

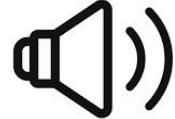
# Colorization and Style Transfer of Images

CS 6220 Big Data Sys & Analytics Workshop Presentation

Group 15 : Kalyani Prasanna Jagdale, Karthik Nama Anil, Prajwal Mavinkere Revanna,  
Sakshi Mittal, Vandana Ramesh



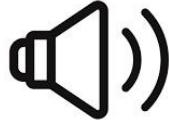
<https://github.com/KarthikNA/Colorisation-Style-Transfer-of-Images>



Kalyani

# Motivation

- Early forms of media and visual arts were black and white
- As technology improved overtime, it transitioned to color gradually
- Image colorization is a technique to add colors to an image that were originally taken in black and white
- Humans have grasped the dexterity to make rare visual experiences by bringing together a variety of styles in images



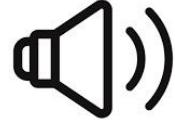
Kalyani

# Goals of Project

- Colorization of black and white images
- Style transfer on images
- Colorization and style transfer on GIFs and videos

# Objective

- Produce a hyper-realistic colorized image
- Produce digital art combining the style image and colorized image

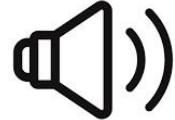


Kalyani

# What is Colorization?

- Colorization is the process of digitally applying color to black & white images(or videos or GIFs)





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# What is Style Transfer?

- Style transfer is the process of modifying the style of an image while still preserving its content

Content Image

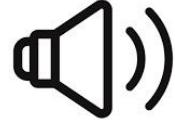


Style Image



Stylized Image

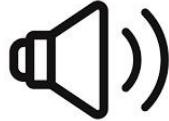




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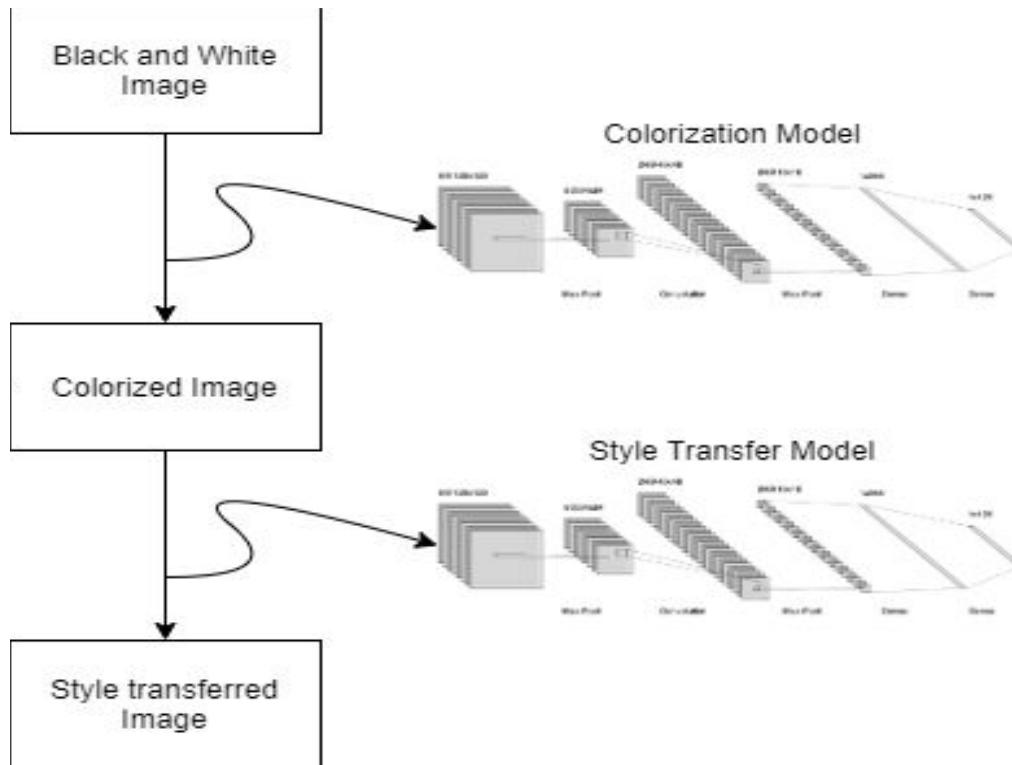
# Related Work

