**IMAGE COLORIZATION**

Hi Everyone,

Today I am going to talk about our project - Image Colorization.

-In this video, we will share the details of the problem statement, the proposed solution, the Applications, limitations and the future scope of Image Colorization.

*Problem Statement :-*

1) Given a gray scale image , our aim is to colorize the image.

2) The major challenge lies in accurately colorizing multiple objects with realistic colors in an image.

3) Further the pixel valueof the colorized objets in the image must map appropriately to the nearest realistic pixel of the object. So, that the entiore image looks natural.

4) To address this probblem, we Group 8 from Batch 1 PGC Program by Wiley in collaboration with IIT Mandi, are a team of 6 people under the leadership of Prof. Arnav Bhavsar & Prof. Aditya Nigam and guidance of TA's Ranjit & Anoushka.

5) I Jay, and my teammates Debashish, Deepika, Dev, Rahul and Skanda have collaborated to address this problem.

6) Roles Assigned are as follows :-

-Rahul and Debashish for Power point Presentation.

-Jay, Deepika & Skanda for introductory video.

-Skanda & Dev for preparing solution description.

-Rahul and Skanda for coding.

-Deepika for training model.

-Jay and Debashish for testing and finding the error loss.

Further, Skanda will now take you through the solution for the problem statement.

Let us start with the main objective of our project i.e, Image colorization.

It is a process of adding colors to a black and white / (grayscale) film by means of a computer.

**Now can we do such an application?**

Yes we can, However it is a very important and yet a challenging task, since a natural looking color image has to be obtained from any grayscale input as introduced in the problem statement by my colleague Jay.

Let us understand a few concepts related to colorization and grayscale images

1. A grayscale image is a kind of image which contains only the intensity values and picturize the image in shades of gray.
2. Image colorization is the process of adding chrominance values to an input grayscale image.
3. Image colorization has been attempted for a long time and some of the available methods include human intervention to describe the color
4. Unlike the previous techniques which included human assistance, neural network based colorization method is a fully automatic technique and is more prominent because of its ability to deal with Image datasets
5. Convolutional Neural Networks include pre-processing, segmentation and feature extraction to generate appropriate models for various tasks
6. The experimental results demonstrated that convolutional neural network method outperforms all the existing techniques.
7. Image colorization is applicable in many areas such as colorization of old black and white photos, old movies and scientific images. We will be going through some of the applications at the end of this video.

With these information on Grayscale Images, Colorization and Convolutional Neural Networks, Let us dive in to the problem in hand. That is Image colorization using Deep Convolutional Generative Adversarial Network.

1. A **generative adversarial network** (**GAN**) is a class of machine learning frameworks where 2 neural networks contest with each other and try to overpower each other.
2. Given a training set, this technique learns to generate new data with the same statistics as the training set. For example, a GAN trained on photographs can generate new photographs that look at least superficially authentic to human observers, having many realistic characteristics.
3. The core idea of a GAN is based on the "indirect" training through the discriminator, which itself is also being updated dynamically. This means that the generator is not trained to minimize the distance to a specific image, but rather to fool the discriminator. This enables the model to learn in an unsupervised manner.
4. Typically, the generative network learns to map from a latent space to a data distribution of interest, while the discriminative network distinguishes candidates produced by the generator from the true data distribution. The generative network's training objective is to increase the error rate of the discriminative network.
5. Training of the GAN model involves presenting the discriminator with samples from the training dataset and the generated images at the generator, until it achieves acceptable accuracy.
6. Independent backpropagation procedures are applied to both networks so that the generator produces better samples, while the discriminator becomes more skilled at flagging synthetic samples.
7. When used for image generation, the generator is typically a de-convolutional neural network, and the discriminator is a convolutional neural network.
8. Hence the name Deep Convolutional GAN’s

Wow, GAN networks can generate different images which are similar in characteristics and yet different from the training images. Looks interesting isn’t it. With GAN’s we are seeing a possibility to achieve our goal of colorizing the images now, don’t we.

