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An efficient Convolutional Neural Network based Image Colorization Technique

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Abstract

Color in any image plays a vital role in better understanding and real image visualization. In the past when there was no concept of colored images, each black-and-white image need to highlight its own merits to explain an image in a better way. But when the concept of colored images started things changed. The color image is used to describe and highlight key features and attributes of an image in a better and more effective manner. The key issue is that the old images and videos are colored and in some cases, it needs to be colorized. There are several applications, which use to color a gray-scale image. The paper presented an efficient deep learning-based image colorization technique. The proposed system maps all the gray contrast pixels of the image into their corresponding colored pixels to produce a colored image using the Convolutional Neural Network technique. The proposed system is automated and avoids any manual work or user hand-define rules. The system tested around 100 images and found an accuracy of about 95%.

Keywords: Image, colorization, convolutional neural network, gray-scale, features

1. Introduction

In this proposed method, the authors present an effective technique to colorize a gray-scale image [1]. For this purpose, the neighborhood pixels matching process was used to find the best color contrast based on provided reference gray-scale image. By using the concept of pixels' adjunct relationship between the core (central pixel) and neighbor pixels' colorization method, and is used to convert each gray-scale image into a color image [2-6]. A completely automatic methodology creates a range of relevant colorization schemes using deep learning techniques and methods. We will train the system to identify basic colors [7-12] so that it can convert grey-scale color pictures to realistic colorizations. The test runs results in the Image Processing Research Lab (IPRL) show that the developed method is a better scheme to translate a gray-scale image into a color image.

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A gray-scale rose image was not thought of as a passionate shot, since there was no color involved in it. The gray-scale images had to use all the relevant pixel information and logic to make use of full snap. On the other hand, a colored image is easy to understand all the dominant and relevant information. Unfortunately, it was not present back in the day for that same problem that we are to make an image colorization technique for using deep learning [13-18].

Prior work on image colorization was scribble based which required a lot of user intervention, the aim to develop this system is to make a model user intervention free to colorize gray-scale images, this model also learns local and global feature information of an image. The main aim of this system is to convert gray-scale images of historic events from art galleries into colored form. The dominant element in photography is shown in Figure 1.

Figure 1: Grey-Scale and Colored Image of Rose

Essentially in Mughal-e-Azam (1960) [19], a film that was marveled at as an innovative standard for its testing with the innovation of color in Bombay cinema has significantly used the word 'classic' because it traveled from the confined and possibly obscure its space of conventional archives back into the space of open show through its re-release in a colorized avatar. Colorized and non-colored scene from Mughal-e-Azam is shown in Figure 2.

Figure 2: Colorized Scene of Mughal-e-Azam

2. Background Research

Many contribution works have been published for image colorization, some key contributions are noteworthy to discuss here. One of the approaches is traditional image colorization which usually consists of user-based coloring by user-specific scribbles to the whole image which requires user intervention [20]. Another approach utilizes Photoshop to color the grey-scale images manually which required a lot of time [21]. Another approach to image colorization includes coloring images with the help of two or more reference images i.e. when we want to colorize an image we input two or more images with it so that these reference images are utilized for the colorization of the actual image [22]. 4. Concurrent work done on colorization that is automatic i.e. Colorful Image Colorization [23] proposed a deep learning technique named 'Algorithmia' but what it does is only extracts the low-level features and classify the image without specifying the boundaries. So the colors filled are not precise.

In [24], it is observed that mid-level and global features are extracted to convert them into a color image. As far as old color images are concerned for recoloring color images, color exchange procedures [25-26] are normally utilized. These compute color measurements in both input and processed images are mapped with the distributed color scheme. By using the concept of texture and lamination information colorization has been done [27]. A face recognition method was discussed in [28] where an original image was split using the wavelet method upto four levels. Among the pool of different frequencies images, a filter-based method such that mutual information was proposed to select the features.

The proposed work described an approach without user intervention that is based on Artificial Neural Networks (ANN), specifically Convolutional Neural Networks (CNN). A CNN is a dominant image-processing technique based on Artificial Intelligence (AI), which normally uses deep learning concepts to compile tasks [29-30]. The different feature networks connected in end to the end fashion for colorization are explained in detail in the next section. First, we resize the input image to a smaller pixel size in the low-level feature network. Furthermore, mid-level features are extracted in the mid-level feature network and after further reducing image size we can extract the global features that are being done in the global feature network [31].

