AUGMENT: IMAGE ENHANCER

A Project Work Synopsis

Submitted in the partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING

IN

Computer Science and Engineering

with Specialization in

ARTIFICIAL INTELLIGENCE AND

MACHINE LEARNING

Submitted by:

DAKSH	**19BCS6050**
SOMYA VISHNOI	**19BCS6056**
ANMOL KUMAR	**19BCS6045**

Under the Supervision of:

PROF. DEEPAK KUMAR

CHANDIGARH UNIVERSITY, GHARUAN, MOHALI - 140413, PUNJAB

FEBRUARY, 2022

Table of Contents

ABSTRACT

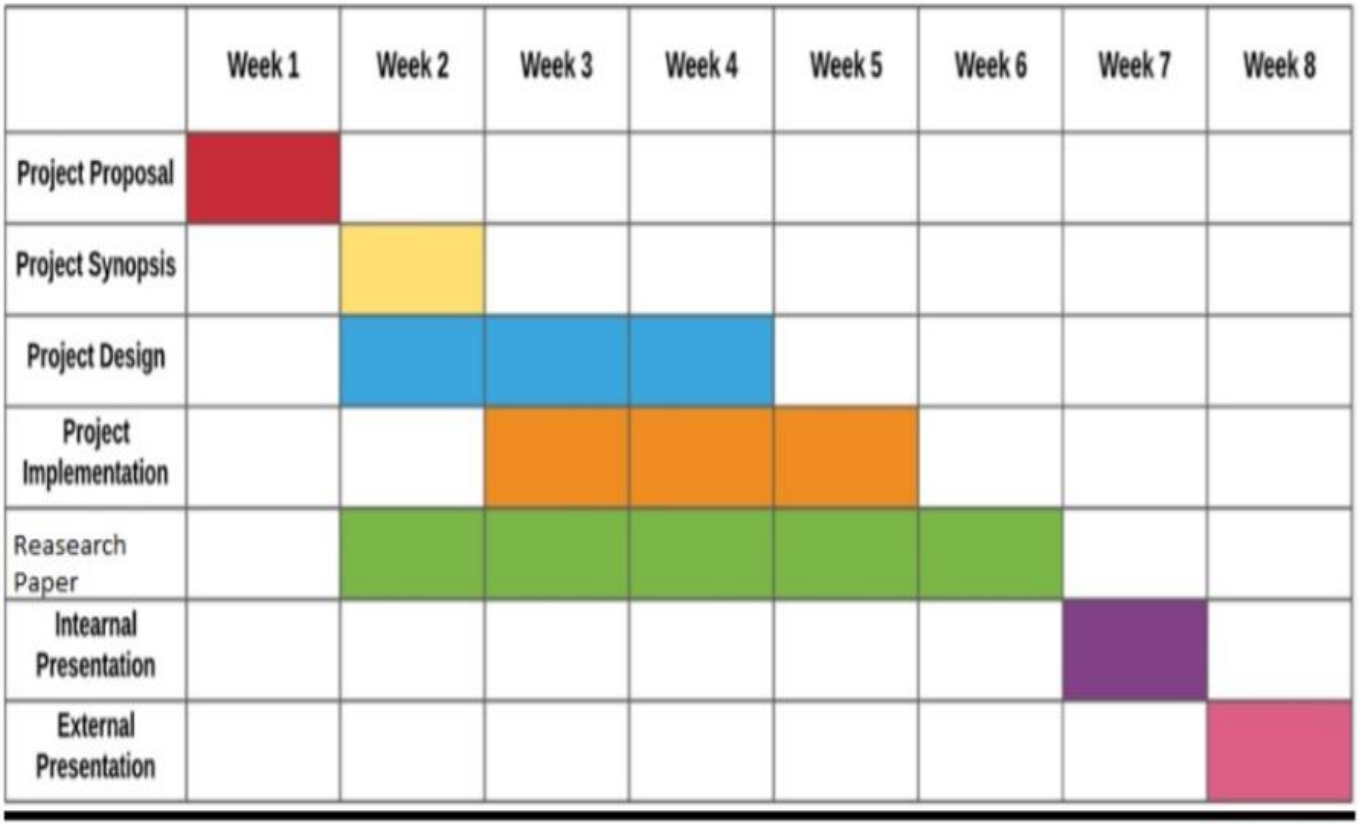
In this project, we aim to look for approaches that perform automatic image colorization and enhance the black and white images to extract information from the grayscale images. Image colorization is a fascinating topic and has become an area of research in the recent years. Color plays a very important role in our day-to-day life. Without colors, we can't imagine the world, how it would be the world without colors. Colors in images not only add aesthetics in the image, but also can be used to extract information that have importance in domains like Historical Research, Crime Control Departments, Forensic department, surveillance feed improvement etc.

Image colorization is a process that adds color to grayscale images. Colorization brings out details that were too faint to see in black and white. The content of black and white images is very limited. So, if we add color components, we can improve the semantics of the image. However it is very challenging nowadays to design and implement a system that is both active and reliable to automate the whole colorization process. Manual image colorization is a tedious task and it is prone to human error. There are existing approaches that aim to colorize images automatically either by using pixel-based scanning , scribble-based or require large number of training examples. Previous approaches to black and white image colorization relied on manual human annotation and often produced desaturated results that were not “believable” as true colorizations. In this project, we are going to colorize black and white images with the help of Deep Learning techniques.

