India. His research interest is mainly inspired by image processing with more inclination towards instrumentation using image processing and pattern recognition.

Prathamesh Prabhudesai is pursuing his BE degree in Electronics and Telecommunication Engineering at Pune Institute of Computer Technology under University of Pune, India**.**His research interest includes image processing and signal processing.

Shri. M.SelvaBalan is an Electronic and communication Engineer, graduated from College of Engineering Guindyduring 1995. He is working with central water and power research station, Khadakwasla, Pune in the hydraulic instrumentation group for last 13 years. He is associated with DGPS based sedimentation studies, automation projects related to hydraulic engineering. He is also a recognized guide/faculty for MoWR training and Pune University.

Sushama Shelke received her BE and ME degrees from Walchand College of Engineering, Sangli, India in 1999 ad 2001 respectively. Currently she has submitted her PhD in the Electronics Department, Walchand College of Engineering under Shivaji University, Kolhapur. Presently she is working as an Associate Professor in the Department of E & TC in Pune Institute of Computer Technology, Pune, India. She has published more than 25 papers in various International conferences and Journals. She was the Principal Investigator, of a research project funded by University of Pune entitled "Document Image Analysis and Understanding" during the year 2008-2010. Her research interests include Image Processing, Pattern recognition, Signal Processing, and Embedded system design.