Image Compression Based on Non-Parametric Sampling in Noisy Environments

Kishan Narotam

Nitesh Nana

Supervisor: Professor Fambirai Takawira

Why?

- Research-based
- Potential new method for image compression
- DCT → JPEG
- DWT → JPEG-2000

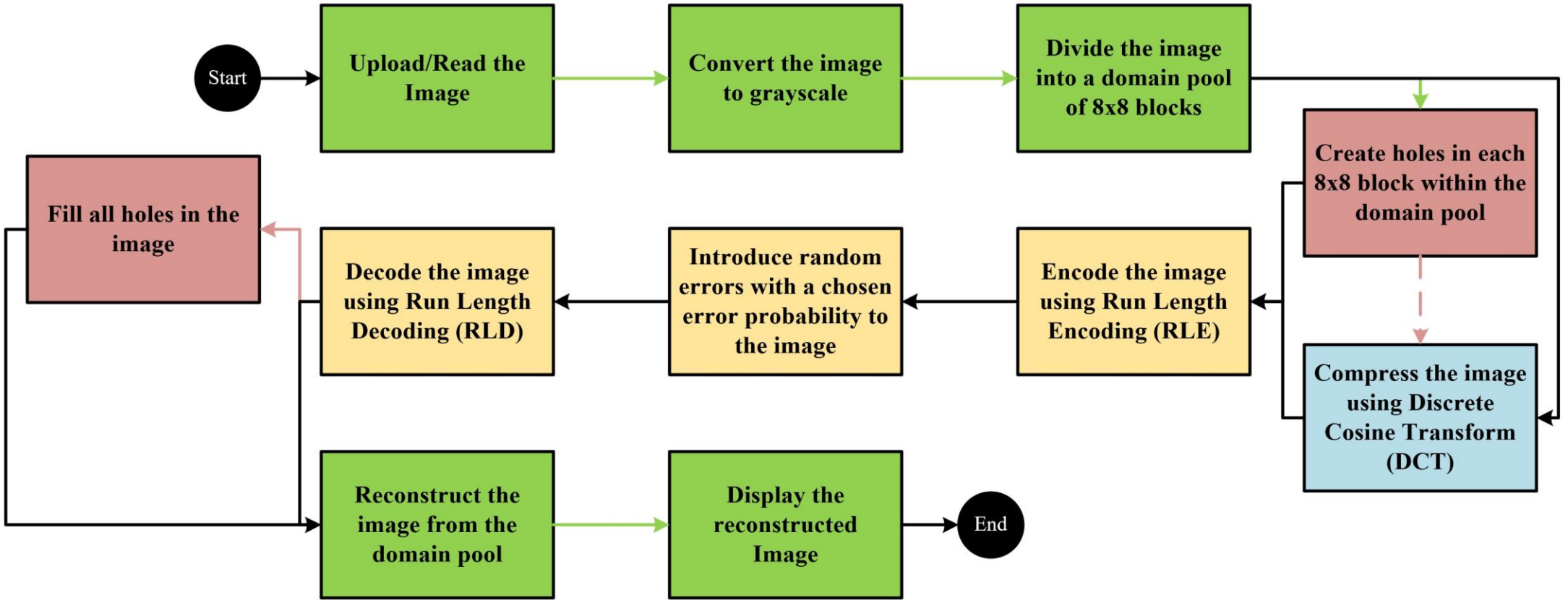
Outline

- Objectives and Specifications
- System Overview
- System Implementation
- Results & Analysis
- Future Work
- Conclusion

