CS 6220 Big Data Sys & Analytics Project Proposal
Colorization and Style Transfer of Images

Group 15 : Kalyani Prasanna Jagdale, Karthik Nama Anil, Prajwal Mavinkere Revanna, Sakshi Mittal, Vandana Ramesh

Introduction

Painting has been one of the most important ways of artistic expression for the longest time. From Michelangelo in the 15th century to Banksy of current art space, artists have used painting to capture the viewer's attention. Presently, people are finding ways to introduce the styles and artistic impressions of such noted works into normal photos captured by them to evoke more emotion and context from the photos. The initial trial of this implementation involved incorporating basic image processing techniques such as filters and morphological transforms. But since it was very complex to create a mathematical construct to capture the style or effect of the noted works, Neural Network models are being used to learn it. The models were given a stock photo and a photo of the artwork(style) and trained to convert the stock photo to have the style of the artwork. A part of the proposed work is training one model to perform style transfer.

Early forms of media and visual arts were Black and White. Gradually over time, as technology improved, it transitioned to color. Some current forms of visual art, such as fine art photography and art films still use Black and White(widely known as Monochrome). Many portrait photographers use monochrome because people perceive more depth and details in a monochrome photo over a color photo. Enthusiasts tried to find old black and white photos and motion pictures and used novel image processing techniques to create the colored version of the images and videos. With the introduction of Neural Network models, the calculation involved became more accurate and simplified. A model is trained to take a Black and White version of a colored image and trained to generate the colored image. The testing involves passing an old Black and White image through the trained model to create the colored version of it. We will work on colorizing images as a part of the model.

We aim to take a black and white image, generate a colored image of the same using one neural network, and then use another neural network to stylize the colored image with the style of a famous artwork. The implementation may also involve applying the same to GIFs and videos by transforming individual frames and reconstructing the video/GIF using the transformed frames ignoring the glitches caused by not taking inter-frame relationships into consideration.

Motivation & Objective

Humans have grasped the dexterity to make rare visual experiences by bringing together a variety of styles in images. Visual perception is another key area where neural networks have been widely used to create high-level artistic impressions. We plan to develop a system using neural networks to perform colorization as well as style transfer of images. We think it would be interesting to see how a machine can not only create but also perceive and apply changes to images.

Image colorization is a technique to add colors to an image that were originally taken in black and white. The algorithm uses deep learning techniques (such as convolutional neural networks) to analyze the colors across a set of color images, and their black and white versions. The algorithm uses multiple feed-forward passes to take in a grayscale image and produce vibrant realistic colorizations. The objective is to produce colorized images so realistic that for a viewer it is difficult to spot fake amongst the real image and the image produced by our system. This whole process of colorization is done without any direct human assistance.

Neural style transfer is a machine learning algorithm belonging to the image-to-image translation techniques. It helps us merge the contents of one image with the style of another image to provide a third image which is a blend of the first two. The algorithm combines the two images based on Gram index matching of pre-trained deep features.

Related Work

Existing implementations of colorization are based on a color transfer process [1] which use one image's color characteristics from another in any three dimension color space directly. The same idea is also proposed in [2] using a feed forward Artificial Neural Network(ANN). In the recent years, Convolutional Neural Networks (CNNs)[3] gained popularity for learning the generic feature representation and using it independently processing and manipulating the content and the style of natural images. [4] presents a review of Neural Style Transfer (NST), a process of using CNNs to generate an image in different styles.

One of the deep learning approach[5] suggests combining low-level cues from user edits with high-level semantic information for user-guided image colorization. [6] address the problem of hallucinating a plausible color version of the photo by evaluating the images, generated using a fully automated approach, using a colorization Turing test. The classification task method[6] has performed 32% better than previous methods when tested by user surveys. We also studied

video colourisation and [7] utilizes the concept of conceptual awareness in colorization with the use of LSTM CNNs, which can be explained as colouring objects in the current frames using the knowledge on the colour of same objects in the previous frames.

