MDCT Image Compression

Project-1_Video Coding Seminar

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Project Structure

- **Task-1 DCT Part**
  - DCT part evaluation for 24 images from git repository
  - https://github.com/Karanraj06/image-compression.git
  - Prepared Table w.r.t PSNR and Compressed ratios of images
  - Checked colored and grayscale Images with multiple coefficients
- **Task-2 MDCT Part**
  - MDCT part evaluation for 24 images from above git repository
  - Checked PSNR and Compressed ratios of images
  - Checked colored and grayscale Images with multiple coefficients
- **Task-3 Perceptual Similarity Comparison**
  - Compared DCT and MDCT part for perceptual similarity
  - Losses, Bandwidth and margins of improvement analyzed

Motivation

- **Data Efficiency**
  - Rise in high-resolution media drives massive data storage needs
  - Efficient compression reduces file size, optimizing storage and bandwidth
  - Critical for streaming, online sharing, and cloud storage

- **Quality Preservation**
  - Balancing compression with image quality is a key challenge
  - Effective compression retains essential visual details
  - Ensures user satisfaction in visual applications

- **Perceptual Relevance**
  - Traditional metrics may not reflect human perception accurately
  - Incorporating perceptual metrics like LPIPS aligns with visual quality
  - Enhances the realism and usability of compressed images

Approach to Image Compression

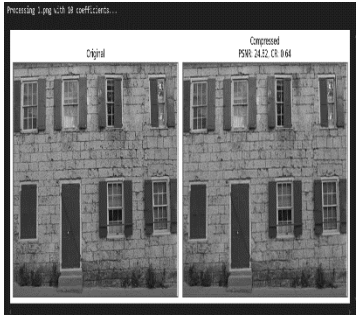
- **Discrete Cosine Transform (DCT)**
  - Breaks down images into frequency components
  - Compresses by retaining significant frequencies and discarding others
  - Commonly used in JPEG compression for its efficiency

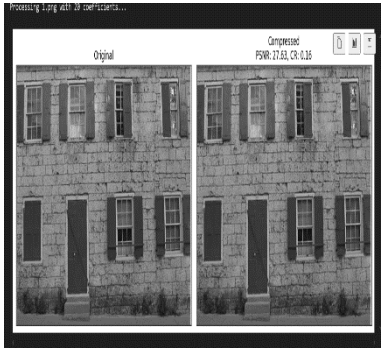
- **Modified Discrete Cosine Transform (MDCT)**
  - Extends DCT with overlapping blocks to reduce artifacts
  - Provides smoother transitions and better compression quality
  - Often used in audio and video compression techniques

- **Perceptual Similarity Measurement**
  - LPIPS metric used to assess how humans perceive image quality
  - Captures visual similarity beyond pixel-wise differences
  - Ensures compressed images remain visually appealing

DCT Compression Results

- Picture 1.png with 5 coefficient
  - Shows PSNR and Compressed ratios
  - Shows grayscale and colored
- Picture 1.png with 10 coefficient
- Picture 1.png with 20 coefficient





DCT Results

- **Table for complete 24 Images**
- Higher PSNR indicates
  - better image quality post-compression
- Compression Ratios (CR)
  - Shows how much image size reduced
- Coefficient Variation:
  - Different DCT coefficients were used
  - impacting compression and quality
- Gray vs. Color
  - Grayscale and color images tested
  - With their respective PSNR and CR values compared

	Image	Num Coefficients	PSNR Gray	CR Gray	PSNR Color	CR Color
0	1.png	5	22.51566648158429	2.56	22.50749316782874	2.56
1	1.png	10	24.821728975051172	0.64	24.7174596277982	0.64
2	1.png	20	27.632499974486038	0.16	27.37726445833619	0.16
3	10.png	5	27.447679474191467	2.56	27.285290273547986	2.56
4	10.png	10	30.150839757787494	0.64	29.736008259542405	0.64
5	10.png	20	32.92768959335878	0.16	32.11215793887962	0.16
6	11.png	5	25.582712677015515	2.56	25.470786646149833	2.56
7	11.png	10	27.59699339942074	0.64	27.356733065000466	0.64
8	11.png	20	30.132926445149977	0.16	29.649108636398072	0.16
9	12.png	5	28.79157821870153	2.56	28.513728956390374	2.56
10	12.png	10	31.276717527883882	0.64	30.761651630849254	0.64
11	12.png	20	33.893930075621	0.16	32.973005912007935	0.16
12	13.png	5	21.032464327056864	2.56	21.001758280885877	2.56
13	13.png	10	22.453293741560053	0.64	22.353628436512125	0.64
14	13.png	20	24.744585173299832	0.16	24.52993679097238	0.16
15	14.png	5	25.037102056350328	2.56	24.896871897934904	2.56
16	14.png	10	26.93704940292217	0.64	26.723899633283455	0.64
17	14.png	20	29.602742249176274	0.16	29.11841998388532	0.16
18	15.png	5	27.412627731583495	2.56	27.113863500632	2.56
19	15.png	10	29.806940289210367	0.64	29.34207200378835	0.64
20	15.png	20	32.45509268053351	0.16	31.62374148894014	0.16
21	16.png	5	28.17319877431439	2.56	27.96575462705245	2.56