List of Tables

List of Figures

Timeline / Gantt Chart



1 INTRODUCTION

Color is a very interesting element of a composition and plays a crucial role in photographs. Meanwhile, black-and-white photos can be considered aesthetic, but colorizing them could provide something valuable about the past that no one knew before. The advantage of colorizing old photos is that people get the opportunity to see them from a new perspective and point of view. Colorization brings out several details that were earlier too faint to see in black and white color. Freckles, surface details and other lighter textures can also get lost while capturing black and white images. In vivid color, those hidden textures and freckles come to life, making them more prominent, highlighted and easier to pick out. While analyzing old photos for clothing, color styles and patterns, these very important kinds of details are lost in the black-and-white medium that could provide ample amount of information about that particular time line. Colorization can make those patterns and details more visible and highlighted especially of the time periods when flashy colors were in vogue.

1.1 Problem Definition

This project explores the problem of colorizing grayscale images and the obstacles associated with it. Hand-colored photos are beautiful, but making them is a very slow and tedious task. The person has to make decisions about which colors to add in, he/she should have the painting skills to place them into the original photo, and a lot of other troubles. Even with the help of modern tools, if an artist is hired to colorize a single historical photo, it might costs between $300 and $500, which is certainly a huge amount that too even for a single photograph. Colorization is fundamentally till date, an ill posed problem which is mainly due to the loss of information across dimensions while converting a color image to grayscale version. Colorization helps to solve problems of domains related to CCTV footages to have better understanding of the scenario as well as make sharper inferences of the situations, and even to MRI images, thus making it easier for doctors to identify diseases. The main challenge arises when various colors give rise to same grayscale values. Mathematically considering, the task is to estimate 3 dimensions (RGB or YUV color space) from single dimension. Normally, this requires human assistance to achieve artifact free color images.

There are many cases where the colors in an image are unique, for example- the exact color of a person’s clothing, the perfect shade of green for a tree, the color of the petals of a flower etc. and these details are lost forever, as soon as a black and white photo is taken. Whereas in other cases, the colors are predictable as they are universal. Skies are usually blue though the shade may vary, nature is green, water is blue etc. Color can be assumed as predictable and hence it’s almost more tractable using Machine Learning. This means Convolution Neural Network can be used to colorize historical black and white photos.

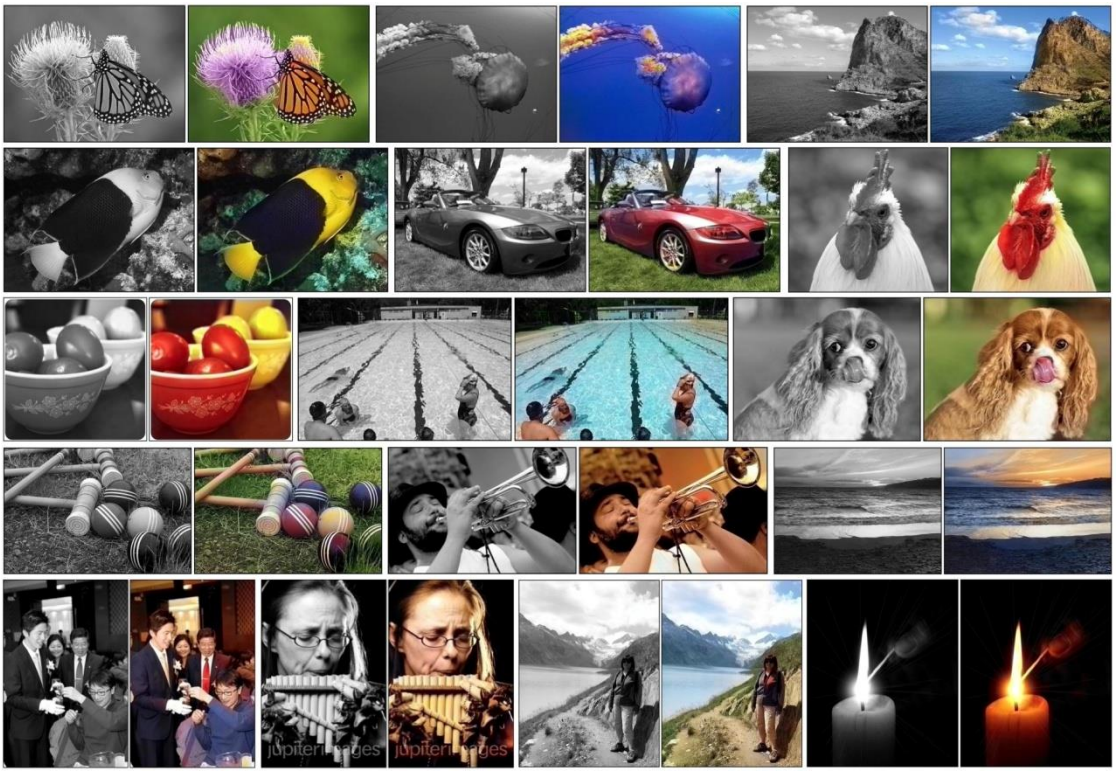


Fig1.1 Black and white images and their colored counterparts

1.2 Project Overview

This project Augment provides the functionality to colorize images without human assistance. The algorithm works by a training a model on a large set of images and then with the help of the developed model to colorize those grayscale images. Deep learning has been successfully applied to various classification, recognition and regression problems and is being widely used in a wide range of problems nowadays. Colorful Image Colorization is an algorithm which uses a CNN to analyze the colors across a set of color images, and their black and white versions. Training data is easy to obtain for image colorizing purpose, any color image can be changed to grayscale, and then paired with its color version to make an easy training example.

