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Modified techniques for color enhancement in Digital images

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ABSTRACT

Enhancement of color image is a very complex task with so many applications. Preservation of hue of the given image in all situations is very difficult. In this paper a very easy algorithm for enhancement is used which preserves the hue and range of the R, G, B channels of color image in very optimal way. The very first step is to transform the intensity image to a target intensity using meaningful strict ordering of pixels in which pixels are aligned in a fixed manner. Implementing the new algorithms on the image and its resulting image after enhancement should fit the image with target intensity. The analysis of new algorithms proposed in this paper is in terms of chromaticity improvement and a comparison with the algorithms given by Naik and Murthy, which is very popular and is histogram-based method for preserving Hue and Range of a color image. The results show that algorithms in this paper give much better enhancement as compared to Naik and Murthy. Despite being very simple, these algorithms give very excellent results insituations where Hue and range preservation is crucial.

I. INTRODUCTION

Image Processing

Image Processing is one of the most explored research area that is been defined under the specification of various associated processes. Image processing is having its importance and requirements in many application areas. These application areas include medical image processing, agricultural image processing, SAR image classification etc. The associated fields to the image processing further divided in several sub areas so that the information processing is defined as the framework so that the image information processing will be done.

Here, the image processing is defined under the specification of image level analysis applied on the information process also described with associated process stages and each process stage itself defines an application area. This process stages includes the recognition system, feature generation, segmentation, classification etc. In recent years, image processing comes up with better functionality and with its integration to many other sub domains such as video system processing, animated image processing will be done in effective and relative way. This kind of information systems are described under the specification of relative image processing issues such as outlier identification, image noise reduction, image feature enhancement etc. This kind of information process is described with specification of cost adaptive computation so that the information objects will be processed.

The image processing is itself devised as the hybrid mechanism defined under application specification with associated processes. This broad process area is defined along with the specification of various sub stages or the sub processes. Some of these sub processes associated to the system are described under.

- Image Information Classification
- Object Identification
- Object Detection
- Signal Feature Analysis
- Information Hiding with Image
- Feature Extraction

- Image Enhancement

The image enhancement plays the vital role in image processing. The visual quality of the image is affected by many factors. The images which are captured from the camera include some distortion or noise into the quality of image. To remove distortion and improving the contrast of the image we do image enhancement. It processes the input image and gives the enhanced output image with good contrast.

II. THEORY OF COLOR IMAGES INFORMATION

The tremendous progress in displaying color images and their enhancement is the main aim. As we know that color, Perception and appearance of the colors are still problems for the color images. The increasing demand for fast and efficient algorithms for improving the color content of digital images has been drastically. There are several applications for the improvement of color images, for example digital and mobile phone cameras, medical imaging, videos, post-production industry, restoration of old movies and old pictures. Color images are viewed and stored in form of three main components/channels): RGB (red, green, and blue). In the following paper, the aim is to design enhancement for color images in the RGB space by considering the three main features in the process, namely the Hue of an image, the preservation of Range of an image i.e. Gamut preservation and the computational complexity to be very low. The hue is the dominant color that covers most of the area of an image and this color is perceived mostly e.g., red color, orange color, magenta color, yellow color and so on[1],[2].

The nice property of Hue is that it remains invariant when undergoes changes in the intensity and direction of the incident light [3]. So the main aim is to preserve the Hue of an image and enhance the brightness which in turn will give us an image that appears to be very colorful. The preservation of Range during this process is usually ignored. For 8-bit coding the value of L is limited, say L=256 and this in a digital image it is for each color channel. The values of L that appears to out of the boundary of [0; L-1], be it larger or smaller during the process of enhancement, the values are clipped back which in turn changes the Hue of an image. When we are dealing with "megapixel" where images are usually taken by phone cameras, resources in implementation of hardware and extensions to video, the computational complexity we need is to be very low.

In this dissertation, we are not looking for the method that is fully automatic for enhancement of an image, but we are focusing on the method based on histogram in which we select the suitable target histogram, which satisfies the user's need with faster algorithms. For the achievement of our goal the algorithms we proposed compose of two simple stages.

(a) The matching of intensity channel of an RGB image with a specified histogram will give us the desired target histogram.
(b) In the next stage, with the target intensity we compute the RGB color values in an optimal way so that the Hue and Range constraints are satisfied.

These stages are briefly described below:

***Stage* (a).**Histogram matching or we can say exact histogram specification (HS), of a gray-valued image has a aim that transforms the image that is inputted to such a image as an output which fits exactly into the prescribed target histogram. We get a uniform histogram by Histogram equalization, which is also a special case of histogram specification (HS).

***Stage* (b).** The expansion of histogram-based methods to RGB images is a relatively composite task. The gray valued images have 1-D histogram whereas the RGB image or color images has 3-D histogram which in turn gives rise to a problem which is an under-determined problem. Additionally producing color images that respect the range constraints of color images is not an easy task. As a essential result of this following paper, optimal and a very general algorithms for color image enhancements are proposed.

Preliminaries

Let us consider an RGB image W=(Wr,Wg,Wb) of size MXN, where Wc €{0.........L-1}, red, green and blue components respectively. RGB image is an 8 bit image for which L=256. Each color channel is reordered column wise is a vector size n: MN and the pixels are addressed by the index seat Πn:= {1,.......n}.
Intensity of an RGB image is calculated using

F = γrWr +γgWg+ γbWb -------------------------------- 2.1

After calculating the intensity of the given RGB image we have to find out the target intensity which is found using algorithm 1. In algorithm 1, we find the exact histogram for the color image. Finding exact histogram means to have a definite shape of the histogram as desired. Thus, histogram equalization corresponds to the well-known technique used for obtaining the uniform histogram of an image. With the help of histogram equalization, the grey levels of the image are spread over the entire scale and each grey level is allocated equal number of pixels. Furthermore, we can say that the equalized image provides better appearance and make details visible for original image in all bright and dark regions. We can attain better results if we consider human visual system.

