Image and Video colorization using Deep Learning

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Abstract — The conversion of old black-and-white images to colored images has been a significant topic of discussion since the introduction of image processing. Colorization refers to the process of using computer-assisted techniques to add color to black-and-white images or videos. Earlier, this procedure required substantial user involvement, including placing several color scribbles, examining related images, and performing segmentation. However, automated colorization systems have been developed with advancements in technology. This feature not only enhances the visual appeal of the image but also serves various real-world purposes such as image improvement for better comprehension and video restoration. This method employs advanced deep neural networks and semantic representation to predict accurate color distribution. The algorithm is trained to anticipate the color texture of each pixel since the color distribution inherently defines many parts of the scene.
Keywords — Deep learning, black and white scale, colorization

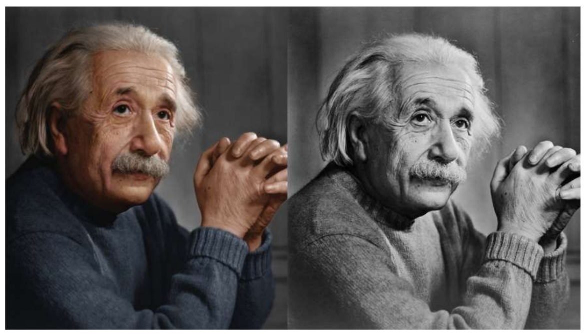

Figure 1: Colored image to black and white image

1. INTRODUCTION

Historical black-and-white images are highly valued for their exceptional artistic value and irreplaceability. However, they fail to provide an accurate representation of the scene as color is a crucial component of visual perception. The colorization of black-and-white images significantly alters the viewer's perspective, making the scene more imaginable and reducing the time gap between the past and present. However, the purpose of colorization is not to reconstruct the color accurately but to deceive the viewer by making the colorized image appear authentic. Colorization is commonly used for restoring old black-and-white films, coloring astronomy photos, and bringing historical images to life. Color is defined by its hue, lightness, and saturation and is influenced by physics, physiology, and psychology. Color perception is subjective and determined by vision and light. Colorization is technically challenging, involving the assignment of three-dimensional RGB (Red, Green, Blue) color information to each pixel with respect to the intensity of a grayscale image in a visually plausible way. However, since many objects in the world appear in different colors, colorization is an ill-posed problem that lacks a unique solution. This complexity keeps the research community interested in colorization, making it an intriguing problem to solve. Deep learning-based image processing is a rapidly growing field, especially for enhancing the quality of digital photographs, and has shown promising results in feature extraction and classification performance. A good digital image must have appropriate saturation, brightness, contrast, and sharpness, which can either make or break its visual appeal. Therefore, it is crucial to maintain these qualities while enhancing image quality.
Deep learning and neural networks have gained significant recognition among researchers in the field of image processing. Convolutional Neural Networks (CNNs) have been successfully employed for image recognition, color recognition, picture sharpening and restoration, pattern recognition, and image generation. Each layer of an image contains essential information about the source images at various levels, and each layer is created by applying various image filters. As a result, each layer of the input image isolates a specific feature from the layer before it.

2. RELATED WORK

[1] In a research paper titled "Image Colorization Using a Deep Transfer Learning," Leila Kiani, Masoud Saeed, and Hossein Nezamabadi-pour explain the use of deep learning methods for image colorization. They address the problem of

data sparsity in real-world scenarios and the need for robust hardware for training by using automatic staining with the VGG19 model of the CNN network as a pre-trained model. The paper also mentions that future work can focus on using hypercolumns on GAN networks to achieve better results.

[2] Ivana Zeger, Sonja Grgic, Josip Vukovic, and Gordan Sisul also contributed to the field of image colorization with their paper titled "Grayscale Image Colorization Methods: Overview and Evaluation." They analyzed algorithms with varying architectures and levels of user guidance, considering objective image quality metrics and the time required for colorization. They also reported that user-guided colorization neural networks outperformed the scribble-based method among the methods requiring user intervention. Furthermore, the use of neural networks was found to improve the visual impression of the resulting colorized images.

[3] Shivani Dere, Anurag Chaudhari, Adarsh Laddha, Yashaswini Deora, and Dhanalekshmi Yedurkar have proposed a web-based application that combines three techniques: Image colorization, Neural Style Transfer, and image inpainting using deep learning. In their approach, they used Neural Style Transfer as an image data augmentation technique and demonstrated that it can significantly improve performance.

[4] Brian Sam Thomas, Rajat Dogra, Bhaskar Dixit, and Aditi Raut have proposed an automatic image and video colorization system using deep learning. They found that their system improves the accuracy of object classification and colorization, and eliminates frame-by-frame color inconsistencies in videos, resulting in a smoother and more visually pleasing viewing experience. This system has potential applications for colorizing old black-and-white movies and images and restoring the color of old images.

