*Proceedings of National Conference on*

*Hydraulic and Water Resources (HYDRO 2012), IIT Bombay, India.*

*7 & 8 December 2012*

# ADAPTIVE COLOR GAMMA CORRECTION FOR SEDIMENT CLASSIFICATION AND QUANTIZATION IN A RESERVOIR

Saif Sayed[1], Prathamesh Prabhudesai[2], Selva Balan[3], Sushma Shelke[4]

***Abstract:*** *Sediment classification and its quantization has always been a challenge to hydraulic engineers. This paper proposes a novel method based on "Adaptive Color Gamma Correction" which gives the classification of sediments deposited as well as suspended in water with the help of pseudo coloring and also suggests a calibration method to quantize them. The algorithm is successfully implemented in a hydraulic model.*

***Keywords:*** *calibration, gamma correction, pseudo coloring, quantization, sediment.*

## I. INTRODUCTION

Sedimentation is the process of settling down the suspended material by gravity. The suspended materials can be the particles like clay or silts. It is a process of gravel accumulation i.e. sediment deposition. Sedimentation occurs when the water velocity decreases to a certain level, after which, further decrease in the velocity will make the water flow unable to carry the particles with it. Therefore particles will no longer remain in a suspension and gravitational force will remove them from the flow. Sedimentation process is the basic principle behind the water treatment plants. Sudden change in the suspension velocity is made causing particles to settle down. These settled particles are then easily removed by physical or chemical processes, yielding us the clear water. Several factors affect this procedure. Some of the most important factors are particle size, water temperature and water current.

**Particle Size:** Particles with larger sizes and greater densities settle down easily by simple gravitational force. In contrast colloidal material or small particles stay in suspension and make the water seem cloudy. The shape of the particle also affects the process. For instance, a round shaped particle will be settled easily compared to the irregular ones.

**Water Temperature:** Rate of sedimentation and the temperature of the water have direct relation between them. As the temperature decreases, the sedimentation process becomes slower and vice versa.

[1] Final year student (BE, Electronics and Telecomm.) PICT college,Pune,India.saifsayed@ieee.org
[2] Final year student (BE, Electronics and Telecomm.) PICT college,Pune,India.prathprabhudesai@gmail.com
[3] Senior Research Officer, Central Water and Power Research Station,Pune,India.msels72@gmail.com
[4] Associate Professor, Pune Institute of Computer Technology, Pune,India.sush_aditi11@yahoo.com

**Water Current:** There are two types of water currents. i. Density Currents ii. Eddy Currents. Water currents separate out the particles and promote flocculation but decreasing the speed of the sedimentation.

Sedimentation in a natural water reservoir is a very complex process. The amount of sedimentation is also quite large. Sedimentation is beneficial in water treatment plants however it has some disadvantages. Consider the example of Dams. Water is stored in a Dam. Since velocity is zero, there will be a huge amount of sediment deposition that can decrease the dead water storage capacity of the Dam [1].

To make quantitative analysis of this whole procedure, different methods are been proposed from many years but no process can fully satisfy the actual need [2]. Hence we propose an altogether a different methodology towards the quantization and categorization of the sediment deposition using Image Processing.

Section I is introduction, while section II introduces Gamma Correction, section III explains the methodology, section IV consists the experimental results, section V explains the calibration method, section VI demonstrates an application in a hydraulic model in CWPRS, India, section VII concludes the paper with limitations.

There are two different approaches adopted here: i. Single Image Based ii. Multiple Image Based

## II. GAMMA CORRECTION (POWER LAW)

The perceived brightness of a digital image is dependent upon the conditions of specimen illumination, sensitivity and linearity of the detector from which the image is acquired, intensity distribution of the display device, where the digital image is viewed and interrelationship of contrast between light and dark regions in the specimen. The effects are characterized by a variable known as 'Gamma (ϒ)' [3] .This exhibits a non-linear relationship. For example, the intensity produced at the surface of a CRT display is approximately the applied voltage, raised to the power 2.2. The numerical value of the exponent of this power function is ϒ. This non-linearity should be compensated so as to achieve correct reproduction of intensities. Since it deals with the power function, it is also known as 'Power Law'.

$$g(m,n) = [f(m,n)]^{\Upsilon} \qquad (1)$$

Where $f(m,n)$ the input, is an image and $g(m,n)$ is an output image. $\Upsilon$ can take either integer or fractional values.

