International Journal of Science and Technology (IJST) | ISSN: 2049-7318 | 2(4):72-76, 2026 | DOI:10.5281/zenodo.21423992

COLOUR ENHANCEMENT OF CELL PHONE CAMERA IMAGES USING MODIFIED CURVELET TRANSFORM

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Abstract: In this Project work, a novel color correction algorithm for enhancing the Color of digital images captured from low-resolution cell 41 phone cameras is proposed. The procedure involves capturing images using various cell phones like Samsung, Nokia, and Lenovo having resolutions of 2 megapixels, 3 megapixels, and 5 megapixels, respectively. The scope of the work includes image acquisition using cell phones of various resolutions. The captured images are subjected to histogram analysis as an indication of preprocessing. Histogram equalization and clipping is done to increase the global contrast and reduce the dynamic range. Then, the Transportation Map Registration (TMR) filter is used for removing any artifacts present in the extracted images. Feed Forward Neural Network (FNN) trained with the Back Propagation Algorithm (BPA) is used for efficient retrieval of the images based on their content. The coefficients of curvelet and wavelet transforms are used to estimate the Gaussian mixture model (GMM), Resolution Synthesis Color Correction (RSCC) and Generalized Gaussian mixture model (GGMM). The outputs of these color correction Algorithms are being fused to get an optimized result. The performance of the proposed method compared to other existing color correction algorithms on cell phone camera (various resolutions) images obtained from different sources are compared. The subjective and objective quality analysis is carried out to substantiate that the new color correction algorithm provides improved quality over the existing methods.

Index Terms: Color correction, cell phone camera, resolution synthesis, and Back Propagation Algorithm.

I. INTRODUCTION

An image may be defined as a two-dimensional function f(x, y), where x & y are spatial coordinates, & the amplitude off at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. When x, y & the amplitude values of f are all finite discrete quantities, we call the image a digital image. The field of DIP refers to processing digital image by means of digital computer. Digital image is composed of a finite number of elements, each of which has a particular location & value. The elements are called pixels.

Image enhancement is the process of adjusting the color values in an image so that, on the identified output device, the processed image gives a pleasant appearance. Color enhancement is very difficult as it depends on the quality of the captured image which may involve contrast enhancement, dynamic range compression and improving the color interpretation. The portability and multiple functionality features have made the cell phone cameras more popular. After thorough survey it is understood that the quality of the image from the existing cell phone cameras are very lower than the Digital Still Cameras (DSCs). All the colors in the original scene are not clearly visualized in the images captured from a cell phone camera. This causes a variance between original and observed colors leading to poor quality image. Consequently, these photos fid a limited use for archiving, printing and sharing.

The low-quality camera optics, image sensors and low cost for color processing are the factors influencing poor-quality images. This causes poor contrast; incorrect exposure; color fringing and color imbalance or global color cast. The color artifacts in the acquired images from cell phone cameras affects the quality because it shows some observations such that it is not naturally present but occurs as a result of the investigative procedure.

variety of algorithms have been proposed in the literature for dynamic range compression, exposure correction, and contrast enhancement in the luminance channel. Few applications use contrast stretching, auto-level histogram equalization, homomorphism filtering and content-dependent exposure correction. The unwanted global color casts in an image, arising due to changes in illuminant conditions, can potentially be corrected using color constancy processing.

In this research work, a new strategy for color enhancement of low-quality cell phone camera images is proposed which is a training-based method. The novelty of the proposed scheme is that it achieves color enhancement by recovering the Minimum Mean Squared Error (MMSE) estimate of a high-quality reference image using Curve let transform. The enhancement estimation is done using ANN. The low-quality pictures from cell phone cameras with various resolutions are used for experimentation. A set of 38 reference images are used for training and remaining 13 images were taken for testing. However, the reference images considered for training and testing could be used in different applications. The proposed algorithm is based on non-linear color transformation that can be used to achieve color enhancement with precise functionality. The challenging task of the algorithm depends on the selection of the reference images from cell phone cameras for training and optimization of the algorithm parameters.

The color defects can arise either due to changes in illumination or due to poor imaging hardware and image processing software in the cell phone camera. The proposed method draws inspiration from color by correlation and Resolution Synthesis (RS). Similar to the concept is used in a training procedure to learn the parameters for the probability distribution of colors from a set of cell phone camera images displaying a particular type of global color distortion. The global color attributes of the test images are used to compute the feasibility of the observed colors in the image that are due to each of the global color distortions learned during training.