We can say that image normalization is attaining through exact histogramspecification. We can approach histogram specification as optimization problem. If we are given the original image histogram and the desired histogram then we have to find the mapping of grey level so that we get the best approximation of the desired histogram. This type of mapping can we found if we group the grey levels simply so that the errors in the desired histogram are approximately minimum. If we consider the classical approach to image enhancement using histogram specification then the intensity is considered as the continuous random variable which is characterized by the probability density function. If we consider statistical approaches for discrete versions, it could have yield exact results but only if CDFs had been invertible. Where pixels have distinct values only there the CDFs are invertible, otherwise they are staircase functions. Usually the numbers of pixels are larger than the number of grey levels but the case of distinct pixels is irrelevant. The CDF of the random variable z also determines the probability $P\{\mathbf{z} \le z\}$ and it is also dependent on the ordering relation that has been used. The problem of discrete exact histogram equalization/ specification is solved if the we replace previous ordering by new ordering relation, which gives strict ordering among image pixels.

III. PRINCIPLE FOR STRICT ORDERING

Let us consider F as a discrete NxM image having number of grey levels equal to L. Now let H= {h0, h1 ,..........hL-1} and this is the histogram that is to be specified. We should notice that H is the non-normalized histogram of an image i.e. h1 is the grey levels L that the number of pixels are having. Let is suppose that the induced ordering among the pixels is strict for the ordering relation, $\prec$. Then we simply proceed to exact histogram specification.

IV. ALGORITHM

Algorithm 1: Strict Ordering of Pixels

1) Order the pixels of image as:

$$F(x1, y1) \prec F(x2, y2) \prec .... \prec F(xNM, yNM) \text{ ---------------4.1}$$

2) Now, we have to split the ordered string of equation (20) from left to right in L groups in such a way that the group j has hj pixels.
3) For all the pixels of group j, assign them with grey levels j.
The exact equalization algorithm considers groups of NM/L pixels in step 2).

Affine Algorithms with Optimal Range Preservation

As we know that the affine algorithm is the convex combination of the shifting and scaling methods for some λ € [0,1]:

$$\hat{W}c[i] = \lambda F\,target[i]F[i]\,Wc[i] + (1-\lambda)(Wc[i] - F[i]) + Ftarget[i] \text{ …………..4.2}$$
$$= \alpha[i]\,(Wc[i] - F[i]) + Ftarget[i]$$

Where,

$$\alpha[i] = = \lambda F\,target[i]/F[i] + (1-\lambda)\text{…………………………………4.3}$$

Now since we know the upper and lower gamut correction So it clearly states for λ=1 we have the scaling model available and for λ=0 we have shifting model. Since we know that the algorithm proposed by Naik and Murthy is valid for α[i]=1 which produces new gamut problem. So we have proposed new methods which tells that after correcting the equations for gamut problem it does not yield new gamut problem.

Preposition 1: We assume that pixel i € Πn in equation 3.3 has and upper gamut problem. Then the correction of Ŵc[i] satisfies

$$0 \le \hat{W}c[i] \le L-1,\ c \in \{r, g, b\}$$

Here we also mention that lower gamut problem obviously cannot appear for the multiplicative model i.e. for $\lambda = 1$.

Preposition 2: Let $\lambda \in [0,1]$. We assume that pixel $i \in \Pi n$ in equation (4.3) has and lower gamut problem. Then the correction of $\hat{W}c[i]$ in equation (3.4) satisfies

$$0 \leq \hat{W}c[i] \leq L-1,\ c \in \{r, g, b\} \quad 33$$

Now by using the preposition 1 & 2, the algorithm for optimal range-preserving approximation of the affine model (4.3) can be easily computed in one iteration where all pixels in the input image are modified only once. The algorithms are explained below.

Algorithm 2 Optimal Range-Preserving Enhancement

1. Compute intensity F of W by equation (3.1) and target intensity Ftarget using algorithm 1
2. For all $i \in \Pi n$ compute M[i] and m[i] by equation (15) & (16) respectively. Then if F[i] = 0, then $\hat{W}[i]=0$ else compute equation (4.4) and

$$G\,\lambda m\,[i] := \alpha\,[i](m[i] - F\,[i]) + Ftarget[i] \text{ -------------------- } 4.5$$
$$G\,\lambda m\,[i] := \alpha\,[i](M[i] - F\,[i]) + Ftarget[i] \text{ -------------------- } 4.6$$

And for all $c \in \{r, g, b\}$;