3. Methodology

The proposed system is based on Convolutional Neural Network (CNN) that will learn complex mappings and will be able to predict colors using several colored sample images. The neural network is formed by several further subcomponents. A completely automatic method creates exciting and representative colorization schemes using Deep Learning techniques and methods. We will train our system to identify basic colors so that it can convert grey-scale color pictures to realistic colorizations. The detailed system diagram is shown in Figure 3. The proposed system consists of the following main features:

- Mobile or web-based application to upload the image
- Using the deep learning model will be trained by using several different images
- All the processing will be done on a cloud while colored images are sent on mobile or designed web app
- A set of historical images are colorized
- Image processing using CNN to change the image into colored images

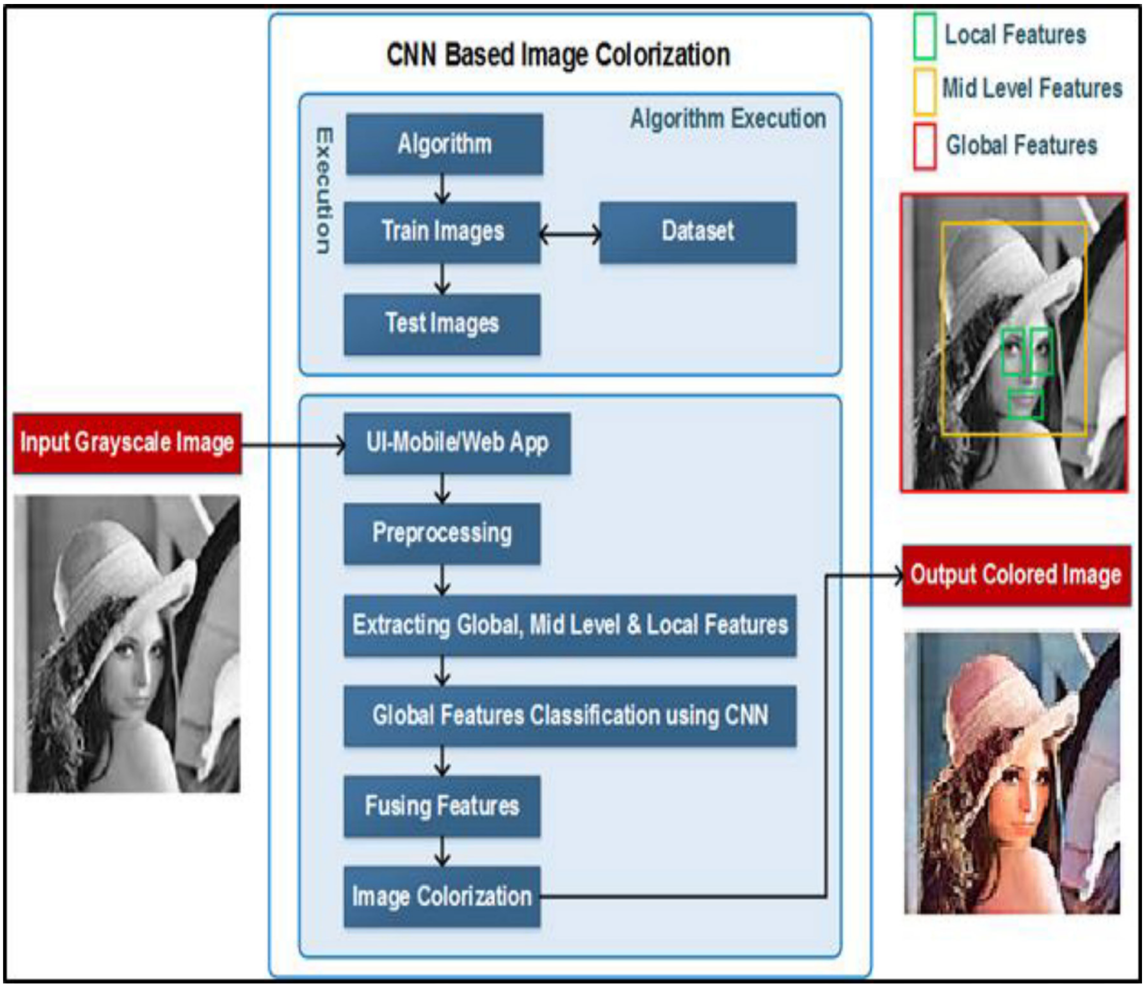

Figure 3: Image Colorization — System Generated Image

A brief explanation of the proposed system is given below the Figure 4. The presented model is designed to overcome some problems related to the image colorization approaches. The system facilitates the optimization using classification training, jointly with colorization. The trained model generates the output which is chrominance as mentioned in Figure 5.

