Enhancing and Colorizing Infrared Images in Low Light Conditions

Nurdaulet Zhuzbay
Robotics and Mechatronics
Nazarbayev University
Nur-Sultan, Kazakhstan
nurdaulet.zhuzbay@nu.edu.kz

Zhamilya Saparova
Robotics and Mechatronics
Nazarbayev University
Nur-Sultan, Kazakhstan
zhamilya.saparova@nu.edu.lz

Mukhamedzhan Nurmukhamed
Robotics and Mechatronics
Nazarbayev University
Nur-Sultan, Kazakhstan
mukhamedzhan.nurmukhamed@nu.edu.kz

***Abstract*—In this paper, we suggest a solution to solve a problem of low visibility of an images under low-light conditions. Two ways are observed, enhancement of RGB images with different methods and colorizing near-infrared (NIR) images by mapping the pixels from the original (target) image to the NIR image. The main goal of this paper is to produce noiseless and less grainy images that are shot in the nighttime. As a result, we obtained that colorized and enhanced NIR images show better results than filtered RGB images.**

***Index Terms*—images, near-infrared, rgb, realsense, enhancement, segmentation, low-light image**

I. Introduction

In the current time, photography became popular. Images are everywhere starting from the people taking photo on their smartphones to the object detection in tracking algorithms on the roads and etc. However, we know that not all images are the same in the means of quality and visibility especially images taken under low light conditions. Large and significant features may be detected on the low-light images, but it still suffers from reflecting clear details and mostly they are “buried” in the dark [1]. To solve this problem, we applied different enhancement methods on RGB images taken in low-light conditions. Moreover, we observed that NIR (Near-infrared) images could show better accuracy than RGB images [2]. NIR is a subset of the infrared band of the electromagnetic spectrum, covering the wavelengths ranging from 0.7 to 1.4 microns, which is outside the range of what humans can see. NIR is very close to human vision but removes the color wavelengths, which result in grayscale images. By using segmentation and mapping colors from original image to NIR image, we colorize NIR images. This paper shows the difference between enhanced RGB image and colorized NIR image under low-light conditions.

II. RGB Low-light Image Enhancement

We investigated several ways of enhancing low-light RGB images. In this section of our paper we present several methods that we found acceptable. In a sense that they remove noise without losing much of image features and overall quality.

A. Dehazing Algorithm

The first algorithm is easy in its implementation but very efficient one. There are 3 steps:

Fig. 1: Input low-light RGB Image

Fig. 2: Input Near-Infrared Image

- Invert the input image
- Applying haze removal algorithm
- Invert the image again

We read this algorithm in the paper of Xuan Dong [3] ”Fast Efficient Algorithm for Enhancement of Low Lighting Video”. The idea here is that after inverting the input, pixels in the background regions of the inverted image usually have higher densities compared to foreground regions in all three channels (RGB). This is very similar to image captured in hazy weather conditions. Therefore, applying dehazing algorithm in this case will be very easy but efficient of enhancing low-light image.

B. Brightness Preserving Dynamic Histogram Equalization

As we know, histogram equalization is the most common method of enhancing the contrast in the images. However, when applying global histogram equalization we can notice some unnecessary noises such as saturation effects. The second

d

Fig. 3: Dehazing algorithm

method used is called Brightness Preserving Dynamic Histogram Equalization (BDPHE), which is intended to solve this issue [4]. The algorithm is also simple in its implementation, first we smooth the input image with Gaussian filter, then we partition the image. Then, histogram equalization is applied to this partitions. Next, we will assign dynamic ranges to these partitions and apply histogram equalisation independently to these partitions based on these dynamic ranges and at the end, we merge everything.

Fig. 4: Brightness Preserving Dynamic Histogram Equalization

C. *Our proposed method*

We propose a method of enhancing low-light RGB image with the following steps:

- Apply histogram equalisation
- Sharpen the image
- Median filtering

First apply histogram equalisation, then sharpening and finally median filter the input image. The histogram equalisation will adjust image intensities to enhance contrast. Sharpening will show edges and some details. Median filtering will remove noises while preserving the edges.