Objectives and Specification

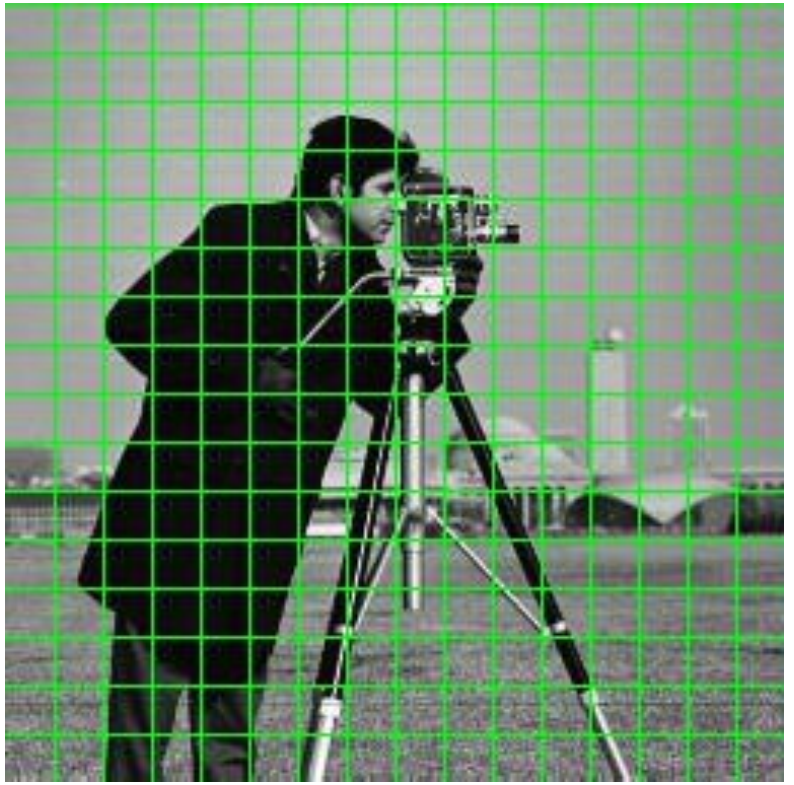
- Create a robust image compression scheme
  - Create holes in the image
  - Encode the image
  - Introduce random errors
  - Filling the holes
- Time frame: 6 weeks
- Budget: R1 200

System Overview



System Implementation (Initial Steps)

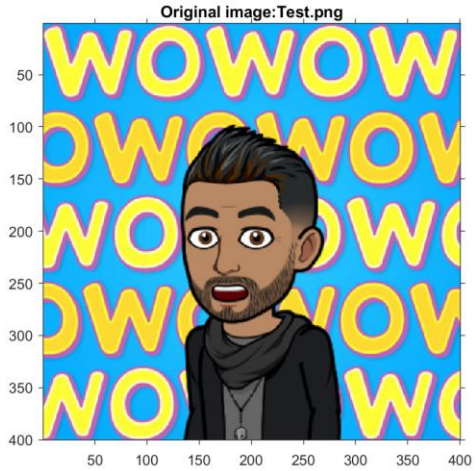
- Reading an image:
  - Height
  - Width
  - Colour map
- 8-bit unsigned integers
- Converting to grayscale:
  - Height
  - Width
- Create the domain pool

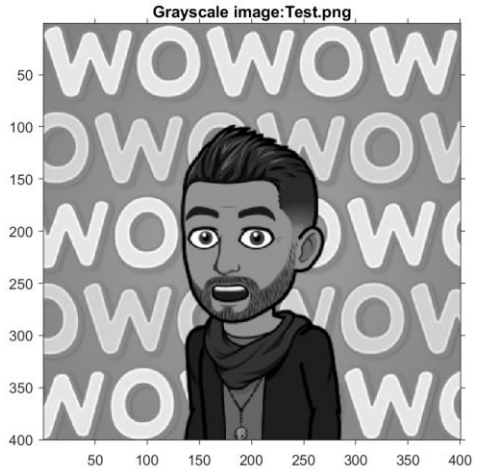


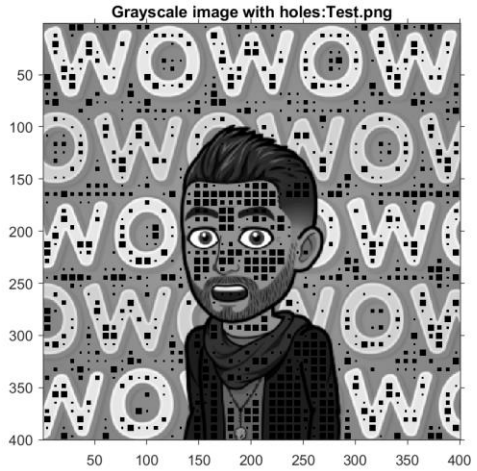
System Implementation (Creating the holes)