1.3 Hardware Specification

Server Side

1. Internet connection
2. 1gHz CPU
3. 500 mB RAM
4. 500 mB HDD/SDD

Client Side

1. Any device that can access discord
2. Internet Connection

1.4 Software Specification

Server Side

1. Python
2. Python Packages
3. Flask
4. Operating System
5. Discord

Client Side

1. Discord
2. Operating System
3. Browser

2 LITERATURE REVIEW

2.1 Existing System

There have been different types of ways to colorize images since earlier times. Today's trend is more focused towards fully automatic image Colorization techniques with less and less requirement of human interaction. This section gives an overview of some of the methods that have been tried, tested and implemented, as well as with their advantages and disadvantages. Then there is a comparison between them in tabular form. Image Colorization is the process of adding colors to Grayscale images, making them meaningful, aesthetically appealing and create a better visual perception of the image. This technique is used to colorize old photos and videos to extract meaningful data about the situation or the time period.

On a wider perspective, Image Colorization techniques can be categorized into Manual approach, Scribble based approach, Example based approach, Learning based approach. At present, the attempt is being made to produce a system which could colorize images in a fully automatic manner, using deep learning methods and less need of human intervention. Some of the existing methods are as follows:

1. **Colorization of Grayscale Images and Videos using a Semi-Automatic Approach**

Approach [1] refers to a semi-automatic approach for Colorization. It makes use of segmentation, and color different areas of images that should be colorized. The algorithm adds color to each pixel by considering position of color markers.

The drawback of this way is that it requires quite a lot of amount of human interaction and that’s not feasible always.

2. Infrared Colorization Using Deep Convolutional Neural Network:

Approach [2] deals with Colorization of Near-infrared (NIR) images of road scenes which are captured from cameras of cars. It makes use of a multi-scale deep convolutional neural network. This approach comprises of 3 parts, which are pre-processing, inference, and post-processing.

The disadvantage of this method is that the resulting colorized images looks more like the paintings than the real world pictures.

3. Fully automatic image Colorization based on Convolutional Neural Network:

A fully automatic approach [3] presents the ability to produce realistic colorization of an input grayscale image. This approach is motivated by the recent success of deep learning techniques

in image processing, so a feed-forward is used, two-stage architecture based on Convolutional Neural Network.

The drawback of this method is that, if the system cannot clearly identify semantic information in the image, then it tends to blur the output with a sepia or brownish tone, which degrades the picture quality.

4. Patch- Based Image Colorization:

This [4] is simple patch-based image Colorization technique which is based on an input image as a color example. This method is based on patch descriptors of luminance features as the name suggests, color prediction model with a general distance selection strategy. A Total Variation (TV) regularization is performed on the colorized image to ensure the spatial color coherency of the final result.

The drawback of automatic color-inaction is the spatial coherency which plays a major part in the algorithm during the color transfer leading to possible inconsistent Colorization in the final result.

2.2 Proposed System

The proposed system will comprise of a discord bot which will have a fully automated way to perform Image Colorization on black and white images which can be used in various domains including restoration of aged or degraded images, Historical Research, Crime Control Departments, Forensic department, surveillance feed improvement etc.

The proposed system will solve the problems that are faced in the existing systems like unrealistic images, blurred images or images having incorrect hues or tones . There are many cases where the colors in an image are unique, for example- the exact color of a person's clothing, the perfect shade of green for a tree, the color of the petals of a flower etc. and these details are lost forever, as soon as a black and white photo is taken. Whereas in other cases, the colors are predictable as they are universal. Skies are usually blue though the shade may vary, nature is green, water is blue etc.

The model used for colorization will work using Generative adversarial networks (GAN). A GAN (generative adversarial network) is made up of two smaller networks called as the generator and discriminator. As the name suggests, the generator's task is to produce results that are indistinguishable from real data.

Literature Review Summary

Table 2.1: Literature review summary

Year and citation	Article Title	Purpose of the study	Tools/ Software used	Comparisn oftecwaithni quedone	Source (Journal/ Conference)	Findings	Data set (if used)	Evaluation parameters
2009	Colorization of Grayscale Images and Videos Using a Semi-Automatic Approach	a semi-automatic process for colorization Colorization of	Segmentation Of images	Increased human intervention	2009 16th IEEE International Conference on Image Processing (ICIP)	Depends on human interaction	Not Specified	Not specified
2016	Infrared Colorization Using Deep Convolutional Neural Networks	Near-infrared (NIR) images of road scenes captured from cameras of cars produce realistic colorization of an input grayscale image using two-stage architecture based on Convolutional Neural Network	Multi-scale deep convolutional neural network.	The resulting colorized images looks more like paintings that real world pictures.	2016 15th IEEE International Conference on Machine Learning and Applications (ICMLA)	Colorized images tend to look less realistic due to smoothening filter	Real-world dataset containing a large amount of road scene images in summer	Not specified
2016	Fully automatic image Colorization based on Convolutional Neural Network	Fully automatic colorization which is able to produce high-quality and realistic colorization even of complex scenes	VGG-16 classifier, 2 stage architecture based on CNN	Blurring of output image with brownish tone due to lack of semantic information	2016 23rd International Conference on Pattern Recognition (ICPR)	Incorrect recognition leads to results being brownish. Color of larger semantic parts affect that of smaller ones	Sun database images	Quaternion Structural Similarity (QSSIM)