III. Near-infrared image colorization

We observed near-infrared (NIR) images along with RGB dataset. NIR is a subset of infrared band and just outside the range of what human eye can see. It can offer more clear detailed image than what is achievable with visible light imaging [5]. Method of NIR image enhancement and colorization consist of these steps below:

Fig. 5: Our method

- Sharpening NIR image
- Segmentation
- Median filtering
- Colorization by mapping the pixels from the original image
- Histogram Equalization

A. *Sharpening*

Sharpening is used to show the edges and fine details of the image. To sharpen our image, we use Gaussian filter to blur an image, then create a mask by subtracting blurred image from original image. That's how we result in edges, then by adding the same mask on original image, we can enhance the edges and details. Also, we can adjust sharpening coefficient. Below can be seen fragment of our code, where I is an image and i,j,k are size of an image.

$$
\begin{gathered}
I\_blurred = imgaussfilt(I, 1); \\
I\_mask(i, j, k) = I(i, j, k) - I\_blurred(i, j, k); \\
I\_sharpen(i, j, k) = I(i, j, k) + coef * I\_mask(i, j, k);
\end{gathered}
$$

B. *Segmentation*

One of the important steps in this project is segmentation. We chose to implement region growing segmentation [6]. It is also classified as a pixel-based image segmentation method since it involves the selection of initial seed points. This approach to segmentation examines neighboring pixels of initial seed points and determines whether the pixel neighbors should be added to the region. The process is iterated on, in the same manner as general data clustering algorithms. The first step in region growing is to select a set of seed points. We chose as a seed point top left pixel. The regions are then grown from these seed points to adjacent points depending on a region membership criterion. The criterion in our case was the intensity of the pixels. Using this algorithm the whole image was segmented into parts.

C. *Median Filtering*

Median Filtering is applied to remove noise from an image. It runs through every pixel and replace it with the median value of the neighboring pixels. Below can be seen fragment of our code, where array consist of 9 neighbouring pixels, 3 by 3.

$$\begin{gathered} array = [XABCDEFGH]; \\ sorted\_array = sort(array); \\ median = sorted\_array(5); \\ M(i,j,k) = median; \end{gathered}$$

D. Colorization

When segmentation is finished the position of pixels in the RGB image with the same intensity value was mapped into the NIR image. Then the average intensity over that region is taken. This value is transferred to the newly created output image. Then the algorithm is repeated 3 times, one for each channel (RGB). We colored the NIR image with the average of the pixel color in the RGB image to get rid of the noises.

E. Histogram Equalization

The last important step is histogram equalisation.

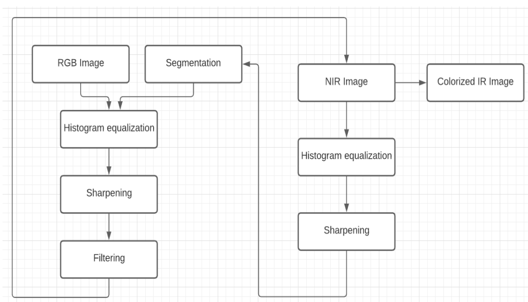

Fig. 6: Colorized NIR image

Fig. 7: Colorized NIR image

IV. Discussion

From the images above we can see that the RGB image was taken in a very low light conditions. We applied Dehazing [2] and BDPHE [3] algorithms and can see that they almost the same results. But Dehazing algorithm performed a little bit better because it is more bright and we can see each detail there. However, our RGB enhancement method and NIR colorized image are totally different. This is because of histogram equalisation. Also, we can see that NIR colorized image is much less grainy, contains less noise and overall is more detailed compared to every RGB image enhancement method described above.

