Image colorizer Using Caffe Model

Black and white image colorize using machine learning.

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***Abstract*—The colorization of black and white images has been a topic of research in image processing and deep learning. This paper presents an advanced image colorization system utilizing deep learning techniques, specifically pre-trained Caffe Model. This application is designed with a graphical user interface(GUI) provide ease of access, allowing users to select grayscale images and obtain high-quality colorized images. To boost image quality the system also integrates post-processing improvements. The approach implementation specifics mathematical models and possible uses of AI-powered image colorization**

***Keywords*—Image Colorization, Deep Learning, OpenCV, Caffe Model, GUI, Post-Processing, Neural Networks, LAB Color Space.**

I. Introduction (*Heading 1*)

Restoring colors to black-and-white images to make them more realistic and aesthetically pleasing is known as image colorization, and it is an essential task in computer vision. Modern deep learning algorithms have automated the procedure with amazing results, while traditional approaches needed a great deal of manual labor. This study introduces a colorization model that ensures effective and high-quality color restoration by utilizing a pre-trained Caffe model and OpenCV's deep neural network (DNN) module. For user convenience, the model is included into a graphical user interface (GUI). AI-powered image colorization is pushing the limits of computer vision with applications in medical imaging, historical image restoration, and the creation of creative content.

II. ORGANIZATION

A synopsis of the document’s contents is provided below.A brief description is given in the section II. Section III provides the description about how the model is designed and how it works. The Section IV contains the methodology of the conversion and mathematical intuition behind the working of the model.

III. Problem Statement

The lack of visual appeal and contextual richness in black-and-white photos makes it challenging to decipher features like time period, object differentiation, and environmental conditions. Traditional hand colorization methods are not as accessible because they take a lot of time and expertise. Poor usability, a lack of human control, and erroneous color prediction are common problems with current automated methods.

This project is aimed to develop an AI-powered image colorization system using deep learning techniques to automatically convert grayscale images into colored images. Here, the model is combined with Graphical User Interface (GUI) for ease of use, allowing users to seamlessly insert, process and save images directly to the folder. Additionally, post-processing enhancements improve the quality of the generated outputs, ensuring realistic and visually appealing results.

IV. Existing system

Manual procedures or early machine learning approaches were the mainstays of traditional image colorization systems, which frequently required a great deal of human interaction and yielded inconsistent results. A number of models have been created to automate the procedure since deep learning gained popularity:
a. ChromaGAN is a generative adversarial network (GAN)-based method that creates realistic colored images by learning color distributions from datasets.
b. DeOldify: Enhances old black-and-white photos with great accuracy using deep learning techniques, such as GANs and self-attention processes.
c. Autoencoder-Based Models: These models use convolutional neural networks (CNNs) to forecast color information and extract features from grayscale images.
One of the most popular deep learning-based colorization models that has been trained on sizable datasets is the pre-trained Caffe Model (Zhang et al., 2016). It produces respectable results but needs post-processing and usability enhancements.

V. Development

In contrast to current methods, our model offers many good feature. In contrast to previous command-line models, we use Tkinter to offer an easy-to-use interface that makes it simple for users to colorize photos. To enhance the quality of colorization, we incorporate methods such as sharpening, contrast modification, and noise reduction.The model makes colorization simple for users without technical knowledge by using a one-click method.

VI. System Architecture

The picture colorization model's system architecture is based on a structured pipeline that is intended to be user-friendly, scalable, and efficient. The first step in the procedure is the Input Module, which ensures compatibility with several input types by accepting grayscale photos in diverse formats. Images are scaled and transformed into the LAB color space as part of the preparation step before processing. By separating the color information (A and B channels) from the luminance (L channel), this transformation enables the model to forecast the missing colors while maintaining brightness details.

The Deep Learning Model, a pre-trained Caffe-based neural network that predicts the A and B color channels and extracts information from the input image, is the central component of the system. The model uses convolutional layers to identify patterns and produce realistic colors after being trained on extensive datasets. Following picture processing by the model, the original L channel is combined with the predicted A and B channels, and the RGB format is restored.

The Post-Processing Module uses methods including sharpening, contrast improvement, and noise reduction to guarantee high-quality results. These modifications improve the final image's clarity and realism by honing the model's predictions. Tkinter was used to create the Graphical User Interface (GUI), which offers users an interactive and user-friendly platform. Users can upload grayscale photographs, colorize them with a single click, watch real-time results, and easily save the finished colored images

The output module, which shows the processed image at the end, allows users to compare the colorized output with the original grayscale input. This methodical approach guarantees a smooth user experience by fusing deep learning with an intuitive user interface to improve the effectiveness and usability of AI-powered image colorization.

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VII. METHODOLOGY

The pipeline used by the image colorization model is structured:

1. Model Initialization:

A neural network that has been trained on sizable datasets makes up the pre-trained Caffe model that the system loads. The colorization network predicts color channels by processing grayscale images.