2012	Patch- Based Image Colorization	Total Variation (TV) regularization	Patch features as pixels descriptors to capture image textures or complex structures	Spatial coherency while color transfer that makes inconsistent colorization in output	Proceedings of the 21st International Conference on Pattern Recognition (ICPR2012)	The colorized result can be seen with a desaturation effect	Not specified	Spatial color coherency

3 PROBLEM FORMULATION

Colorization has been a concept of importance and studied by the researchers in the field of computer graphics and image processing. Since Wilson Markle created the colorized pictures from the Apollo space program in 1970, image colorization has been quite popular.Colorization brings out details that were too faint or light to see in black and white. The content of black and white images is very limited, the texture, surface details are completely lost. So, if color components can be added, the semantics of the image can be improvised. However, it is very challenging nowadays to design as well as implement a system which is active, doesn't need human interaction and is reliable to automate the whole colorization process. Colorization is a process which is still till date an ill posed problem. This is due to the loss of information across dimensions when a color image gets converted in to a grayscale version. The main challenge arises due to various colors giving rise to same grayscale values. Mathematically stating, the problem is estimating 3 dimensions (RGB or YUV color space) from single dimension. It is generally a tedious task and normally requires human assistance to achieve artifact free color images. Multiple colorization techniques are widely used in the domain of astronomy, MRI scans, and black-and-white image restoration. Though, the colorization problem has been quite challenging since, given a grayscale image, there is no unique correct colorization technique due to the absence of any information from the user.

- Talking about the progress of Colorization techniques over the last decade, the process of automatic image colorization has found uses in multiple application areas including restoration of aged or degraded images.

- This problem is ill-posed because of large degrees of freedom during the assignment of color information. There are no rules that should be followed but still the universal colors of the things should remain intact. For example we have multiple hues and tones of a single color. And deciding which shade would be better for what portion of image is the main area of difficulty.

- Manual image colorization is a tedious task and it is prone to human error. There are existing approaches that aim to colorize images automatically either by using pixel-based scanning, scribble-based or require large number of training examples.

- Previous approaches to black and white image colorization depended heavily on manual human interactions and often produced results that were not "believable" as true colorizations of the images.

4 OBJECTIVES

The project aims on achieving the following objectives:

- The project aims to provide a fully automated way to perform Image Colorization Which can be used in various domains. Traditional models often relied on significant user input alongside a grayscale image, in Augment there would be no explicit human intervention.

- The proposed system is designed in such a way that it can be used in multiple application areas including restoration of aged or degraded images, Historical Research, Crime Control Departments, Forensic department, surveillance feed improvement etc.

- To provide an interface, rather than just a model, Augment would be fully deployed and integrated with a discord bot such that it is user friendly and anyone could use it without any prior knowledge of domains like Machine Learning, Deep Learning, GANs etc.

- To have minimal interaction with the user for his convenience. The user wont be disturbed again and again for giving inputs at each and every steps. The user just needs to give a black and white image as the input to the discord bot and he/she would receive the colored image as the output.

- To provide quick service, that is provide the output to the user quickly within a short interval of time.

- To provide a hassle free interface with no need to login or sign up to an app or a website. The user just needs to have a discord account that nearly everyone nowadays owns. The proposed system would be integrated into Discord, thus user will not be bothered about the sign up or login process.

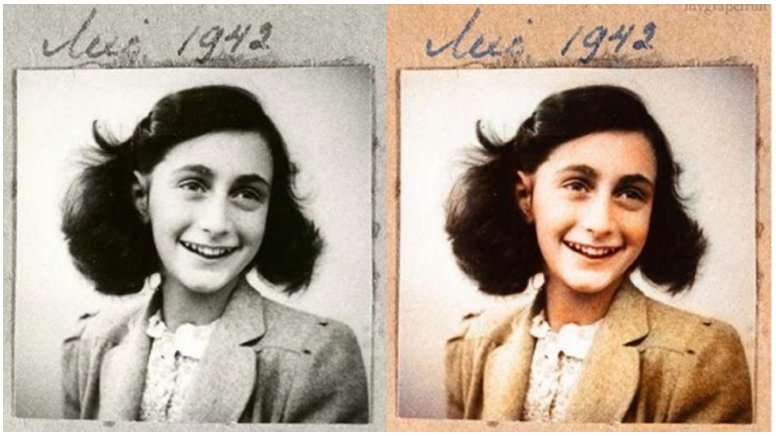


Fig 4.1: Black and white input image, coloured output image

5. METHODOLOGY

The following methodology will be followed to achieve the objectives defined for proposed research work. The proposed aim will be achieved by dividing the work into following:

1. **Dataset selection**: A dataset of colored images would be taken for example the CIFAR-10 dataset which is a collection of images and is commonly used to train machine learning and computer vision algorithm. But the dataset would be customized according to the need of the project. The images in the dataset that would be taken would be converted into the black and white images. Since the task of colorization requires both the black and white images as well as their colored counterparts, for the purpose of training the model, hence we keep both black and white, colored images.