Fig. 8: Dehazing

Fig. 9: BDPHE

Fig. 10: Our method

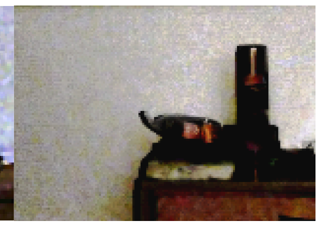

Fig. 11: Image colorization

V. Limitations

We used Inte Realsense camera to capture NIR and RGB images. However, their sensors were located in the different positions so we couldn't obtain aligned images. Even if the resolution was the same, we obtained different images for the same set of frames. So, we had to crop the NIR image and resize it. Because of this some information could get lost and we obtained blurred output image when colorizing the NIR image. It can be seen from the figures below. Even though we couldn't match the exact pixels in NIR and RGB images it can be clearly seen that NIR colorized image contains much less noise and is more detailed.

Fig. 12: BDPHE

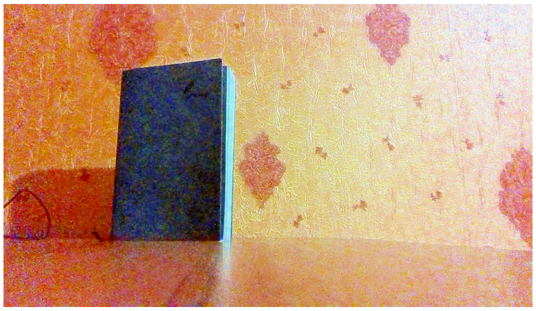

Fig. 13: Dehazing

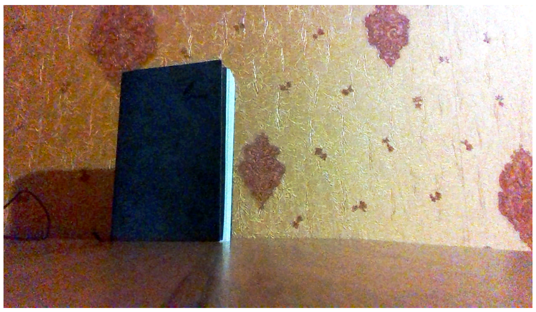

Fig. 14: Our RGB enhancement method

Fig. 15: Colorized NIR image

VI. Conclusion

In this paper we investigated different ways of enhancing the RGB image, namely Dehazing algorithm and BDPHE methods and suggested our own methods. We first computed histogram equalisation the sharpened the image and finally filtered the image to get rid of noises. Dehazing, BDPHE and our RGB enhancement methods all worked good in low-light conditions. But, dehazing algorithm was bit better in preserving the details of the image. Also, we proposed our approach to colorize the infrared image. We saw that it outperforms the other image enhancement methods. However, since we average the pixel values for each segment of the image, for the very detailed image it will fail to assign corresponding pixel values. It will lose detailed information but still it will contain much less noise.

References

[1] X. Guo, Y. Li, and H. Ling, "LIME: Low-Light Image Enhancement via Illumination Map Estimation," IEEE Transactions on Image Processing, vol. 26, no. 2, pp. 982–993, 2017

[2] H. Yamashita, D. Sugimura, and T. Hamamoto, "Low-light color image enhancement via iterative noise reduction using RGB/NIR sensor," Journal of Electronic Imaging, vol. 26, no. 04, p. 1, 2017.

[3] Dong, X., Pang, Y. (., amp; Wen, J. (. (2010). Fast efficient algorithm for enhancement of low lighting video. ACM SIGGRAPH 2010 Posters on - SIGGRAPH '10. doi:10.1145/1836845.1836920

[4] Ibrahim, H., amp; Pik Kong, N. (2007). Brightness preserving dynamic histogram equalization for image contrast enhancement. IEEE Transactions on Consumer Electronics, 53(4), 1752-1758. doi:10.1109/tce.2007.4429280

[5] Jee, S., amp; Kang, M. G. (2019). Sensitivity improvement of extremely low Light scenes With RGB-NIR Multispectral filter Array sensor. Sensors, 19(5), 1256. doi:10.3390/s19051256

[6] Jiang, H., He, B., Fang, D., Ma, Z., Yang, B., amp; Zhang, L. (2013). A region growing vessel segmentation algorithm based on spectrum information. Computational and Mathematical Methods in Medicine, 2013, 1-9. doi:10.1155/2013/743870