Image Compression Benchmark

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1 Problem Statement

Image compression is a type of data compression applied to digital images to reduce their cost for storage or transmission. The objective of image compression is to represent an image with as few bits as possible while still maintaining a high degree of fidelity to the original image. Current state-of-the-art classical algorithms take advantage of visual perception and the statistical properties of image data. Learning-based strategies, on the other hand, are making tremendous contributions in this field. However, a systematic benchmark and comprehensive analysis of these image compression methods are lacking.

In this project, we aim to conduct a comprehensive survey and benchmark the existing image compression methods. We plan to evaluate the recent image compression methods based on diversified evaluation measures, summarize their merits, and create hybrid approaches for specific design choices.

2 Motivation

The majority of modern businesses are involved in digital image processing. The key obstacle for many applications is the amount of data required to represent a digital image. Images typically contain a huge amount of redundant data. Use of digital images without compression is not easy or viable due to high storage and transmission costs. Compressing images saves storage space and communication bandwidth with a little compromise on the image quality. However, there are a few drawbacks, like increased compute time and cumulative degradation of images with lossy compression. Hence, studying these methods can help us reveal the shortcomings in some of the algorithms. With this analysis, we aim to move a step closer towards higher-efficiency image compression.

3 Solution Approach

Techniques for compression can be divided into 2 broad categories: traditional algorithms(eg: JPEG/JFIF, PNG) and learning-based algorithms(eg: PCA, K-means clustering, NN-based methods).

3.1 Classical Algorithms

Classical algorithms use techniques from data compression literature like delta encoding and Huffman encoding to compress images, or make assumptions about images(e.g., humans are not sensitive to high-frequency content in images) to give a good compression ratio for certain domains of images. Different applications have different types of images, different requirements for compression ratios, compression times, etc. Thus, the assumptions underlying algorithms (e.g., data encoding techniques), as well as the appropriate implementation(e.g., single-threaded, vectorized, multi-threaded, GPU-accelerated), vary accordingly. We will start by implementing the basic JPEG and PNG algorithms and then introduce variations on those as discussed above to get different points in the design space.

3.2 Learning-based algorithms

Machine Learning-based algorithms (e.g., PCA, K-means clustering, neural networks) can be used to find a more compact representation of images, which helps compress them. There is a whole range of approaches that can be used for compression using ML. Some of them are supervised approaches, similar to autoencoder-style approaches, and others are unsupervised, like clustering, which finds structure in the image and represents it using fewer pixels. We plan to implement 1-2 ML-based approaches and optionally use ideas from some recent approaches on neural compression [4], [2], [1] to create hybrid approaches.

4 Evaluation

We will evaluate our approaches on various datasets such as CLIC, [3], Kodak, Kaggle datasets.

The different axes that are important for image compression is compression ratio($\frac{Originalsize}{Compressedsize}$) encoding speed, decoding speed, and reduction in image quality for the compressed image, which can be measured using multiple metrics(e.g., PSNR, SSIM).

5 Timeline

Time	Task
Week 1-2	JPEG + PNG implementation
Week 3-4	ML-based compression methods (1-2 methods implementation)
Week 5 - 6	Experiments for introducing novelty (eg: improving codec runtime/compression ratio, fusing classical + ML-based approaches)
Week 7	Evaluation on datasets + Interpretation of results/inferences
Week 8	Demo + Webpage + Final PPT + Report

References

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[4] Fabian Mentzer, Eirikur Agustsson, Michael Tschannen, Radu Timofte, and Luc Van Gool. Practical full resolution learned lossless image compression. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2019.