[5] Trushna Mavekar, Ketki Chaudhari, Ujjwala Bhosale, and Dr. Savita Sangam have developed an efficient, fully-automated approach to image colorization using deep neural networks. Their method uses informative but discriminative functions, including a patch function, DAISY function, and a new semantic function, as input to the neural network. The output chrominance values are further refined using joint bilateral filtering to ensure high-quality, artifact-free colorization results.

[6] C. Santhanakrishnan, Neeraj Durgapal, and Deepak Yadav have conducted a survey on auto-image colorization using deep learning techniques with user input. They suggest that incorporating optional user hints can improve the prediction ability of CNNs to achieve more realistic and optimal results. They also recommend training CNNs on randomized data to simulate user input and cover common human errors.

3. Methodology/Experimental

The expression of each color channel ranges from 0 (least saturated) to 255. (Most saturated). This means that the RGB color space can represent a total of 16,777,216 distinct colors. Pixel grids can be used to represent black-and-white images. Each pixel has a value associated with it that describes its brightness. The range of values, from black to white, is 0 to 255. Red, green, and blue layers make up the three layers that make up a color image. So every colored image is a combination of RGB layers.

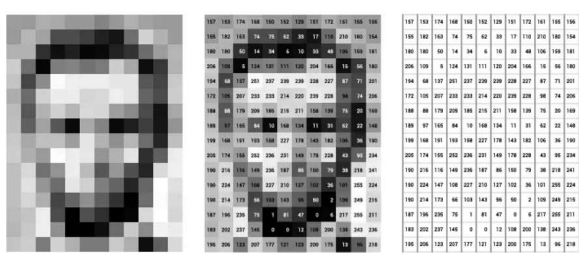

Figure 2: Each pixel with its corresponding brightness(ranges from 0 to 255)[15]

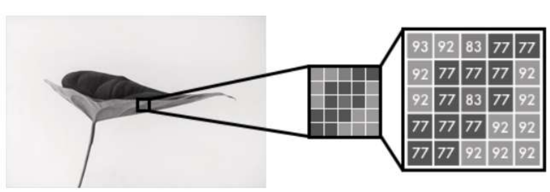

Figure 3: Zoomed patch of black white image with its corresponding value of brightness[14]

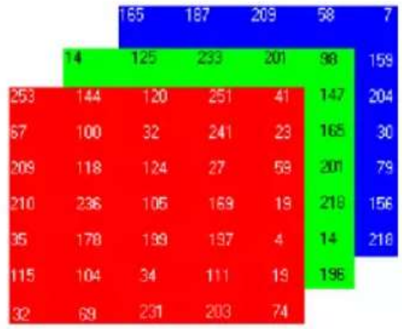

Figure 4: RGB layers[15]

Consider dividing a leaf into three sections and placing it on a white background. You might assume based on appearance alone that the plant is only found in the green layer.
However, as you can see below, there is a leaf in each of the three channels. The layers control brightness in addition to color.

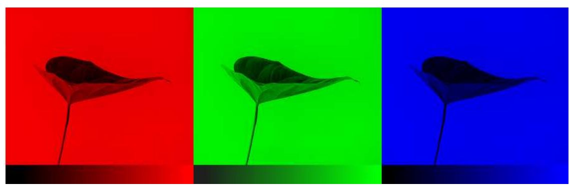

Figure 5: Image of leaf in RGB channels[14]

Each layer in a color image has a value between 0 and 255, just like black and white images do. The number 0 indicates that this layer has no color. The picture pixel is black if all of the color channels have a value of 0.
It is known that a neural network establishes a connection between an input value and an output value. The network must discover the qualities that connect grayscale images with colored ones in order to be more accurate with our colorization task.
Characteristics are being considered that relate to a grid of grayscale values to the three color grids overall.

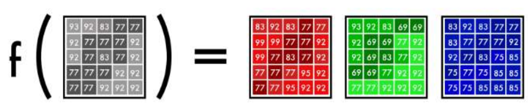

Figure 6: Mapping brightness to corresponding RGB values[14]

Thus, the values of each grayscale pixel to colored RGB value can be mapped. Hence colorized image from a black and white image can be produced.
Video data is composed of a sequence of still images. So, a black-and-white video into frames and saved it into a file can be converted sequentially. Now those black and white images to colored images using our model will be converted. Then the output images to convert images to video using OpenCV would be merged, keeping in mind that frames per second of input video should be equal to the output video.
To give a final touch to video extraction of the audio from the input video and put into the colorized video using moviepy would be extracted.

