Assignment 5 – 2D Feedbackward Predictive Coding (DPCM)

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1. Objective:

This assignment implements DPCM for grayscale image compression using three predictor types (order1, order2, adaptive) and variable quantization levels (8, 16, 32). The goal is to analyze how predictor selection and quantization impact compression performance.

2. Code Overview:
- Implemented in Java with modular structure for clarity.
- Inputs: grayscale image path, predictor type, and quantization level.
- Outputs: reconstructed image, MSE, compression ratio, file sizes.
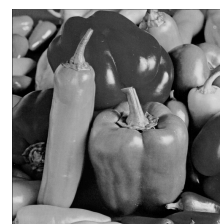- Includes validation, error handling, and readable outputs.

3. Predictors Implemented:
- Order-1: Use the pixel to the left (A).
- Order-2: A + B - C, combining top and diagonal neighbors.
- Adaptive: JPEG-LS style predictor using min/max rules.
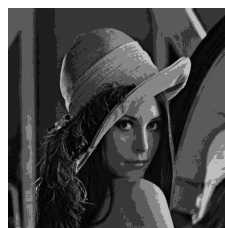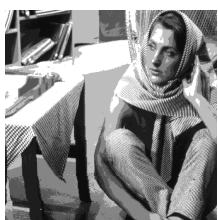
4. Evaluation Metrics:
- Mean Squared Error (MSE)
- Compression Ratio
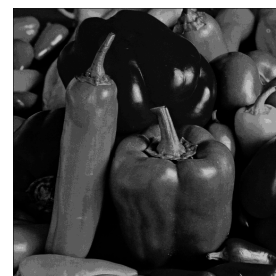- Bit Sizes (Original vs. Compressed)

5.sample visuales:

-This is the original photos :

-This is the first order 1 :

-The second order 2:

-The Adaptive :

6.Sample Results:
===== Barbara_gray | Predictor: order1 | Levels: 8 =====
MSE: 91.52
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 786432 bits (96.00 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Barbara_gray_order1_8.png

===== Barbara_gray | Predictor: order1 | Levels: 16 =====
MSE: 21.28
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1048576 bits (128.00 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Barbara_gray_order1_16.png

===== Barbara_gray | Predictor: order1 | Levels: 32 =====
MSE: 5.49
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1310720 bits (160.00 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Barbara_gray_order1_32.png

===== Barbara_gray | Predictor: order2 | Levels: 8 =====
MSE: 89.76
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 786432 bits (96.00 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Barbara_gray_order2_8.png

===== Barbara_gray | Predictor: order2 | Levels: 16 =====
MSE: 21.60
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1048576 bits (128.00 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Barbara_gray_order2_16.png

===== Barbara_gray | Predictor: order2 | Levels: 32 =====

MSE: 5.54
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1310720 bits (160.00 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Barbara_gray_order2_32.png

===== Barbara_gray | Predictor: adaptive | Levels: 8 =====
MSE: 91.60
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 786432 bits (96.00 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Barbara_gray_adaptive_8.png

===== Barbara_gray | Predictor: adaptive | Levels: 16 =====
MSE: 21.31
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1048576 bits (128.00 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Barbara_gray_adaptive_16.png

===== Barbara_gray | Predictor: adaptive | Levels: 32 =====
MSE: 5.48
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1310720 bits (160.00 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Barbara_gray_adaptive_32.png

===== Lena_gray | Predictor: order1 | Levels: 8 =====
MSE: 88.39
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 786432 bits (96.00 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Lena_gray_order1_8.png

===== Lena_gray | Predictor: order1 | Levels: 16 =====
MSE: 20.74
Original Size: 2097152 bits (256.00 KB)

Compressed Size: 1048576 bits (128.00 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Lena_gray_order1_16.png

===== Lena_gray | Predictor: order1 | Levels: 32 =====
MSE: 5.48
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1310720 bits (160.00 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Lena_gray_order1_32.png

===== Lena_gray | Predictor: order2 | Levels: 8 =====
MSE: 87.36
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 786432 bits (96.00 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Lena_gray_order2_8.png

===== Lena_gray | Predictor: order2 | Levels: 16 =====
MSE: 20.77
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1048576 bits (128.00 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Lena_gray_order2_16.png

===== Lena_gray | Predictor: order2 | Levels: 32 =====
MSE: 5.51
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1310720 bits (160.00 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Lena_gray_order2_32.png

===== Lena_gray | Predictor: adaptive | Levels: 8 =====
MSE: 88.34
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 786432 bits (96.00 KB)
Compression Ratio: 2.67

Reconstructed image saved to: reconstructed_Lena_gray_adaptive_8.png

===== Lena_gray | Predictor: adaptive | Levels: 16 =====
MSE: 20.74
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1048576 bits (128.00 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Lena_gray_adaptive_16.png

===== Lena_gray | Predictor: adaptive | Levels: 32 =====
MSE: 5.48
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1310720 bits (160.00 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Lena_gray_adaptive_32.png

===== Cameraman_gray | Predictor: order1 | Levels: 8 =====
MSE: 98.51
Original Size: 3359232 bits (410.06 KB)
Compressed Size: 1259712 bits (153.77 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Cameraman_gray_order1_8.png

===== Cameraman_gray | Predictor: order1 | Levels: 16 =====
MSE: 20.63
Original Size: 3359232 bits (410.06 KB)
Compressed Size: 1679616 bits (205.03 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Cameraman_gray_order1_16.png

