The Prophet in The Transform: S+P transform

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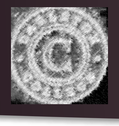


Carleton Logo Compressed Diff:
Scale 10000, CR 7.98, Entropy 0.003,
MSE 2045, PSNR 15.0226

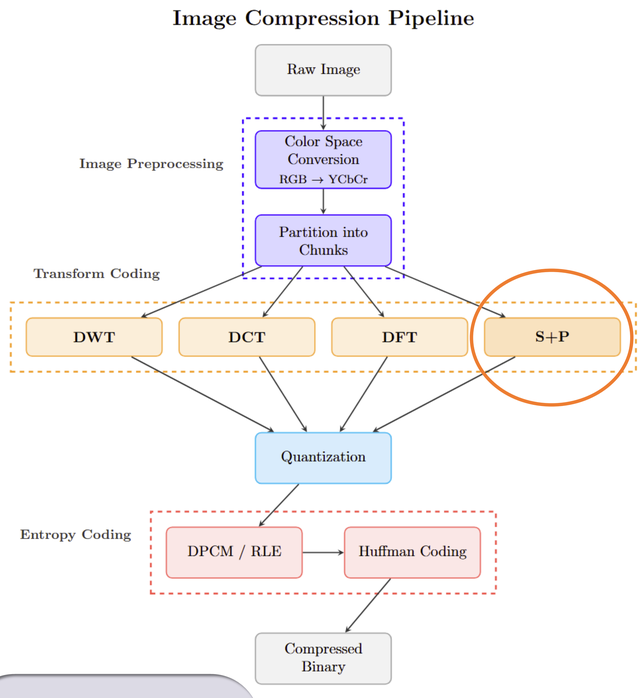
Github Repo

1. Abstract

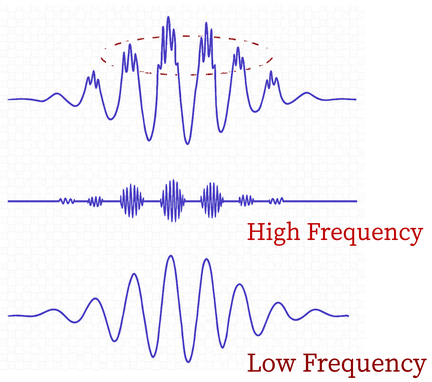
In investigation of compression algorithms, We compare transform methods in a modular image-compression pipeline. Transform coding converts an image from the pixel domain into patterns of frequency, so that redundant information can be represented more compactly.

2. Background

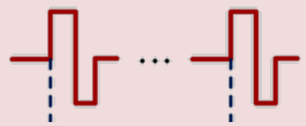
Why compress? Smaller files → faster sharing, lower storage.
Two approaches: *Predictive* (encode differences) and *Transform* (re-express as frequencies).
My focus: S+P hybrid → prediction inside a reversible transform.



3. Wavelets are mathematical patterns that represent a signal at different levels of detail. They help compression by separating smooth regions (low-freq.) from fine details (high-freq.), so patterns can be stored with fewer numbers.



