SCTR's PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE - 411043
Department of Computer Engineering
S.No.-27, Pune Satara Road, Dhankawadi, Pune-411043

Laboratory Practice-VI (AY 2022-23)

Batch- R4 Sem- 8

Group members (Roll no and Name):

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Title of project: Build a deep learning model that converts old black and white images to colorful images.

1. Introduction

a. Motivation

images to colorful images stems from the desire to revitalize and enhance the visual experience of historical photographs, artworks, and memories captured in monochrome.

Preserving Historical Heritage: Black and white images hold significant historical and cultural value, providing a glimpse into the past. By transforming these images into colorful representations, we can bring them to life, making them more relatable and engaging for present and future generations.

Enhancing Visual Appeal: Adding color to black and white images can greatly enhance their visual appeal. Colors can evoke emotions, improve the interpretation of scenes, and provide a more immersive viewing experience. This motivation drives the desire to restore and augment the aesthetic qualities of old photographs and artworks.

Recreating Realism and Context: Colorization of black and white images allows us to recreate the original context and details present in the scenes. By accurately predicting colors based on contextual information, the model can help bridge the gap between the past and the present, enabling viewers to better understand the historical context and visual nuances.

Accessibility and Engagement: Colorful images tend to be more accessible and relatable to a broader audience. By converting black and white images into color, we can make them more engaging and accessible to individuals who may struggle to interpret or connect with monochrome visuals. This motivation promotes inclusivity and wider appreciation of historical content.

Artistic Expression and Creativity: The process of colorization offers an avenue for artistic expression and creativity. Deep learning models can learn complex patterns and generate plausible colorizations, allowing users to experiment with different color palettes and artistic interpretations. This motivation drives the exploration of new possibilities for artistic endeavors and visual storytelling.

Educational and Research Applications: Colorizing black and white images can aid in educational settings and research endeavors. It can provide valuable insights into historical events, cultural practices, and scientific observations. The colorized images can serve as visual aids, facilitating better comprehension and analysis.

Technological Advancements: Developing a deep learning model for black and white to color image conversion presents a technological challenge. It requires exploring and refining state-of-the-art deep learning architectures and techniques, pushing the boundaries of image processing, computer vision, and machine learning. This motivation fosters advancements in the field and contributes to the development of sophisticated algorithms.

b. Objective/ Purpose

The purpose of building a deep learning model that converts old black and white images to colorful images is to leverage the capabilities of artificial intelligence and computer vision to restore, enhance, and revitalize historical photographs and artworks. By adding color to black and white images, the purpose is to:

Preserve Historical Legacy: The purpose is to ensure that the visual heritage captured in black and white images is not lost or forgotten. Colorization enables us to breathe new life into these images, preserving their historical significance and allowing future generations to connect with the past.

Improve Visual Interpretation: The purpose is to enhance the interpretation of black and white images by adding color cues. Colorization provides additional visual information, making it easier to discern details, understand the context, and interpret the scenes depicted in the images.

Enhance Aesthetic Appeal: The purpose is to improve the aesthetic qualities of black and white images by introducing color. Colorization can make the images more visually striking, captivating, and engaging, appealing to a wider audience and fostering a deeper appreciation for historical visuals.

Bridge the Gap Between Past and Present: The purpose is to bridge the gap between the past and the present by transforming black and white images into colorful representations. Colorization helps viewers relate to historical events, cultural practices, and personal memories by bringing them closer to the realities of the time.

Facilitate Educational and Research Endeavors: The purpose is to support educational efforts and research initiatives by providing colorized visuals that aid in the study of history, culture, art, and science. Colorized images can serve as valuable resources for analysis, interpretation, and documentation.

Stimulate Artistic Expression: The purpose is to provide a platform for artistic expression and creativity. Colorization allows artists and enthusiasts to explore different color palettes, experiment with artistic interpretations, and reimagine black and white images in new and captivating ways.