4. Results and Discussions

This system works well for images/videos having good quality and resolution. This privilege helps in accurate object detection and further colorizing the overall scenario although this model gives some errors while predicting colors of some objects having unpredictable or having an immense variety of colors for any one object, for ex. Butterflies, flowers etc. This thing is visible in Result image 2.

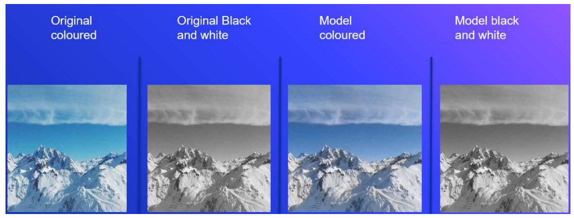

Figure 7: Result from image 1

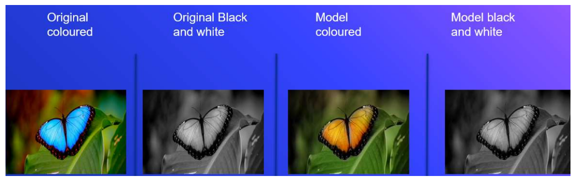

Figure 8: Result from image 2

5. Conclusion and future work

The primary objective of this project is to colorize grayscale images and extend the same technique for coloring old black-and-white videos. The system has successfully addressed the challenge of frame-by-frame color inconsistencies in videos, leading to smoother color transitions and an aesthetically pleasing visual experience. The proposed system is capable of colorizing old black-and-white movies with good picture quality and resolution.

Furthermore, this project can be deployed using a website, making it accessible to remote users. Additionally, this system can be used as a feature in many video editing software, enabling users to colorize a particular part of a video according to their preferences. The integration of this technology into existing software can greatly enhance the functionality of video editing tools, providing users with new possibilities for creative expression.

6. References

[1] kiani, Masoud Saeed, Hossein Nezamabadi-pour, “Image Colorization Using a Deep Transfer Learning Leila”, CFIS 2020

[2] Ivana Žeger , Sonja Grgic, Josip Vuković, Gordan Šišul, “Grayscale Image Colorization Methods: Overview and Evaluation”, 2021 IEEE

[3] Shivani Dere, Anurag Chaudhari, Adarsh Laddha, Yashaswini Deora, Dhanalekshmi Yedurkar, “Digital Image Colorization, Style Transfer and Image Inpainting using Deep Learning”

[4] Brian Sam Thomas, Rajat Dogra, Bhaskar Dixit, Aditi Raut, “Automatic Image and Video Colorisation using Deep Learning”,

[5] Trushna Mavekar, Ketki Chaudhari, Ujjwala Bhosale, Dr. Savita Sanga, “Image Colorization Using Deep Learning”, 2022 IJCRT

[6] C.Santhanakrishnan, Neeraj Durgapal, Deepak Yadav, “A Survey On Auto-Image Colorization Using Deep Learning Techniques With User Proposition”, 2019 Journal of Physics

[7] Vaibhav Pandit, Rushabh Gulati, Chaitanya Singla, Dr. Sandip Kr. Singh, “DeepCap: A Deep Learning Model to Caption Black and White Images”, 2020 IEEE

[8] Madhab Raj Joshi, Lewis Nkenyereye, Gyanendra Prasad Joshi, S. M. Riazul Islam, Mohammad Abdullah-Al-Wadud, Surendra Shrestha, “Auto-Colorization of Historical Images Using Deep Convolutional Neural Networks”, 2020 Mathematics

[9] Shu-Yu Chen a, Jia-Qi Zhang b, You-You Zhao c, Paul L. Rosin d , Yu-Kun Lai d , Lin Gao, “A review of image and video colorization: From analogies to deep learning”, 2022 Visual Imformatics

[10] Gairav Subedi, Subodh Raj Satyal, “An Efficient Automatic Digital Image Colorization Method Using Convolutional Neural Network”, 2019 KEC Conference

[11] Xujia Qin, Mengjia Li, Yuehui Liu, Hongbo Zheng, Jiazhou Chen, Meiyu Zhang, “An efficient coding-based grayscale image automatic colorization method combined with attention mechanism”, 2022 IET

[12] Manoj Nagarajan, Arjun Gurumurthy, Ashok Marannan, “Machine Learning based Efficient Image colorization”

[13] Yu Chen, Yeyun Luo, Youdong Ding, Bing Yu, “Automatic Colorization of Images from Chinese Black and White Films Based on CNN”, 2018 ICALIP

[14] https://blog.floydhub.com/colorizing-b-w-photos-with-neural-networks/

[15] https://cv-tricks.com/opencv/deep-learning-image-colorization/