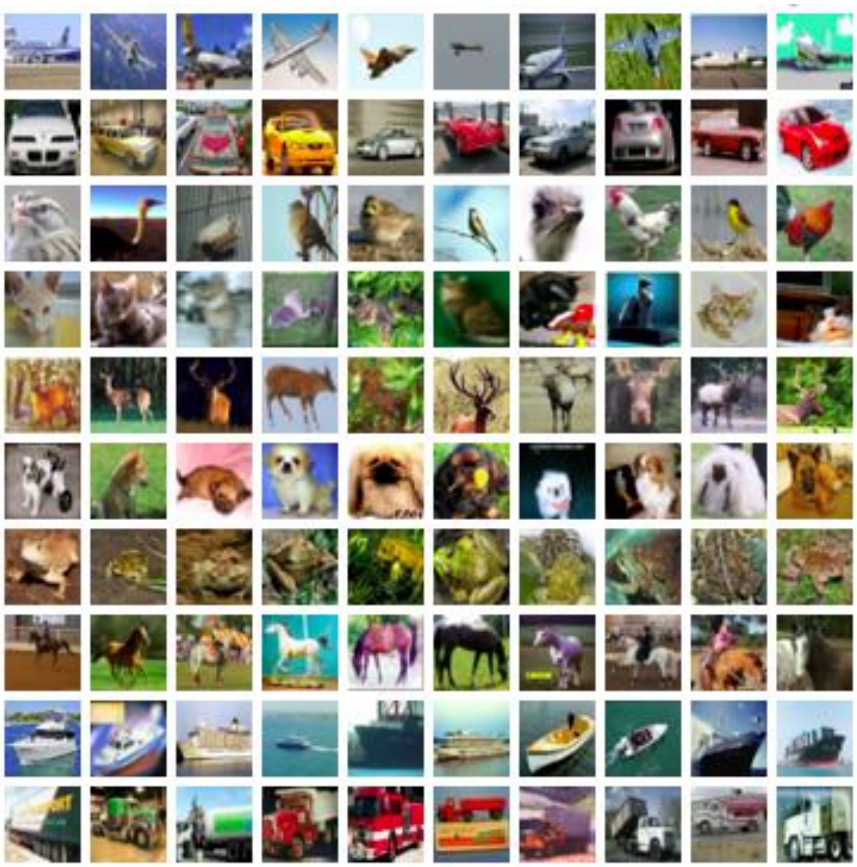


Fig 5.1: Dataset Example- CIFAR-10

2. **Model Design and Creation:** The model used for colorization will work using Generative adversarial networks (GAN).A GAN(generative adversarial network) is made up of two smaller networks called as the generator and discriminator. As the name suggests, the generator's task is to produce results that are indistinguishable from

real data.

The discriminator's task is to classify whether a sample came from the generator's model distribution and the original data distribution. Both of these sub networks are trained simultaneously until the generator is able to consistently produce results that the discriminator cannot classify.

The architectures of the generator and discriminator both follow a multilayer Perceptron model. Since colorization is a class of image translation problems, the generator and discriminator are both convolution neural networks (CNNs).

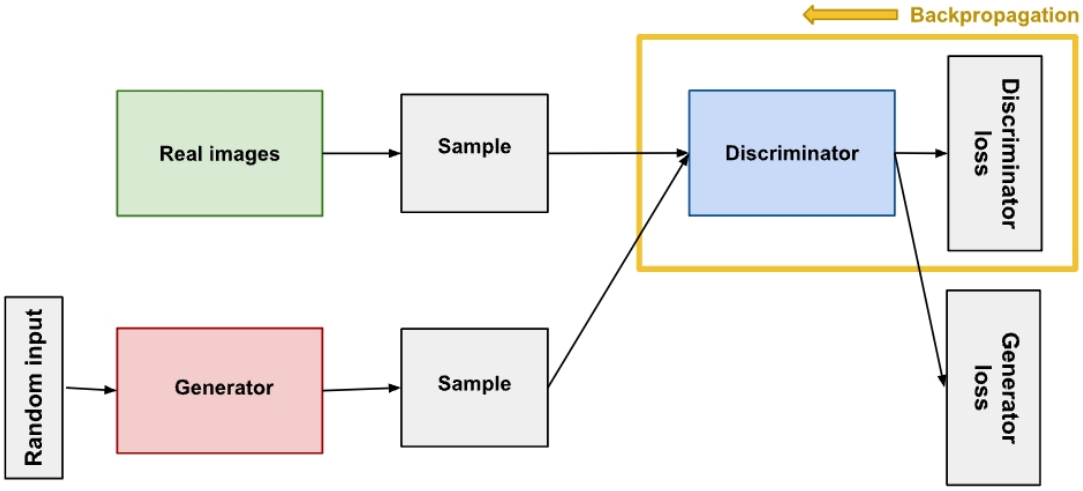


Fig 5.2: Training GAN model

3. **Training and testing the model:** In depth study of GANs would be done to get an insight of their working and their implementation for the purpose of Image Colorization. A GAN has three primary components: a generator model for generating new data, a discriminator model for classifying whether generated data are real faces, or fake, and the adversarial network that pits them against each other.
   The model would be trained on the dataset. In GAN networks, the discriminator network learns a loss function for image classification while the generator network is trained to minimize the loss function. Competition between these two networks is an important factor in producing real images. The GAN networks can achieve good results using a pair of training data and are suitable for converting an input image into an output image.

