Turbidity detection using Image Processing

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***Abstract*—The motivation behind this projected work is to design a new technique to determine turbidity of water samples using Image Processing. Classical method of turbidity detection implies manual procedures characterized by long calibration time, additional common errors and lower repeatability. The technique suggested in this paper consists of capturing water sample images using high definition camera and applying image processing techniques to characterize those samples with different amount of turbidity. Data base is created for water samples with different amount of turbidity using laboratory method of turbidity measurement is can be used anywhere and at anytime in the world wherever Image Processing technique is used for turbidity detection. Image processing outcomes are compared with this data base to give direct and accurate turbidity measurement in fraction of seconds.**

***Index Terms*—Image processing, turbidity, nephelometry, thresholding, histogram.**

I. Introduction

In today's world the measurement of turbidity of domestic water supplies became very important, as water supplied from domestic water supplies often undergo process of water treatment which can be affected by turbidity. Turbidity may cause severely if not taken into consideration for example, blocking of filters and stop them from working effectively, filling of tanks and pipes with mud and silt, damaging valves and taps,etc are the adverse effects of high turbidity. Whereas low turbidity will prevent the chlorine from killing the germs in the water efficiently during chlorination. Turbidity is nothing but the cloudiness or haziness of a fluid due to large numbers of particles that are either visible or invisible to the naked eye. The measurement of turbidity is a key test of water quality. It is measured in NTU which is nephelometric turbidity unit. For pure water it should be below 5 NTU. This study presents a method for detecting impurity events of drinking water based on the Image Processing theory. The detection method is useful to protect water supply systems from accidental and intentional contamination events.

The arrangement of this paper is fragmented in VII units. Unit II traditional methods and their comparison,unit III shows the block diagram of proposed method,unit IV gives the algorithm for Digital image processing, unit V shows the experimental outcomes and unit VI gives the final results after comparison with stored Data base in system whereas unit VII concluded the work.

II. Traditional methods and their comparison

Turbidity, as an optical property of water, is one of the more difficult parameters to measure. The practice of using an electronic turbidity meter or a turbidity tube is generally performed to measure turbidity. Both methods have advantages and disadvantages. A turbidity meter consists of a source of light which is used to illuminates a water sample and also consists of photoelectric cell used to measures the intensity of light scattered at a 90 angle by the particles in the water sample.Turbidity is measured in nephelometric turbidity units or NTUs. It is very accurate, and especially useful for measuring very low turbidities (less than 5 NTU). But the cost of unit is very high,it requires power supply, gets easily damaged and expertise required. The turbidity tube are simple in design, low in cost and not easily get damaged but can't be used to measure very low turbidities (usual minimum is 5 NTU) and less precise.

III. Proposed Method

In the proposed method we capture an image of water of which turbidity is to be checked. Image processing techniques are used to detect the impurity present in the water sample. Comparison is done with standard database to give final turbidity of water sample.

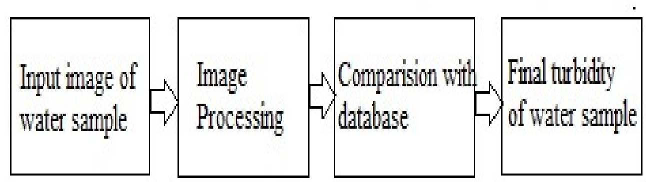

Fig. 1. Block diagram of proposed method

IV. Algorithm

To get the desired results in digital image processing everyone has to follow certain steps. These steps mainly include image acquisition which means capturing image by image capturing device and sending it to image processing system or software. Then next step is image processing which include image enhancement, image filtration, colour image to gray

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image conversion,etc. Further step is of Image segmentation by Thresholding or any other technique, Image analysis by plotting histogram and finally obtaining the results either by comparison or pattern recognition.

