

# M.Sc. Project – Reflective Essay

<b>Project Title:</b>	Image Colorization using Generative Adversarial Networks
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The study coveted to address the challenge of understanding the unstructured data in the form of images by progressively performing research and development methods in order to colorize black and white images with the help of a deep learning algorithm known as Generative Adversarial Networks (GAN's), and also classifying real coloured image and fake (or computer generated or AI generated) coloured images. The study briefly introduces with various other methods of colorizing black and white images into coloured images. Along with that, it has also described why GAN's are the best network to implement on this study.

## Approach:-

The approach was a bit complicated as for doing image colorization, the main purpose is not to give black and white image as an input to the first network of the model i.e., the generator, the main purpose is to colorize a black and white image which itself would be created from a set of coloured images given as an input to the generator. The generator is designed in such a manner that it will take coloured image, convert it into black and white and then colorize it. This complication is introduced in this study because I wanted to perform a study where the next step after the colorization should be classifying original coloured images and coloured images generated by the generator, so that, the problem of identifying fake images that are present in enormous number on the internet could be solved. These fake images tends to misguide a user from the originality of the product. This usually happens in the case of E-commerce websites, Videography websites, a website loaded with humungous images etc. As the discriminator classifies original and fake images, the study will eventually help the user to understand how an AI generated image is different from the original image.

There are two types of output that I achieved in this study. The first output depicts the accuracy of my GAN model, this accuracy shows how accurately my model has classified real and fake images. This is a GAN model, we should aim for best in class generated images, colorizing it, extracting features etc. This eventually gets satisfies by the second output obtained from the study. This output shows a comparative view of original coloured images, black and white images generated from the generator and the colourised images of black and white images that even by generator.

The last but not the least challenge that I faced while implementing this approach was to understand the behaviour of generator. As the quality of generator is that, it learns from itself while training, and improves the quality of generated images during the time of training. This is so because the training of generator and discriminator takes place

simultaneously in GAN. Generator tends to fool the discriminator and vice versa. At one side I was abide to improve the performance of generator and at the other go I was abide to improve the performance of discriminator. In order to fulfil the scope of the project it was necessary that both the networks perform well. This happened to a great extent and has given good results that eventually satisfies the purpose of study.

### **Practical challenges:-**

As a student of Data Science, in addition to writing a research paper I have to demonstrate practical view of the problem. Which means, implementing the problem statement with the help of a high level programming language. I used Python as the programming language in order to implement the problem. There were lots of challenges through which I went to while doing the implementation. Let's discuss some of the major challenges which I faced:

1. **Challenge to select the platform:** - The first challenge was to choose a perfect python environment in which I could do the coding. I have chosen Google Colaboratory as the platform. The best part of choosing Google Colaboratory is that, it can be linked to the Google Drive. Via Google Drive, I was able to easily call the dataset, which I stored in my Google Drive, on my Colaboratory Notebook. Addition to it, the Colaboratory provides an extra advantage of built in python libraries. I was not required to install python libraries to execute the code as Colaboratory has those libraries already installed into it.

Colaboratory also has provided an advantage of utilising free GPU service from Google. As my local machine does not have GPU in it, and in order to implement this project, I was abide to use GPU so that the whole model could be executed in less amount of time. I easily utilised free GPU of Google Colaboratory. The only disadvantage with this free service, is that, we can use it for a limited amount in a day, after which we can't use it. And if we want to use GPU more, we have to purchase the subscription of Google Colaboratory Pro or Google Colaboratory Pro+.

2. **Challenge to select the type of Deep Learning Model:** - Colorization of black and white images is a genuine task of deep learning. Choosing the right deep learning model was a major task. Lots of researches that has occurred in the past regarding the Image colorization has used Convolutional Neural Network (CNN). However, I wanted to implement Generative Adversarial Networks (GAN's). It was not possible to completely use GAN for the project as one of the scope of the project was to classifying the real and fake coloured images, that's why this project has utilised CNN also for the issue of classification in the form of discriminator.