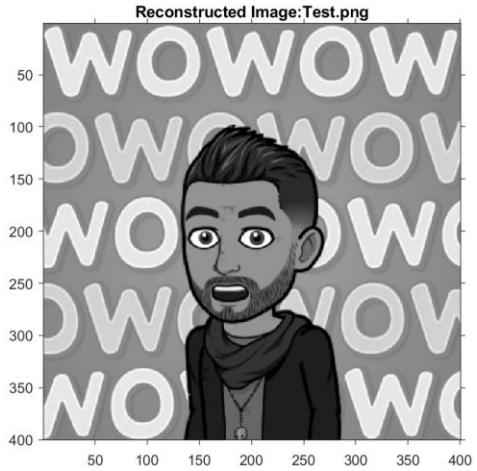
1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8
2,1	2,2	2,3	2,4	2,5	2,6	2,7	2,8
3,1	3,2	3,3	3,4	3,5	3,6	3,7	3,8
4,1	4,2	4,3	4,4	4,5	4,6	4,7	4,8
5,1	5,2	5,3	5,4	5,5	5,6	5,7	5,8
6,1	6,2	6,3	6,4	6,5	6,6	6,7	6,8
7,1	7,2	7,3	7,4	7,5	7,6	7,7	7,8
8,1	8,2	8,3	8,4	8,5	8,6	8,7	8,8