2. GUI implementaion:

Users can upload black-and-white photographs and process them with a single click using the Tkinter-based interface. Real-time previews are also available through the interface.

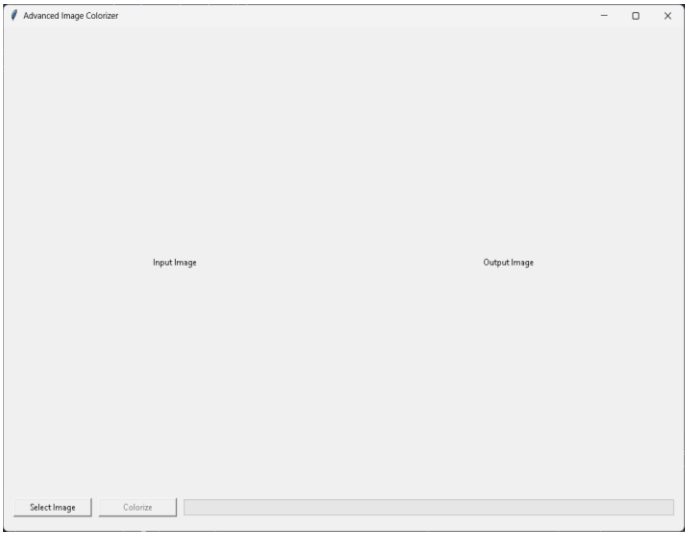

Fig 1. GUI Implementation

3. Image Preprocessing:

To extract the luminance channel, input photos are scaled and transformed to the LAB color space. The missing a and b color channels are predicted by the neural network.The mathematical transformation is given as:

$$L, a, b = f_{lab}(I_{gray})$$

where I_{gray} is the grayscale image f_{lab} and represents the function mapping grayscale to LAB color space.

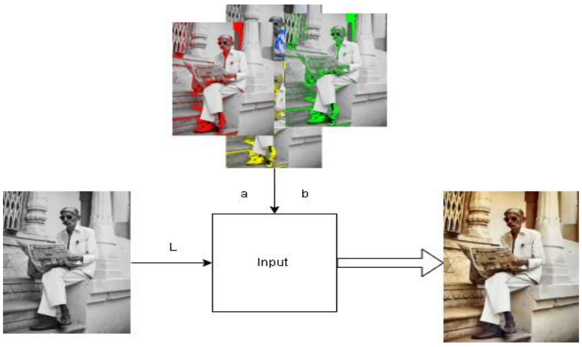

Fig2. LAB conversion

4. Colorization and Post-Processing:

To improve quality, the colorized output is subjected to post-processing procedures such sharpening, contrast modification, and noise reduction.The color prediction is refined using:

$$I_{colorized} = g(L, a_{pred}, b_{pred})$$

Where **g** is the inverse LAB transformation.

5. Output Display and Savings:

The finished image is stored to the system for later use and shown on the GUI. A hassle-free user experience is guaranteed by the simplified procedure.

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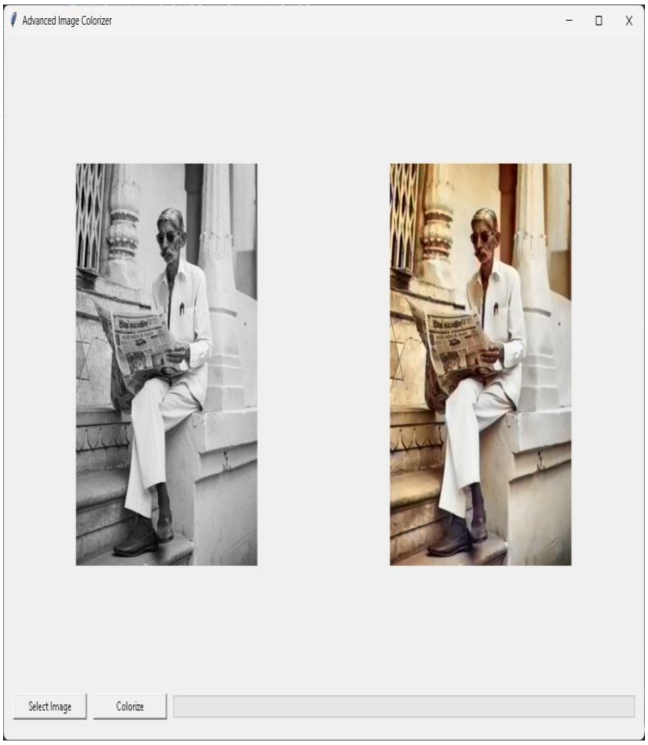