The low-level feature network is shared between two branches global and mid-level. In this network, the approach extracts the local features from the uploaded gray-scale image to extract edges and corners along with resizing of the image to a lower resolution. In this way, processing could be more efficient at different layers, lowering the resolution also decreases the computation time and memory usage.

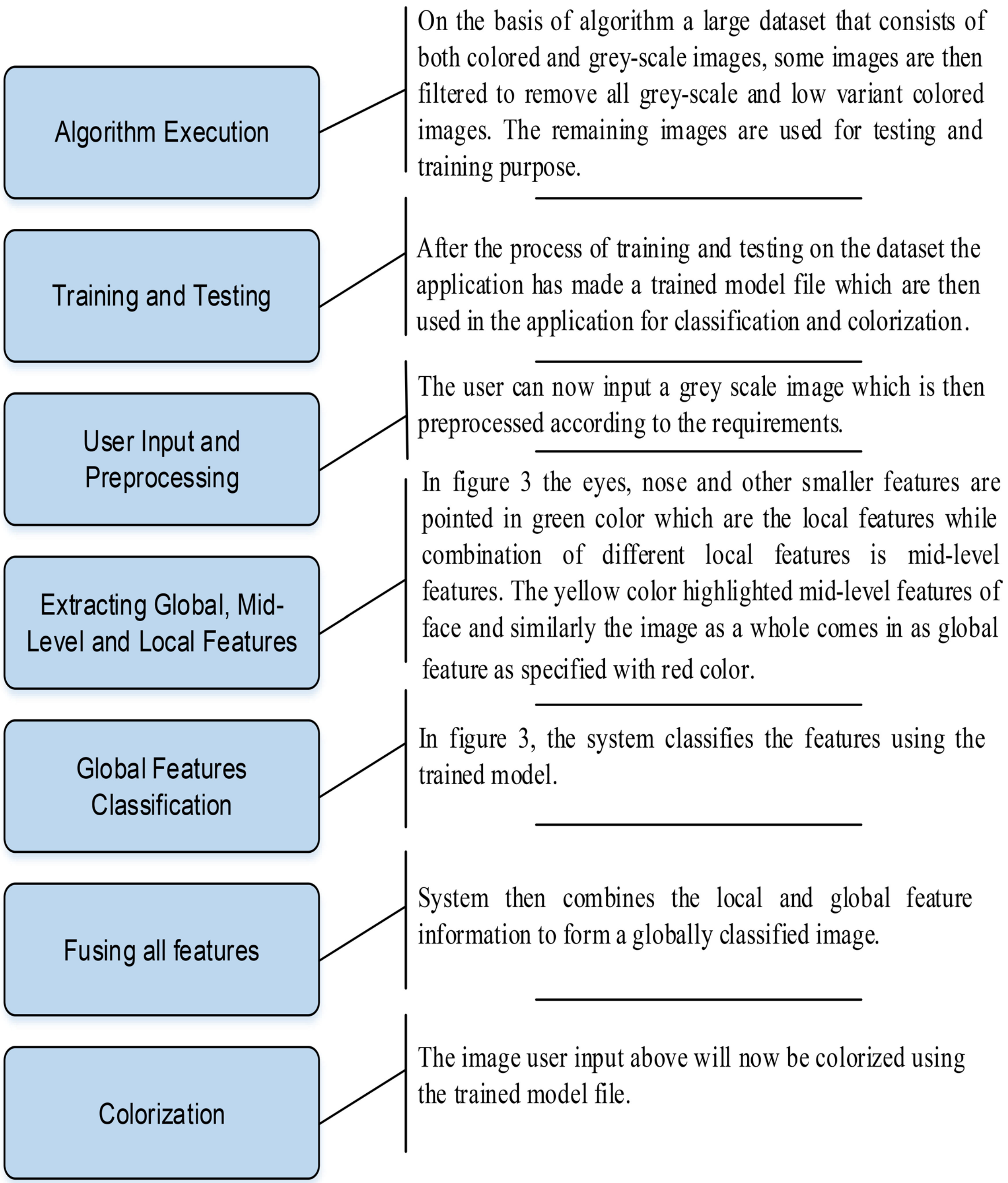

Figure 4: Working Flow Diagram of Proposed System

In the global feature network, the approach resizes the image into a smaller resolution and makes the pixels denser which results in highlighting the global features [31]. The system further processes the local features and then extracts features like texture that is mid-level feature extraction as shown in Figure 5. A classification network is trained to predict the classes of different labels. It is an important part of the developed model which increases the accuracy by classifying different parts of the image.