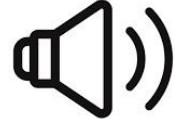
- Feed forward artificial neural network(ANN)
- Convolutional neural network(CNN)
- Combining low-level cues from user edits with high-level semantic information
- LSTMs with conceptual awareness for colorization
- Style transfer using variational autoencoders(VAE) and generative adversarial networks(GANs)



Kalyani

# System Architecture





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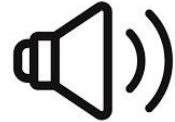
# Dataset

## CIFAR-10

- 60K 32x32 color images in 10 classes
- 50K training images and 10K test images.
- 5 training batches and 1 test batch (each 10K images)

## Places365

- More than 10M images comprising 400+ unique scene categories
- The dataset features 5K to 30K training images per class



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# Technology Stack

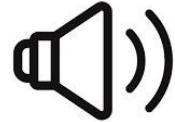


Dash  
by plotly

ngrok



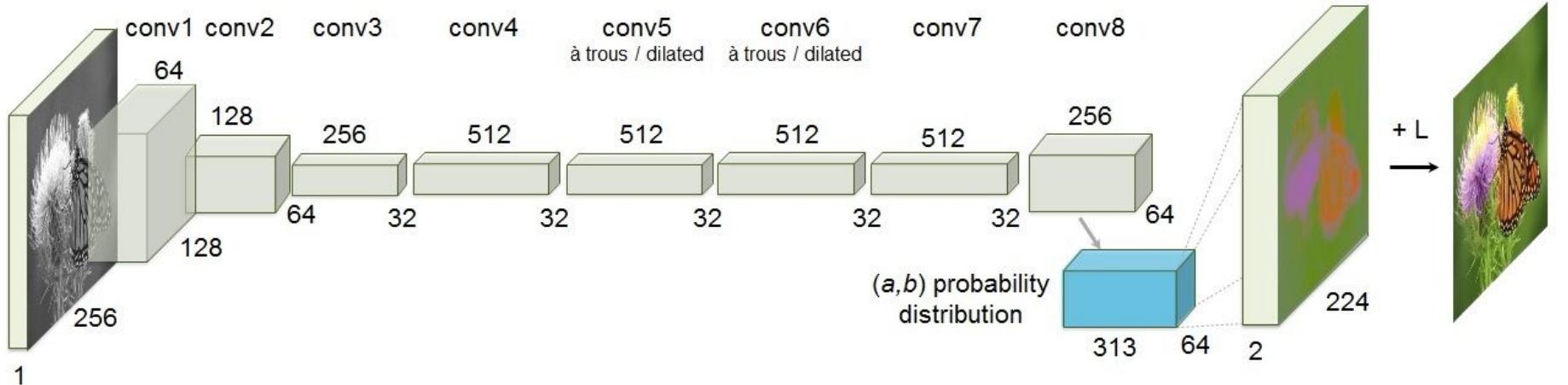
PySimpleGUI

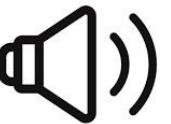


Karthik

# Colorisation Network Structure

Lightness  $L$





Karthik

# Colorization Examples

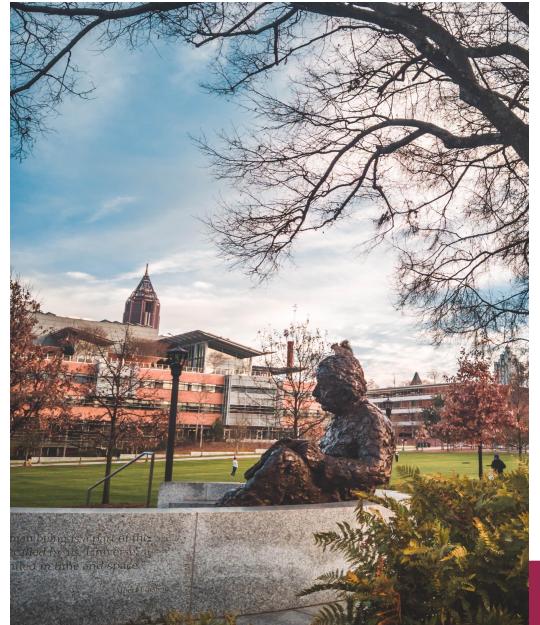
Black and White Image

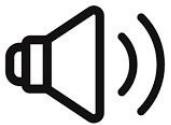


Generated Color Image



Original Color Image





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# Colorization Analysis

Generated Color Image



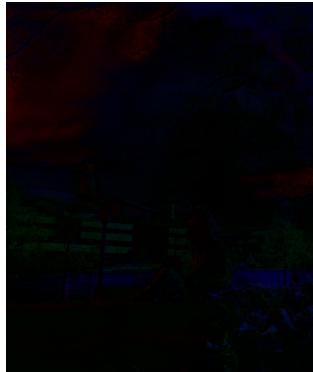
Original Color Image

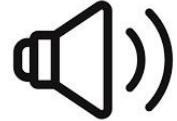


Clamped [0, 1]



