Low Light Image Enhancement Using Zero-DCE algorithm

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Abstract - *In modern world image enhancement is one of the complex task. The proposed Low Light image enhancement using Zero DCE (Zero Reference Deep Curve Estimation) algorithm improves the quality, color correction and accuracy of the image. It is useful in many of the applications such as military applications, object detection, recognition, and also in 3D reconstruction of images. When image is captured in low light objects are not clearly visible, lot of noise and image disturbances present because of that image is not clearly visible. Normally images contains light over specific range of wavelength corresponding to the visible portion of the spectrum.By using Zero DCE(Zero Reference Deep Curve Estimation) we improved the image quality and accuracy via DCE-Net(Deep Curve Estimate Network) and LE(light Enhancement) curve.*

1. INTRODUCTION

Images plays very vital role in modern world. Detecting the object in low light image is very challenging task. In today's world low light image enhancement is highly demanded. It needs to improve the visual appearance of the image to provide better transform for future image processing. Low light images contains noise, low contrast which needs to be enhance and produce accurate, denoise image. At some movements of life we can't click images again and again like our childhood images. We need cleared images that can be done by using Zero DCE. Various image enhancement algorithms are proposed, they focuses on contrast enhancement. However the Zero DCE algorithm focuses on uniform enhancement. We present the framework of Zero-DCE (Zero Reference Deep Curve Estimation). The algorithm contains DCE-Net, LE curve and non-reference loss function. DCE-Net algorithm estimates the best fitting LE Curves onto an given input image. Framework performs mapping of input version's RGB channel pixels by applying curves iteratively for obtaining final enhanced version. DCE-Net finds the best fitting curve parameters between input image and output image. It improves the pixel quality of the dark image. Then the next stage of the image is LE curve. We iteratively apply LE curve which contains parameters α and number of iterations n. Then next stage of image is non reference loss function that evaluate the quality of the enhance image. This algorithm is also works with DSLR images and dark video.

1.1 Motivation

In today's hustle bustle life the technologies main goal is to make the things more clear, accurate, less time consuming and easy to understand. As we know that images plays very precious role in our life like by using images we can represent whole life journey in a few minutes. There is some condition where images are captured in low light circumstances because of which objects inside images are not clearly visible. So, to overcome this problem we proposed a system for low light image enhancement using Zero DCE which take dark images as an input and producing enhanced images as an output.

1.2 AIM and Objective

The main aim of this project is to accept the low light image as input and produce the enhanced image as output by using Zero DCE (Zero Reference Deep Curve Estimation) algorithm.

Following are the objectives:

1 .To be used in many real application like automated driving.

2. To be used for task like for classification, segmentation, recognition, scene understanding and also for 3D reconstruction of images.

1.3 Basic Concept

Our solution is to transfer the dark image as enhance image via Zero DCE algorithm. The algorithm focuses on the color correction. If the input image has some noise , Zero DCE result will also has noise, hence we improve the result by doing denoising .Zero DCE focuses on three steps such as color correction, Denoising and retrain the model.

2. Background study:

The basic idea of this project came from a background study of [3] which formulates light enhancement as a task of image-specific curve estimation with a deep network and "A CNN-Based Method to Enhance Low-Light Remote-Sensing Images" written by Linshu Hu , Mengjiao Qin , Feng Zhang , Zhenhong Du and Renyi Liu[10] they used SRCNN(Super Resolution CNN) , Remote Sensing images are enhanced on basis of new architecture using SRCNN(Super Resolution CNN)[10]

Li Tao , Chuang Zhu, Jiawen Song, Tao Lu, Huizhu Jia implemented Low Light image enhancement using CNN and channel priority.Using CNN framework to denoise an low light image. Then on basis of atmosphere scattering model produced an simple enhanced image prior with high contrast. Denoising done using AWGN(Additive White Gaussian Noise) method. On basis of VDSR(Super resolution CNN) and DnCNN(denoising network CNN) they proposed a denoising CNN to remove image noise. Then the noise free image is converted to enhanced image. In this paper, a joint effective method is proposed by combining denoising and contrast enhancement for low-light images.[2]

3. Block Diagram:

Input Image: Noisy Image which will be denoised using STN(Structure Texture Noise Decomposition).

Zero DCE: Zero Reference Deep Curve Estimation algorithm used to enhance low light image using a zero reference image.

Convolution Layer: The original input image is converted into greyscale matrix. After transformation of image into big matrix we multiplied this big matrix with predefined small matrix of sharpen convolution layer. The new version of image we get has clearly visible edges.[2]

CNN Model:While constructing a Neural Network, at the initial stage, we initialize weights with some random values or any variable for that fact. It's not necessary that whatever values of the weights we have selected need to be correct or it fits the model best.