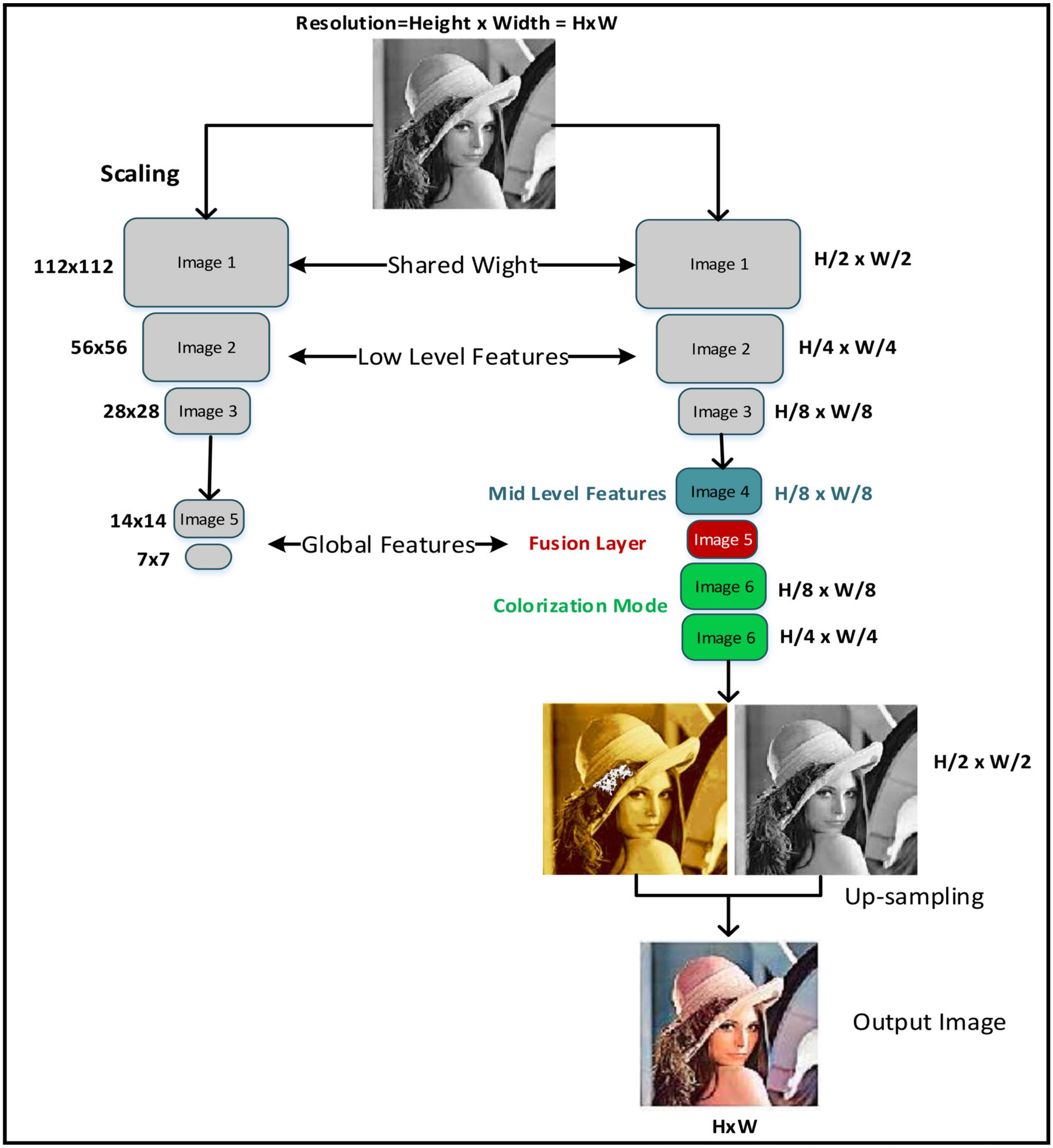

Figure 5: Methodology from Input to Output Image

4. Results

Figure 6 described some results generated by the proposed automated image colorization system with acceptable accuracy. For this purpose thirty images were selected for system learning, then more than 70 images were tested with the developed algorithm. Images were selected from different domains with different contrast.

