PARALELLIZATION OF HISTOGRAM EQUALIZATION

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ABSTRACT:

Histogram equalization is contrast enhancement technique in a spatial domain in image processing using histogram of the image. A histogram is an accurate representation of the distribution of numerical data. It is an estimate of the probability distribution of a continuous variable. Histogram equalization usually increases the global contrast of the processing image. This method is useful for the images which are very bright or very dark.

OBJECTIVE:

The aim of the following project is to achieve greater speed in Histogram Equalization by using MPI and OpenCL. This is achieved using parallelism in the algorithm.

INTRODUCTION:

Histogram is one of the important features which are very related to image enhancement. The histogram does not only gives us a general overview on some useful image statistics but it also can be used to predict the appearance and intensity characteristic of an image. A histogram is a display of statistical information that uses rectangles to show the frequency of data items in successive numerical intervals of equal size. In the most common form of histogram, the independent variable is plotted along the horizontal axis and the dependent variable is plotted along the vertical axis. The data appears as colored or shaded rectangles of variable area.

If the histogram is concentrated on the low side of the intensity scale, the image is mostly a dark image. On the other hand, if the histogram is concentrated on the high side of the scale, the image is mostly a bright image. If the histogram has a narrow dynamic range, the image usually is an image with a poor contrast .Contrast enhancement is an important area in the field of digital image processing for human visual perception and computer vision. It is extensively used for medical image processing and as a preprocessing step in speech recognition, texture synthesis, and many other image/video processing applications. To obtain this contrast enhancement we use Histogram equalization.

LITERATURE REVIEW:

According to Nicholas Sia Pik Kong, Haidi Ibrahim, and Seng Chun Hoo, in their paper **"***Histogram Equalization and Its Variations for Digital Image Enhancement***"** There are many Histogram Equalization (HE) methods for digital image contrast enhancement. One of the well-known HE methods is Global Histogram Equalization (GHE). The basic idea of GHE method is to remap the gray levels of an image based on the image's gray levels cumulative density function. GHE uses the information of the whole intensity values inside the image for its transformation function and thus this method is suitable for global enhancement. Its goal is to redistribute the intensity of an image uniformly over the entire range of gray-levels (i.e. the image’s cumulative histogram is linear) which is very effective for enhancing low contrast detail of an image and maximize the entropy of an image.

According to Omprakash Patel, Yogendra P. S. Maravi and Sanjeev Sharma , in their paper **“***A Comparative Study of Histogram Equalization based Image Enhancement Techniques for Brightness Preservation and Contrast Enhancement***”** ,GHE attempts to “spread out” the intensity levels belongs to an image to cover the entire available intensity range. GHE flattens and stretches the dynamic range of the resultant image histogram and as a consequence, the enhanced image will optimally utilize the available display levels. This then yields an overall contrast improvement.

METHODOLOGY:

Consider the discrete grayscale input Image $X = x(i,j)$, with the L discrete levels, where $x(i,j)$ represents the intensity levels of the image at the spatial domain (i,j) Let histogram of Image X is $H(X)$. Now the probability density function $pdf(X)$ can be defined as-

$$pdf(X_k) \text{ or } pdf(X_k) = n_k / N \qquad (1)$$

Where, $0 \leq k \leq (L-1)$

L is the total number of gray levels in the image,

N is the Total number of pixels in the image,

n_k is the total number of pixels with the same intensity level k.

From the $pdf(X)$ (1) the cumulative distribution function $cdf(X_i)$ is defined as-

$$cdf(X_i) \text{ or } c(X_i) = \sum_{i=0}^{k} pdf(X) \qquad (2)$$

Note that $cdf(X_{L-1}) = 1$ from eq. (1) and (2).

Histogram equalization is a scheme that maps the input image into the entire dynamic range [X_0, X_{L-1}] by using the cumulative distribution function as a transform function. Let's define the transform function using cumulative distribution function F(X) as-