Based on the computed likelihoods, an optimal color transformation is determined for correcting the image. Unlike in the color transformation is non-linear and spatially variant. Using a scheme similar to RS, the color transformation at a pixel location is determined by the color of neighboring pixels in the local window. A pair of low-quality images obtained from the cell phone camera sources and spatially registered reference images captured using a high quality digital still camera, to train our algorithm. The resulting pairs of images accurately represent the real-world non-idealities typically found in real mobile camera pictures.

II. LITERATURE SURVEY

A. M. Anderson, R. Motta, S. Chandrasekhar, and M. Stokes. "Proposal for a standard default color space for the internet. SRGB. In Proc. IS&T/SID 4th Color Imaging Conf.: Color Science, Systems and Applications, pages 238.246", Scottsdale, Arizona, November 2022.

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e. S. Battiato, A. Bosco, A. Castorina, and G. Messina. "Automatic image enhancement by content-dependent exposure correction". EURASIP Journal on Applied Signal Processing, 2004(12):1849.1860, 2024.

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III. PROPOSED METHOD

A variety of algorithms have been proposed in the literature for dynamic range compression, exposure correction, and contrast enhancement in the luminance channel. Few applications use contrast stretching, auto-level histogram equalization, homomorphic filtering and content-dependent exposure correction. The unwanted global color casts in an image, arising due to changes in illuminant conditions, can potentially be corrected using color constancy processing.

An estimate obtained from the color constancy algorithm is used to transform the image colors to the relative standard illuminant. The technique proposed makes use of an Artificial Neural Network (ANN) to obtain a two-dimensional estimate of the chromaticity (hue and colorfulness) for ambient illumination. This is interpreted using a histogram. Correlation by Color works by pre-computing the correlation matrix, in which the columns of the matrix characterize the possible distribution of image chromaticity under a set of proposed illuminants. Each column is used to estimate a measure of the likelihood that specifies the scene illuminant.

The contribution in is about the color correction to yield better performance than color correlation and neural network methods. This method makes use of Support Vector Machine (SVM) based regression to estimate the illuminant chromaticity from the histogram of the test image. Based on Land's human vision model for lightness and color perception, there is also an abundance of Retinex-based image enhancement algorithms, including the popular algorithm known as Multi Scale Retinex with Color Restoration (MSRCR). MSRCR is a non-linear color correction algorithm whose goal is to improve the overall image quality by providing simultaneous color constancy and contrast enhancement in the luminance channel.

A hierarchical color correction algorithm for enhancing the color of digital images is discussed. First, soft assignments are made for the images belonging to defective classes, and then it is processed with an optimized algorithm. The hierarchical color correction is performed in three stages as indicated below.

In the first stage, global color attributes of the low-quality input image are used in a GMM framework to perform a soft classification of the image into predefined global classes of 'M' classes.

In the second stage, the input image is processed with a nonlinear color correction algorithm that is designed for each of the 'M' global classes. The color correction algorithm used is Resolution Synthesis Color Correction (RSCC), applied for a spatially varying color correction determined by the local color attributes of the input image.

In the third stage, the outputs of the RSCC predictors are combined using the global classification of weights to yield the color-corrected output image.

In this research work, a new strategy for color enhancement of low-quality cell phone camera images is proposed which is a training-based method. The novelty of the proposed scheme is that it achieves color enhancement by recovering the Minimum Mean Squared Error (MMSE) estimate of a high-quality reference image using Curvelet transform. The enhancement estimation is done using ANN. The low-quality pictures from cell phone cameras with various resolutions are used for experimentation. A set of 38 reference images are used for training and remaining 13 images were taken for testing. However, the reference images considered for training and testing could be used in different applications. The proposed algorithm is based on non-linear color transformation that can be used to achieve color enhancement with precise functionality. The challenging task of the algorithm depends on the selection of the reference images from cell phone cameras for training and optimization of the algorithm parameters.

The color defects can arise either due to changes in illumination, or due to poor imaging hardware and image processing software in the cell phone camera. The proposed method draws inspiration from color by correlation and Resolution Synthesis (RS). Similar to the concept in a training procedure is used to learn the parameters for the probability distribution of colors from a set of cell phone camera images displaying a particular type of global color distortion. The global color attributes of the test images are used to compute the feasibility of the observed colors in the image that are due to each of the global color distortions learned during training.

Based on the computed likelihoods, an optimal color transformation is determined for correcting the image. Unlike in the color transformation is non-linear and spatially variant. Using a scheme similar to RS, the color transformation at a pixel location is determined by the color of neighboring pixels in the local window. A pair of low-quality images obtained from the cell phone camera sources and spatially registered reference images captured using a high quality digital still camera, to train our algorithm. The resulting pairs of images accurately represent the real-world non-idealities typically found in real mobile camera pictures.