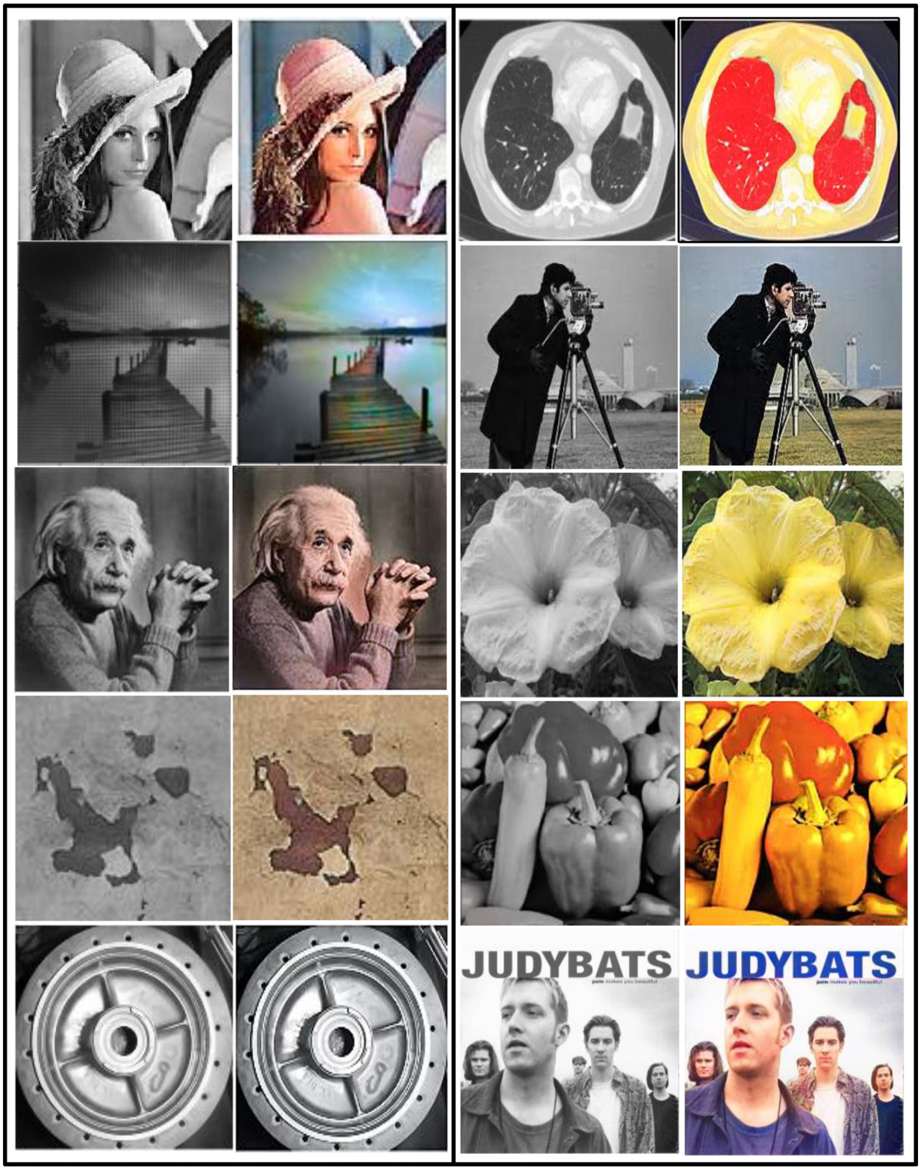

Figure 6: System-Generated Colorized Images

Table 1, shows the accuracy, precision, sensitivity, and specificity of the proposed automated colorization system. In a test run, 100 samples have been tested using CNN based image colorization technique. During the test runs around 98 samples of gray-scale images were correctly colorized as true Positive with an accuracy of 95.23%.

Table 1: Key parameters and performance of the system

Parameter	Image Colorization	Parameter	Performance (%)
Number of true positive (TP)	98	$Accuracy = \frac{TP + TN}{TP + FP + FN + TN}$	95.23
Number of true negative (TN)	5	$Precision = \frac{TP}{TP + FP}$	97.02
Number of false positive (FP)	4	$Senitivity = \frac{TP}{TP + FN}$	98.00
Number of false negative (FN)	5	$Specificity = \frac{TN}{FP + TN}$	40.00

5. Conclusion

The proposed system is a very useful tool to convert gray contrast images into colorized images. In this regards the developing team is working to collect and convert the old historical images of Pakistan into a color format for the best understanding and to save the records in a more appropriate format. The proposed system has an acceptable level of accuracy. During the test runs a variety of images are tested to check the system strength and accuracy in the Image Processing Research Lab.

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