Fig 3. B/W image conversion

VIII. FLOWCHART

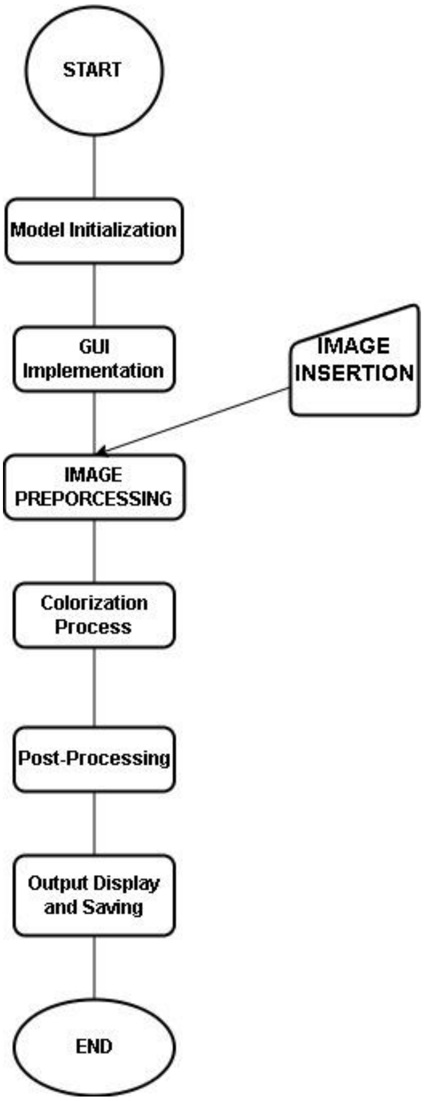

Fig 3. Complete conversion procedure.

i. Complete Conversion Procedure-

Model initialization- Pre-Trained Caffe model is loaded and the deep learning network is initialized.

GUI implementaion- TKinter based GUI launches which allows image selectin feature.

Image Preprocessing- Converting grayscale image to color space and L channel is extracted here.

Colorization Process- Predict a and b channel using neural network and combine it with L channel.

Post-Processing- Noise reduction is performed along with the contrast and sharpness is enhanced.

Then the output is generated.

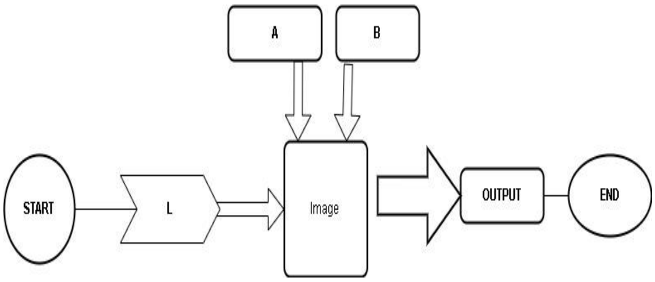

Fig 4. LAB channel

Only lightness intensity is encoded by the L channel. Green-red is encoded by the a channel, and blue-yellow by the b channel.

IX. IMPROVEMENTS FROM THE PREVIOUS MODEL

Our most recent implementation offers significant enhancements over the last iteration:

i. Graphical User Interface (GUI): This model has an interactive and user-friendly GUI, which makes it more accessible to a larger spectrum of users than the previous command-line-based version.

ii. Improved Image Quality: To increase the overall clarity and realism of the colorized photographs, post-processing techniques like noise reduction, contrast correction, and sharpening have been applied.

iii. Ease of Use: By lowering the technological hurdles to entry, a graphical user interface (GUI) streamlines the workflow and makes it possible for users to upload, process, and store photographs with ease.

X. RESULTS AND DISCUSSION

Black-and-white photographs can be properly colored using the established methodology while retaining vibrant, natural hues. The clarity and contrast of images are greatly enhanced by post-processing procedures. By incorporating an intuitive graphical user interface (GUI), the system becomes easier to operate and requires less work for non-technical users. Although small variations in color prediction continue to be a problem for complex inputs, performance analysis demonstrates that the model effectively analyzes images with a balance between speed and accuracy.

The effectiveness of the model is evaluated using structural similarity index measure (SSIM) and peak signal-to-noise ratio (PSNR):

$$SSIM = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)}$$

$$PSNR = 10 \log_{10} \left(\frac{MAX_I^2}{MSE} \right)$$

where μ_x and μ_y are mean intensities, σ_x and σ_y are standard deviations, σ_{xy} is covariance, and MSE is the mean squared error.

XI. CONCLUSION AND FUTURE WORK

This paper demonstrates an effective approach to AI-driven image colorization, leveraging deep learning and OpenCV. The developed system provides a simple yet powerful tool for restoring colors to grayscale images. The focus on ease of use makes it accessible to a broad range of users, including those without technical expertise. Future improvements could focus on training custom models for specific datasets, enhancing real-time processing, and integrating additional image enhancement techniques for even more realistic results. Further research can explore adaptive deep learning models that dynamically adjust to different image styles and content for higher accuracy.Also the development should focus on eliminating the problem of over fitting

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