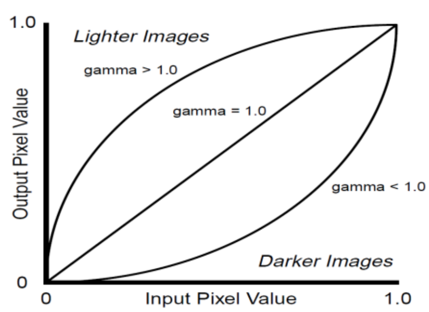



**Fig. 1: Gamma Correction**

Whenever we have to deal with the particular frequency components of an image or a color, we prefer gamma correction for the detailed analysis of it. When the value of gamma is less than one, the image appears to be a dark image while if the value of the gamma is greater than one, the image appears to be a bright image.
In this paper, the monochrome images with a light background and brown sediment deposition are considered. Since we are interested in the sediment depositions, we will adjust gamma for all shades of brown and then Thresholding will be done so as to get the exact sediment deposition. While correcting gamma, only the green component of the color is taken into consideration as brown majorly has a green component in it. This can be observed with the naked eye [4].
The further explanation about the gamma correction will be given while we proceed through the methodology.

## III. METHODOLOGY

There are two approaches with which we can deal with the quantization and categorization of the sediment depositions.
By just observation we can identify and differentiate between the sediment depositions. Lighter brown shades indicate the sediment suspension i.e. suspended particles while the darker brown shades indicate the sediment deposition. By varying gamma, suspended particles can be isolated from the deposited ones.
There are 3 types of sediment deposits in a basin, based on the space between sediment particles, they are

1. Compressed sediments: very less inter particular space
2. Hindered sediments: Less inter particular space
3. Flocculent sediments: large inter particular space

**Behavior of Light:**
Light will not reflect from particles which are compressed, while some light may succeed in getting reflected in the case of hindered sediments. The amount of light reflected in flocculent sediments is greater than hindered sediments. Light will completely get reflected in clear water.

### A. Based on a single image:

In this method, the amount of the sediment deposition is found with the help of 'Adaptive Color Range Gamma Correction'. The obtained image is a pseudo colored one [4]. The image on which the processing is to be done should be a monochrome, light background image containing brown colored sediments.
A detailed algorithm is explained below:

1. Store the image in a matrix, I(x,y,3)
2. Get the green component of the RGB image, I(x,y,2)
3. r=0, ϒ=5,comp=0,hind=0,floc=0,clea=0;
4. r=r+1
5. $O(x,y) = (I(x,y,(0,0,0);(0.01,r,0.01,));I(x,y,(0,0,0);(0,255,0,)),\Upsilon)$
6. $ipmean = \frac{\sum_{i=x,j=y}^{i=0,j=0} I(i,j)}{x*y}, opmean = \frac{\sum_{i=x,j=y}^{i=0,j=0} O(i,j)}{x*y}$

7. If $opmean - ipmean > 0$ , go to step 9
8. Go to step 4.
9. $if\ 10 \geq \sum_{i=x,j=y}^{i=0,j=0} O(i,j) \geq 0, comp = comp + 1$
10. $if\ 60 \geq \sum_{i=x,j=y}^{i=0,j=0} O(i,j) > 10, hind = hind + 1$
11. $if\ 150 \geq \sum_{i=x,j=y}^{i=0,j=0} O(i,j) > 60, floc = floc + 1$
12. $if\ 255 \geq \sum_{i=x,j=y}^{i=0,j=0} O(i,j) > 150, clea = clea + 1$
13. $compression = (comp/x * y) * 100$
14. $hindered = (hind/x * y) * 100$
15. $flocullent = (floc/x * y) * 100$
16. $clear = (clea/x * y) * 100$
17. Exit

$O(x, y)$ is the new image obtained after gamma correction, step 5 indicates mapping the green component of input image ranging from 0 to r, to new range, 0 to 255. $compression$ will indicate the percentage of sediments in compression, $hindered$ will indicate percentage of hindered sediments, $flocullent$ will give flocculent sediments and $clear$ will show clear water percentage.