Proposed Work

We have two phases in this project. For our first phase, which involves the colorization of a black and white image, we plan to use the CIFAR 10 and Places365 for the training of the model. In our second phase, we would be using a reference artwork to stylize the colorized images. For this phase, we plan to explore models such as VAEs and GANs, two of the most generative models available currently.

Our architecture diagram is as shown below. We would take a grayscale image as user input and apply our colorization model on it to produce a colorful vibrant image. Next, we would apply the style transfer model on this image using a reference artwork or his own input image and obtain a stylized image.

Additionally, we plan to have a Graphical User Interface where we would take in the user's input image and display the resultant colorized as well as stylised image.

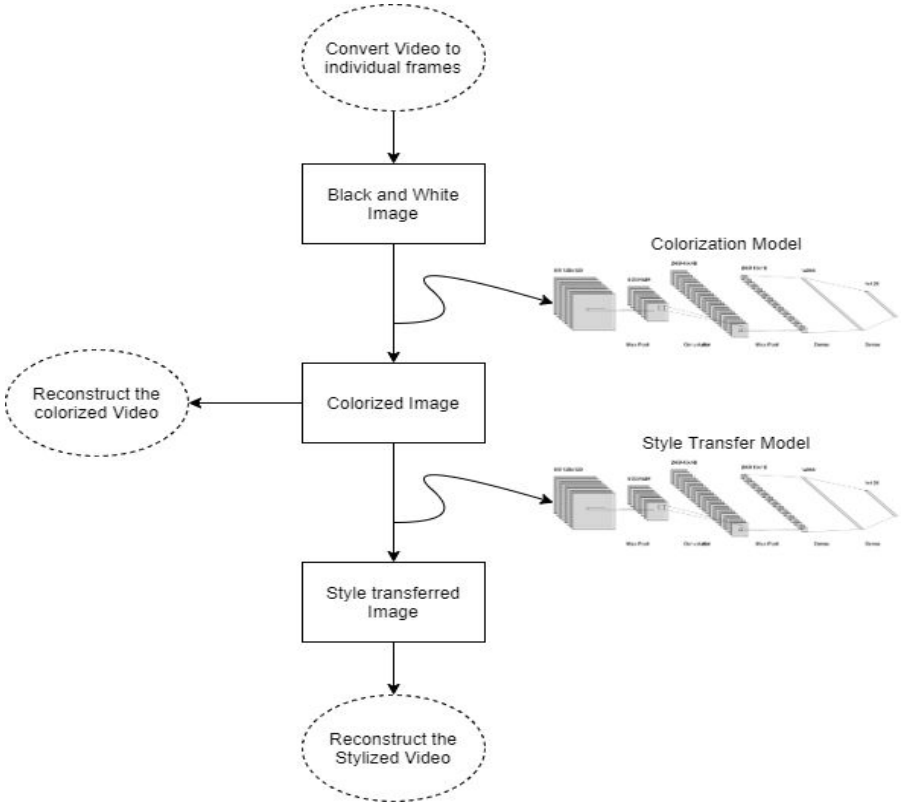

Figure 1: System architecture for image colorization and style transfer

Stretch Goals

We aim to extend the project to videos if time permits. First, we break down the black and white videos into individual frames, colorize the frames and obtain the colorized video. The colorized frames are also stylized by the style transfer model. The stylized frames are recombined to obtain the stylized videos. The main challenge with applying stylization on videos is that we lose the inter-frame data when stylization is applied to consecutive frames which could result in flickering. Subtle transitions and changes in successive frames may be lost during the stylization process. Furthermore, successive frames may get different colors for the same components depending on the style transfer algorithm.

