COL 783
Digital Image Analysis

Assignment 1

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A. Demosaicing

We have performed the following operations on bayer images:

- Mosaiced image – just coded with the Bayer filter colors.
- Bilinear interpolation on image.
- Complete Implementation of the Demosaicing Paper.
- Comparison of our output with Matlab’s demosaic() algorithm.

Mosaiced image – just coded with the Bayer filter colors

Output image (without Bilinear Interpolation)

Groundtruth image

Mosaiced image – just coded with the Bayer filter colors

Bilinear interpolation on image(edges are not very clear)

Groundtruth image

Mosaiced image – just coded with the Bayer filter colors

Complete Implementation of the Demosaicing Paper. Added the delta term in the Bilinear Interpolation image(above). Edges are very clear.

Groundtruth image

Mosaiced image – just coded with the Bayer filter colors

Complete Implementation of the Demosaicing Paper. Added the delta term in the Bilinear Interpolation image(above). Edges are very clear.

Output of Matlab's demosaic() algorithm

Mosaiced image – just coded with the Bayer filter colors

Output image (without Bilinear Interpolation)

Groundtruth image

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Bilinear interpolation on image(edges are not very clear)

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Output of Matlab's demosaic() algorithm

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Output image (without Bilinear Interpolation)

Groundtruth image

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Output of Matlab's demosaic() algorithm

Mosaiced image – just coded with the Bayer filter colors

Output image (without Bilinear Interpolation)

Groundtruth image

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Bilinear interpolation on image(edges are not very clear)

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Mosaiced image – just coded with the Bayer filter colors

Complete Implementation of the Demosaicing Paper. Added the delta term in the Bilinear Interpolation image(above). Edges are very clear.

Output of Matlab's demosaic() algorithm

Demosaicing Results

Image id	1	2	3	4
Time taken	44.15 sec	44.69 sec	44.11 sec	44.11 sec
only bilinear interp PSNR	(36.6651, 38.7759, 36.8431)	(36.2197, 38.575, 36.5564)	(31.7031, 33.3861, 31.7276)	(33.8583, 35.6594, 33.887)
Final image PSNR	(38.4209, 40.7874, 38.2838)	(38.1996, 39.3575, 37.3814)	(32.1601, 35.0893, 32.2311)	(34.8433, 37.4291, 35.0586)
Improvement over bilinear image	([1.7558, 2.0115, 1.4407)	(1.9799, 0.7825, 0.825)	(0.457, 1.7032, 0.5035)	(0.985, 1.7697, 1.1716)
Matlab image's PSNR	(38.6859, 41.2405, 38.5204)	(38.4807, 40.5134, 37.6879)	(32.6112, 35.2309, 32.5493)	(35.1662, 37.8272, 35.3879)

B. Image Enhancement (Night time)

We have performed the following operations on the nighttime images.

- Gamma Correction.
- Histogram Equalization.
- Adaptive Histogram Equalization.
- Gamma Correction + Adaptive Histogram Equalization.
- Dual Illumination Estimation for Robust Exposure Correction.

Dataset

Verdict.

Dataset

Input Image

Expected Result

Dataset

Input Image

Expected Result

Dataset

Input Image

Expected Result

Dataset

Along with the given input images we have captured a few images on our mobile devices with the night mode turned off and below are those images.

Gamma Correction

We have applied gamma correction at different values of gamma ,which helped in increasing the brightness of the image.

The following slides shows the result of images at different gamma values.

In most of the cases the best results were obtained when the gamma value was equal to 2.

Gamma Correction Results.

Input image 1 with gamma = 2.0

Input image 2 with gamma = 2.0

Gamma Correction Results.

Input image 3 with gamma = 2.0

Input image 4 with gamma = 2.0

Gamma Correction Results.

Input image 5 with gamma = 2.0

Histogram Equalization

We have applied histogram equalization ,which helped in increasing the contrast of the image.

The following slides shows the result of images after histogram equalization.

Histogram equalization was applied at different colour spaces.

- HSV
- YUV
- LAB
- YCrCb

In most of the cases the results had a very high increase in the contrast value.

Histogram Equalization Results.

Image 1 output in HSV

Image 1 output in LAB

Histogram Equalization Results.

