German University in Cairo
Faculty of Media Engineering and Technology
Winter 2024

DMET 901 – Computer Vision

Assignment #1
(Due on 7th of November)

This assignment's main aim is to experiment with images' histogram analysis approaches, to be further utilized in the image modification. As discussed in class we used the histogram analysis to help in applying different techniques to enhance the image, in which we needed multiple parameters to search for in order to reach the new modified output image.

In more detail, given an input image, as a first step, you need to reach your techniques' parameters by calculating the boundaries of the modification range which will be done using **slope-based** and **percentage-based** approaches. Secondly, applying the two enhancement approaches which are: **contrast stretching** and **histogram equalization**.

As per that, the following components are to be implemented:

1. **Calculate Histograms:**
    a. Image histogram.
    b. Cumulative histogram.
2. **Analyze histogram:**
    a. Color covering percentage.
    b. Maximal slope.
3. **Modify histogram:**
    a. Contrast stretching .
    b. Histogram equalization.

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Required Components Description:

1. Calculate Histograms

As discussed in class, histograms are a useful statistical tool that is utilizable in the domain of images. Hence, in this part, you are asked to implement the following **two functions**:

a. **CalculateHistogram**

- **Input:** 2D array representing the image (feel free to use a predefined function to transform an image into an array).
- **Output:** 1D array representing the histogram.
- **Description:** Calculate the histogram as discussed in class.

b. CalculateCumulativeHistogram

- **Input:** 1D array representing the histogram.
- **Output:** 1D array representing the cumulative histogram.
- **Description:** Calculate the cumulative histogram as discussed in class.

2. Analyze Histogram

In this part, you are asked to get your parameters by deciding the minimum and maximum color intensities which are later utilized in the process of image modification. This is achieved by the following **two functions**:

a. GetColorAtPercentage

- **Inputs:** 1D array representing the cumulative histogram and a percentage value.
- **Outputs:** two numbers representing color intensities.
- **Description:** Given a cumulative histogram and a certain percentage as an input to the function, the percentage is used as a clipping tool to the cumulative histogram in order to get the color intensities at which this percentage is fulfilled at both ends of the cumulative histogram.
  For example, if the percentage is 5%, then the minimum color intensity bound to be found is the first achieving **approximately 5%** out of the total color intensities, while the

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maximum color intensity bound to be found is the first achieving **approximately 95%** out of the total color intensities.

b. GetColorsAtMaxSlope

- **Input:** 1D array representing the cumulative histogram.
- **Outputs:** two numbers representing color intensities of the maximum slope.
- **Description:** For each pair of color intensities (i, j), a slope-like score is calculated, then the pair with the maximal score of all the slopes is returned. The slope-like score is calculated as follows:

$$S_{i,j} = \frac{(hc(j)-hc(i))^4}{j-i} | i \in [0, 254],\ j \in]i, 255]$$

3. Modify Histogram

In this part, you are asked to implement the following **two functions**:

a. StretchContrast

- **Input:** 2D array representing the image (feel free to use a predefined function to transform an image into an array), and four numbers representing color intensities.
- **Output**: An image presenting the effect of the contrast stretching on the input image.
- **Description:** Implement contrast stretching as discussed in class using the boundaries from previously implemented methods.

b. EqualizeHistogram

- **Input:** 2D array representing the image (feel free to use a predefined function to transform an image into an array), and two numbers representing color intensities.
- **Output:** An image presenting the effect of the histogram equalization on the input image.
- **Description:** Implement histogram equalization as discussed in class with the modification of tuning the linearization as per the frequency of the given color intensities using the boundaries from previously implemented methods.

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Evaluation Methods Required:

After implementing all of the above functions, the testing is performed to evaluate the two following parts, the analysis, in consequence, the modification. Therefore, the testing for each part of them will be as follows:

1. **Analyze Histogram**

   a. Evaluate the color intensities covering the three percentages, **5%**, **10%** and **15%** for the **GetColorAtPercentage** function.
   b. Evaluate the pair of color intensities calculated by the **GetColorsAtMaxSlope** function.

2. **Modify Histogram**

   a. Each pair of color intensities found in the previous step are to be used in the **StretchContrast** function.
   b. Each pair of color intensities found in the previous step are to be used in the **EqualizeHistogram** function.

→ For the test Images:

1. **Please use the following links to access the test images:**

- https://networkcameratech.com/wp-content/uploads/2016/10/HIKVISION-DS-2CD2142FWDI_2016-Nov-09_21_59_05.png
- https://networkcameratech.com/wp-content/uploads/2016/10/HIKVISION-DS-2CD2142FWDI_2016-Nov-09_21_52_01.png
- https://networkcameratech.com/wp-content/uploads/2016/10/AXISP3364_2016-Oct27_03_50_22.png
- https://networkcameratech.com/wp-content/uploads/2017/08/Dahua-IPC-HFW4431R-Z-with-strong-IR-reflection.jpg
- https://networkcameratech.com/wp-content/uploads/2018/07/IPC-HDW5231R-Z_2018-Jul-25_08_05_15.jpg

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- https://networkcameratech.com/wp-content/uploads/2018/07/IPC-HDW4431C-A_2018-Jul-26_08_02_02-1080.jpg
- https://www.mathworks.com/help/examples/matlab/win64/DisplayGrayscaleRGBIndexedOrBinaryImageExample_02.png

2. **You May use this command to access and load the image from the link without having to re-upload the image for each run:**

   !wget -O image.png <”**The Image Link**”> im = Image.open("image.png").convert('L')

<u>You are asked to deliver the following:</u>

1. **A notebook (.ipynb/.py) showing your implementation of all the required functions representing the outputs for each, alongside all the test scenarios required representing their results.**
2. **A report that includes the following:**

   The images before and after applying the techniques

   - **Each with its histogram and cumulative histogram.**
   - **Histograms and Cumulative histograms representing each image’s minimum and maximum parameters on them. Note each graph to be represented separately for each technique.**
   - **Your comments and a clear clarification about the outputs, how each technique affected the image taking into consideration the parameters being used. You can use a comparator function (feel free to use a predefined function) to represent a comparison between the input and output image.**

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Submission Guidelines:

1. **Teams:**
   - This assignment should be done **individually** or in **teams up to 4**.
     - ➔ To ensure submitting your team's info to get a team number for submission, please fill this form if you have not filled it already. It is the same form posted to CMS.
     - ➔ **Kindly note that the deadline to fill the teams form is on Sunday, 3rd of November, 2024**
     - ➔ The team numbers list will be posted on the CMS after the deadline mentioned above.

2. **Assignment Submission:**
   - Keep in mind that copying code from other teams or ChatGPT is **totally prohibited**. A cheating detector will be used to confirm that. Any cheating case detected will be a **ZERO**.
   - You **are not allowed** to use any **predefined functions for any of the requirements** except for the mentioned ones along with any other additional functions you want to add.
   - You should submit the assignment through submission form mentioned below taking into consideration the following notes:
     - ➔ The .ipynb/.py file containing your assignment's implementation (the notebook should be submitted showing the cells being run before and representing the output).
     - ➔ The file should be uploaded on your drive and provide us with the link and make sure to be accessible.
     - ➔ Submit the assignment through this form.
     - ➔ **Kindly note that the deadline to submit the assignment is on Thursday,7th of November, 2024**