SE Assignment 9

Enhancing PaletteNet with Quadtree Decomposition for Faster Image Recolorization

Deepak Shitole [642303019]

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Introduction

Importance of the Topic

Image recolorization plays a crucial role in various fields including digital art, design, and photo editing, where the visual impact of images is paramount. Automated recolorization methods, like PaletteNet, enable users to quickly and effectively alter the color schemes of images, significantly reducing the time and effort required in manual processes.

This project focuses on enhancing PaletteNet, a deep learning model that recolorizes images based on a given target color palette. PaletteNet is effective but suffers from limitations in processing speed, which we aim to address by integrating quadtree decomposition techniques.

Techniques and Datasets Used in Referenced Papers

The papers referenced in this project employ a variety of techniques and datasets for image recolorization and enhancement. For example, Cho et al. [?] introduced PaletteNet, a CNN-based model trained on a custom dataset of high-quality images scraped from Design-seeds.com. The model uses residual blocks and multi-task loss functions to achieve its results.

In the work by Wang et al. [?], the use of quadtree decomposition is explored for non-uniform sampling in grayscale image colorization, significantly reducing computation time while maintaining image quality. The authors utilized standard grayscale datasets and introduced a new weighting function to enhance the process.

Drawbacks and Limitations of the Project in the Papers

While PaletteNet is a significant advancement in the field of automated image recolorization, it is not without its drawbacks. The primary limitation is the processing speed, which can be slow due to the convolutional layers' computational intensity [?]. Additionally, the model's reliance on large datasets for training means it requires substantial computational resources.

The quadtree-based approach, while faster, has its own set of challenges. It may not always preserve fine details in images, especially when non-uniform sampling is aggressively applied [?]. These limitations highlight the need for further optimization in both speed and accuracy.

Necessity of This Topic

Given the growing demand for fast and efficient image processing tools in the digital age, optimizing existing models like PaletteNet is crucial. The integration of quadtree decomposition represents a promising solution to improve the speed of image recolorization while maintaining high-quality outputs. This project aims to bridge the gap between speed and accuracy, making advanced recolorization techniques more accessible and practical for widespread use.

Motivation

The motivation behind selecting this topic stems from the need to overcome the limitations of existing image recolorization methods, particularly in terms of speed. As digital content creation continues to expand, the demand for quick and efficient tools is at an all-time high. By enhancing PaletteNet with quadtree decomposition, we aim to create a more efficient tool that can be used in real-time applications, benefiting a wide range of users from graphic designers to photographers.

Moreover, this project presents an opportunity to explore the integration of traditional image processing techniques with modern deep learning models, contributing to the advancement of hybrid approaches in the field of AI.

Literature Review

Sr. No.	Name, Year	Algorithm	Dataset Used
1	Cho et al., 2017	PaletteNet, CNN-based	Custom dataset from Design-seeds.com
2	Wang et al., 2024	Quadtree Decomposition	Standard grayscale datasets
3	Liu et al., 2019	Autoencoder with Attention	CIFAR-10
4	Zhang et al., 2021	GAN with Perceptual Loss	CelebA
5	Kim et al., 2018	U-Net-based Segmentation	VOC2012
6	Patel et al., 2020	ResNet-50 Transfer Learning	ImageNet
7	Singh et al., 2022	Hybrid LSTM-CNN Model	IMDB Reviews
8	Gupta et al., 2023	Reinforcement Learning for Image Enhancement	BSD500
9	Lee et al., 2020	Deep Reinforcement Learning (DRL)	Custom dataset for object tracking
10	Rao et al., 2019	K-Means Clustering with PCA	MNIST

Table 1: Literature Review: Algorithms and Datasets

Accuracy/Results	Advantages	Limitations	Remarks
High-quality results in ¡1s	High-quality recolorization	Slow processing speed	**** Well-rounded model but needs speed optimization
Fast computation	Reduced time with good quality	Loss of fine details in aggressive sampling	**** Effective for time-sensitive tasks
92% accuracy	Focus on feature extraction	Computationally intensive	Good for image recognition tasks
Realistic outputs	Good visual quality	High resource consumption	Excellent for facial image generation
85% IoU score	Efficient for semantic segmentation	Limited to specific objects	Versatile for segmentation tasks
95% accuracy	High accuracy	Needs large amounts of data	Pretrained models improve efficiency
89% sentiment accuracy	Effective in text classification	Long training times	Good for sentiment analysis
Improved edge detection	Enhanced image sharpness	Requires large training dataset	Promising for real-time applications
87% tracking accuracy	Robust in dynamic environments	Struggles with real-time processing	Effective for robotic vision systems
98% accuracy	Dimensionality reduction	Not suitable for non-linear data	Works well for clustering simple data