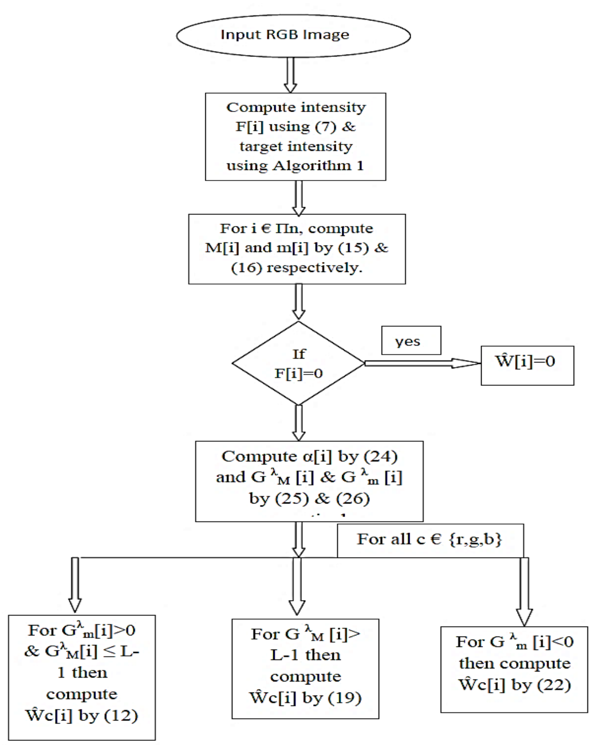
$$\hat{w}c\,[i] = \alpha[i]\,(\hat{w}c\,[i] - F\,[i]) + Ftarget[i]$$
$$\text{if } G\,\lambda m\,[i] \geq o \text{ and } G\,\lambda M\,[i] \leq L-1$$
$$\hat{w}c\,[i] := L-1-F\,target[i]M[i]-F[i]\,((Wc\,[i] - F\,[i]) + Ftarget[i]$$
$$\text{if } G\,\lambda M\,[i] > L-1$$
$$\hat{w}c\,[i] := F\,target[i]F[i]-m[i]\,(\hat{w}c\,[i] - F\,[i]) + Ftarget[i]$$
$$\text{if } G\,\lambda m\,[i] < 0\,.$$

Multiplicative, Additive Algorithms and their Combinations

From the algorithm 3 for $\lambda \in \{0,1\}$ we get two simple range preserving algorithms i.e. scaling and shifting algorithms known as Multiplicative and Additive algorithms respectively. Observing that,

$$G0m\,[i] = m[i] - F\,[i] + Ftarget[i] \text{ ------------------ } (4.7)$$
$$G0m\,[i] = M[i] - F\,[i] + Ftarget[i] \text{ ------------------ } (4.8)$$
$$G1M = Ftarget[i]F[i]\,M[i] \text{ -------------------------------- } (4.9)$$

Flow Chart for Algorithm 2

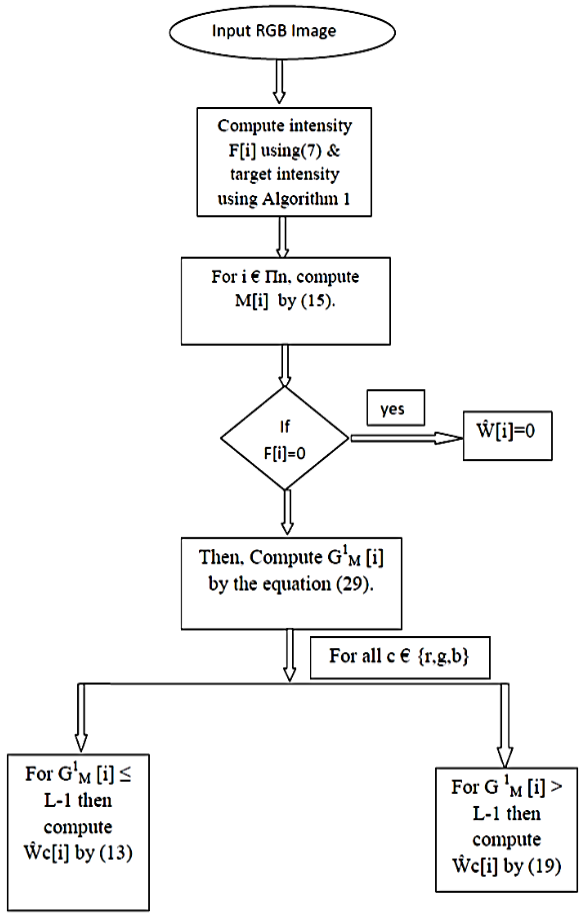


Algorithm 3 Multiplicative Color Enhancement

Step 1: Compute intensity F of W by equation (7) and target intensity Ftarget using algorithm 1
Step 2: For all i € Πn compute M[i] by equation (4.5). Then if F[i] = 0, then Ŵ[i]=0 else compute equation (4.9) and for all c € {r, g, b} ;

ŵc [i]:= L−1−F target[i]/(M[i]−F[i]) ((Wc [i] - F [i]) + Ftarget[i]
if G 1M [i] > L-1
ŵc [i]:= F target[i]/F[i] *(ŵc [i] - F [i]) + Ftarget[i]
if G 1m [i] ≤ L-1