Compression Techniques Evaluation

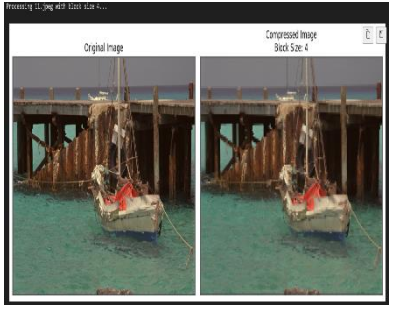
- **Compression Efficiency**
  - DCT and MDCT show significant reduction in image size.
  - MDCT achieves smoother transitions with overlapping blocks
  - Compression ratio improved while maintaining quality

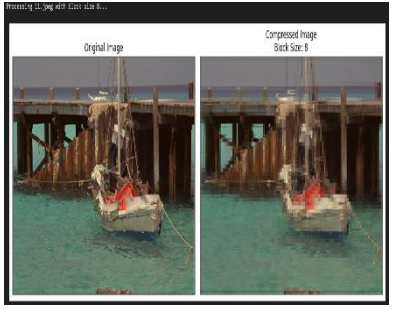
- **Quality Assessment**
  - PSNR values indicate minimal loss in image fidelity
  - Perceptual similarity (LPIPS) aligns with human visual system
  - MDCT performs better in preserving details compared to DCT

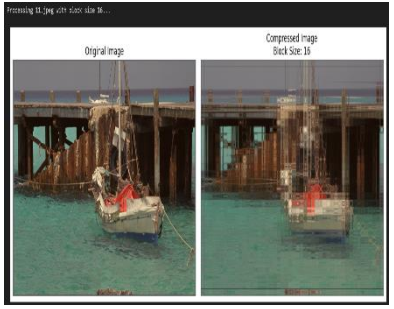
- **Comparative Analysis**
  - MDCT slightly outperforms DCT in both compression ratio and visual quality
  - Trade-off between compression efficiency and computational complexity
  - Results confirm the effectiveness of using MDCT for higher quality compression

MDCT Evaluation

- Image Quality Comparison
  - Original shows stone building with red features
  - Compressed images show quality loss
  - Differences increase with compression level
- Compression Techniques
  - Methods labeled
  - "Block Size" 4, 8, 16
  - Yields distinct results
  - Larger blocks cause more degradation
  - MDCT-based JPEG compression demonstrates efficacy in data reduction
  - Preserving key elements, with visual quality inversely proportional to block size.







Perceptual Similarity Analysis

- **Definition and Purpose**
  - Measures visual quality beyond traditional metrics
  - Uses deep learning models to assess perceptual differences
  - Aligns with human visual assessment for more accurate evaluation

- **Methodology**
  - LPIPS metric is used for comparison
  - Computes perceptual distance between original and compressed images
  - Normalized scores indicate similarity levels

- **Results and Insights**
  - Highlights perceptual quality differences between compression methods
  - Reveals which method preserves visual fidelity better
  - Provides additional insight beyond PSNR and CR values

Summary and Conclusion

- **Compression Efficiency**
  - DCT and MDCT significantly reduce image file sizes
  - MDCT achieves smoother transitions and higher quality
  - Compression ratio improved while maintaining image fidelity

- **Quality Assessment**
  - PSNR values show minimal loss in image quality
  - Perceptual similarity metrics (LPIPS) align with human visual perception
  - MDCT outperforms DCT in preserving visual details

- **Comparative Analysis**
  - MDCT slightly better in compression ratio and visual quality
  - Trade-offs exist between compression efficiency and computational complexity
  - Results validate MDCT's effectiveness for high-quality compression

References

- [1] Karanraj06, "image-compression," GitHub repository, 2023. [Online]. Available: https://github.com/Karanraj06/image-compression.git. [Accessed: June. 13, 2024]

- **Group_Project Repository for MDCT Image Compression**

  - [2] A. Zahoor, “Video-Coding-Seminar-Project,” GitHub repository, Aug. 12, 2024. [Online]. Available: https://github.com/Annszahoor27/Video-Coding-Seminar-Project-.git