Drive Technological Advancements: The purpose is to push the boundaries of deep learning, computer vision, and image processing techniques. Developing a deep learning model for colorization contributes to advancements in these fields and fosters the development of more sophisticated algorithms for image analysis and manipulation.

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Scope of Project

The scope of the project involves the following key aspects:

Dataset Collection and Preparation:

Collecting a diverse dataset of black and white images with corresponding color images, either from publicly available sources or through appropriate permissions.

Preprocessing the dataset by aligning and resizing the images, ensuring they are suitable for training the deep learning model.

Deep Learning Model Development:

Designing and implementing a deep learning architecture suitable for colorization tasks, such as Convolutional Neural Networks (CNNs) or Generative Adversarial Networks (GANs).

Exploring and experimenting with different network architectures, loss functions, and regularization techniques to improve the model's performance and convergence.

Training and Evaluation:

Splitting the dataset into training, validation, and testing subsets.

Training the deep learning model using the training data and optimizing its parameters through iterative forward and backward passes.

Evaluating the model's performance by measuring metrics such as color accuracy, perceptual quality, and preservation of image details.

Dataset Augmentation and Enhancement:

Exploring techniques to augment the dataset, such as data augmentation methods like rotation, scaling, and flipping, to increase its diversity and improve the model's generalization capabilities.

Investigating methods to enhance the dataset by incorporating additional metadata or semantic information to guide the colorization process.

Optimization and Fine-tuning:

Optimizing the hyperparameters of the deep learning model, including learning rate, batch size, and regularization parameters, to improve its convergence and overall performance.

Fine-tuning the model by leveraging transfer learning from pre-trained models or considering techniques like domain adaptation to handle specific types of images or improve performance on specific subtasks.

Post-processing and Refinement:

Implementing post-processing techniques to further enhance the colorized images, such as adjusting contrast, brightness, and color balance, or applying denoising and sharpening filters.

Exploring methods to refine the colorization results based on user feedback or incorporating interactive mechanisms to allow users to provide guidance or correct inaccuracies.

Performance Evaluation and Comparison:

Conducting comprehensive performance evaluations of the trained model using appropriate metrics and benchmarks.

Comparing the results of the colorization model against existing state-of-the-art methods or human experts to assess its effectiveness and superiority.

User Interface and Deployment:

Developing a user-friendly interface that allows users to input black and white images and visualize the corresponding colorized output.

Ensuring the model can be deployed on various platforms or integrated into existing applications for widespread accessibility and usability.

Documentation and Reporting:

Documenting the entire project, including the methodology, implementation details, experimental setup, and findings.

Preparing a comprehensive report summarizing the project's scope, objectives, approach, results, and recommendations for future improvements.

2. Overall Description

- ### Functional requirements
    - Dataset Acquisition and Preprocessing:
    - Functionality to collect a diverse dataset of black and white images with corresponding color images, ensuring appropriate permissions and copyright compliance.

- Preprocessing capabilities to align, resize, and normalize the images, preparing them for training the deep learning model.
- Model Architecture and Training:
- Implementation of a deep learning architecture suitable for colorization, such as CNNs or GANs.
- Training functionality to iteratively optimize the model's parameters using the collected dataset.
- Ability to configure and fine-tune hyperparameters like learning rate, batch size, and regularization techniques.
- Evaluation and Performance Metrics:
- Calculation of performance metrics, such as color accuracy, perceptual quality, and preservation of image details, to assess the model's effectiveness.
- Evaluation functionality to measure the model's performance on a separate validation or testing dataset.
- Comparison capabilities to benchmark the model against existing state-of-the-art methods or human experts.
- Dataset Augmentation and Enhancement:
- Functionality to augment the dataset using techniques like rotation, scaling, flipping, or introducing additional noise to increase diversity and improve generalization.
- Integration of methods to enhance the dataset by incorporating metadata or semantic information to guide the colorization process.
- Optimization and Fine-tuning:
- Optimization functionality to fine-tune hyperparameters, such as learning rate, weight decay, or dropout, to improve the model's convergence and performance.
- Ability to leverage transfer learning from pre-trained models or apply domain adaptation techniques to handle specific image types or subtasks.
- Post-processing and Refinement:
- Implementation of post-processing techniques to enhance the colorized images, including contrast adjustment, brightness correction, denoising, or sharpening filters.