Flow Chart for Algorithm 3



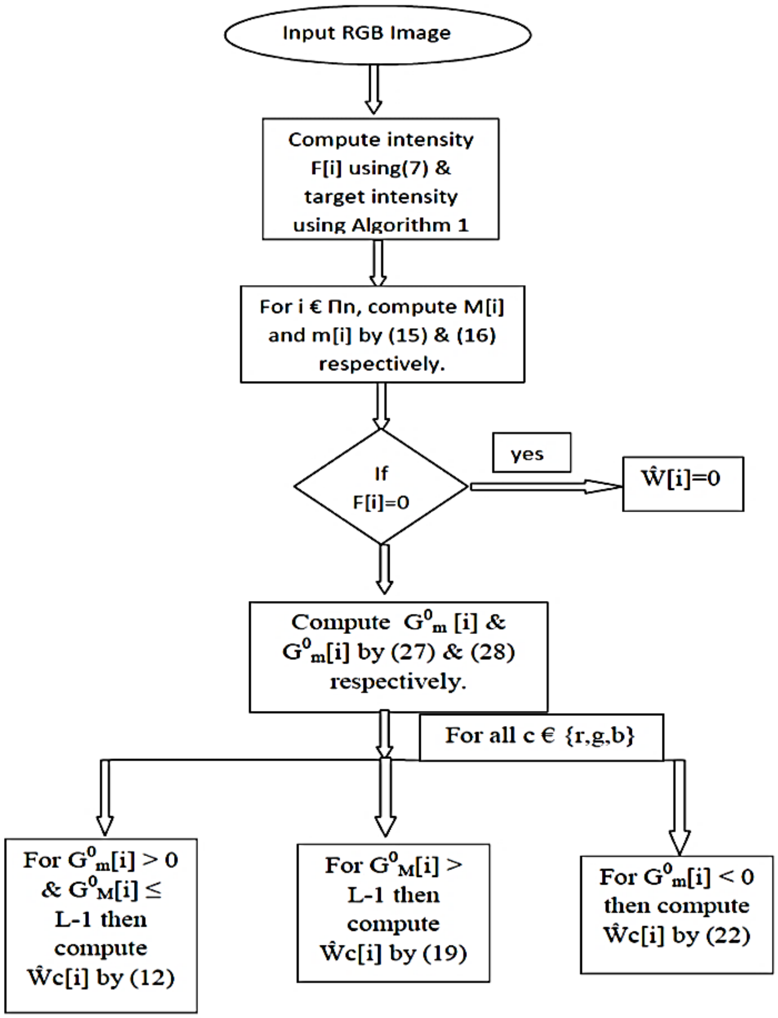
Algorithm 4 Additive Color Enhancement

Step 1: Compute intensity F of W by equation (4.7) and target intensity F target using algorithm 1

Step 2: For all i € Πn compute M[i] and m[i] by equation (4.5) & (4.6) respectively. Then if F[i] = 0, then Ŵ[i]=0 else compute equation (4.7) & (4.8) and for all c € {r, g, b} ;

ŵc [i] = α[i] (ŵc [i] - F [i]) + Ftarget[i]
if G 0m [i] ≥ o and G 0M [i]≤ L-1
ŵc [i]:= L−1−F target[i]/(M[i]−F[i]) ((Wc [i] - F [i]) + Ftarget[i]
if G 0M [i] > L-1
ŵc [i]:= F target[i]/(F[i]−m[i]) (ŵc [i] - F [i]) + Ftarget[i]
if G 0m [i] < 0 .

Flow Chart for Algorithm 4



Algorithm 5: Naik And Murthy's Algorithm

Case 1) $\alpha(lx) \leq 1$

$$x'k = \alpha(lx)\, xk \text{ for all } k = 1, 2, 3.$$

Case 2)

(i) Transform the RGB color space x to CMY color space y by y=(y1, y2, y3) , where yk = 1- xk , k = 1, 2, 3

(ii) Find $ly = y1 + y2 + y3 = 3 - lx$

(iii) Find $g(ly) = 3- F(lx)$, $\alpha(ly) = g(ly)/ ly$, note that $\alpha(ly) < 1$

(iv) $y'k = \alpha(ly)\, yk$ for all k =1, 2, 3

(v) Convert back to RGB space by transformation

$x' = (1- y'1, 1- y'2,1- y'3)$

Flow Chart for Algorithm 5

Figure 5.1 shows the original image with its image histogram

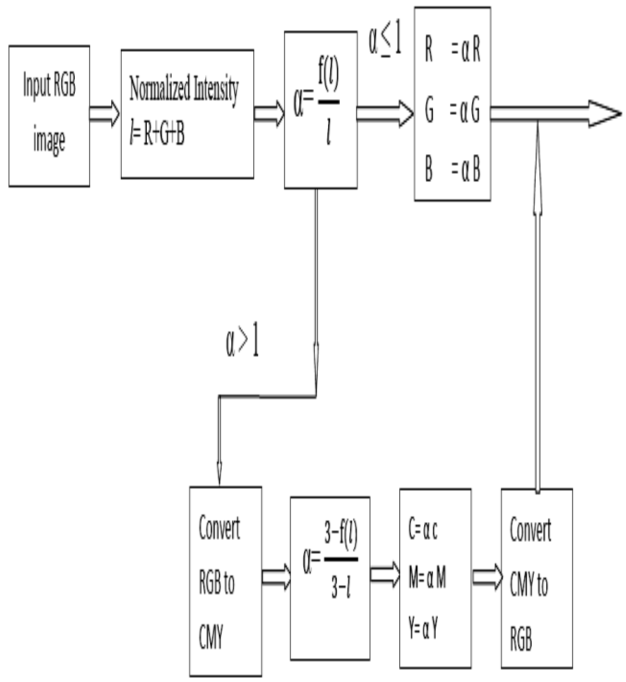


Figure 5 shows the original image with its image histogram

VI. SIMULATION RESULT

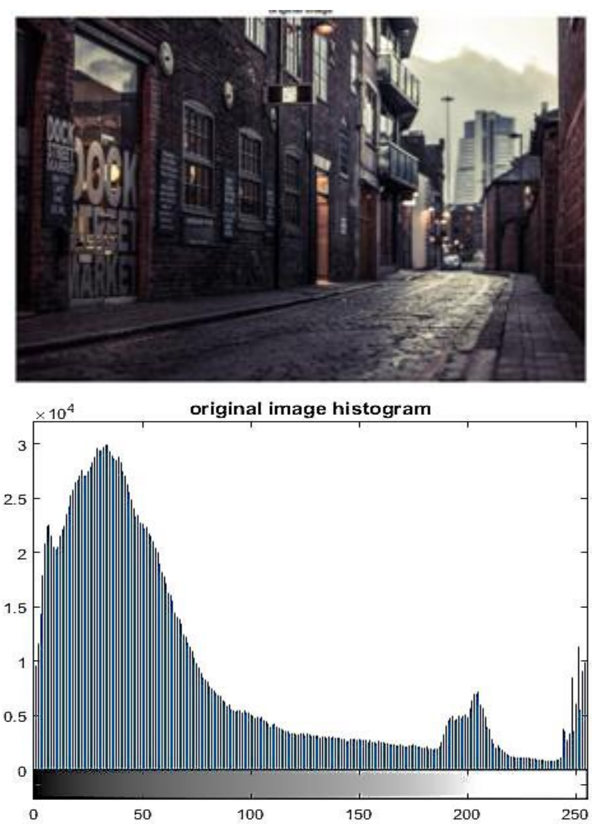


Fig 6: Shows the Original Image and Its Histogram

RESULTS FOR ALGORITHM 2:

From figure 6 and figure 7 we can see that there is noticeable enhancement is there due to the use of algorithm 2. Figure 8 represents the enhancement of images using various values of λ

Fig 7: Shows the Enhancement by Algorithm 2 for λ=0

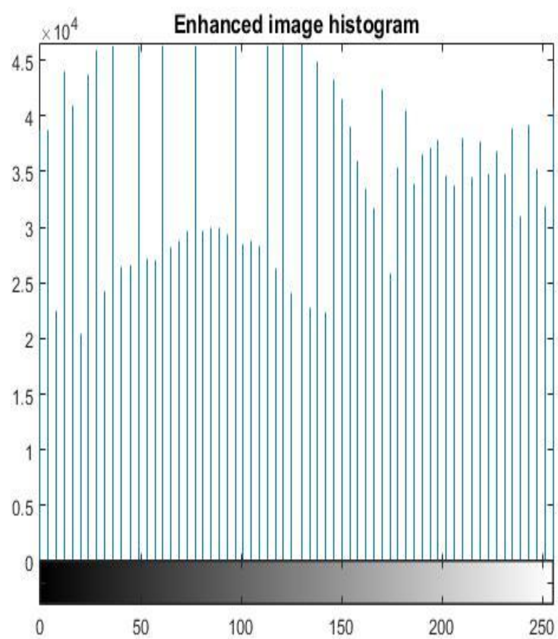


Fig 8: Shows Exact Histogram by implementing algorithm1 via algorithm 2

Figure 8 shows a comparative study of the noise enhancement techniques for various values of λ. We can see a noticeable change in the images as the value of λ goes on increasing.