Plan of Action

We plan to use Google Colab or rent out VMs from the Google Cloud Platform (GCP) to train and test the models. The virtual systems will give us access to high end GPUs which would help in reducing training time drastically. This would give us more time to explore different models and tweak hyperparameters to obtain the best possible model pair and corresponding hyperparameters. We will use Javascript with HTML-CSS (Bootstrap) to build the GUI for this project.

Table 1: Project timeline

Sept 14 - Sept 18	Project ideation
Sept 19 - Sept 21	Literature survey
Sept 22 - Sept 25	Project proposal
Sept 26 - Oct 2	Finalization of the dataset
Oct 3 - Oct 16	Design and implementation of colorization model
Oct 17 - Oct 31	Design and implementation of the stylization model
Nov 1 - Nov 5	Design and implementation of the GUI
Nov 6 - Nov 10	Fine tuning the models
Nov 10 - Nov 14	Evaluation of the project
Nov 15 - Nov 17	Prepare for the demo

Evaluation & Testing Method

We would employ both qualitative and quantitative methods to evaluate the model. It is quite challenging to come up with objective qualitative metrics since the different algorithms work on different principles and in many cases not possible to compare them based on certain qualitative criteria.

The colorization model is evaluated by using a “Colorization Turing test”, asking human participants to choose between a generated and ground truth color image. We first convert the color image to a black and white image and recolorize it. Later an user is asked to pick which of them is the actual image. Previous studies[7] have shown that 32% of individuals have not been able to differentiate between the original image and recolorized image. The colorization time is another metric we would employ to determine the time taken by the algorithm to colorize a given black and white image.

The style model is evaluated by a combination of qualitative and quantitative methods. Qualitative methods compare outputs by putting outputs of different algorithms side by side. Training time[8] is the time taken to train the model that is used for stylisation. We plan to evaluate the time taken by the model for different epochs of training and compare their output. Stylisation time[7] is the time taken by the model to extract the style from the style image and apply it to the original image. Some papers try to compare the change of loss values of loss function as well as the final values of loss functions of different algorithms. However, the values of loss function[9] do not always correspond precisely to the quality of output images and hence we do not intend to use these metrics.

References

[1] Xiao, Xuezhong & Ma, Lizhuang. (2006). Color transfer in correlated color space. Proceedings - VRCIA 2006: ACM International Conference on Virtual Reality Continuum and its Applications. 305-309. 10.1145/1128923.1128974.

[2] Khalil, Yazen & Muhammad Ali, Peshawa. (2013). “A Proposed Method for Colorizing Grayscale Images”.

[3] L. A. Gatys, A. S. Ecker and M. Bethge, "Image Style Transfer Using Convolutional Neural Networks," 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Las Vegas, NV, 2016, pp. 2414-2423, doi: 10.1109/CVPR.2016.265.

[4] Y. Jing, Y. Yang, Z. Feng, J. Ye, Y. Yu and M. Song, "Neural Style Transfer: A Review," in IEEE Transactions on Visualization and Computer Graphics, doi: 10.1109/TVCG.2019.2921336.

[5] Zhang, R., Zhu, J., Isola, P., Geng, X., Lin, A.S., Yu, T., & Efros, A.A. (2017). Real-time user-guided image colorization with learned deep priors. *ArXiv, abs/1705.02999*.
[6] Zhang, R., Isola, P., & Efros, A.A. (2016). Colorful Image Colorization. *ECCV*.
[7] B. S. Thomas, R. Dogra, B. Dixit and A. Raut, "Automatic Image and Video Colourisation using Deep Learning," *2018 International Conference on Smart City and Emerging Technology (ICSCET)*, Mumbai, 2018, pp. 1-4, doi: 10.1109/ICSCET.2018.8537308.
[8] Jing, Y., Yang, Y., Feng, Z., Ye, J., & Song, M. (2019). Neural Style Transfer: A Review. IEEE transactions on visualization and computer graphics.
[9] Haochen Li, “A Literature Review of Neural Style Transfer”, pp. 4321-4329.