

HW1 Report

Abstract

This report describes an interactive image mosaic generator that reconstructs input images using smaller tile pieces arranged in a grid. The system includes adaptive grid sizing, color reduction features, and performance measurement tools with a web-based Gradio interface for real-time parameter adjustment.

1. Implementation

1.1 Core Algorithm

The mosaic creation process works through four main steps: (1) Input images are resized while maintaining proportions using LANCZOS resampling, (2) Grid creation using fixed sizes (8×8, 16×16, 32×32) or adaptive mode that creates smaller sections in complex areas, (3) Tile selection by calculating average RGB color per grid section and finding closest matches using Euclidean distance, and (4) Final assembly by resizing and positioning chosen tiles.

1.2 Key Features

Adaptive Grid: Uses color variance analysis to subdivide complex regions while maintaining larger tiles in uniform areas. The algorithm checks if `variance > threshold` and `size > 8` pixels before subdivision.

Color Quantization: Implements K-means clustering (4-32 colors) using MiniBatchKMeans for efficiency, applied to both input images and tile matching.

Tile Management: Supports two modes - custom uploaded images (converted to 50×50 pixels) and 13 predefined colored squares (red, green, blue, yellow, magenta, cyan, orange, purple, pink, brown, gray, black, white). Interface includes multi-file upload, preview grid, and format validation.

2. Performance Evaluation

2.1 Metrics

Three quantitative measures assess quality: **Mean Squared Error (MSE)** for pixel-level accuracy (lower is better), **Structural Similarity Index (SSIM)** for structural preservation (0-1 scale, higher is better), and **Peak Signal-to-Noise Ratio (PSNR)** for reconstruction quality in decibels (higher is better).

2.2 Test Results

Testing used three synthetic images with two tile sets:

Colored Squares Results:

Image Type	Grid Type	MSE	SSIM	PSNR
Gradient	Fixed 32×32	2309.4	0.7994	14.50
Gradient	Adaptive	2336.7	0.7922	14.44

Image Type	Grid Type	MSE	SSIM	PSNR
Geometric	Fixed 32×32	2047.9	0.8488	15.02
Geometric	Adaptive	1461.0	0.8301	16.48
High Contrast	Fixed 32×32	7468.8	0.6624	9.40
High Contrast	Adaptive	1516.9	0.8240	16.32

Vancouver Photo Tiles Results:

Image Type	Grid Type	MSE	SSIM	PSNR
Gradient	Fixed 32×32	3396.2	0.2539	12.82
Gradient	Adaptive	3558.6	0.2659	12.62
Geometric	Fixed 32×32	2259.9	0.7930	14.59
Geometric	Adaptive	1731.9	0.7754	15.75
High Contrast	Fixed 32×32	7317.5	0.6598	9.49
High Contrast	Adaptive	1522.9	0.8203	16.30

3. Results and Analysis

3.1 Key Findings

Tile Type Impact: Colored squares outperform photo tiles for gradient images (SSIM: 0.80 vs 0.25) due to texture interference, while both perform similarly on geometric (SSIM ~0.79) and high contrast images (SSIM ~0.82).

Adaptive Grid Performance: Shows consistent improvements for complex content - 28.6% MSE reduction on geometric patterns and 79.7% on high contrast images, but slight degradation on smooth gradients (1.2% MSE increase).

Content-Specific Optimization: Results suggest using colored squares for smooth gradients, either approach for geometric patterns, and adaptive grids for high contrast content.

3.2 System Performance

The implementation achieves efficient color matching through vectorized operations, provides intuitive tabbed interface design, supports flexible tile switching, and includes comprehensive error handling. Current limitations include RGB-only color matching, no texture consideration, and sequential processing constraints.

4. Conclusion

This mosaic generator successfully combines technical functionality with user-friendly design. The adaptive grid feature provides measurable quality improvements for complex images (up to 79% MSE reduction), while comprehensive performance metrics enable objective evaluation. The system balances technical depth with practical usability, creating a tool suitable for both artistic applications and algorithm research. Testing reveals that optimal configuration depends on input content type, with different tile and grid combinations showing distinct performance characteristics across image categories.