- Capability to incorporate user feedback or interactive mechanisms to refine colorization results based on user input or corrections.
- User Interface and Integration:
- Development of a user-friendly interface allowing users to input black and white images and visualize the corresponding colorized output.
- Compatibility with various platforms and integration options to enable seamless deployment and usage within existing applications or frameworks.
- Documentation and Reporting:
- Capability to generate comprehensive documentation, including methodologies, implementation details, experimental setups, and findings.
- Reporting functionality to summarize the project's scope, objectives, approach, results, and recommendations for further improvements.
- Scalability and Performance:
- Consideration of scalability to handle large datasets and ensure efficient utilization of computational resources.
- Optimization of code and algorithms to achieve reasonable inference and processing times for colorization.

Hardware Requirements:

- Processor: Intel Core i5 or higher
- RAM: 8 GB or higher
- Storage: At least 50 GB of free disk space
- Internet connection: A high-speed internet connection is required for downloading and processing large language models and datasets.

Software Requirements:

- Operating System: Any major operating system such as Windows, MacOS, or Linux
- Python: Version 3.x or higher
- Text editor or IDE: Any text editor such as Sublime Text, Jupyter Notebook or an IDE such as PyCharm

3. Implementation details along with screenshots

main.py > ...

```python
import numpy as np
import argparse
import cv2
import os

# Load Files
DIR = r"./colorize"
PROTOTXT = os.path.join(DIR, r"colorization_deploy_v2.prototxt")
POINTS = os.path.join(DIR, r"pts_in_hull.npy")
MODEL = os.path.join(DIR, r"colorization_release_v2.caffemodel")

# Argparser
ap = argparse.ArgumentParser()
ap.add_argument("-i", "--image", type = str, required = True, help = "Path to input BW image")
args = vars(ap.parse_args())

# Loading the model
print("Load Model...")
net = cv2.dnn.readNetFromCaffe(PROTOTXT, MODEL)
pts = np.load(POINTS)

# Loading Centres for AB channel
class8 = net.getLayerId("class8_ab")
conv8 = net.getLayerId("conv8_313_rh")
pts = pts.transpose().reshape(2, 313, 1, 1)
net.getLayer(class8).blobs = [pts.astype("float32")]
net.getLayer(conv8).blobs = [np.full([1, 313], 2.606, dtype = "float32")]

# Loading input image
image = cv2.imread(args["image"])
scaled = image.astype("float32") / 255.0
lab = cv2.cvtColor(scaled, cv2.COLOR_BGR2LAB)

# Tune parameters
resized = cv2.resize(lab, (224, 224))
L = cv2.split(resized)[0]
L -= 50

# Colorizing
print("Colorizing the image")
net.setInput(cv2.dnn.blobFromImage(L))
ab = net.forward()[0, :, :, :].transpose((1, 2, 0))
ab = cv2.resize(ab, (image.shape[1], image.shape[0]))
L = cv2.split(lab)[0]
colorized = np.concatenate((L[:, :, np.newaxis], ab), axis = 2)
colorized = cv2.cvtColor(colorized, cv2.COLOR_LAB2BGR)
colorized = np.clip(colorized, 0, 1)