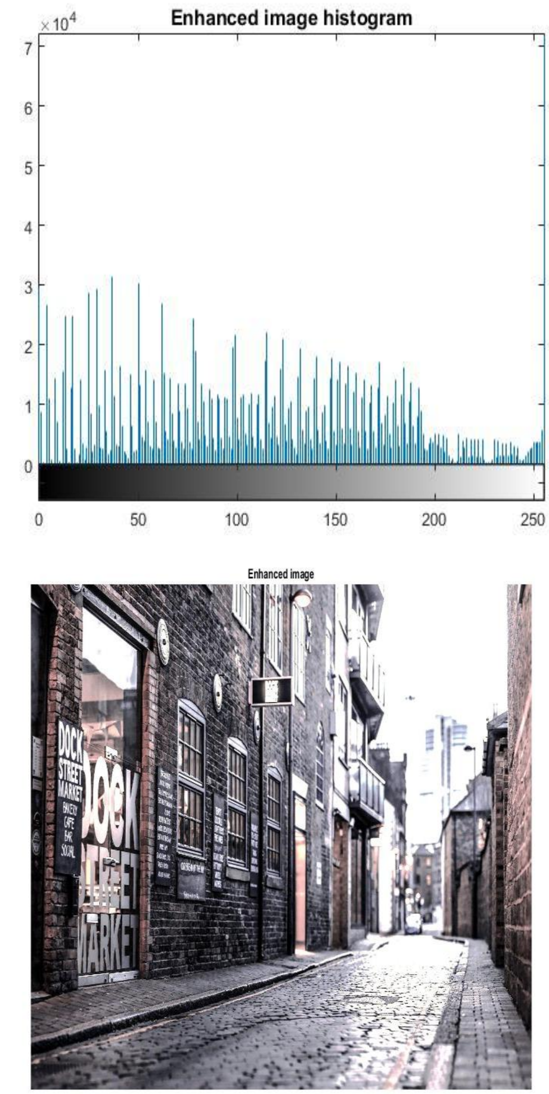


Fig 9: Shows the Enhancement by Algorithm 2 for λ=1/4

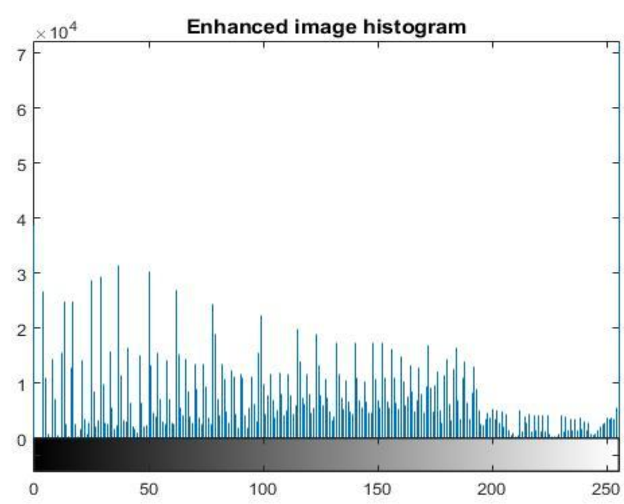


Fig 10: Shows the Enhancement by Algorithm 2 for λ=1/2

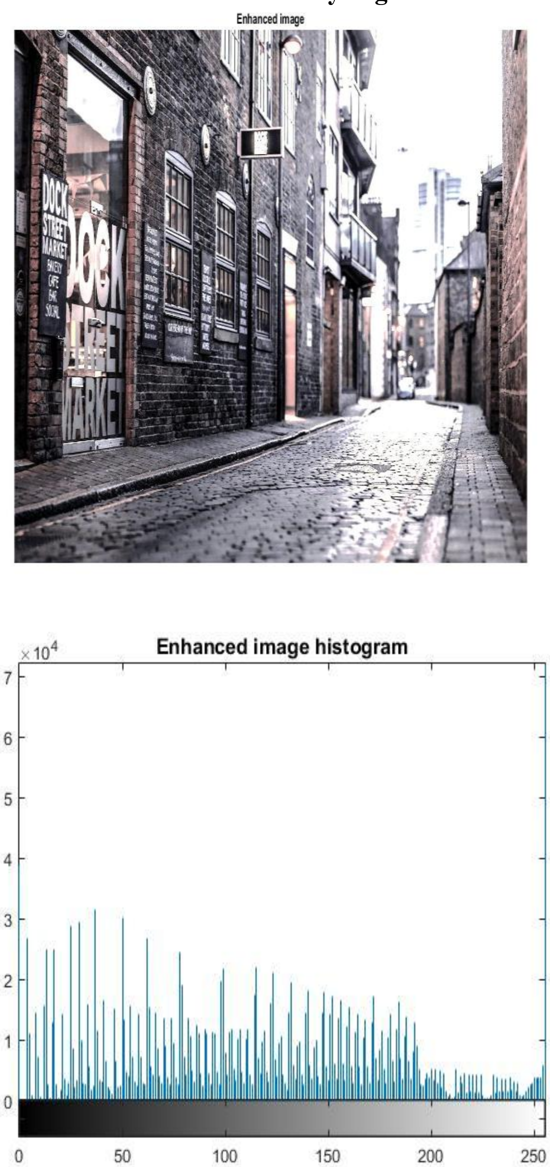


Fig 11: Shows the Enhancement by Algorithm 2 for λ=3/4

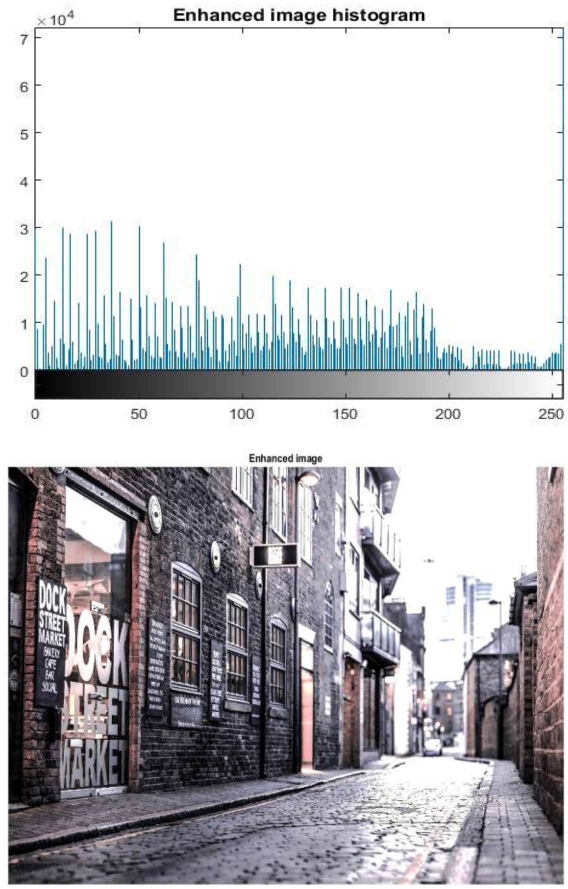
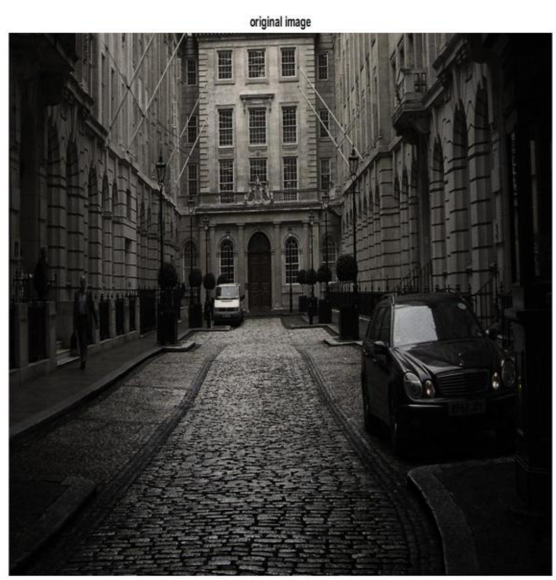


Fig 12: Shows the Enhancement by Algorithm 2 for λ=1

Results of Multiplicative Algorithm

Figure 12 shows the original image with its histogram. When we make use of multiplicative algorithm on this image for λ=0 the result are shown in figure 5.6. the exact histogram diagram for the enhanced image is shown also with figure.



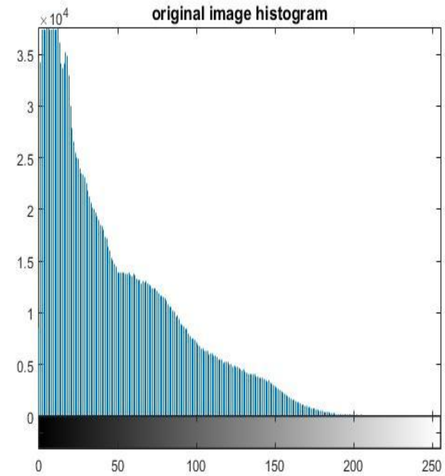
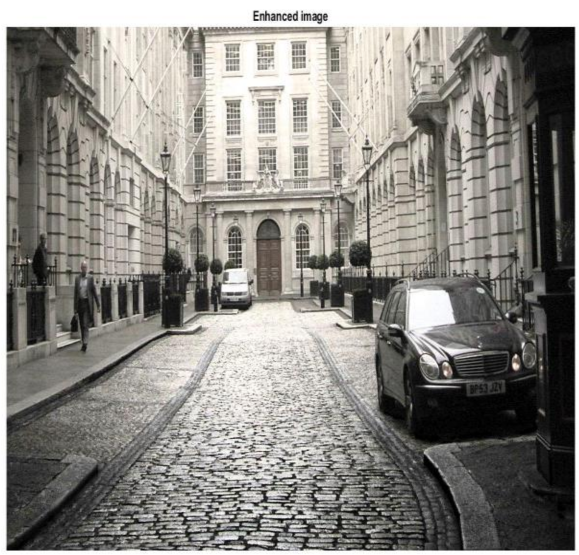