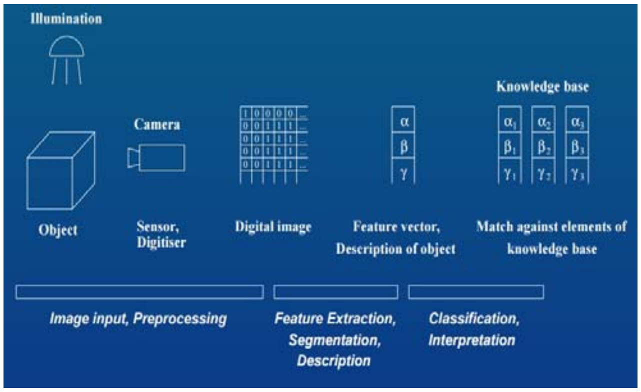

Fig. 2. Algorithm of Digital Image Processing

1. Input Image: Image is captured using camera having minimum resolution of 620*850, which can be obtained using digital camera of minimum 3 MP. This captured image is send to the computer for further processing.

2. RGB to Gray conversion: Colored image mainly consist of three components RED, GREEN, BLUE. The representation of a colour image using intensity function is done as shown below

$$I_{RGB} = (f_R * f_G * f_B) \tag{1}$$

Where $f_R(m,n)$, $f_G(m,n)$ and $f_B(m,n)$ represents the intensities of the pixel (m,n) present in the red color band, Green color band and Blue color band respectively. The intensity of each color band can be stored using 8 bits, 16 bits but generally eight bits storage is preferred, which represents the quantization level 0 to 256. Gray levels are the representation of quantization levels done in gray scale image processing. Today, 8-bit storage method is mostly preferred for storage. In an 8 bit gray scale image total 256 gray levels ar present and pixels have intensity value from 0 to 255, where 0 represents black and 255 as white. The command to converts RGB images to grayscale is given bye,

$$I = rgbtogray(image) \tag{2}$$

It operates by eliminating the hue and saturation information while retaining the luminance of an image.

3. Image Filtration: As images are captured in real tine, quality of an image get affected due to many parameters of the surrounding which causes random variations in intensity and brightness, this random variations in image quality is called as noise. There are different types of noises occurs during image processing, like impulse noise, salt and pepper noise, Gaussian noise. In Salt and pepper noise black and white intensities occurs randomly. Whereas, impulse noise represents random occurrence of white intensity levels. But in Gaussian noise Gaussian distribution causes the intensity to vary randomly in an image. Linear smoothing filters are preferred to remove Gaussian noise and many other types of noises as well. Implementation of a linear filter is done by taking the weighted sum of the pixels in successive windows. Generally, the pattern of weights that we use in each window is same, which makes linear filter invariant. Gaussian filter - It is mostly prefered filter for smoothing of a distorted image. Gaussian kernel uses certain properties of the Gaussian like the central limit theorem, minimum space-bandwidth product. The point spread function and transfer function for the continuous Gaussian filter is given below:

$$h(m,n) = g_{2D}(m,n) = (\frac{1}{\sqrt{2\pi\sigma}} \exp^{\frac{-m^2}{2\sigma^2}})(\frac{1}{\sqrt{2\pi\sigma}} \exp^{\frac{-n^2}{2\sigma^2}}) \tag{3}$$

$$= g_{1D}(m) * g_{1D}(n) \tag{4}$$

4. Histogram : The histogram of an image measures the number of pixels with a given gray or colour value. Histograms of colour images are not normally used, so we have plotted histogram of gray image only. Consider a grayscale image having N number of different intensity levels is provided, the intensity gray level histogram can be represented using a function,

$$h(g), \quad where \;\; g \in [0...N] \tag{5}$$

where 0 to N are the intensity levels in the image or in the region of interest.

$$h(g) = N_g \tag{6}$$

Ng- Number of pixels in image or in the region of interest that have intensity level equal to g. The function obtained by normalizing histogram with number of pixels in the image is called Probability Density Function (PDF) of the intensity levels.

$$p(g) = \frac{h(g)}{M} \tag{7}$$

Where M= image height x image width,
PDF has following properties

P(g) $\geq$0 ,

$$\int_{-\infty}^{\infty} (g)dg = 1$$

5. Thresholding image: This is a simple method of differentiating between an object and the background, which works provided they are of different intensities. Thresholding is the creation of binary images from gray images. It convert all pixels below threshold value to 0 and above threshold value to 1. If B(x, y) is gray version then to obtain a thresholded version G(x,y) with threshold value T, G is set equal to 1 if B (x,y) â T and zero otherwise. function used for thresholding is given by,