```

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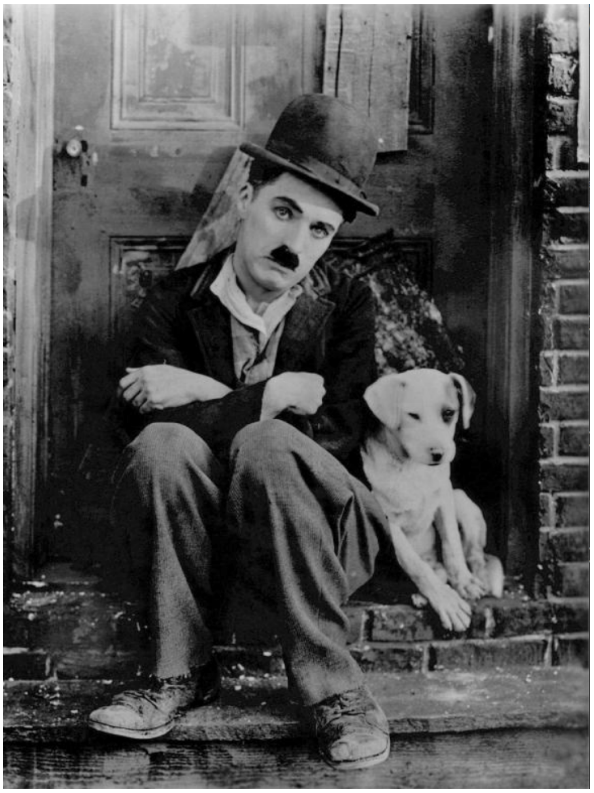

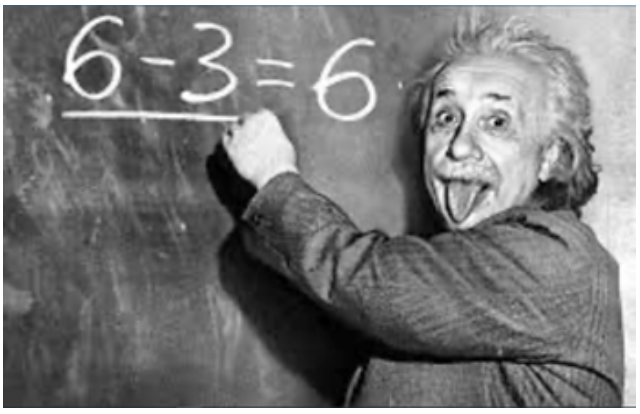

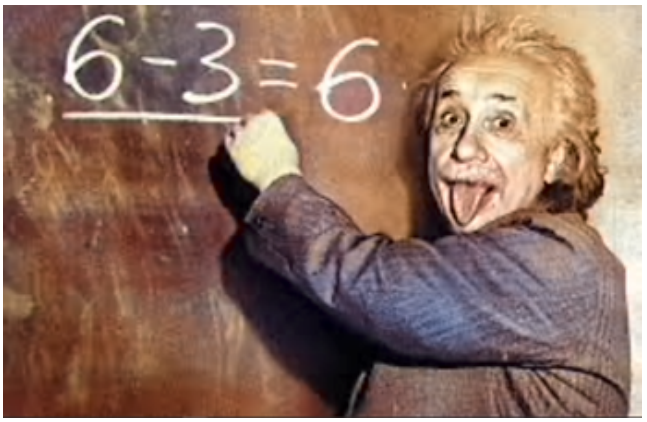

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4. Conclusion

In conclusion, this report has demonstrated the application of clustering algorithms to segment mall customers based on their shopping behaviors. By analyzing customer transaction data and using Silhouette method clustering techniques, the report identified distinct customer segments based on demographics, purchase history, and visit frequency.

The report provided insights into the different types of customers that visit the mall and their shopping behaviors, which can be useful for targeted marketing, promotions, and events. Additionally, the report identified the most effective clustering method for mall customer segmentation, which can be used to optimize store layouts, product placements, and inventory management.

Overall, this report has shown that clustering is a powerful technique for segmenting mall customers, providing insights into customer behavior patterns and preferences, and identifying opportunities for improving business performance. By implementing the recommendations provided in this report, mall management and retail businesses can better cater to each customer segment's needs, ultimately leading to increased customer satisfaction, retention, and revenue growth.

In conclusion, this report has provided valuable insights into mall customer segmentation using clustering, demonstrating the technique's potential for optimizing business operations and improving customer experiences.