Fig 13: Shows the original image and its Exact Histogram



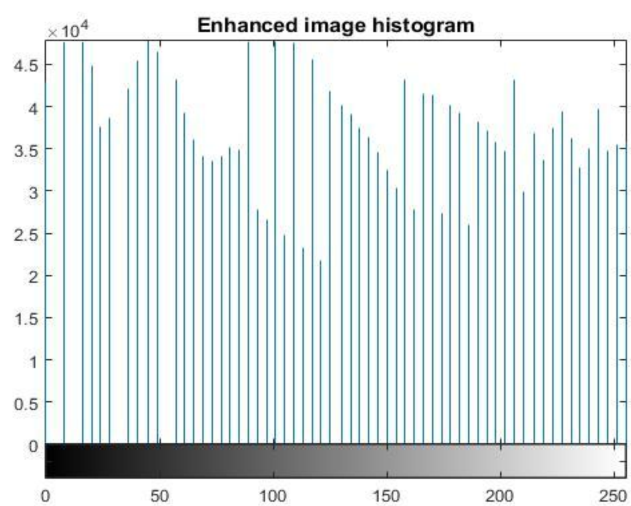


Fig 14: Shows the Enhancement by Multiplicative Algorithm 3 and its Exact Histogram

Results of Additive Algorithm

Figure 15 shows the original image with its histogram to be processed using additive algorithm. The results are processed using λ=0 values and are shown in figure 5.8

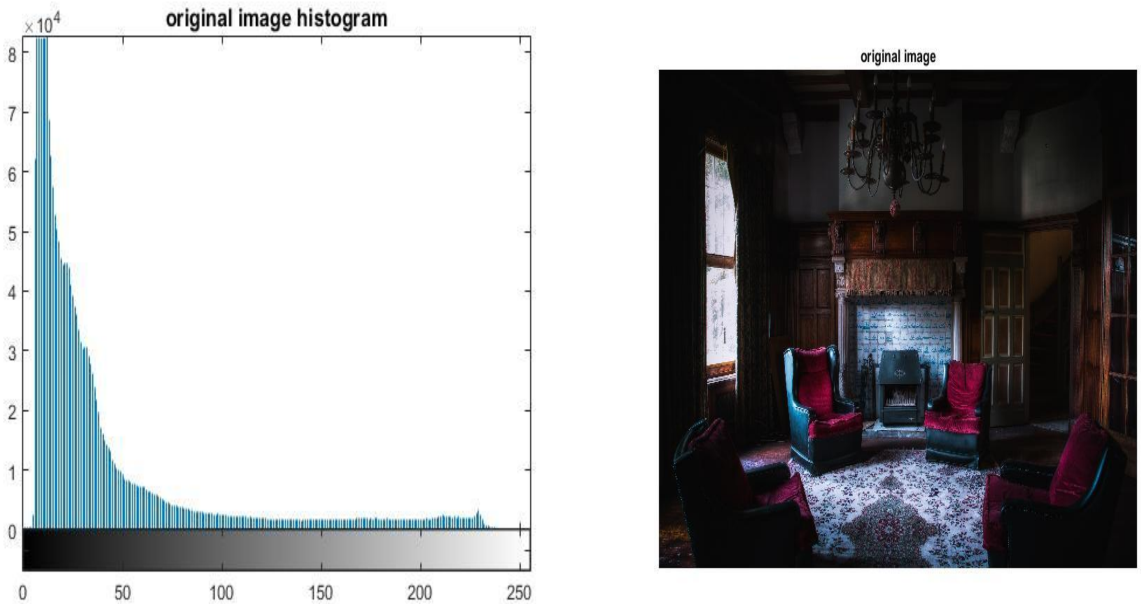


Fig 15 Shows the Original Image and its Histogram for implementation of Algorithm 4