**B. Based on a set of images.**

This method is based on the comparison. An image is captured first and gamma correction is applied on it. Another image is captured after some time instant and undergone through the same process. Then difference between the two images is taken; so as to get the comparative analysis and ratio of the percentage sedimentation change.

But there are some limitations to this method. The image should be taken when the water is settled i.e. suspension velocity should be tending to zero. The time between two images may accordingly vary.

For example, a task is given to analyze the sedimentation process in a dam in a rainy season. On day 1, an image is captured when all the water stored is completely settled. Consider it has $x$ amount of sediments. Then after heavy rains, on day 5, second image is taken and compared with the previous one. It is found that the amount of sedimentation is increased. The increment is found to be $\Delta x$. Assume that on day 5, the dam has $y$ amount of sedimentation. Therefore we can say that

$$\boldsymbol{y = x + \Delta x} \qquad (2)$$

And percentage sedimentation increased will be

$$\frac{x + \Delta x}{x} \times 100 \qquad (3)$$

With the help of this analysis, we can get the information about the 'dead storage' of the dam and some action can be taken so as to increase it.

A detailed algorithm is explained below:

1. Perform steps 1-16 from first approach for the set of 'n' images you want for inspecting sediments.

2. Compression rate = $\frac{(compression2-compression1)+(compression3-compression2)+ \ldots\ldots(compression(n)-compression(n-1))}{n}$
3. Hindered rate = $\frac{(hindered2-hindered1)+(hindered3-hindered2)+ \ldots\ldots(hindered(n)-hindered(n-1))}{n})$
4. Flocculent rate = $\frac{(flocullent2-flocullent1)+(flocullent3-flocullent2)+ \ldots\ldots(flocullent(n)-flocullent(n-1))}{n}$

Steps 2, 3 & 4 will give a percentage rate of compression, hindered & flocculent rate of sedimentation in percentage per image. If the time is calculated between the images when they are captured, then the rate can be percentage per unit time.

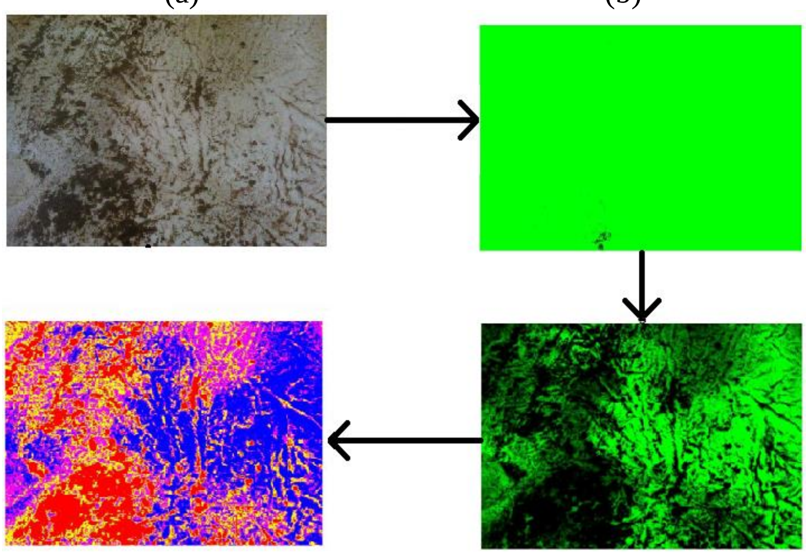
## IV. EXPERIMENT RESULTS

Experimental setup: A rectangular white box with dimensions 60cm*50cm*8cm was used. procedure. Water was filled up to height of 6cm.