===== Cameraman_gray | Predictor: order1 | Levels: 32 =====
MSE: 5.16
Original Size: 3359232 bits (410.06 KB)
Compressed Size: 2099520 bits (256.29 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Cameraman_gray_order1_32.png

===== Cameraman_gray | Predictor: order2 | Levels: 8 =====
MSE: 95.07
Original Size: 3359232 bits (410.06 KB)
Compressed Size: 1259712 bits (153.77 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Cameraman_gray_order2_8.png

===== Cameraman_gray | Predictor: order2 | Levels: 16 =====
MSE: 21.09
Original Size: 3359232 bits (410.06 KB)
Compressed Size: 1679616 bits (205.03 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Cameraman_gray_order2_16.png

===== Cameraman_gray | Predictor: order2 | Levels: 32 =====
MSE: 5.30
Original Size: 3359232 bits (410.06 KB)
Compressed Size: 2099520 bits (256.29 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Cameraman_gray_order2_32.png

===== Cameraman_gray | Predictor: adaptive | Levels: 8 =====
MSE: 98.42
Original Size: 3359232 bits (410.06 KB)
Compressed Size: 1259712 bits (153.77 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Cameraman_gray_adaptive_8.png

===== Cameraman_gray | Predictor: adaptive | Levels: 16 =====
MSE: 20.59
Original Size: 3359232 bits (410.06 KB)
Compressed Size: 1679616 bits (205.03 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Cameraman_gray_adaptive_16.png

===== Cameraman_gray | Predictor: adaptive | Levels: 32 =====
MSE: 5.15

Original Size: 3359232 bits (410.06 KB)
Compressed Size: 2099520 bits (256.29 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Cameraman_gray_adaptive_32.png

===== Peppers_gray | Predictor: order1 | Levels: 8 =====
MSE: 79.75
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 786432 bits (96.00 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Peppers_gray_order1_8.png

===== Peppers_gray | Predictor: order1 | Levels: 16 =====
MSE: 21.80
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1048576 bits (128.00 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Peppers_gray_order1_16.png

===== Peppers_gray | Predictor: order1 | Levels: 32 =====
MSE: 5.56
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1310720 bits (160.00 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Peppers_gray_order1_32.png

===== Peppers_gray | Predictor: order2 | Levels: 8 =====
MSE: 79.75
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 786432 bits (96.00 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Peppers_gray_order2_8.png

===== Peppers_gray | Predictor: order2 | Levels: 16 =====
MSE: 21.80
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1048576 bits (128.00 KB)

Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Peppers_gray_order2_16.png

===== Peppers_gray | Predictor: order2 | Levels: 32 =====
MSE: 5.56
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1310720 bits (160.00 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Peppers_gray_order2_32.png

===== Peppers_gray | Predictor: adaptive | Levels: 8 =====
MSE: 79.75
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 786432 bits (96.00 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Peppers_gray_adaptive_8.png

===== Peppers_gray | Predictor: adaptive | Levels: 16 =====
MSE: 21.80
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1048576 bits (128.00 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Peppers_gray_adaptive_16.png

===== Peppers_gray | Predictor: adaptive | Levels: 32 =====
MSE: 5.56
Original Size: 2097152 bits (256.00 KB)
Compressed Size: 1310720 bits (160.00 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Peppers_gray_adaptive_32.png

===== Goldhill_gray | Predictor: order1 | Levels: 8 =====
MSE: 85.40
Original Size: 460800 bits (56.25 KB)
Compressed Size: 172800 bits (21.09 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Goldhill_gray_order1_8.png

===== Goldhill_gray | Predictor: order1 | Levels: 16 =====
MSE: 21.70
Original Size: 460800 bits (56.25 KB)
Compressed Size: 230400 bits (28.13 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Goldhill_gray_order1_16.png

===== Goldhill_gray | Predictor: order1 | Levels: 32 =====
MSE: 5.70
Original Size: 460800 bits (56.25 KB)
Compressed Size: 288000 bits (35.16 KB)
Compression Ratio: 1.60
Reconstructed image saved to: reconstructed_Goldhill_gray_order1_32.png

===== Goldhill_gray | Predictor: order2 | Levels: 8 =====
MSE: 85.40
Original Size: 460800 bits (56.25 KB)
Compressed Size: 172800 bits (21.09 KB)
Compression Ratio: 2.67
Reconstructed image saved to: reconstructed_Goldhill_gray_order2_8.png

===== Goldhill_gray | Predictor: order2 | Levels: 16 =====
MSE: 21.70
Original Size: 460800 bits (56.25 KB)
Compressed Size: 230400 bits (28.13 KB)
Compression Ratio: 2.00
Reconstructed image saved to: reconstructed_Goldhill_gray_order2_16.png

===== Goldhill_gray | Predictor: order2 | Levels: 32 =====
MSE: 5.70
Original Size: 460800 bits (56.25 KB)
Compressed Size: 288000 bits (35.16 KB)
Compression Ratio: 1.60
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===== Goldhill_gray | Predictor: adaptive | Levels: 8 =====

MSE: 85.40

Original Size: 460800 bits (56.25 KB)

Compressed Size: 172800 bits (21.09 KB)

Compression Ratio: 2.67

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Compression Ratio: 1.60