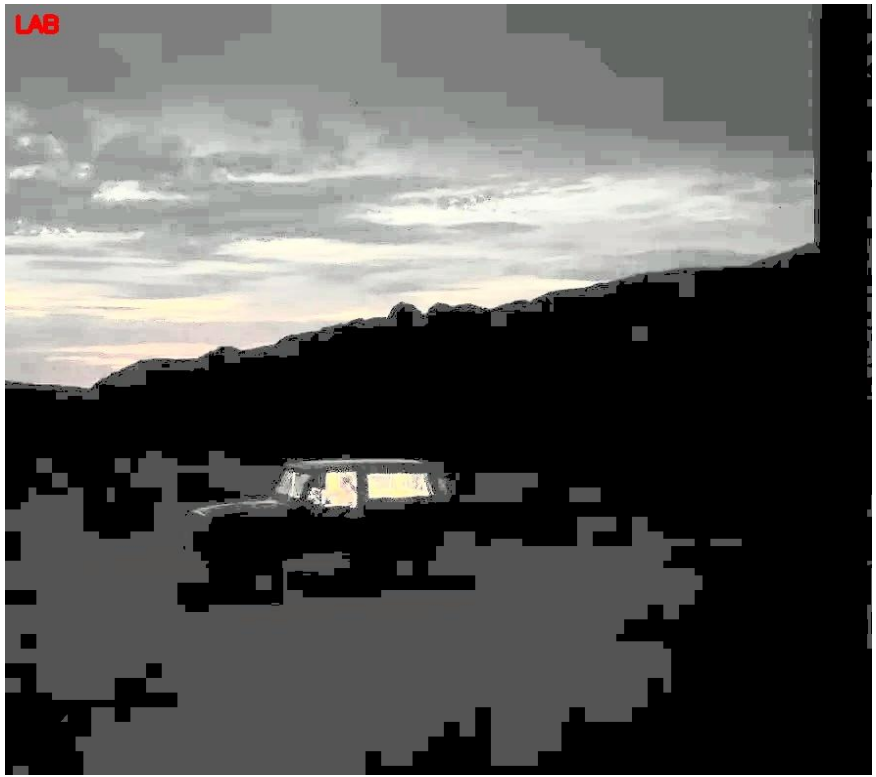
Image 1 output in YUV

Image 1 output in YCrCb

Histogram Equalization Results.

Image 2 output in HSV

Image 2 output in LAB



Histogram Equalization Results.

Image 2 output in YCrCb

Image 2 output in YUV

Histogram Equalization Results.

Image 3 output in HSV

Image 3 output in LAB

Histogram Equalization Results.

Image 3 output in YCrCb

Image 3 output in YUV

Histogram Equalization Results.

Image 4 output in HSV

Image 4 output in LAB

Histogram Equalization Results.

Image 4 output in YCrCb

Image 4 output in YUV

Histogram Equalization Results.

Image 5 output in HSV

Image 5 output in LAB

Histogram Equalization Results.

Image 5 output in YCrCb

Image 5 output in YUV

Adaptive Histogram Equalization

We have applied adaptive histogram equalization with different patch sizes ,which helped in increasing the contrast of the image.

The following slides shows the result of images after adaptive histogram equalization.

Adaptive Histogram equalization was applied at different colour spaces.

- HSV
- YUV
- LAB
- YCrCb

In most of the cases the results had a increase in the contrast value.This results are good compared to that of the normal histogram equalization.

Adaptive Histogram Equalization Results.

Image 1 output in HSV

Image 1 output in LAB

Adaptive Histogram Equalization Results.

Image 1 output in YUV

Image 1 output in YCrCb

Adaptive Histogram Equalization Results.

Image 2 output in HSV

Image 2 output in LAB

Adaptive Histogram Equalization Results.

Image 2 output in YCrCb

Image 2 output in YUV

Adaptive Histogram Equalization Results.

Image 3 output in HSV

Image 3 output in LAB

Adaptive Histogram Equalization Results.

Image 3 output in YCrCb

Image 3 output in YUV

Adaptive Histogram Equalization Results.

Image 4 output in HSV

Image 4 output in LAB

Adaptive Histogram Equalization Results.

Image 4 output in YCrCb

Image 4 output in YUV

Adaptive Histogram Equalization Results.