Color Restoration:In this step greyscale images restore their colour using RGB space values. Output Image: The result of above steps is an Enhanced Image eg: Fig1.1

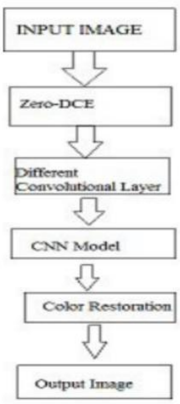


Fig -1.1

4. Algorithms:

4.1.1:

Light Enhancement Curve (LE-Curve):

The curve adjustments methods used in photo editing softwares inspired us to implement the same design such that , a LE curve which can map a low light image to its enhanced version.

Self adaptive curve parameters depends on input image. Three objectives of the design:

A) The pixel value of each in the enhanced version should be within range [0,1] , leads to avoiding information loss at time of overflow truncation.

B) Monotonous curve to preserve contrast of neighbouring pixels.

C) Form of curve should be differentiable before gradient propagation.

Below is an illustration of the mechanism:

Eq 1 --> $LE(I(x); \alpha) = I(x) + \alpha I(x)(1 - I(x))$,
Here, x is denoted as pixel coordinates
$LE(I(x); \alpha)$ denotes enhanced version of input.

$I(\alpha)$ is the trainable curve parameter , must be within [-1, 1].

Exposure level in the input is controlled by $I(\alpha)$.

The LE- Curve is applicable for not only enhancing the darker regions but also diminishing over-exposure effects.

4.1.1.1:

Higher Order Curves:

Equation 1 can be modified as following to iteratively enable more versatile modifications to the input to overcome low light conditions .Specifically,
$LE_n(x) = LE_{n-1}(x) + \alpha_n LE_{n-1}(x)(1 - LE_{n-1}(x))$, (2)

4.1.1.2

Pixel-Wise Curve:

A limitation of higher order curve is that it produces an over/under enhanced local regions in input image. To address the issue we formulate α as pixel wise parameter, each pixel value will have a corresponding best-fitting curve to modify its dynamic range.

Hence, Eq.(2)
$LE_n(x) = LE_{n-1}(x)+A_n(x)LE_{n-1}(x)(1-LE_{n-1}(x))$, (3)

Here, A is a parameter map with the same size as the given image. Here, we assume that pixels in a local region have the same intensity (also the same adjustment curves), and thus the neighboring pixels in the output result still preserve the monotonous relations. In this way, the pixel-wise higher-order curves also comply with three objectives.[3]

4.1.2

ZERO DCE:

A DCE net algorithm maps the input image to its best fitting curve. Zero DCE takes an low light image as an input and produces an enhanced version. Deploying a plain CNN of 7 convolution layers with a symmetrical concatenation. The DCE net architecture has 32 convolution kernels of 3x3 size and 1 stride. Discarding the down sampling and normalizing training batch. Training data consists of 79,416 images of 256x256x3 size.

4.1.2.1

DCE-Net ‘s Non-Reference Loss Functions :

To enable zero-reference learning in DCE-Net, we provide diffrentiable non-reference losses that allows to evaluate the quality of enhanced version. The following four types of losses are adopted to train our DCE-Net[3]. Spatial Consistency Loss. The spatial consistency loss L_{spa} encourages spatial coherence of the enhanced image through preserving the difference of neighboring regions between the input image and its enhanced version: L_{spa} = 1 K K i=1 j∈Ω(i) (|(Yi − Yj)|−|(Ii − Ij)|) 2, We denote Y and I as average of intensity of exposure in the enhanced version and input .We empirically set the size of the local region to 4×4.

Input

Zero-DCE

w/o L_{SPA}

W/0 L_{exp}

W/0 L_{COL}

w/0 L_{tvA}

Ablation study of the contribution of each loss (spatial consistency loss L_{spa}, exposure control loss L_{exp}, color constancy loss L_{col}, illumination smoothness loss L_{tvA}).