Once, I decided to use GAN as the deep learning model, the next challenge was to execute the model, as it was my first time that I was building a model in which two neural networks should run simultaneously (here generator and discriminator). It was so because both the networks were abide to fool each other and would try to diminish the accuracy of each other and improving their own while training. This was the most challenging part, and I believe that the results obtained were well as per the expectations.

3. **Challenge of choosing the dataset:** - From the complete cycle of deploying a machine or deep learning model, choosing of appropriate dataset takes a lot time, and I faced this challenge as well. For this project, I wished to have a dataset which contains coloured images and multiple classes. At the beginning of the project, I implemented the whole model on a dataset which I downloaded randomly from internet. It wasn't a common dataset like FMNIST, KMNIST, CIFAR 10, ImageNet etc., it was a very basic dataset having images of natural beauty, human beings and vehicles. After I implemented the whole model, I realised I wasn't getting a satisfactory accuracy score, and I thought to change the dataset. It was a great challenge to implement the project on new dataset, because the network which build for previous dataset, started performing much poorer on the new datasets. After trying to implement the model on different datasets, I found a dataset named as Stanford Dogs Dataset, which contains 120 different breeds of dogs. This dataset is basically a subset of very famous ImageNet dataset. This dataset is originally developed in order to perform a task of fine-grained image categorization. However, I utilised this dataset for my project of image colorization. This particular dataset gives me desired results. It took around 40% time of whole project for selecting the dataset.
4. **Challenge of searching research papers for Literature Review:** - While writing my own project paper, it was a challenge to look for journals or papers that were published in the past for the task of image colorization of black and white images. Since, it was purely implementation based project, so there were immense number of study performed in the past, with the help of different machine or deep learning models, as well as, with the help of manual methods of image colorization.
5. **Challenge of inserting images in Latex:** - I was provided with a Latex Template from my university for writing the paper. When I started writing the paper, it was quite obvious to insert images in the paper so as to make the content relatively simple for the readers. As image is the best form of visualising something. Overleaf is a platform where we can use the Latex template, I faced the challenge of inserting the images into it. As whenever I tried to insert an image in between the content, the whole alignment of the paper gets disturbed. Sometimes, the size of the image becomes an issue, sometimes the quality of image becomes an issue (in the case when I stretch the image, the image becomes blurry).

### **Personal Development:-**

It was a great opportunity for me to perform and complete this study irrespective of several challenges that comes across the way of finishing it. The aim and purpose of the study gets satisfactorily fulfilled and I obtained the desired results. I was a data science enthusiast since my under graduation where I chose Data Science as specialisation, I got to know the basics of data science there and in order to excel more I joined the MSc. Big Data Science with Machine Learning Systems in January 2022. By joining this course, I attained a very deep understanding of the core concepts of data science, such as Machine Learning, Deep Learning, Big Data, etc. At the end of the course, i.e., third semester, I have to do a research

project. I chose Sebastian Berns as my supervisor and he guided me throughout the project. I must acknowledge him for helping me in choosing the right dataset and implementing GAN model on it. As GAN is a new deep learning model at the beginning of the project, he guided me a lot to learn the concepts of GAN's, and at the end of this project I must say that I have attained a sound knowledge of GAN's. Not only performing image colorization of black and white images using GAN's, I also learnt a lot about GAN's, how it is being utilised for generating artificial images and it genuinely creates real like images. Since, any deep learning algorithm requires a good volume of data in order to perform well, but in the real world it is difficult to get a dataset with huge volume of data. One option is to use pre-trained models, but the pre-trained models has a disadvantage of not performing well as the dataset used in the pre-trained models, may not match the features and characteristics of dataset used in original project. Hence, GAN's helps to generate data, and solves the issue of lack of data, and successfully overcomes the disadvantage of pre-trained models. At whole, this project has improved my quality of writing, research and development skills.

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