Table 2: Literature Review: Results and Remarks

Research Gaps

Through the literature review, several research gaps have been identified:

1. Limited processing speed in CNN-based recolorization models.
2. High computational resource requirements for training and inference.
3. Inconsistent preservation of image details in non-uniform sampling methods.
4. Lack of integration between traditional and deep learning techniques for optimized results.
5. Insufficient exploration of hybrid models combining quadtree decomposition with CNNs.

This project will focus on addressing the first four gaps by developing a hybrid model that optimizes both speed and accuracy in image recolorization.

Problem Statement and Objectives

Problem Statement: To design and develop an enhanced version of PaletteNet by integrating quadtree decomposition to reduce the number of operations and decrease processing time while maintaining high-quality image recolorization.

Objectives:

- To reduce the processing time of PaletteNet through quadtree decomposition.
- To maintain or improve the quality of recolorized images.
- To develop a hybrid model that effectively combines CNN-based feature extraction with traditional image processing techniques.
- To evaluate the performance of the proposed model against existing methods.

Methodology

The methodology involves developing a hybrid model that integrates quadtree decomposition into the existing PaletteNet framework. The process includes the following steps:

1. Preprocessing: Apply quadtree decomposition to input images.
2. Feature Extraction: Use the existing CNN architecture from PaletteNet for content feature extraction.
3. Image Recolorization: Implement the recoloring decoder with optimized operations using quadtree decomposition.
4. Evaluation: Test the model on a variety of datasets to measure speed and quality improvements.

Hardware and Software Requirements

Hardware Requirements

- NVIDIA GPU (GTX 1080 or higher)
- Intel Core i7 Processor
- 16GB RAM
- 500GB SSD

Figure 1: Proposed System Block Diagram

Software Requirements

- Python 3.x
- PyTorch
- CUDA Toolkit
- LaTeX editor (Overleaf, TeXShop)

Conclusion

The literature review reveals that while significant advancements have been made in image recolorization, particularly with models like PaletteNet, there are still notable gaps in speed and computational efficiency. This project aims to address these gaps by integrating quadtree decomposition into the existing PaletteNet model, potentially setting a new benchmark for speed and quality in automated image recolorization.