ABS Diff





Karthik

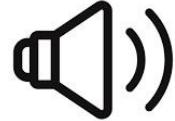
# Colorization Examples: Analysis

Clamped



ABS Diff





Karthik

# Colorization Examples

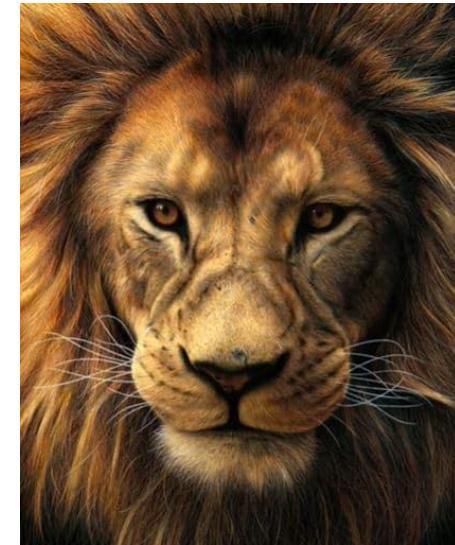
Black and White Image

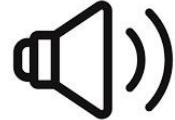


Generated Color Image



Original Color Image





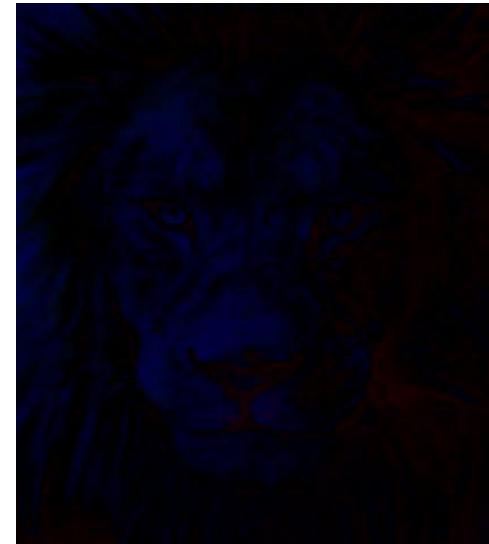
Karthik

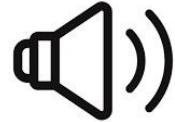
# Colorization Examples - Analysis

ABS Diff



Clamped





Karthik

# Colorization Examples

Black and White Image

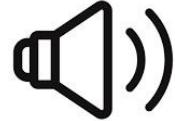


Generated Color Image



Original Color Image





Karthik

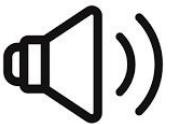
# Colorization Examples - Analysis

ABS Diff



Clamped

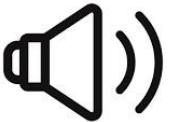




Sakshi

# Colorization Examples - Bad Colorization





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# Evaluation - Colorization Turing Test

1a Colorized



1b Original



2a Colorized



2b Original

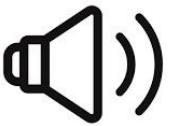


Image 1b  
39.6%

Image 1a  
60.4%

Image 2b  
52.1%

Image 2a  
47.9%



Sakshi

# Colorization Turing Test

3a Colorized



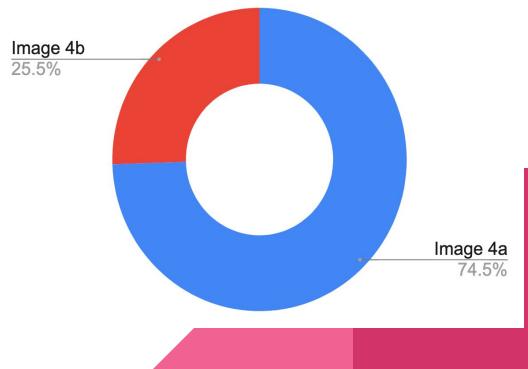
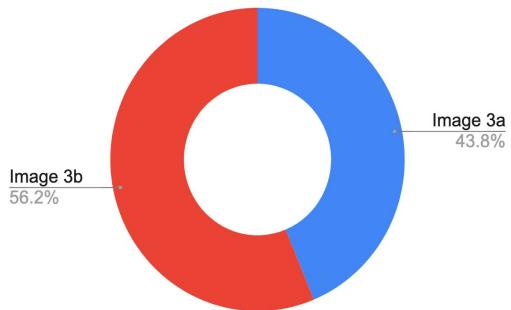
3b Original