Chebyshev Distance = 1

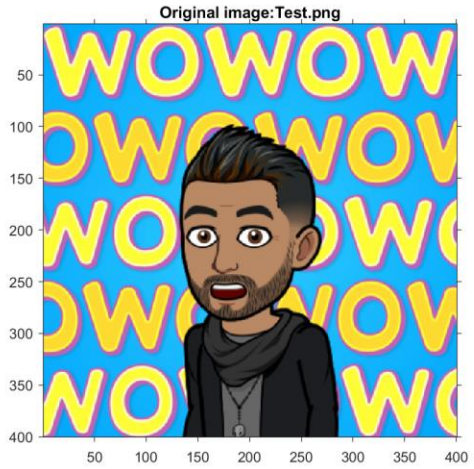


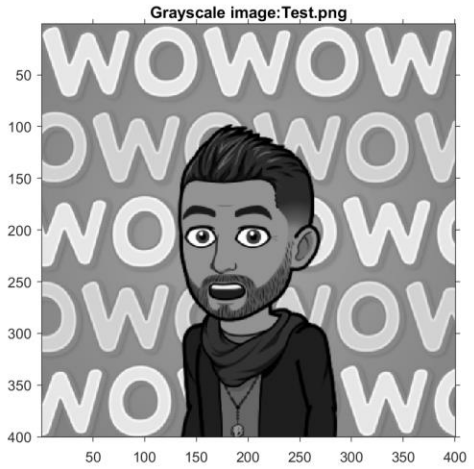


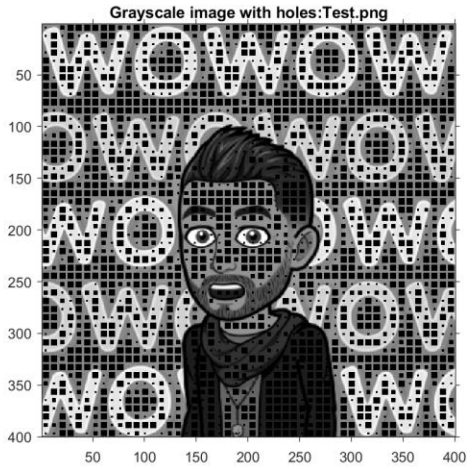


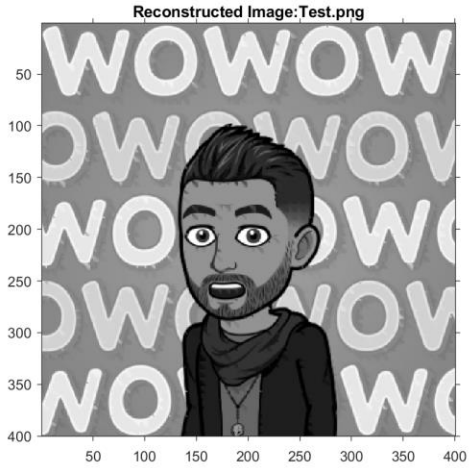


Chebyshev Distance = 10

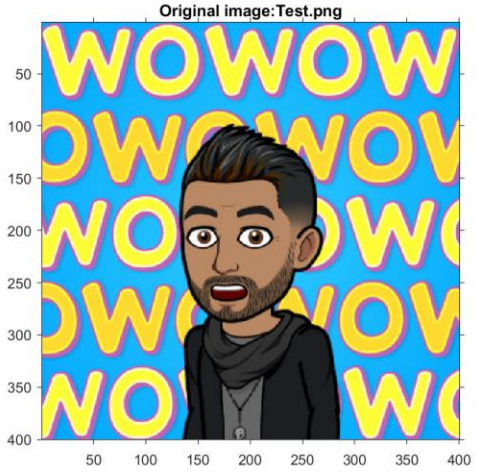


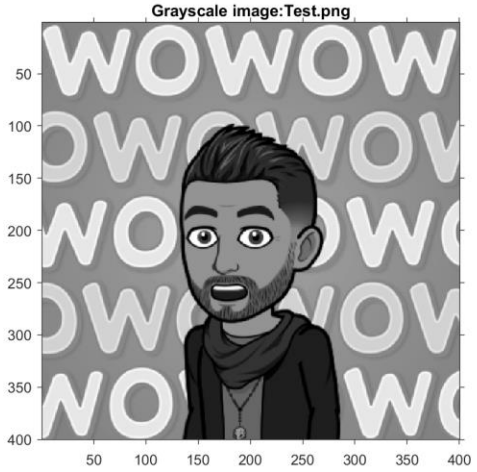


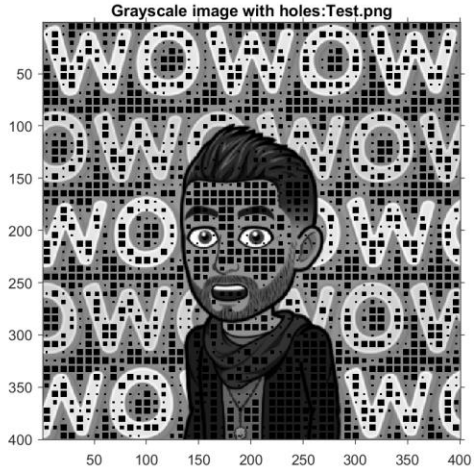