Is there a way that we can create a model which can take grayscale input images, convert it to a color image, then compare this colored images generated with the data set of original color images?

Yes, that is the attempt which are trying to make in this project.

We will be designing a model which accepts grayscale images and converts it to a colored image with the help of Deep Convolutional GAN networks (DCGAN)

As we have got to know that the Generative network of a GAN model gets the input from a latent space multinomial distribution. If are to consider the distribution of natural colors, it would be a complex task and there will be many combinations which can be obtained. Hence we are considering a Encoder-Decoder network as the image generator network of DCGAN.

1. Encoder – Decoder network is another class of a machine learning and convolutional neural network which consists of 2 neural networks combined together and the input data is convolved to a smaller dimension latent space and then de-convolved to the original input dimension.
2. By using a Encoder network we will be able to pre-process and extract the important features of the input data and store it in a smaller dimension latent feature space.
3. Then the decoder network uses this latent feature space to sample different data and up-sample using the de-convolutional network to generate different images.
4. This generated color image is then compared with the Ground Truth and the loss is calculated and back propagated to the decoder and encoder network
5. Once the training of the networks is completed. The Decoder network will be in a position to sample new images from the latent feature space which has the similar characteristics of the training data yet different from the training data.

This architecture helps in generating colored images from the grayscale images.

**Lastly,** The colored images generated by the our Encoder – Decoder network are then compared with the realistic colored images using a discriminator model which classifies the images as real or fake.

The Loss function of the GAN can be considered as a min - max loss. The loss at the discriminator has to maximize in order to successfully train the model of a Generator and the Generator has to minimize the loss in order to generate images similar to the Ground Truth.

The Generator loss is then further back propagated in the Encoder – Decoder network to generate better colored images from the input Grayscale images.

The generative network in our solution is trained in such a way that the discriminator network has a high loss and fails to classify the real and colorized images.

This loss helps in determining whether the colorized image is similar to that of the original color image and if we are successful in fooling the discriminator network, then we can colorize any grayscale images with a better accuracy.

To efficiently train the model, we are taking the CIFAR-10 dataset which has 60,000 colored images distributed among 10 different classes. Among which we are using 50000 images for training and validation of the model. Remaining 10,000 images for testing the model. We are executing the model for 200 epochs to get better accuracy and performance

For training our model, we will be using the laboratory feature provided by google (google co-lab pro) to run the codes as these require higher computational power and more memory.

Next up, my colleague Deepika will be listing some of the applications where Image colorization will be helpful and the future scopes of such Deep Convolutional Image Colorization networks. Over to Deepika.

**FUTURE SCOPE**

Image Colorization model can have the Limitations:

1. We may lack appropriate evaluation metrics, in benchmarking datasets.
2. State-of-the-art methods application to critical real-world scenarios is restricted due to inadequate metrics, network complexity, and failure to handle real-life degradations.

Now let us see... some examples..some areas where colorization is used. This is an extension to the model we've proposed. .... There are network models which can do comparison among the colorization produced by ResNet models and models based on conditional GAN, as the results when they are put together.

Image Colorization models can be classified on the basis of structure, input, domain, and type of network.

On the basis of Structure Image Colorization models can be explored:

1. Plain Networks

* Deep Colorization

1. User-Guided Networks

* Real-time User-Guided Colorization

1. Domain-Specific Networks

* Infrared Colorization

1. Text-based Colorization

* Learning to color from language

1. Diverse Colorization Networks

* Unsupervised Diverse Colorization

1. Multi-Path Networks

* PixColor

1. Exempler-based Colorization Networks

* Instance-Aware Image Colorization

1. Video Based Colorization

The proposed use cases are above n beyond the scope of our project.

Our solution has limited scope, but the model proposed can address the needs of above applications with different combinations of different network models like Deep CNN, Advanced GANs etc etc..

Are you excited to see the black n white photos , videos of 1920s coloured. ?

We'll attempt make it a reality in our capstone project.

Stay tuned till we get you the colored images. Thank You!