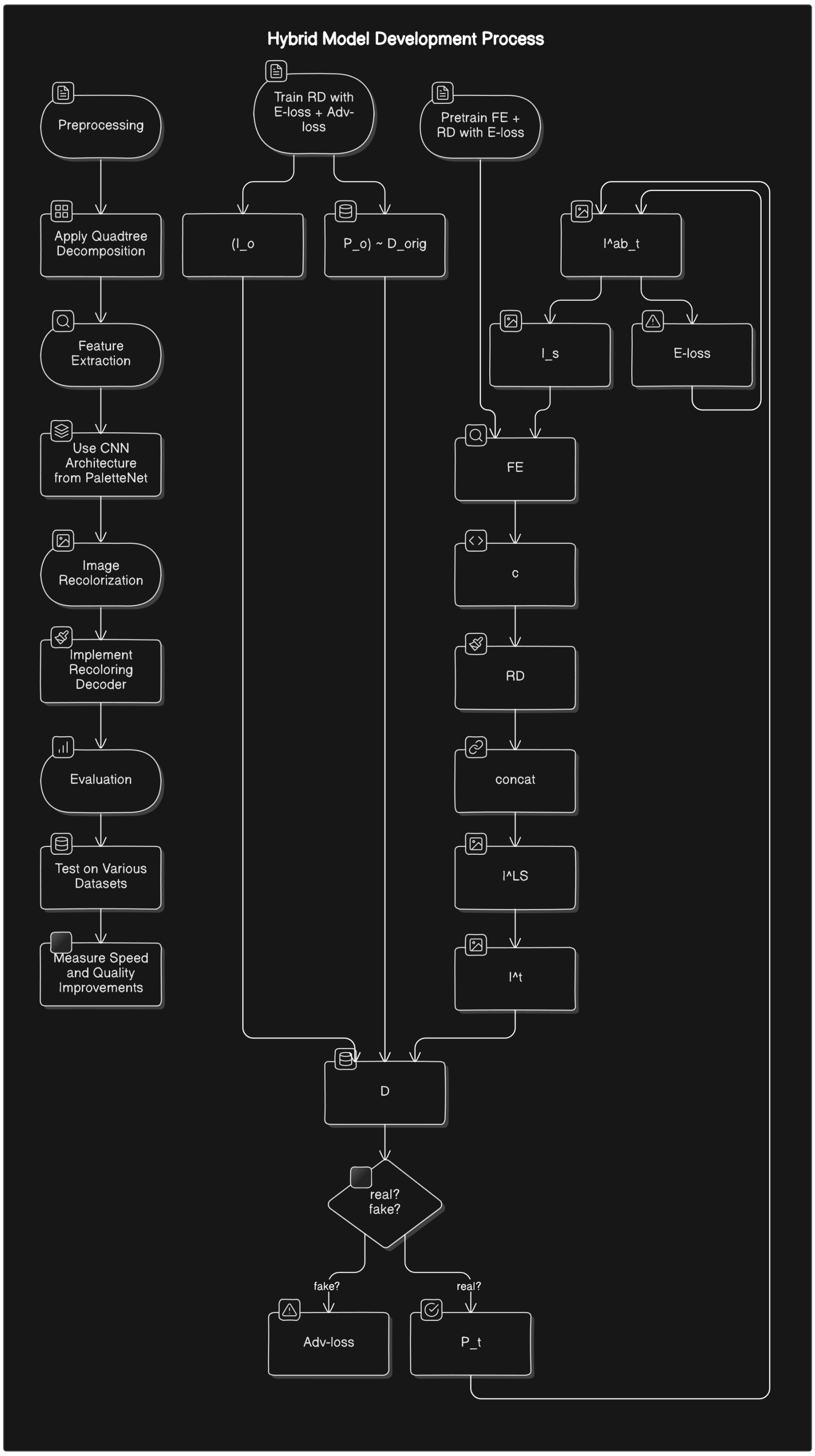

Figure 2: Data Flow Diagram

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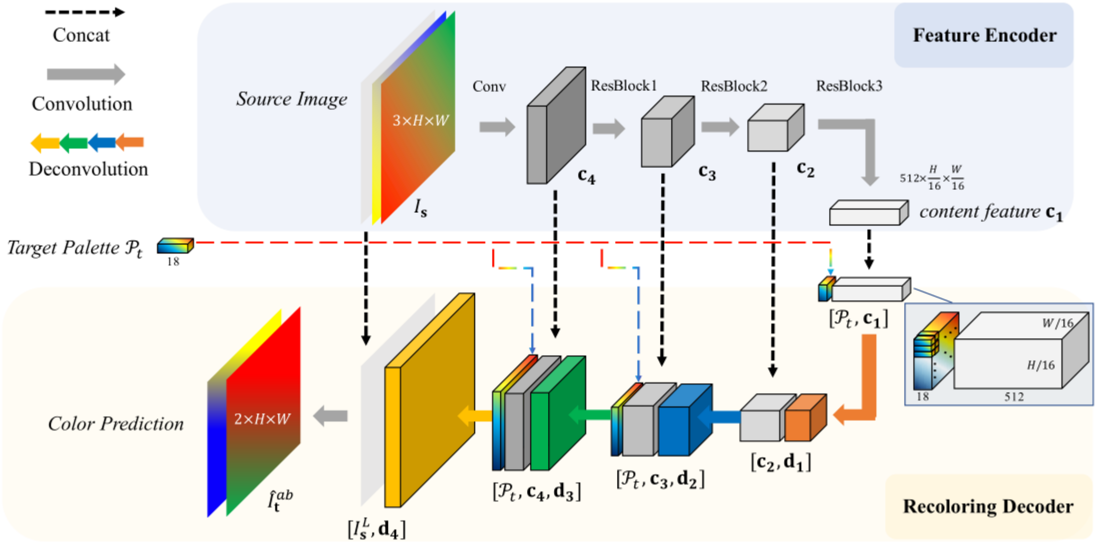

Figure 3: System Architecture

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