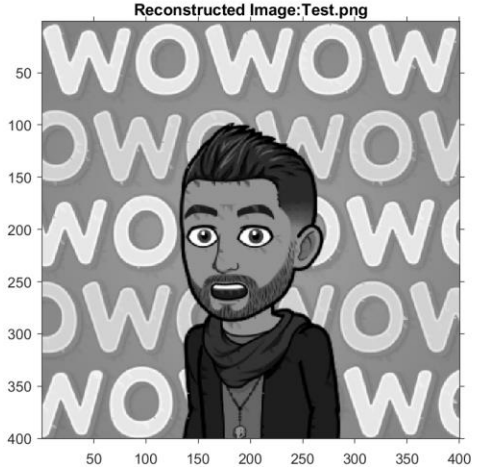


Chebyshev Distance = 6



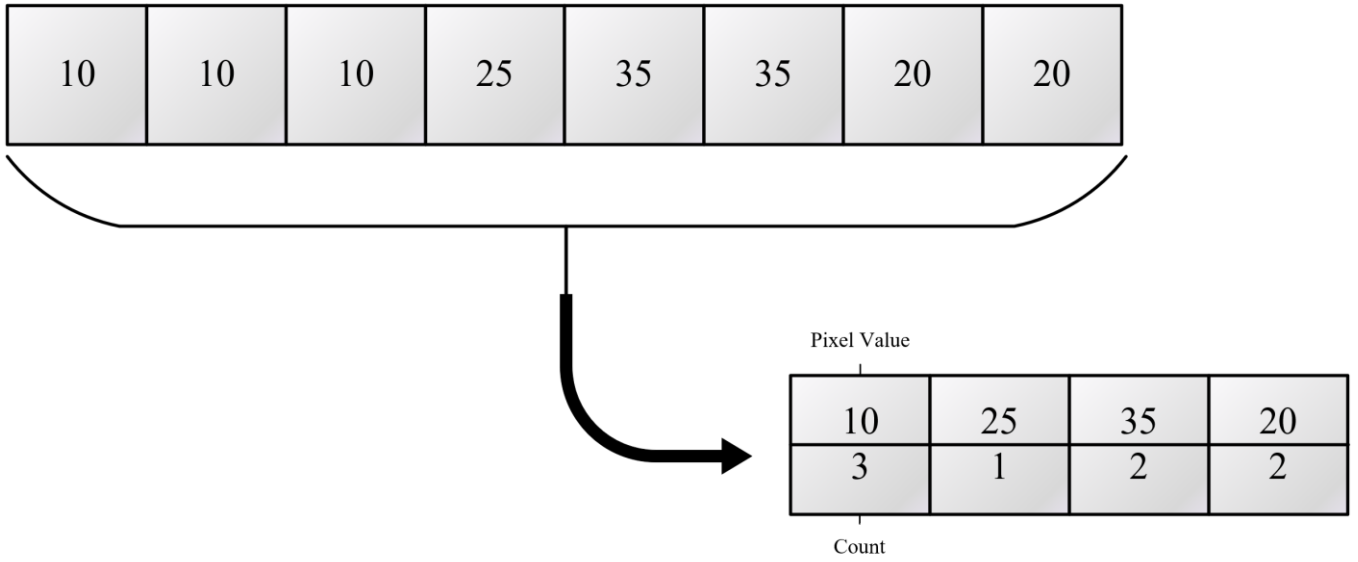






System Implementation (Encoding)

- Run Length Encoding



$10 \rightarrow 0000\ 1010$

$10 \rightarrow 1010$

System Implementation (Error Introduction)

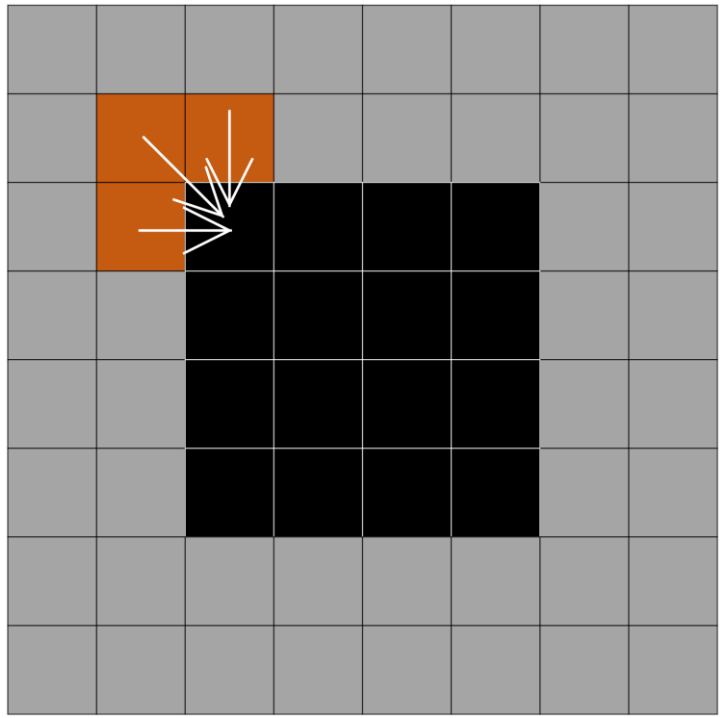
- Bit flip
- 62 → 11 1110
- Fourth bit to be flipped
- 11 1010 → 58