$$I = graythresh(image) \tag{8}$$

V. Experimental Outcomes

1. Input images:

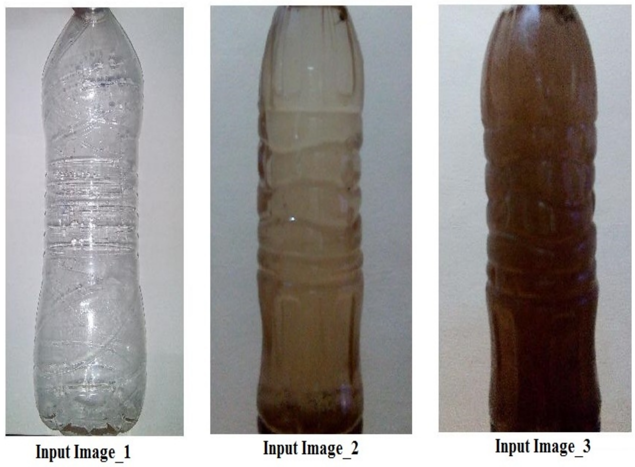

Fig. 3. input images of samples

Fig.3 shows the input images of water samples whose turbidity is to be determined.These samples are having different amount of turbidities. These images are captured by high definition camera. Different Image processing steps are performed over these images to get different texture characteristics of an image like filtered image, gray image, gray contrast image, threshold image and many other.

2. Contrast Gray Images:

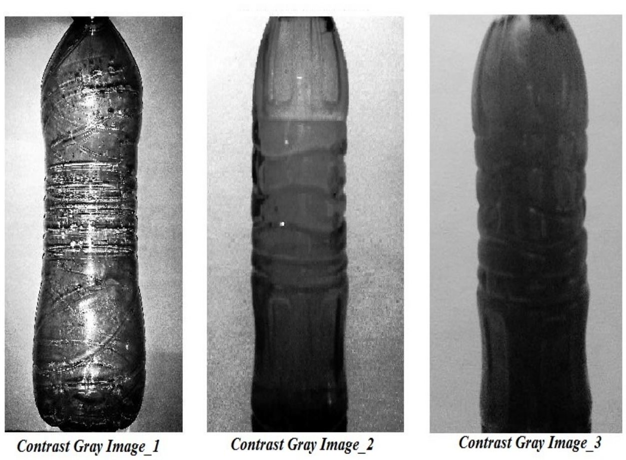

Fig. 4. Contrast Gray Images

Fig.4 shows the contrast gray scale image of respective input image having pixel intensity from 0 to 255. The contrast of gray scale image is defined as visual capacity to differentiate the different objects in the image from each other. Contrast is mainly depend on luminance and it is given by,

$$Contrast = \frac{ChangeinLuminance}{AverageLuminance} \tag{9}$$

Contrast is the capacity of an image to utilize of whole range of pixel intensities available. It do not dependent on the brightness of an image. It can be calculated as,

$$C_g = \frac{max_I - min_I}{max_I + min_I} \tag{10}$$

3. Threshold Images:

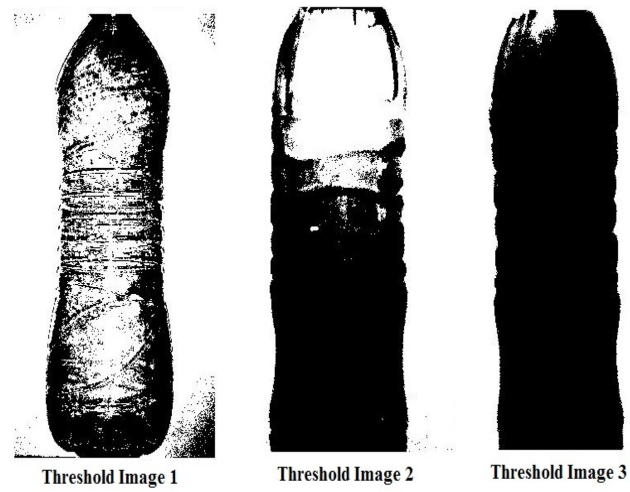

Fig. 5. Thresholded image of input image

Threshold image give the location of presence of impurity in the water sample. It is obtained by normalization of the pixel value in between 0 and 1 which converts gray image into binary image obtained by converting each pixel below some threshold value to 0 and otherwise equal to 1. The blackish portion is representing the portion of turbidity in water sample and white or bright portion is showing less turbid or pure portion in water sample. Image thresholding will help to detect presence of any other kind of impurity present in water sample.