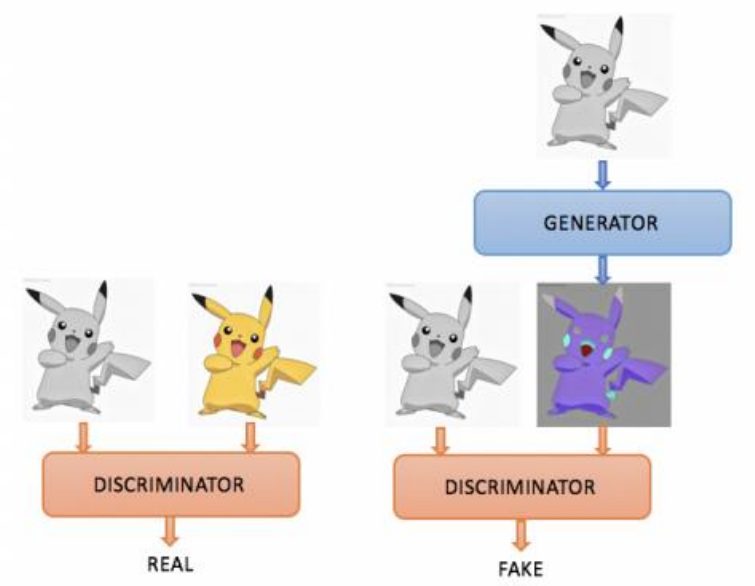


Fig 5.3: GAN Visualisation

After multiple iterations according to the output received, the model would be trained and can be tested using the test data. Unlike other deep learning neural network models that are trained with a loss function until convergence, a GAN generator model is trained using a second model called a discriminator that learns to classify images as real or generated. Both the generator and discriminator model are trained together to maintain an equilibrium. After multiple iterations, when the almost accurate results are obtained, the model would get trained.

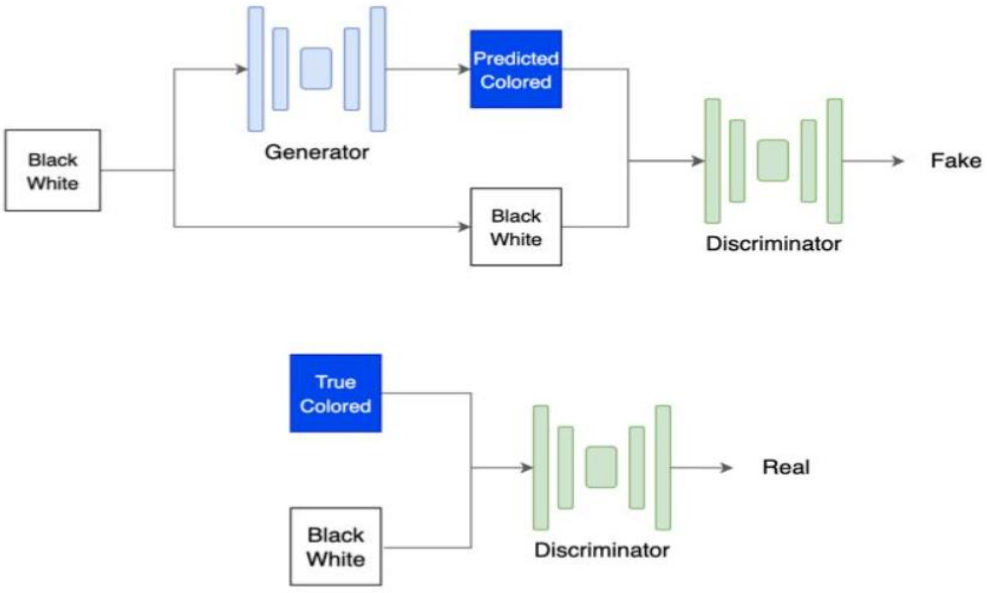


Fig 5.4: Algorithm for GAN

4. **Model deployment using Flask Framework**: To put it to use in order to predict the new data, we have to deploy it over the internet so that the outside world can use it.

Flask Framework is being used provide the interaction link between this model and the user.

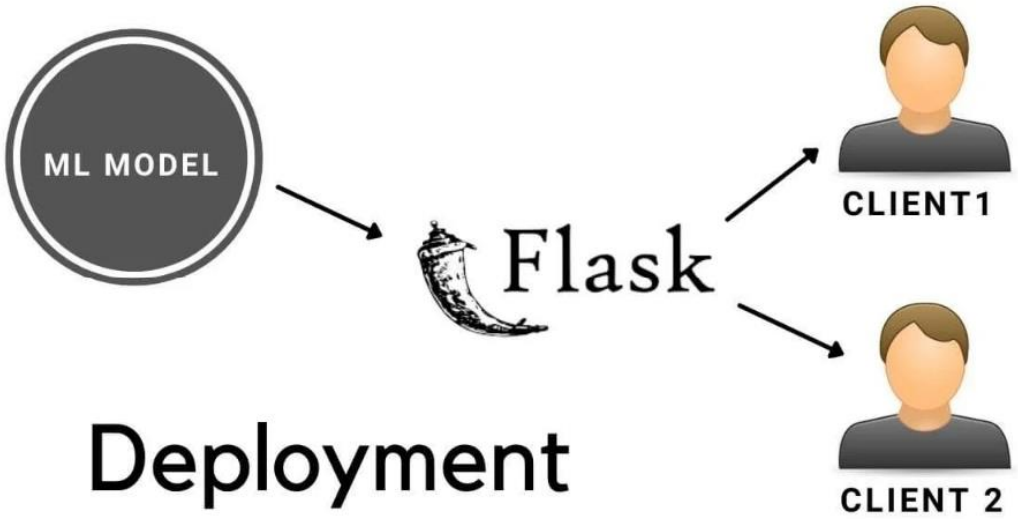


Fig 5.5: Deployment of model using Flask

5. **Deploy Machine Learning Model with Flask on Heroku:** Building/Training a model using various algorithms on a large dataset is one part of the data. Though this is not the end as using these model within different application is second part of deploying machine learning in the real world.

   Heroku is platform which enables developers to build, run and operate application entirely on cloud rather than doing locally on user's machine. The model would be deployed on the Heroku Server.