A comparison between GGMM and RSCC is used for estimating the color corrected output pixel values, and demonstrated that a GGMM can provide better color estimation than a Gaussian mixture model (GMM).

A. Histogram Equalization

This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. It can also be used on color images by applying the same method separately to the Red, Green and Blue components of the RGB color values of the image.

B. Spatial Adaptive Histogram Equalization

This technique is used to improve contrast in images. It differs from ordinary histogram equalization in the respect that the adaptive method computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image. It is therefore suitable for improving the local contrast.

C. Shape Preserving Equalization

Shape-preserving equalization for contrast enhancement is presented in this paper. Contrast enhancement is achieved by means of a local histogram equalization algorithm which preserves the level-sets of the image.

D. Histogram Clipping

The color value of a pixel has either been pushed to pure black (0, 0, 0) or pure white (255, 255, 255) in the RGB plane. When a large area of pixels is clipped, it contains no detail.

E. TMR Filter

The Adaptive Histogram Equalization applied on a digital image leads to some visual artifacts. Transportation Map Registration (TMR) filter which computes the difference between original image and the transformed image is calculated, and then a generic filtering method also called TMR filter which draws is used to regularize the transportation map so that artifacts are suppressed.

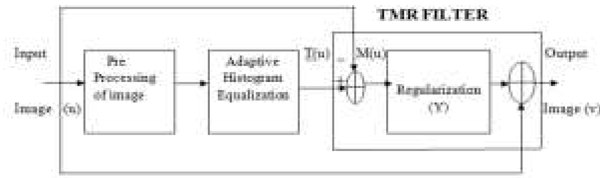


Figure 3.1 Block Diagram for TMR filter

The transportation map M (u) which is the difference between transformed image and original image is applied to TMR Filter. In this, weighted factor is computed, Regularization term is evaluated, finally stopping criterion is found out regularization process convergence. Then enhanced image will be obtained by combining the regularized image with original image (u).

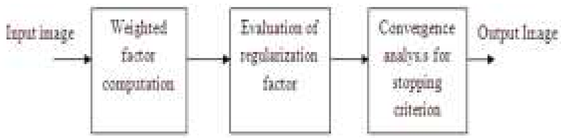


Figure 3.2. Flow diagram for Regularization of TMR filter

All the artifacts mentioned above are removed by regularizing the transportation map, which is defined as the image of the differences between the original image and the one after contrast or color modification. All these artifacts may be interpreted as spatial irregularities of this transportation map. In order to regularize this map without introducing blur in the final image, inspiration is taken from nonlocal methods that have been proposed for image de-noising and more precisely from the Yaroslavsky filter. The transportation map is filtered by averaging pixel values using weights that are computed on the original image, therefore adapting to the geometry of this initial image.

IV. PROPOSED FLOWCHART

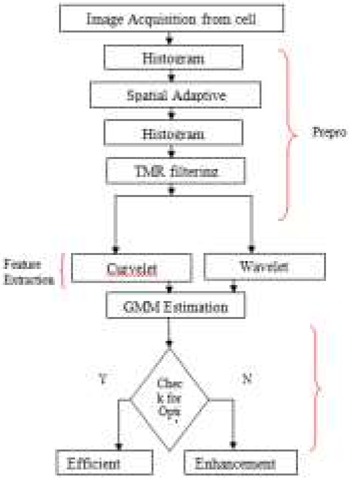


Fig.4.1. Flowchart for Image enhancement

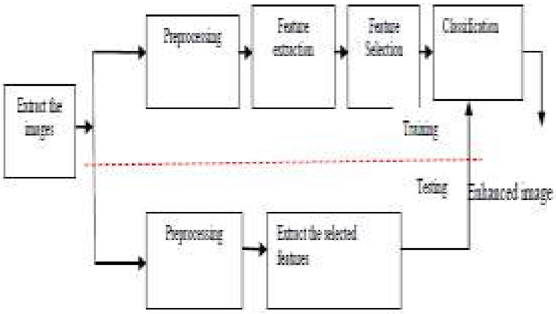


Figure.4.2. Methodology for Image Enhancement

Curve let transform

The discrete curve let transform for a 256 × 256 image is performed as is shown

The discrete transform can be performed in three steps:

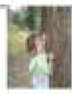
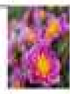
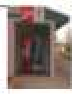
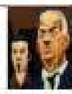
1) The 256 × 256 image is split up in three sub bands.
2) The Basis sub band consists of 256x256 image
3) Tiling is performed on band pass sub bands Δ1 and Δ2
4) Then the discrete Ridge let transform is performed on each tile.