$$F(X) = X_0 + (X_{L-1} - X_0) \times cdf(X_i) \qquad (3)$$

Then the output image of histogram equalization Y = y(i,j) can be expressed as

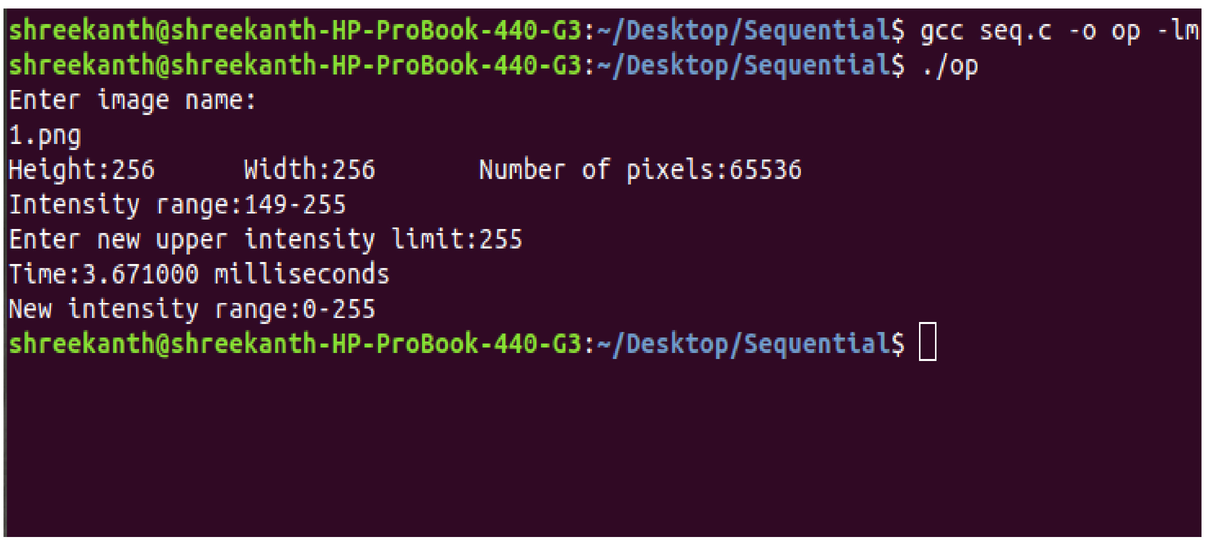
$$Y = F(x) \tag{4}$$

$$Y = \{\, F(x(i,j)) \mid \forall\ x(i,j) \in X \,\} \tag{5}$$

The above describe the histogram equalization on gray scale image. However it can also be used on color image by applying the same method separately to the Red, Green and Blue Component of the RGB color image.

RESULTS:

SEQUNTIAL IMPLEMENTATAION:



MPI IMPLEMENTATION:

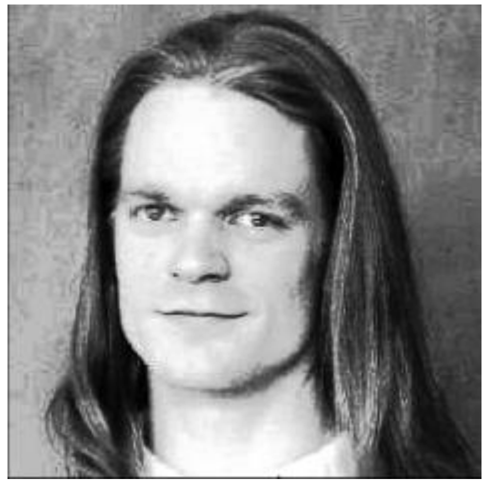
```
shreekanth@shreekanth-HP-ProBook-440-G3:~/Desktop/MPI Implementation$ ./compile.sh
shreekanth@shreekanth-HP-ProBook-440-G3:~/Desktop/MPI Implementation$ ./run.sh 16
Enter image name:
1.png
Height:256      Width:256       Number of pixels:65536
Intensity range:149-255

Enter new upper intensity limit:255

Time-log 1:     4.315 milliseconds

Time-log 2:     0.379 milliseconds

Time-log 3:     0.668 milliseconds

Total-Time:     5.362 milliseconds

New intensity range:0-255

Image saved as 'finalimage.png'
shreekanth@shreekanth-HP-ProBook-440-G3:~/Desktop/MPI Implementation$
```

OPENCL IMPLEMENTATAION:

```
kkv@HP-ProBook-440-G3:~/Documents/LABS/PCAP LAB/zMini-Project/OpenCL Implementation$ ./run.sh
Enter image name:
Images/1.png
Height:256      Width:256       Number of pixels:65536

Intensity range: 149-255

Enter new upper intensity limit:256

Frequencies time:                       0.396 milliseconds

Probablities time:                      0.313 milliseconds

Cumulative Probabilities time:          0.294 milliseconds

Replacement values time:                0.281 milliseconds

Final Matrix time:                      0.335 milliseconds

Total time for execution:               1.619 milliseconds


New intensity range:0-256

Image saved as 'finalimage.png'

kkv@HP-ProBook-440-G3:~/Documents/LABS/PCAP LAB/zMini-Project/OpenCL Implementation$
```

Since the complexity of the calculation in our project is less, the overhead of creating processes and communication between them in case of MPI and some cases of OpenCL, offsets some of the benefits of parallelization. However, we still see an improvement of around 55% as compared to the serial code.

INPUT IMAGE



OUTPUT IMAGE

LIMITATION and POSSIBLE IMPROVEMENTS:

1. Histogram equalization is not the best method for contrast enhancement because the mean brightness of the output image is significantly different from the input image. There are several extensions of histogram equalization has been proposed to overcome the brightness preservation challenge.
2. The image reading and writing works only for image of type **.**png . This is due to the limitation of the programming language. This can be overcome if we use python or some other programming language for implementation.
3. After a certain point as the no of process increases, the execution time also increases. This is because the time needed to parallelize and create new processes is more than the actual computation. The basic way to overcome is this is by only parallelizing the programs which have heavy computation requirements. Also we can overcome this if we use better hardware (GPU).

CONCLUSION:

The results accomplished through this parallelization can be accounted to the higher computing speeds to achieve faster equalization and better results.

REFERENCES:

- Omprakash Patel, Yogendra P. S. Maravi and Sanjeev Sharma, "*A COMPARATIVE STUDY OF HISTOGRAM EQUALIZATION BASED IMAGE ENHANCEMENT TECHNIQUES FOR BRIGHTNESS PRESERVATION AND CONTRAST ENHANCEMENT*". Signal & Image Processing: An International Journal (SIPIJ) Vol.4, No.5, October 2013.

- Nicholas Sia Pik Kong, Haidi Ibrahim, and Seng Chun Hoo," *Histogram Equalization and Its Variations for Digital Image Enhancement*". International Journal of Innovation, Management and Technology, Vol. 4, No. 4, August 2013

- *https://www.tutorialspoint.com/dip/histogram_equalization.htm*

- https://www.youtube.com/watch?v=PD5d7EKYLcA