**A. Based on a single image**

***1. Camera axis perpendicular to reservoir base***.

(a) (b)



(c) (d)

**Fig. 2: Illustration of single image based quantization**

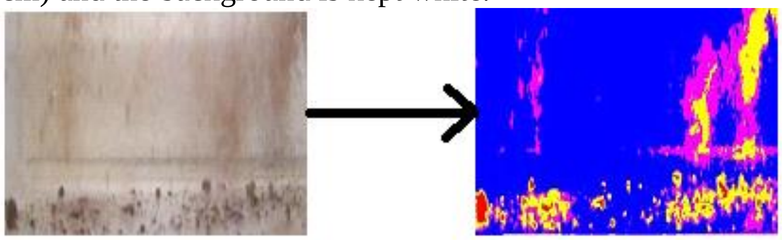
Figure (2a) represents the original image with sediments in it. Figure (2b) represents the image with r=25, while figure (2c) is obtained after adjusting the range (after step 8 of part1 algorithm) while figure (2d) is obtained after pseudo coloring the image.

The percentages of sediments obtained are

- Compressed=19.0020%
- Hindered=22.5283%
- Flocculent=27.4847%

- Clear=30.9850%

2. ***Camera axis oblique to reservoir base***: Here the reservoir is completely made up of glass (60cm*50cm*8cm) and the background is kept white.



**(a) (b)**

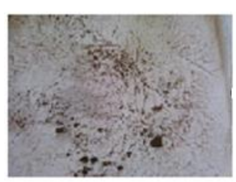
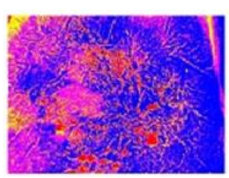
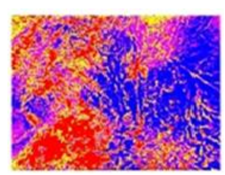
**Fig. 3: Implementation of algorithm for reservoir base oblique to the camera axis**

Figure 3(a) shows a particular frame of a video which was taken while immersing sand in the reservoir. The figure clearly shows the deposited particles with some suspended in water.
Figure 3(b) shows the final pseudo colored image. The quantization based on the pixel count was also done in the same manner. The red colored pixels are the compressed particles which can be either stones or compressed fine sand. The pixels colored in yellow are the particles which are not completely compressed and water can flow through them. The pixels colored in pink are the flocculent particles where water can easily flow through them. The blue pixels are the one which is clear water. Some of the flocculent particles are misinterpreted with clear water because of the shadow in the background.

- Compressed=2.053%
- Hindered=13.3656%
- Flocculent=14.7217%
- Clear=69.8605%

**B. Based on a set of images:**

Procedure: A known quantity of soil was added and photo was taken. This process was continued till the sand got completely saturated in water

| | | |
|---|---|---|
|  (a) |  (b) |  (c) |
|  (p) |  (q) |  (r) |

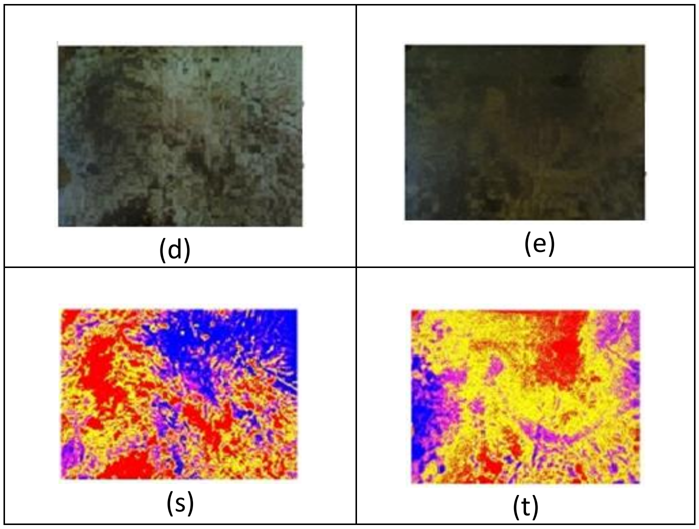



**Fig. 4: Images obtained after processing**

Images of Figure 4(a), (b), (c), (d) and (e) column indicates gradual rise in the sediment quantity, while Figure 4(p), (q), (r), (s), and (t) indicates the pseudo colored images of the corresponding images.