4. Histogram of Images:

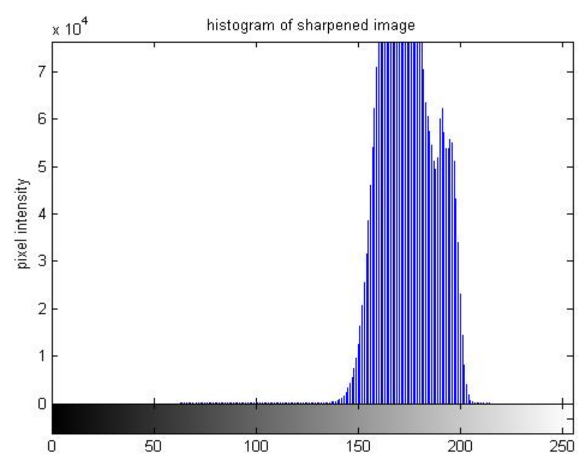

Fig. 6. Histogram of input image1

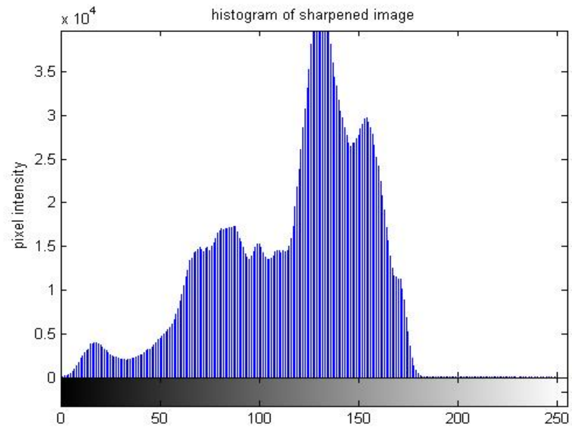

Fig. 7. Histogram of input image2

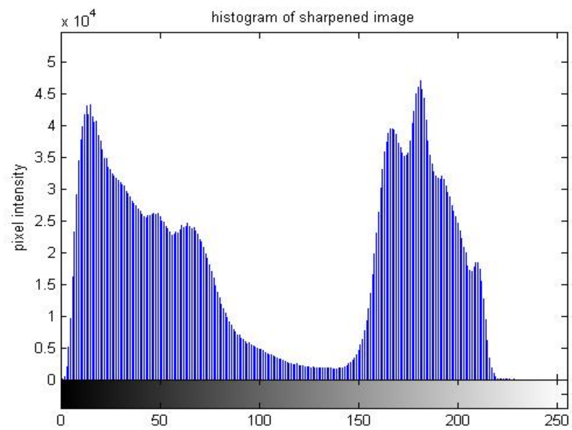

Fig. 8. Histogram of input image3

As we know that histogram is the graph of pixel intensity on Y axis versus number of pixels on X axis. From experimentally obtained histogram it is cleared that numbers of pixels are almost constant and are nearly in range of 120 to 180 in all the three images so the comparison is based only on pixel intensity. Comparing this pixel intensity value with the system data base which consists of a table having amount of turbidity for given value of pixel intensity, we get the final turbidity of samples.

VI. Result

The table 1 gives the comparison between turbidity measured by Laboratory method and Image processing method along with histogram value. In the table 1, column 1 gives the names of input samples that are captured by high definition camera. column 2 gives the histogram value obtained after characterization of those sample images using digital image processing techniques. This histogram values are compared with data base stored in system to get corresponding turbidity value. Column 3 gives the turbidity value measured by conventional laboratory method and column 4 gives the turbidity value obtained from digital image processing technique.

TABLE I
Comparison and Result

Name	Histogram value	Turbidity(NTU) by Laboratory method	Turbidity,(NTU) by Image processing
Image_1	80,000	2.8	2
Image_2	43,000	8.5	8
Image_3	35,000	14.6	15

VII. Conclusion

The results by Digital Image processing method are obtained in fraction of seconds with good accuracy whereas Laboratory method is very time consuming and expensive.The accuracy can be further increased with increase in camera quality, number of stored samples of data base and many other point operations on the image using DIP.So finally from this paper it can be concludes that Image processing technique is the best alternative method to laboratory method for turbidity detection.

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