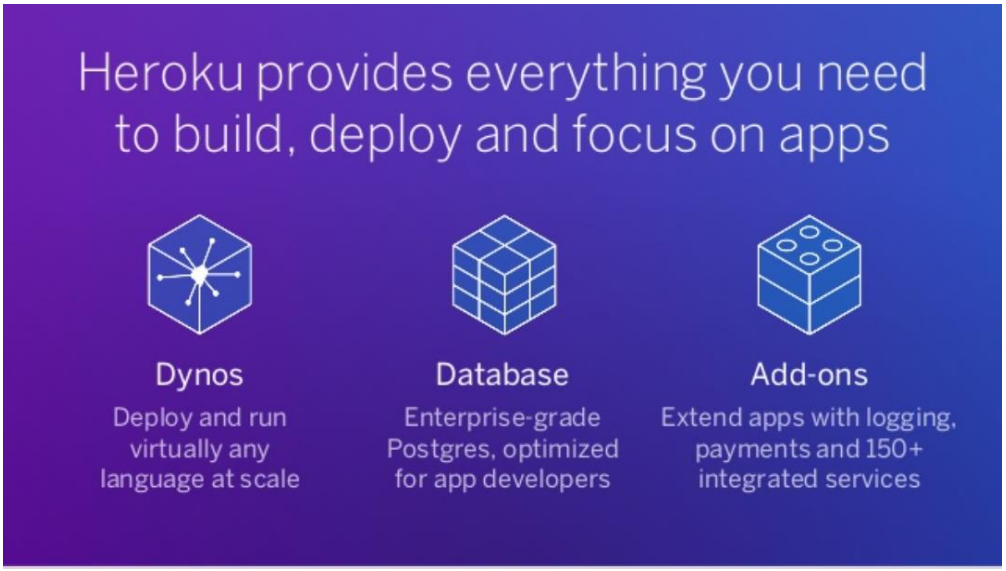


Fig 5.6: Heroku

6. **Creation of Discord Bot**: Once the model has been deployed, in order to make it useful for the real time applications, the deployed model would be integrated with a discord bot, that can be used in the discord servers and get the desired functionality of colorizing the black and white images.

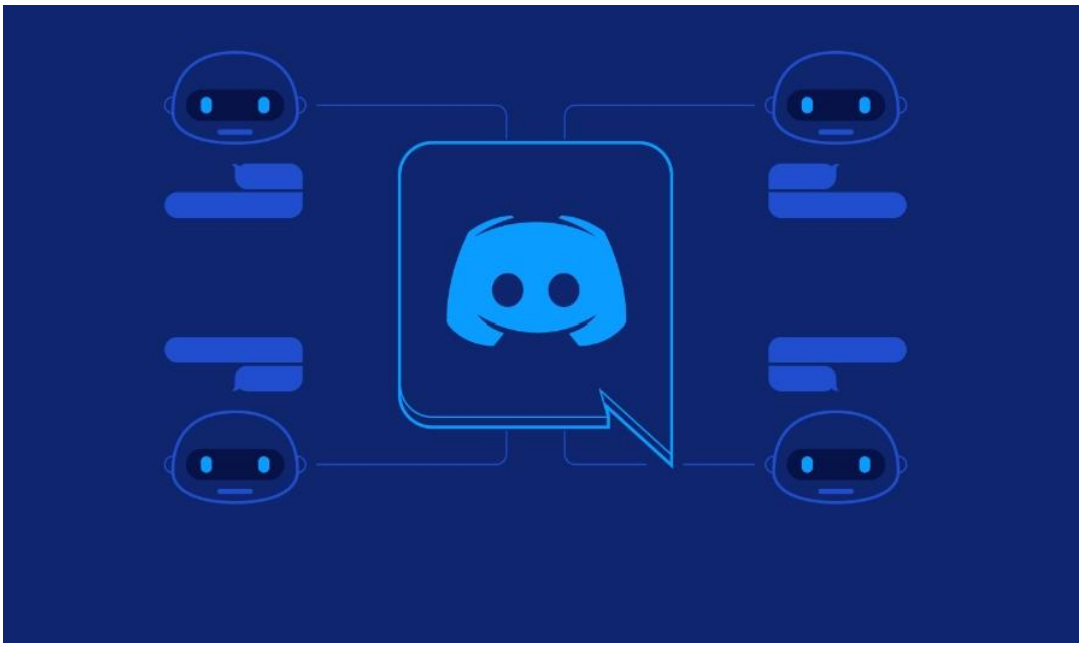


Fig 5.7: Discord

Creation of the discord bot that would be integrated together with the image colorizer model made using GANs. This would result in the creation of AUGMENT: Image Enhancer which could be used for a number of real life applications like the domain of astronomy, MRI scans, surveillance footage etc.

Fig 5.8 Augment

6. TENTATIVE CHAPTER PLAN FOR THE PROPOSEDWORK

CHAPTER 1: INTRODUCTION

This chapter will cover the overview of the project as well as the problem formulation which is Colorizing the black and white images. The introduction has been divided into two parts:

1. Problem Definition: This section highlights the necessity of colorizing the black and white images and how adding colors to an image brings out plethora of information.

2. Project Overview: This section provides insight on the project, the functionality it would provide and a basic overview of the methodology adopted for solving the problem.