Image 5 output in HSV

Image 5 output in LAB

Histogram Equalization Results.

Image 5 output in YCrCb

Image 5 output in YUV

Gamma Correction + Adaptive Histogram Equalization

We have applied gamma correction + adaptive histogram equalization with different patch sizes ,which helped in increasing the brightness and the contrast of the image.

The following slides shows the result of images after gamma correction + adaptive histogram equalization.

gamma correction + Adaptive Histogram equalization was applied at different colour spaces.

- HSV
- YUV
- LAB
- YCrCb

In most of the cases the results had a increase in the brightness and the contrast value.This results are good compared to that of the normal histogram equalization and adaptive histogram equalization.

Gamma Correction + Adaptive Histogram Equalization Results.

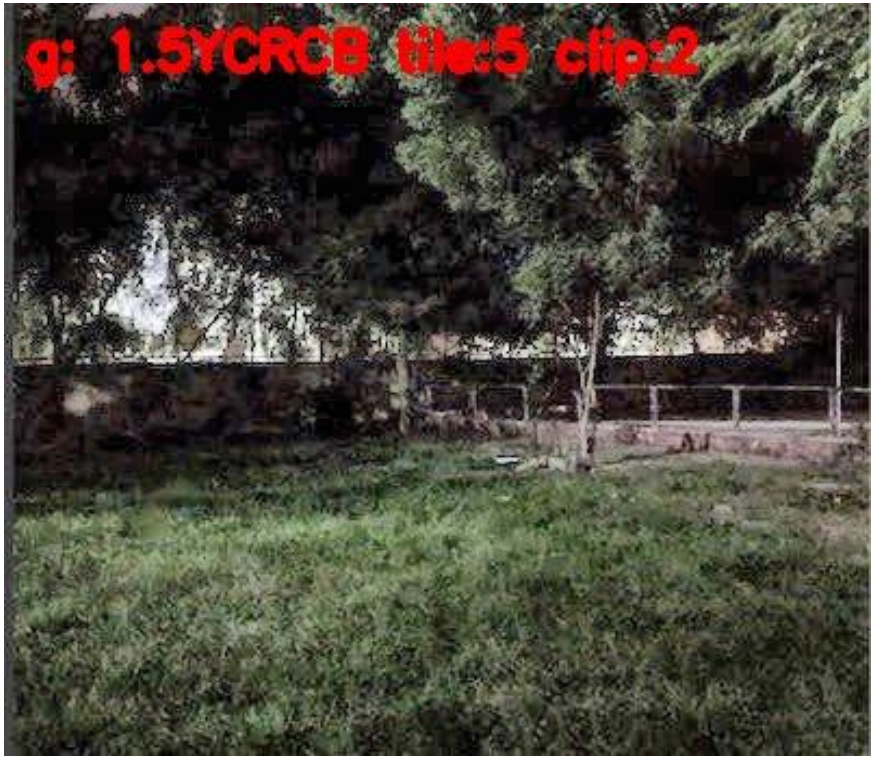
Image 1 output in HSV

Image 1 output in LAB

Gamma Correction + Adaptive Histogram Equalization Results.

Image 1 output in YUV

Image 1 output in YCrCb



Gamma Correction + Adaptive Histogram Equalization Results.

Image 2 output in HSV

Image 2 output in LAB

Gamma Correction + Adaptive Histogram Equalization Results.

Image 2 output in YCrCb

Image 2 output in YUV

Gamma Correction + Adaptive Histogram Equalization Results.

Image 3 output in HSV

Image 3 output in LAB

Gamma Correction + Adaptive Histogram Equalization Results.

Image 3 output in YCrCb

Image 3 output in YUV

Gamma Correction + Adaptive Histogram Equalization Results.

Image 4 output in HSV

Image 4 output in LAB

Gamma Correction + Adaptive Histogram Equalization Results.

Image 4 output in YCrCb

Image 4 output in YUV

Gamma Correction + Adaptive Histogram Equalization Results.

Image 5 output in HSV

Image 5 output in LAB

Histogram Equalization Results.

Image 5 output in YCrCb

Image 5 output in YUV

Dual Illumination Estimation for Robust Exposure Correction.

We have applied Dual Illumination Estimation for Robust Exposure Correction. at different values of gamma and lambdas,which helped in increasing the brightness and contrast of the image and hence enhancing the image.