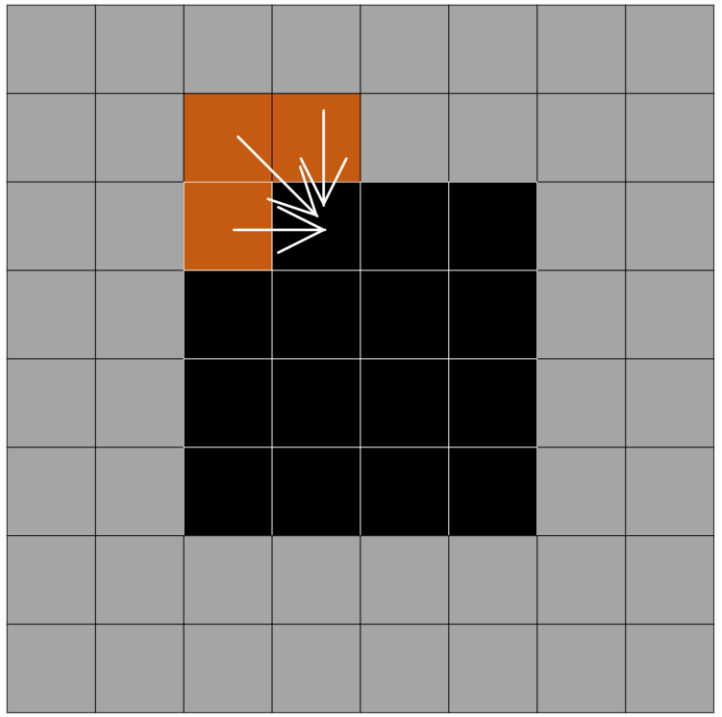
- Ones Compliment
- 62 → 11 1110
- Ones compliment
- 00 0001→ 1



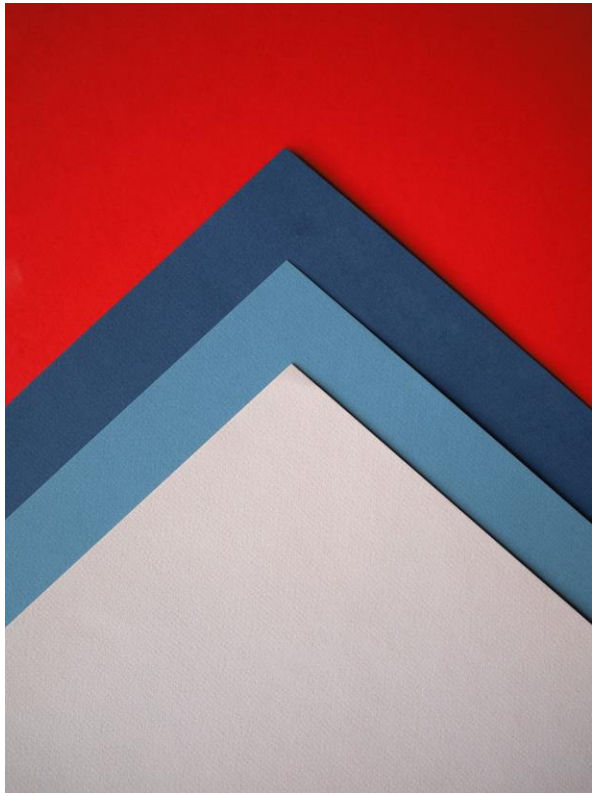

System Implementation (Filling the Holes)

- Current literature → pattern matching
- Created method → averaging method





Results & Analysis

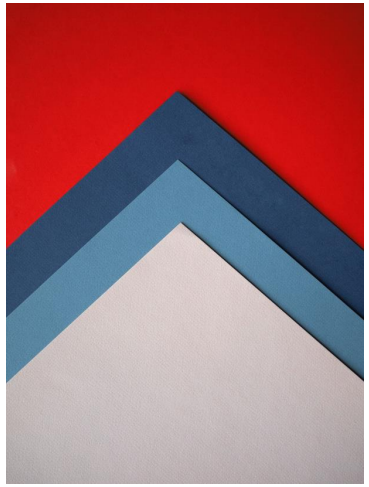
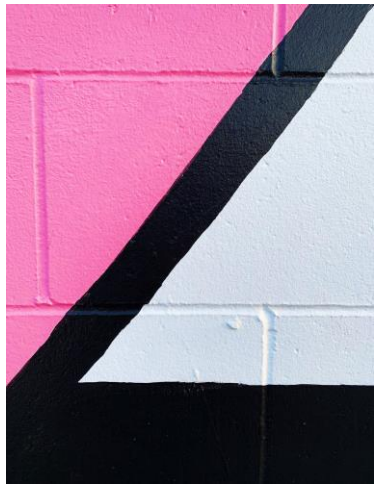
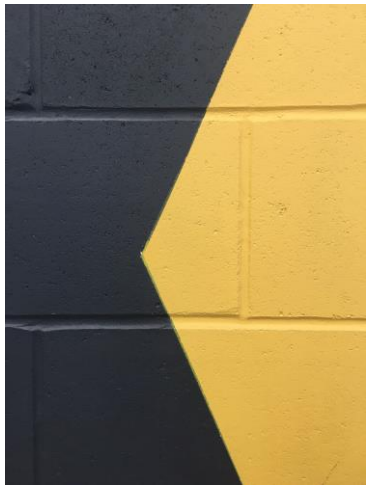