**C. Result table:**

| Images | Compressed (%) (Orange colored) | Hindered (%) (Yellow colored) | Flocculent (%) (Pink colored) | Clear (%) (Blue colored) |
|---|---|---|---|---|
| Image 1 | 0.0059 | 0.0072 | 0.0049 | 99.9821 |
| Image 2 | 6.3242 | 12.7350 | 34.3324 | 46.6084 |
| Image 3 | 19.0020 | 22.5283 | 27.4847 | 30.9850 |
| Image 4 | 25.1419 | 34.6224 | 19.2985 | 20.9372 |
| Image 5 | 36.7292 | 37.8704 | 14.3577 | 11.0426 |
| Rise Rate(% per image) | 7.3662 | 7.6446 | 2.87 | --- |

**Table 1: Experimental result for testing the algorithm for sequence of images**

Similar observations can be made for axis of camera oblique to the reservoir base for series of images.

**D. QUANTIZATION OF SEDIMENTS**

The quantization of the sediments can be easily done by properly calibrating the setup. If the real time area of the basin captured is known, then the approximate 2 dimensional area covered by each type of sediments can easily be stipulated.

If the area of the terrain whose image is captured is ‘A’$cm^2$ and if the resolution of the image is X*Y, then the area covered by each pixel will be,

$$P=A/(X*Y) \qquad (3)$$

Where, P is a single pixel area.

So, if P=1$cm^2$/pixel, A=100 $cm^2$ and if the percentage of compressed sediments is 10%, then the real time cumulative 2D planar area covered by compressed sediments is about 10$cm^2$. In this way a cumulative quantization and categorization of the sediments can be possible.

## V. CALLIBRATION

It is preferred to place the camera perpendicular to the surface of the basin, for easy computation. This can be easily be illustrated from the figure,

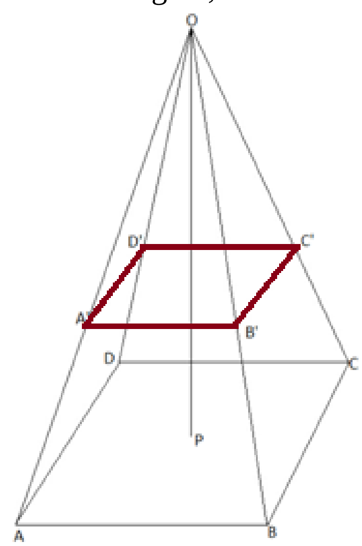



**Figure 5(a): Schematic Diagram showing plane of basin perpendicular to the camera**

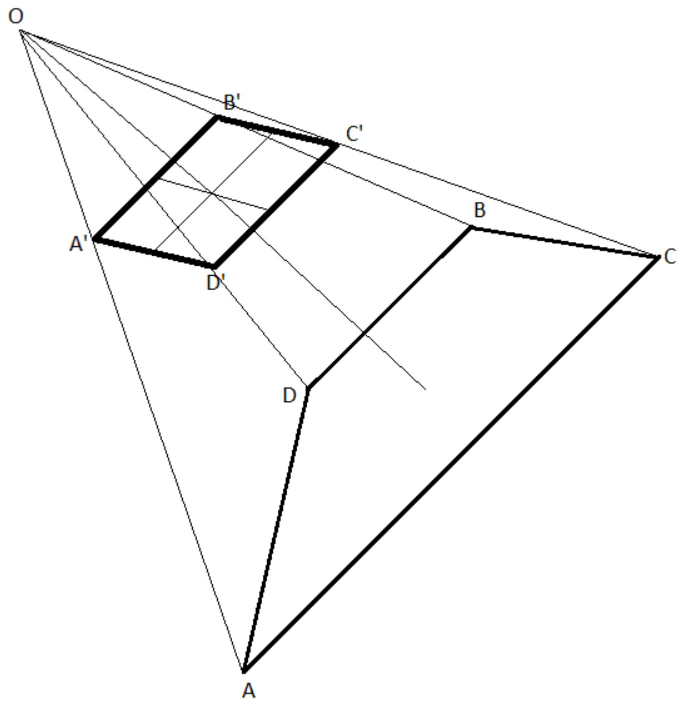
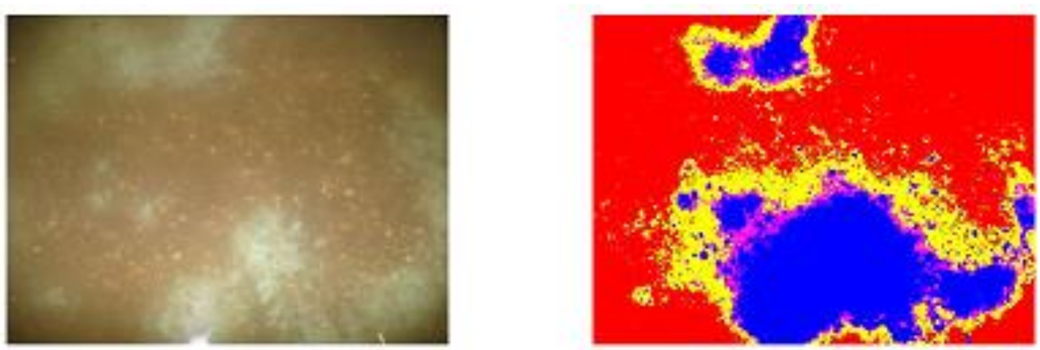



