Image Colorization for Vintage Portraits

Interim Report

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1. Progress Report

1.1. Project Overview

We proposed to work on developing a convolutional neural network based model that performs two main tasks:

1. Image *colorization* of vintage portraits from greyscale to full color
2. Removal of salt-like noise, scratches etc. as part of *restoration*

In order to achieve this, we divided our entire project into five major milestones:

1. Literature Review
2. Dataset Pre-processing
3. Preliminary Model Implementation
4. Evaluation
5. Improvement

We have worked on and achieved the first three milestones which are discussed as follows:

1.2. Literature Review

There are multiple techniques in literature that address the image colorization problem aspects like problem structure, input, domain, type of network etc. A brief overview of these techniques is shown as follows:

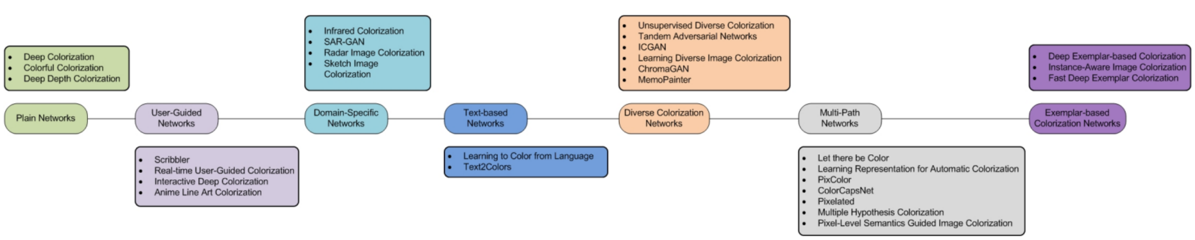

Figure 1: Taxonomy [1]

Since our project is essentially Single-Image Deep Colorization, we focused on the following works, because they best correlate with our problem set-up:

- Deep Colorization [2]

- Colorful Colorization [3]
- Deep Depth Colorization [4]

1.3. Model Selection & Data Preprocessing

After the literature review, we decided to use a U-Net model due to its encoder-decoder architecture which is proven to perform well in many pixel to pixel applications. For converting data from full color to greyscale we used the lightness component of the *Lab color space in D65 (6500K) lighting condition. This was done due since *Lab color space also captures the white balancing information of the image and its chromatic components can be easily manipulated based on different temperature light sources. Finally in order to give the input greyscale images a more realistic vintage feel we also decided to add salt noise to the lightness component. The output of the model was original *L and ab components of the image.

1.4. Initial Model Implementation

Once the data preprocessing was done, we worked on training the U-Net model on preprocessed UKTFaces dataset. We used Adam as the optimizer with a learning rate of 1e-4 and betas of 0.5 and 0.999. For the loss function we used the L1 Norm. After running the model for 25 epoch the test results shown in Figure 2: Left – Input Images; Right – Colorized. The next step is to improve the results by implementing the model in Wasserstein GAN configuration with Gradient Penalty. A simple vanilla GAN will not be used to avoid training issues such as vanishing gradient problems and mode collapse etc. We will further discuss the mathematical and implementational details of WGANs in the final presentation and report.

Figure 2: Left – Input Images; Right – Colorized

2. Problems Encountered

The primary issue that we are encountering right now with our model is that even though the performance is reasonably well on facial colorization, the background of some images which contain a large level of color information is not being recovered properly as shown in Figure 3. This in our opinion is due to the lack of data of general landscape images in the dataset. Through the supplement of the dataset with other landscape image datasets such as DIV2K or Flickr2K, this issue can likely be resolved. But it is also very likely that we would need to increase the number of parameters in the model resulting in prolonged training times. We would consider doing this in the improvements part of the project.

Figure 3: Background Colorization Issue

3. References

[1] S. Anwar, M. T. C. Li, A. Mian, F. S. Khan and A. W. Muzaffar, "Image Colorization: A Survey and Dataset," arXiv, 2022.

[2] Z. Cheng, Q. Yang and B. Sheng, "Deep Colorization," *IEEE International Conference on Computer Vision,* pp. 415-423, 2015.

[3] R. Zhang, P. Isola and A. A. Efros, "Colorful Image Colorization,," *European Conference on Computer Vision,* pp. 649-666, 2016.

[4] F. M. Carlucci, P. Russo and B. Caputo, "Deep Depth Colorization," *IEEE Robotics and Automation Letters,* vol. 3, no. 3, pp. 2386-2393, 2018.