The following slides shows the result of images at different gamma and lambda values.

Dual Illumination Estimation for Robust Exposure Correction.

Input image 1 with gamma = 0.6

Input image 2 with gamma = 0.6

Dual Illumination Estimation for Robust Exposure Correction.

Input image 3 with gamma = 0.6

Input image 4 with gamma = 0.6

Dual Illumination Estimation for Robust Exposure Correction.

Input image 5 with gamma = 0.6

Verdict on Night time Image Enhancement

From the above analysis we have come to a conclusion that

- Gamma correction + adaptive histogram equalization
- Dual Illumination Estimation for Robust Exposure Correction

Produces better results compared to other.

In all the other cases there are presence of noise.But in the above two cases there is less amount of noise and their results are very comparable to that of the expected output.

B. Image Enhancement (Foggy)

We have performed the following operations on the foggy images.

- Adaptive histogram equalization.
- Efficient Image Dehazing with Boundary Constraint and Contextual Regularization

Dataset.

Verdict.

Dataset

Input Image

Expected Result

Dataset

Input Image

Expected Result

Dataset

Input Image

Expected Result

Adaptive Histogram Equalization

We have applied adaptive histogram equalization with different patch sizes ,which helped in increasing the contrast of the image.

The following slides shows the result of images after adaptive histogram equalization.

Adaptive Histogram equalization was applied at different colour spaces.

- HSV
- LAB

In most of the cases the results had a increase in the contrast value.

Adaptive Histogram Equalization Results.

Image 1 output in HSV

Image 1 output in LAB

Adaptive Histogram Equalization Results.

Image 2 output in HSV

Image 2 output in LAB

Adaptive Histogram Equalization Results.

Image 3 output in HSV

Image 3 output in LAB

Efficient Image Dehazing with Boundary Constraint and Contextual Regularization

We have applied Efficient Image Dehazing with Boundary Constraint and Contextual Regularization, at different values of beta,which helped in dehazing the image.

Post the above step we have applied unsharp masking and gamma correction to get a clear structure of the objects.

The following slides shows the result of images at different beta values.

Efficient Image Dehazing with Boundary Constraint and Contextual Regularization

Image 1 output without gamma correction.

Image 1 output with gamma correction

Efficient Image Dehazing with Boundary Constraint and Contextual Regularization

Image 2 output without gamma correction.

Image 2 output with gamma correction

Efficient Image Dehazing with Boundary Constraint and Contextual Regularization

Image 3 output without gamma correction.

Image 3 output with gamma correction

Verdict on Foggy Image Enhancement

From the above analysis we have come to a conclusion that

- Efficient Image Dehazing with Boundary Constraint and Contextual Regularization

Produces better results compared to other.

In all the other cases there are presence of noise.But in the above cases there is less amount of noise and the edges are sharp and clear hence their results are very comparable to that of the expected output.

C. Video Enhancement

We have performed the following sequence of operations on the video.

1. Converted the video into a sequence of frames.
2. On each frames we first performed de-hazing.
3. We applied nighttime image enhancement on the de-hazed images using the Dual illumination method.
4. Converted all the modified frames into a video of 30FPS.

Link to the output:
https://drive.google.com/file/d/1KiLekBdWgPJIn323J51lY1_AaRp8Gmhw/view

References

[1] H. S. Malvar, L.-w. He, and R. Cutler, “High-quality linear interpolation for demosaicing of bayer-patterned color images,” in 2004 IEEE International Conference on Acoustics, Speech, and Signal Processing, vol. 3. IEEE, 2004, pp. iii–485.

[2] Qing Zhang and Yongwei Nie and Weishi Zheng. "Dual Illumination Estimation for Robust Exposure Correction". Computer Graphics Forum, 2019, 38.

[3] G. Meng, Y. Wang, J. Duan, S. Xiang and C. Pan, "Efficient Image Dehazing with Boundary Constraint and Contextual Regularization," 2013 IEEE International Conference on Computer Vision, 2013, pp. 617-624, doi: 10.1109/ICCV.2013.82.

[4] https://github.com/Utkarsh-Deshmukh/Single-Image-Dehazing-Python

[5] https://github.com/pvnieo/Low-light-Image-Enhancement