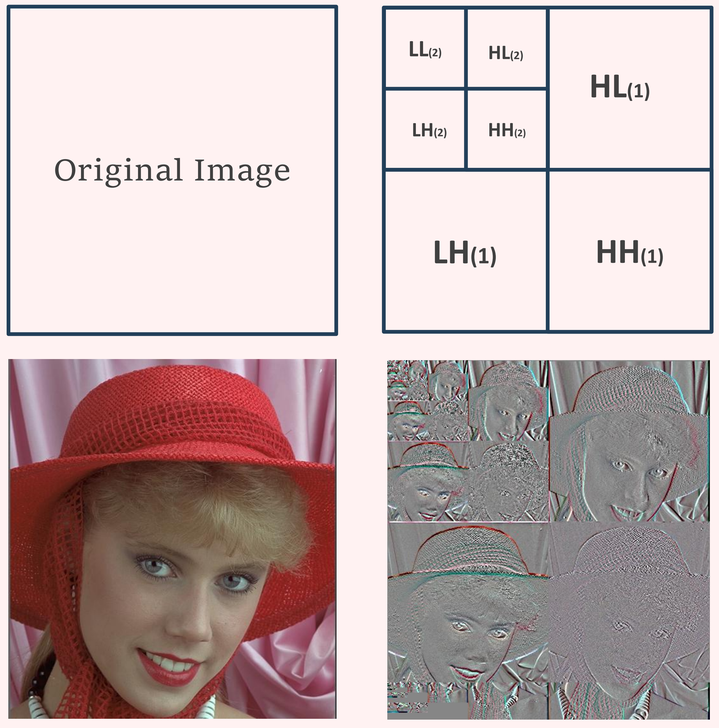
4. S+P: Wavelet



The Haar wavelet, used in the S+P transform, is the simplest form: it averages and differences neighboring pixels to capture edges efficiently with perfect reversibility.

5. SP Transform Image Encoding

H: High freq.
L: Low Freq.

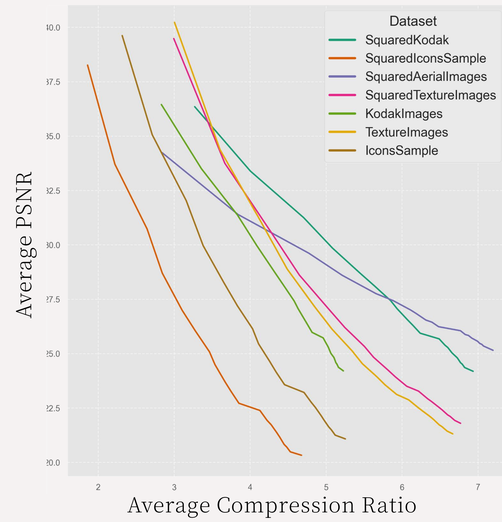


6. SP Transform Design

-Int-to-int, reversible transform combining transforms with predictive coding.
-Transform: converts each block into sum and difference components: Low & High.
-Predict: within the transformed domain, odd samples are predicted from neighboring even samples to reduce residual energy and redundancy.
-Recursive structure: applies the same transform–predict–update sequence on the low-frequency band (LL) to build a multiresolution hierarchy.
-Quantization design: uses finer quantization for low-frequency components and coarser quantization for high-frequency ones, balancing compression ratio and image fidelity.

7. Results

Quality–Compression Tradeoff Across Datasets

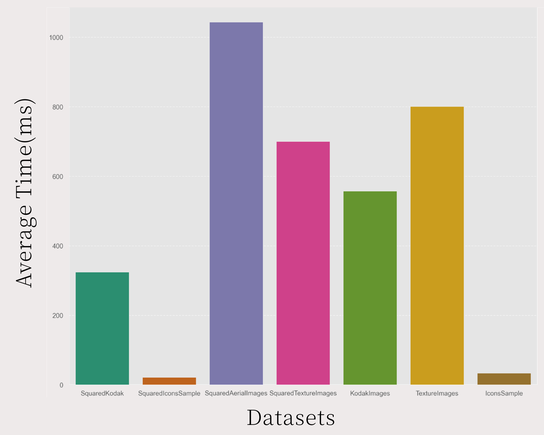


This graph shows how image quality changes as we compress more. Each line represents a different dataset tested with the S+P transform.

The vertical axis (PSNR) measures how close the compressed image is to the original.

The horizontal axis (Compression Ratio) shows how much we shrink the file: higher means smaller size. As the lines move down and right, we see the natural trade-off: smaller files come at the cost of lower image quality.

Decoding Time Across Datasets



This bar chart compares the average decoding time of the S+P transform across different image datasets.

This shows that the computational cost of S+P decoding grows with image size and texture complexity, but remains practical even for large images.

8. References

· A. Said and W. A. Pearlman (1993). "*Reversible Image Compression via Multiresolution Representation and Predictive Coding.* → Introduced the S+P Transform, an integer-to-integer multiresolution lifting scheme for reversible image compression.
· K. Jayasankar, A. Devi, and S. Sathishkumar (2021). "*A Survey on Data Compression Techniques: From the Perspective of Data Quality, Coding Schemes, and Data Characteristics.*" → A modern review of image compression trends and the balance between efficiency and quality.
· D. Taubman and M. Marcellin (2002). *JPEG2000: Image Compression Fundamentals, Standards and Practice.* Springer.