Pattern

Landscape

High Contrast

Images used for Testing

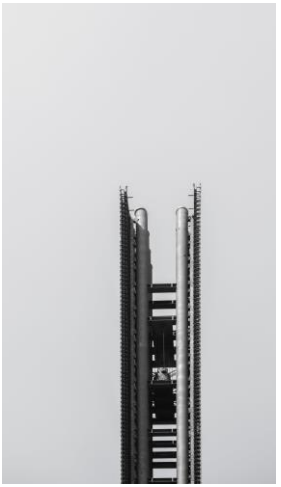




Pattern



Landscape



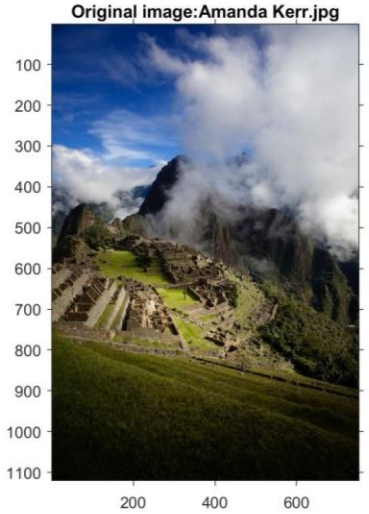


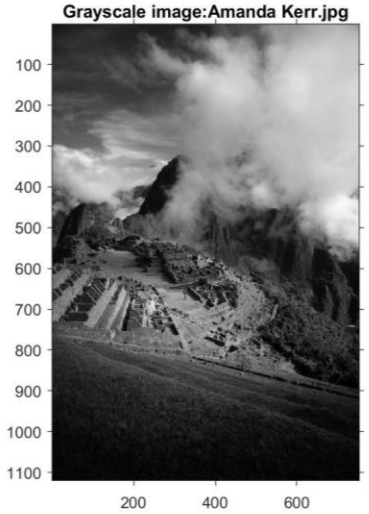
High Contrast

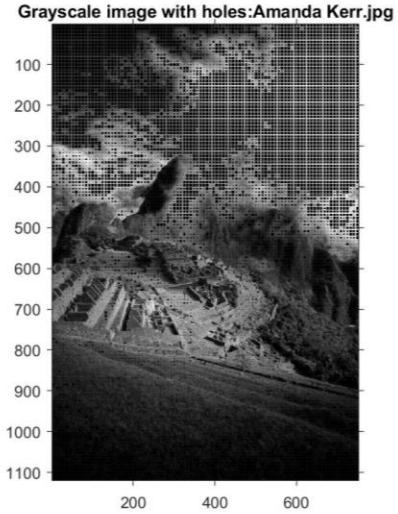
Results (Average Compression Ratio)

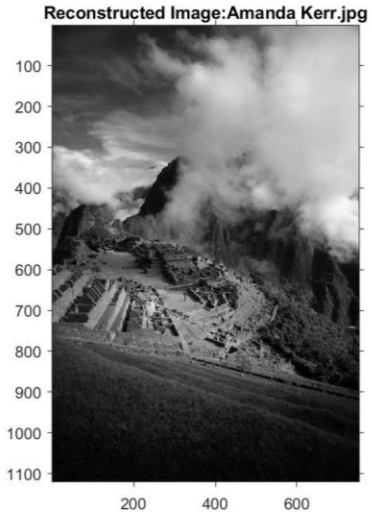
- Tests:
  - functionality of ***Holes***-only
- Average image size:
  - 1200x800 pixels
- Chance of errors being introduced:
  - 0% (No errors)