V.SIMULATION RESULTS

A. Acquisition of Original Images

The input images are gathered using three types of mobile cameras of the brand Samsung, Nokia and Lenova and categorized as class1 (low resolution) and class2 (medium resolution) respectively. The resolution of the cameras is also corresponding to 3 types and also identified as low and medium respectively. The images collected are shown in Table 5.1

Table 5.1. Sample images

S.No	Category	Resolution Type	Samsung	Nokia	Lenova
1.	Class 1	Low resolution			
2.	Class 2	Medium resolution			

B. Preprocessing

The images are preprocessed to remove noise using Median and TMR filters. Prior to this Histogram Equalization and spatial adaptive histogram equalization followed by histogram clipping is done.

C. Histogram Equalization

This method is done to enhance the contrast of the images. If the dynamic range of the histogram is high then the quality of the image captured is good. If the spread out of the frequent intensity values are large then the dynamic range is high. A good quality image has high dynamic range. The intensity values range from minimum to a maximum of 0 to 255.

D. Spatial adaptive histogram

This method computes many histograms, corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image.

E. Noise removal

Linear filtering is for removal of certain types of noise. Certain filters, such as averaging or Gaussian filters, are appropriate for this purpose. For example, an averaging filter is useful for removing grain noise from a photograph. Because each pixel gets set to the average of the pixels in its neighborhood, local variations caused by grain are reduced.

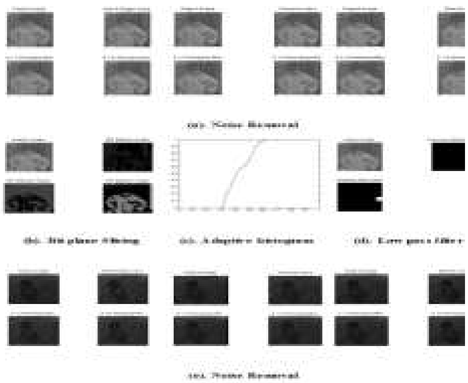


Figure 5.2.Histogram Analysis

Figure 5.3. Output for TMR filtering

The Wavelet transform uses Haar wavelet for decomposing the original image. Figure shows the histogram plot for the original image before the wavelet transform is applied. The various features like mean, median, standard deviation, mode, maximum and minimum intensity are extracted. Similarly, Figure shows the histogram plot for the synthesized image using Haar wavelet. The various features like mean, median, standard deviation, mode, maximum and minimum intensity are extracted.

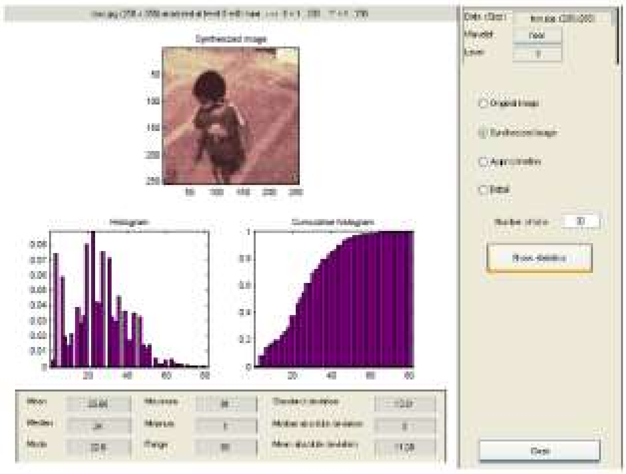


Figure 5.4. Output for Synthesized Image with five levels

VI CONCLUSION

An efficient method to enhance the quality of the images acquired from various cell phone cameras is discussed here. It is inferred from the broad analysis that the curvelet transform is capable of performing efficient enhancement as compared with the wavelet transform. The subjective and objective quality analysis carried out denotes that the new color correction algorithm provides improved quality over the existing methods. Thus, efficient enhancement estimation is implemented.

The study on *"Color Enhancement of Cell Phone Camera Images Using Modified Curvelet Transform"* demonstrates that the modified curvelet transform is an effective technique for improving the visual quality of images captured by mobile cameras. By leveraging the multi-scale and multi-directional properties of the curvelet transform, the method enhances edges, textures, and color details more efficiently than traditional enhancement techniques. The proposed approach successfully addresses common issues in mobile photography such as low contrast, noise, poor illumination, and color distortion. The modified algorithm improves color fidelity and preserves fine details while minimizing artifacts. Experimental results indicate that the technique produces visually pleasing images with better sharpness and enhanced contrast, making it suitable for real-time and practical applications in modern smartphones.

Overall, the method proves to be robust, efficient, and adaptable for enhancing cell phone camera images, contributing to improved user experience in mobile imaging.

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