4.1.3

CNN FOR DENOISING:

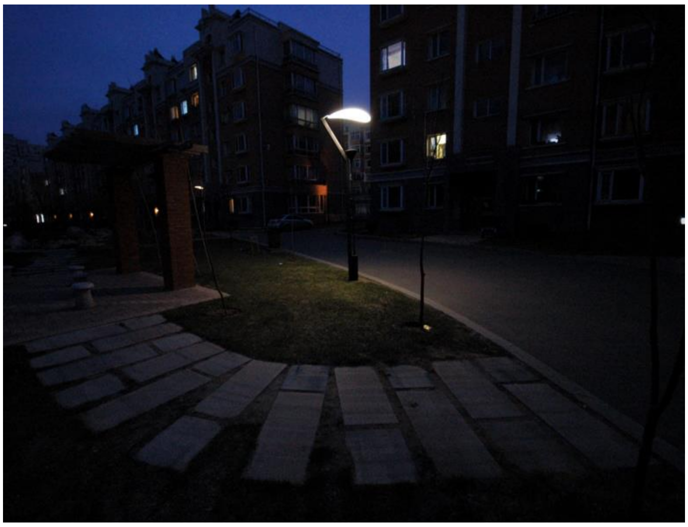
Most commonly, noise signal in images is assumed to be independent, identically distributed. Thus, denoise methods usually focus attention on the problem of attenuating additive white Gaussian noise (AWGN). These methods assume that the standard deviation σ of the AWGN has been accurately estimated. Many methods do estimate the variance accurately in most cases but still have non-negligible errors in some special situations.[2]

4.1.4:

Illuminant Estimation Performs color balancing via histogram normalization. 1. Determine the histogram for each RGB channel and find the quantiles that correspond to our desired saturation level. 2. Cut off the outlying values by saturating a certain percentage of the pixels to black and white. 3. The saturated histogram is then scaled for full range of 0-255.

Results:

A)Input:



Input low light image taken in 800x640 resolution

B) Zero-DCE$_{LOW}$:

Zer-DCE$_{Low}$

light image converted to slight exposure version

C) Zero-DCE$_{LargeL}$:

D) Zero-DCE$_{LargeLH}$:

Performs color balancing via histogram normalization

E)Output Enhanced version:

5. CONCLUSION

We proposed a deep network for low-light image enhancement. It can be trained end-to-end with zero reference images. This is achieved by formulating the low-light image enhancement task as an image-specific curve estimation problem, and devising a set of differentiable non reference losses. Experiments demonstrate the superiority of our method against existing light enhancement methods. In future work, we will try to introduce semantic information to solve hard cases and consider the effects of noise[3]

REFERENCES

[1] Lin Li, Ronggang Wang,Wenmin Wang, Wen Gao, "A LOW-LIGHT IMAGE ENHANCEMENT METHOD FOR BOTH DENOISING AND CONTRAST ENLARGING", 2015,

[2] Li Tao, Chuang Zhu, Jiawen, Tao Lu,Huizhu Jia, "LOW-LIGHT IMAGE ENHANCEMENT USING CNN AND BRIGHT CHANNEL PRIOR", 2017 , IEEE

[3] Chunle Guo, Chongyi Li, Jichang Guo, Chen Change Loy, Junhui Hou ," Zero- Reference Deep Curve Estimation for Low-Light Image Enhancement" ,2020,IEEE

[4] K. Elissa, "Title of paper if known," unpublished. Jaemoon Lim, Minhyeok Heo, Chul Lee, Chang-Su Kim, "Contrast Enhancement of Noisy Low-Light Images Based on Structure-TextureNoise Decomposition" ,2017 , Journal Visual Communication and Image Representation

[5] Shi Yangming, Wu Xiaopo," Low-light Image Enhancement Algorithm Based on Retinex and Generative Adversarial Network" , 2019, IEEE

[6] Yu Zhang, Xiaoguang Di, Bin Zhang, Qingyan Li, Shiyu Yan, "Self-supervised Low Light Image Enhancement and Denoising" ,2021, Article on arxiv

[7] Anjali Ratate, Priyanka Patil, Siddhi Wavre, "Low Light Image Enhancement using Convolutional Neural Network", 2020, International Research Journal of Engineering and Technology (IRJET)

[8] Eunjae Ha, Heunseung Lim, Soohwan Yu, "Low-light Image Enhancement Using Dual Convolutional Neural Networks for Vehicular Imaging Systems", 2020, IEEE International conference on Consumer Electronics

[9] Junyi Xiea, , Hao Biana,, Yuanhang Wua , Yu Zhaoa , Linmin Shana , Shijie Haoa, "Semantically-guided low-light image enhancement" ,2020, International Association for Pattern Recognition

[10] Linshu Hu , Mengjiao Qin , Feng Zhang , Zhenhong Du and Renyi Liu, "A CNN-Based Method to Enhance Low-Light Remote-Sensing Images", 2021, Multidisciplinary Digital Publishing Institute

[11]]https://uwaterloo.ca/vision-image-processing-lab/research-demos/vip-lowlight-datase