**Fig. 5(b): Schematic Diagram representing plane of basin oblique to the camera**

In both the figures (5a & 5b), ABCD is the plane of the shallow basin, while A'B'C'D' is the plane of the image obtained. Both image planes observed in camera will be rectangular but in real-time the image captured in case (5(a)) is of rectangular terrain while that in case (5(b)) is a trapezoidal nature, with irregular dimensions, which make it difficult to calculate its real-time area.

## VI. APPLICATION

The algorithm was applied in the Bombay port model in CWPRS, INDIA and positive results were obtained the images are as follows, figure (6a) is the original while (6b) is the processed one.



**(a)** **(b)**

**Fig. 6: Practical application in a Hydraulic Model.**

Due to low ambient light and deep nature of the water body, the image had very poor resolution which forced us to change ϒ, but sediments were easily quantized. Thus by increasing the gamma value will help us to get more information from the image.

## VII. LIMITATIONS`

There are some limitations to this proposed methodology.

1. The sediments we are going to consider are brown in color or should be a shade of brown, the color adjustments can be done for different colored soils. Brown mud and stones are taken for laboratory measurements.
2. Monochrome light background surface is considered as the darker surface will make the identification difficult for a naked eye and so for the image processing, there should be a proper contrast between the sediments and the background.
3. No reflection should be incurred in the images taken as it creates unexpectedly brighter/dark region in an image.
4. The algorithms work for the shallow basins or reservoirs having calm water as that ensures an end of the sedimentation process. Little drizzles are allowed but deposited structure should not be disturbed.
5. The ambience light should be sufficiently bright for elimination of errors.

## VIII. REFERENCES

[1] Newton de Oliveira Carvalho, Naziano Pantoja Filizola Júnior, Paulo Marcos Coutinho dos Santos, Jorge Enoch Furquim Werneck Lima. reservoir sedimentation assessment guideline
[2] Fan Yong, Coll. Of Water Conservancy & Hydropower Eng., Hohai Univ., Nanjing, China. Study on Mathematical Model of Sediment in Fluctuating Backwater Area, in International Conference on Computational Intelligence and Software Engineering (CiSE), 11-13 Dec. 2009
[3] Doustar M. F., Shahrood Univ. Of Technol., Shahrood, Iran, Hassanpour H. A locally – adaptive approach for image gamma correction, in 10th International Conference on Informational Sciences Signal Processing and their applications (ISSPA), 2010
[4] Filiberto Pla, Gema Gracia, Pedro García-Sevilla, Majid Mirmehdi, and Xianghua Xie. Multi-spectral Texture Characterization for Remote Sensing Image Segmentation. H. Araujo et al. (Eds.): IbPRIA 2009, LNCS 5524, pp. 257-264, 2009