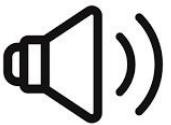


4a Colorized



4b Original





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# Colorization Turing Test

5a Original



5b Colorized



6a Original



6b Colorized



Image 5a  
24.0%

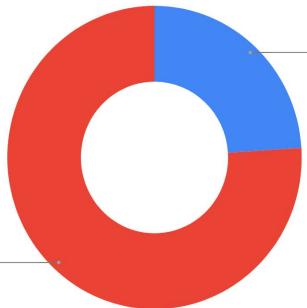


Image 5b  
76.0%

Image 6a  
19.4%

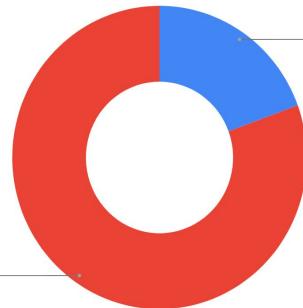
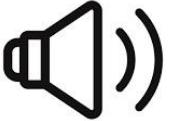
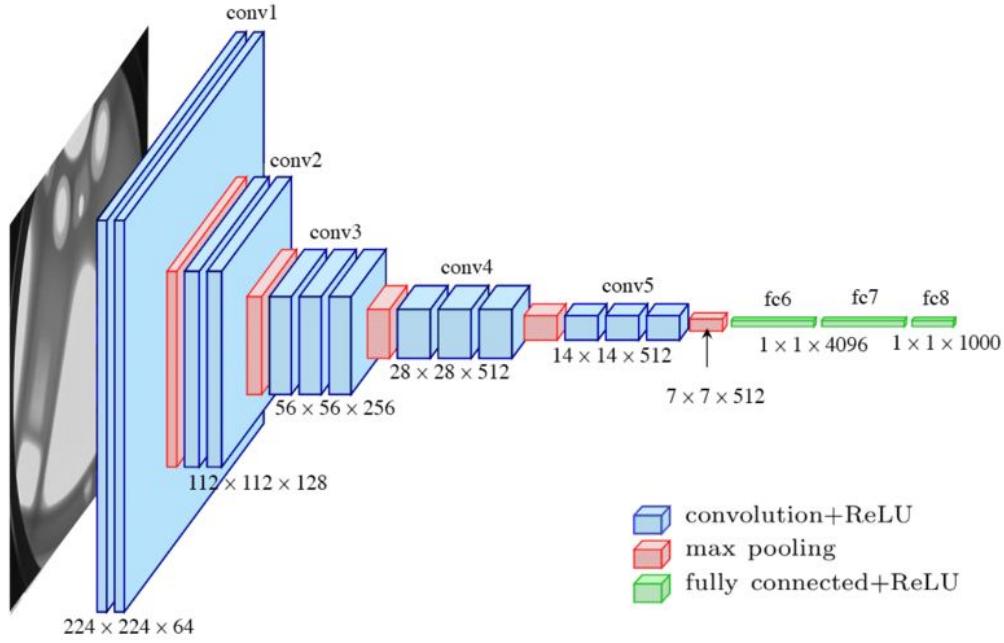


Image 6b  
80.6%



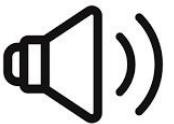
Sakshi

# Style Transfer CNN structure



VGG16

- $3 \times 3$  convolution layers
- $2 \times 2$  size max pooling layers
- fully connected layers
- total 16 layers