CHAPTER 2: LITERATURE REVIEW

This chapter include the literature available for the existing methods. The findings of the researchers will be highlighted and that will become basis of current implementation. There would be comparisons between the exiting systems and the proposed systems. On the baisis of the detailed comparisons done, it was found out that the existing methodologies have some or the other flaws, some of them being:-

1. Increased requirement of human interaction.

2. Images tend to look less realistic.

CHAPTER 3: BACKGROUND OF PROPOSED METHOD

This chapter will provide introduction to the concepts which are necessary to understand the proposed system.This section will give the information about how the proposed system is more advantageous in comparison to the existing system in terms of features and efficiency. The techniques that will be employed to bring out the best of the project are mentioned as well.

CHAPTER 4: METHODOLOGY

This section covers the technical details of the proposed approach. This section will give us the information about how the project will proceed step by step and various functions for the smooth working of the project. A dataset of colored images would be take. But the dataset would be customized according to the need of the project. Since the task of colorization requires both the black and white images as well as their colored counterparts, for the purpose of training the model, hence we keep both black and white, colored images.

The model used for colorization will work using Generative adversarial networks (GAN).The

model would be trained on the dataset. After multiple iterations according to the output received, the model would be trained and can be tested using the test data. After multiple iterations, when the almost accurate results are obtained, the model would get trained.
To put it to use in order to predict the new data, we have to deploy it over the internet so that the outside world can use it. Flask Framework is being used provide the interaction link between this model and the user. Further the model would be deployed using the Heroku application and would be integrated into a discord bot to create Augment.

CHAPTER 5: EXPERIMENTAL SETUP

This chapter will provide information about the subject system and tools used for evaluation of proposed method. The information about the important libraries which will be used in the project and all other setup details. For the proposed system, n in depth knowledge of domains like Deep Learning, Convolution Neural Networks, deployment using Flask and Heroku application is required. The proposed system requires an extensive use of Deep Learning, model creation, training, testing and evaluating it using different matrices.

CHAPTER 6: RESULTS AND DISCUSSION

The result of proposed technique will be discussed in this chapter. This section will provide information about what will be the final goal of the project. The proposed system is a discord bot that would colorize the black and white images without the need of human interaction. It is intended to be used in plethora of domains such as restoration of aged or degraded images, Historical Research, Crime Control Departments, Forensic department, surveillance feed improvement etc. It would be an improvised version as the existing systems have a lot of flaws like creating unrealistic images, blurred images or images having incorrect hues or tones.
Since Augment is a discord bot, so the user just needs to have a Discord account and give the Black and white image as an input. The output would be a near perfect colorized image.

CHAPTER 7: CONCLUSION AND FUTURE SCOPE

Augment is designed to colorize the black and white images without the need of human interaction. The proposed system will solve the problems that are faced in the existing systems like unrealistic images, blurred images or images having incorrect hues or tones . Augment has a wide future scope due to its usage in multiple fields like restoration of aged or degraded images, Historical Research, Crime Control Departments, Forensic department, surveillance feed improvement etc.

REFERENCES

7. REFERENCES

[1] V. G. Jacob and S. Gupta, "Colorization of grayscale images and videos using a semiautomatic approach," 2009 16th IEEE International Conference on Image Processing (ICIP), 2009, pp. 1653-1656, doi: 10.1109/ICIP.2009.5413392.

[2] Matthias Limmer, Hendrik P.A. Lensch, Infrared Colorization Using Deep Convolutional Neural Networks, arXiv:1604.02245

[3] D. Varga and T. Szirányi, "Fully automatic image colorization based on Convolutional Neural Network," 2016 23rd International Conference on Pattern Recognition (ICPR), 2016, pp. 3691-3696, doi: 10.1109/ICPR.2016.7900208.

[4] A. Bugeau and V. Ta, "Patch-based image colorization," Proceedings of the 21st International Conference on Pattern Recognition (ICPR2012), 2012, pp. 3058-3061.

[5] A. Krizhevsky, I. Sutskever, and G. E. Hinton. Imagenet classification with deep convolutional neural networks. In Advances in neural information processing systems, pages 10971105, 2012.

[6] J. Long, E. Shelhamer, and T. Darrell. Fully convolutional networks for semantic segmentation. arXiv preprint arXiv:1411.4038, 2014

[7] A. Levin, D. Lischinski, and Y. Weiss. Colorization using optimization. In ACM SIGGRAPH 2004 Papers, pages 689694, 2004

[8] A. Y.-S. Chia, S. Zhuo, R. K. Gupta, Y.-W. Tai, S.-Y. Cho, P. Tan, and S. Lin. Semantic colorization with internet images. In TOG, volume 30, page 156. ACM, 2011

[9] T. Welsh, M. Ashikhmin, and K. Mueller. Transferring color to greyscale images. ACM Trans. Graph., 21(3):277280, July 2002.

[10] Cheng, Zezhou, Qingxiong Yang, and Bin Sheng. ”Deep colorization.” Proceedings of the IEEE International Conference on Computer Vision. 2015.

[11] E. Tola, V. Lepetit, and P. Fua. A fast local descriptor for dense matching. In CVPR, pages 18. IEEE, 2008.

[12] W.W. Ouyang and X. Wang. Joint deep learning for pedestrian detection. In ICCV, pages 20562063. IEEE, 2013

[13] Tomihisa Welsh, Michael Ashikhmin and Klaus Mueller, 2002, “Transferring color to greyscale Images”. ACM Journal.

8 APPENDICES

Making of Augment: Image Enhancer

Augment: Image Enhancer

Date: 22nd February, 2022

Project leader: Daksh

Project Members: SomyaVishnoi, Anmol Kumar

Development Phase of the Project: Initiation phase (Started Designing the project plan and assigning the team members their respective work for the same)

For approval: Prof. Deepak Kumar