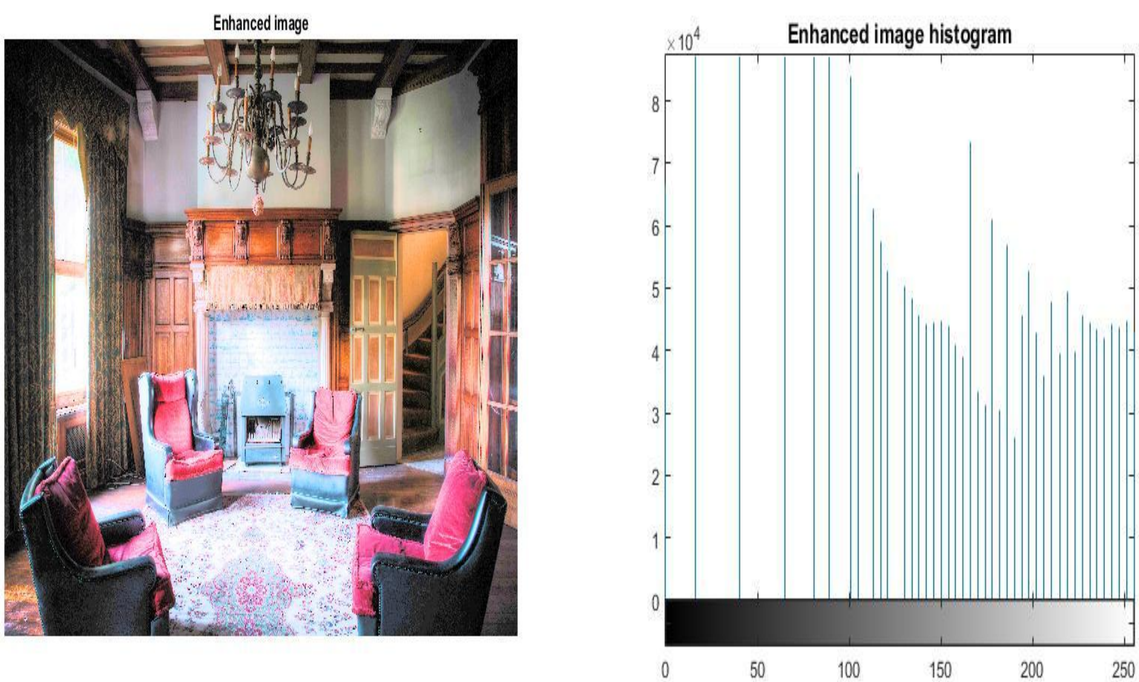


Fig 16 Shows the Enhancement by Additive Algorithm 4 and its Exact Histogram

Results For Naik And Murthy's Algorithm

Figure 5.9 shows a the results processed by Naik and Murthy algorithm. As from above results we can easily compare that the proposed algorithm have higher efficiency in enhancement of image than Naik and Murthy algorithm.

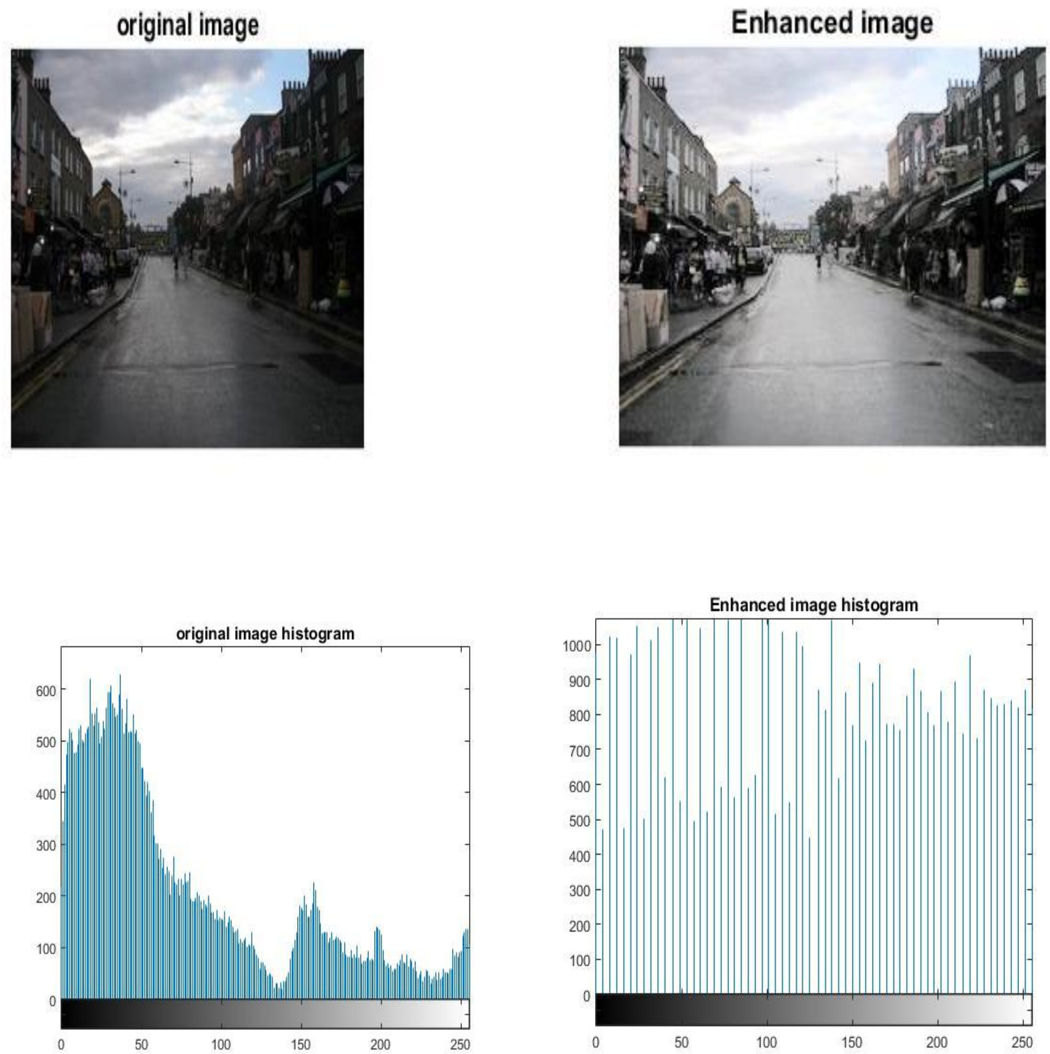


Fig 17: Shows the Original image and its Enhancement of byNaik and Murthy's Algorithm

CONCLUSION

In this dissertation we provide the most comprehensive and precise presentation of histogram specification along with affine algorithm for color image enhancement. We have proposed an algorithm that is fast and preserves the hue and range of an image. We analyze the performances of this algorithm and of two of its important instances as well as the gamut preserving method.

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