Prajwal

# Style Transfer Examples

Original Image

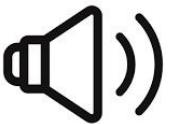


Style Image



Stylized Image





Prajwal

# Style Transfer Examples

Original Image

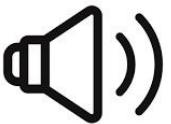


Style Image



Stylized Image





Prajwal

# Style Transfer Examples

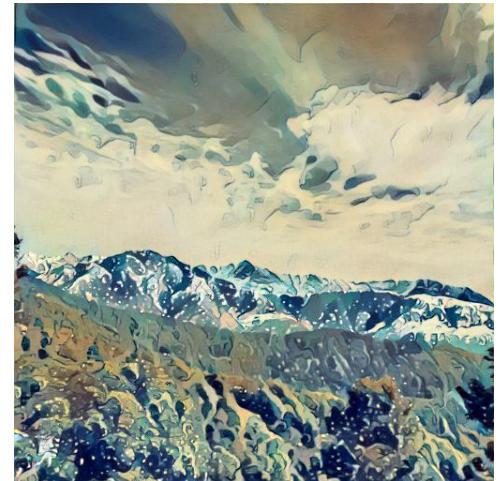
Original Image

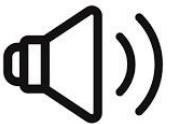


Style Image



Stylized Image





Prajwal

# Style Transfer Examples

Original Image

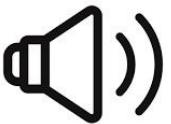


Style Image



Stylized Image

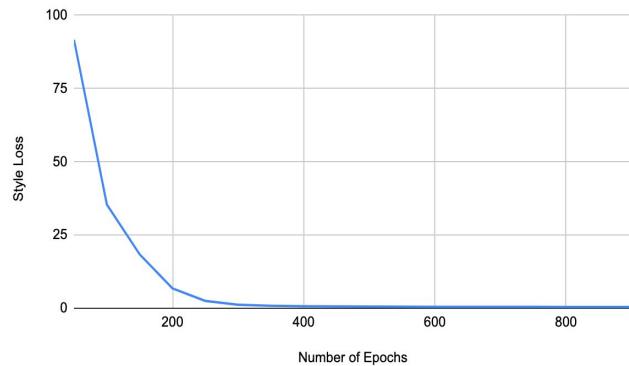




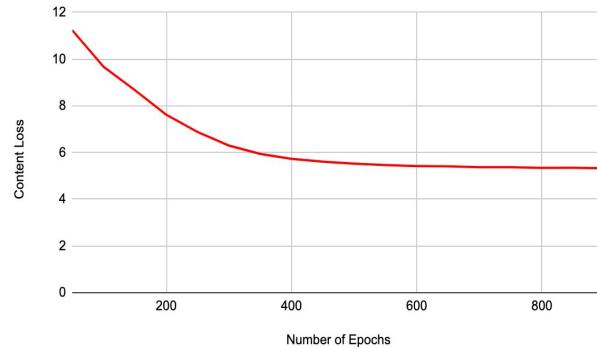
Prajwal

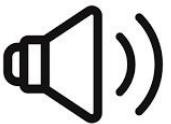
# Evaluation for Style Transfer - Losses

Style Loss vs. Number of Epochs



Content Loss vs. Number of Epochs





# Evaluation for Style Transfer - Number of Epochs

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100 Epochs

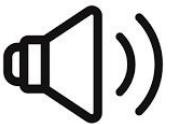
300 Epochs

500 Epochs

700 Epochs

900 Epochs





Prajwal

# Evaluation for Style Transfer - Reverse

Stylized Image

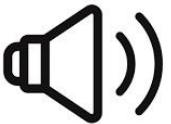


Reverse Style Transfer Image



Original Image





Vandana

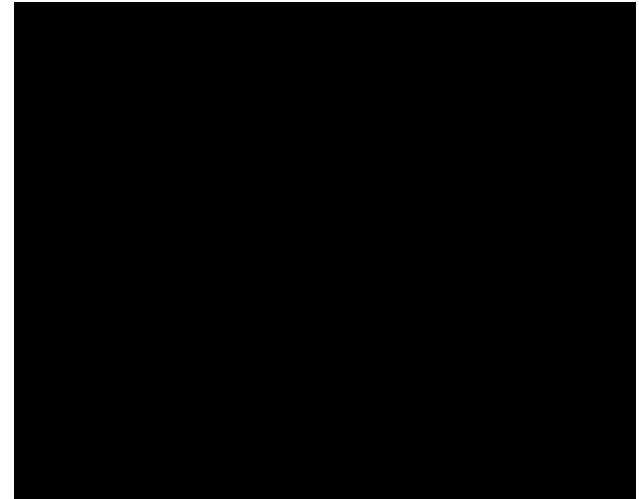
# Experiments with Video



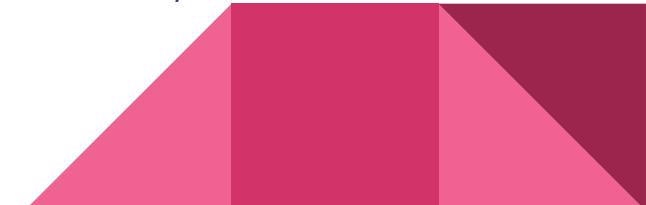
Original Video

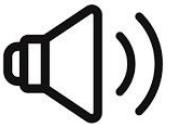


Style Image



Stylized Video





Vandana

# Colorization + Style Transfer Examples

B/W image



Colorized Image

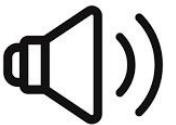


Style Template



Stylized Result





Vandana

# Colorization + Style Transfer Examples

B/W Image



Colorized Image

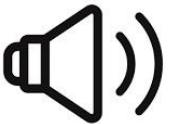


Style Template



Stylized Result

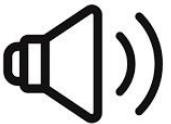




Vandana

# Areas of Improvement

- Train the colorization model on larger dataset
- Introducing inter frame correlation for style transfer to minimise unwanted artifacts
- Multiple forms of evaluation
- Content / Style trade off

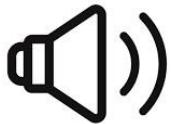
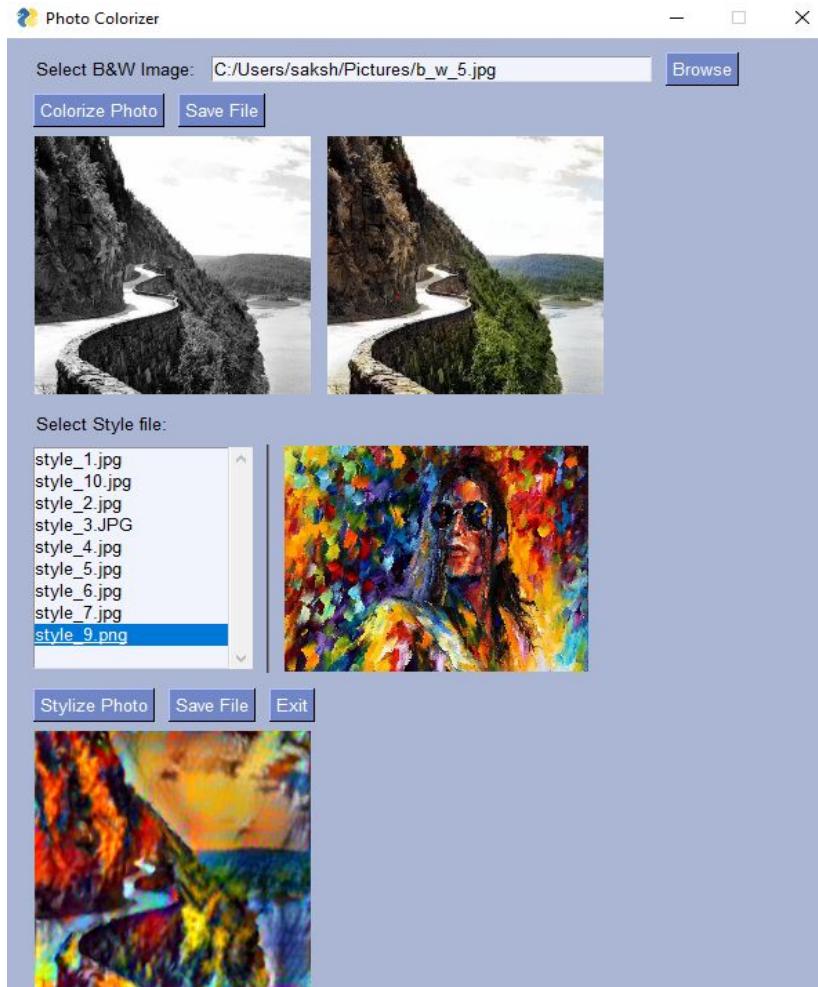


Vandana

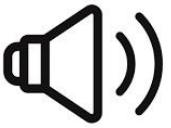
# Conclusion and Future Work

- Colorization network can be adapted to perform object detection, classification and image segmentation
- Compare the output of our model with the outputs of deeper networks employing conditional GANs
- Modify the models to run on lower compute devices like mobiles and tablets
- Interactive user inputs to aid colorization and style transfer and give control over the amount of style transfer.
- Colorization and style transfer networks can be used for image augmentation tasks
- Transfer style but not color

# Application GUI



Sakshi



Sakshi

# Application Demo

# Q & A