Step-by-Step Process on a Landscape Image

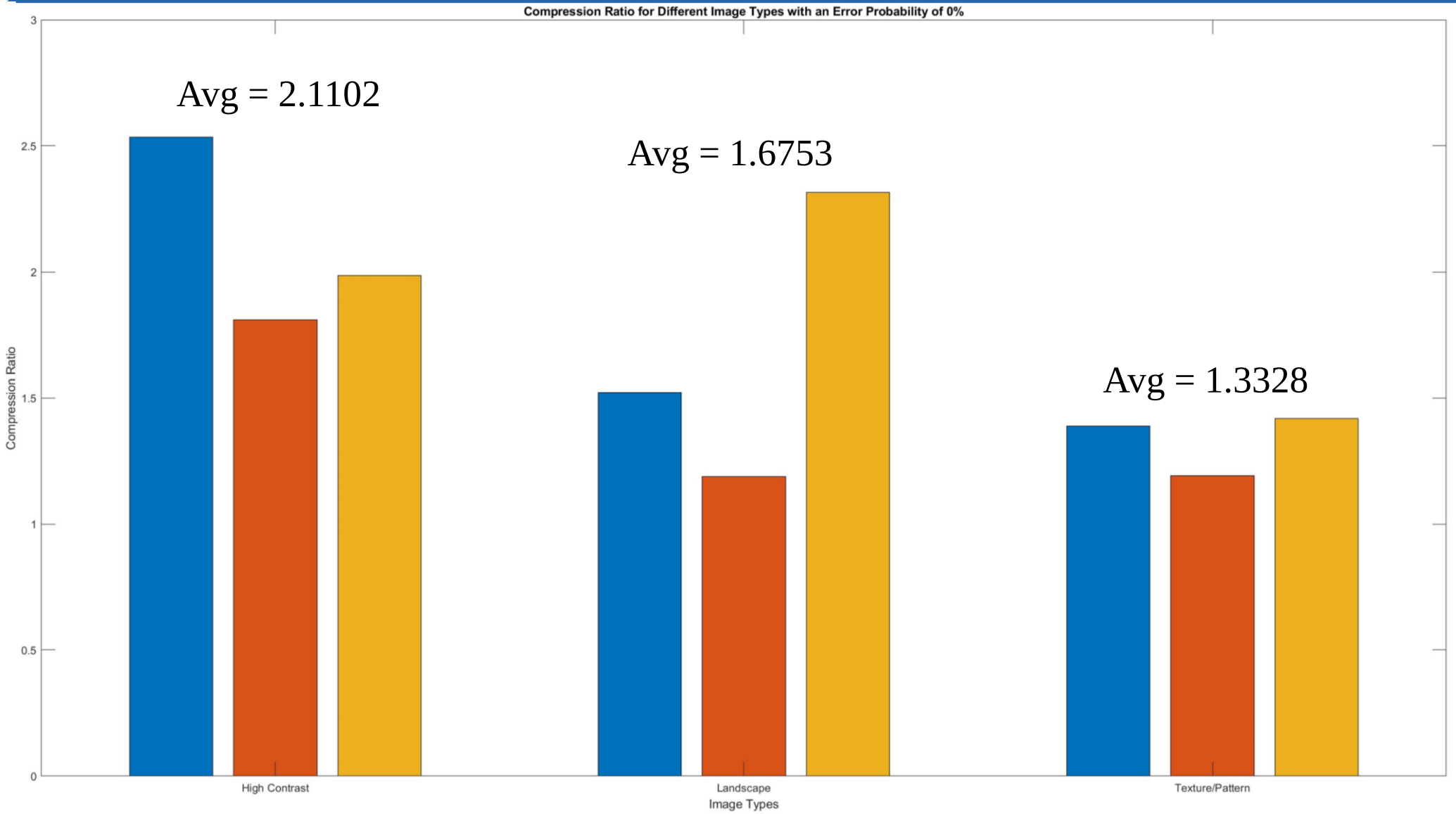








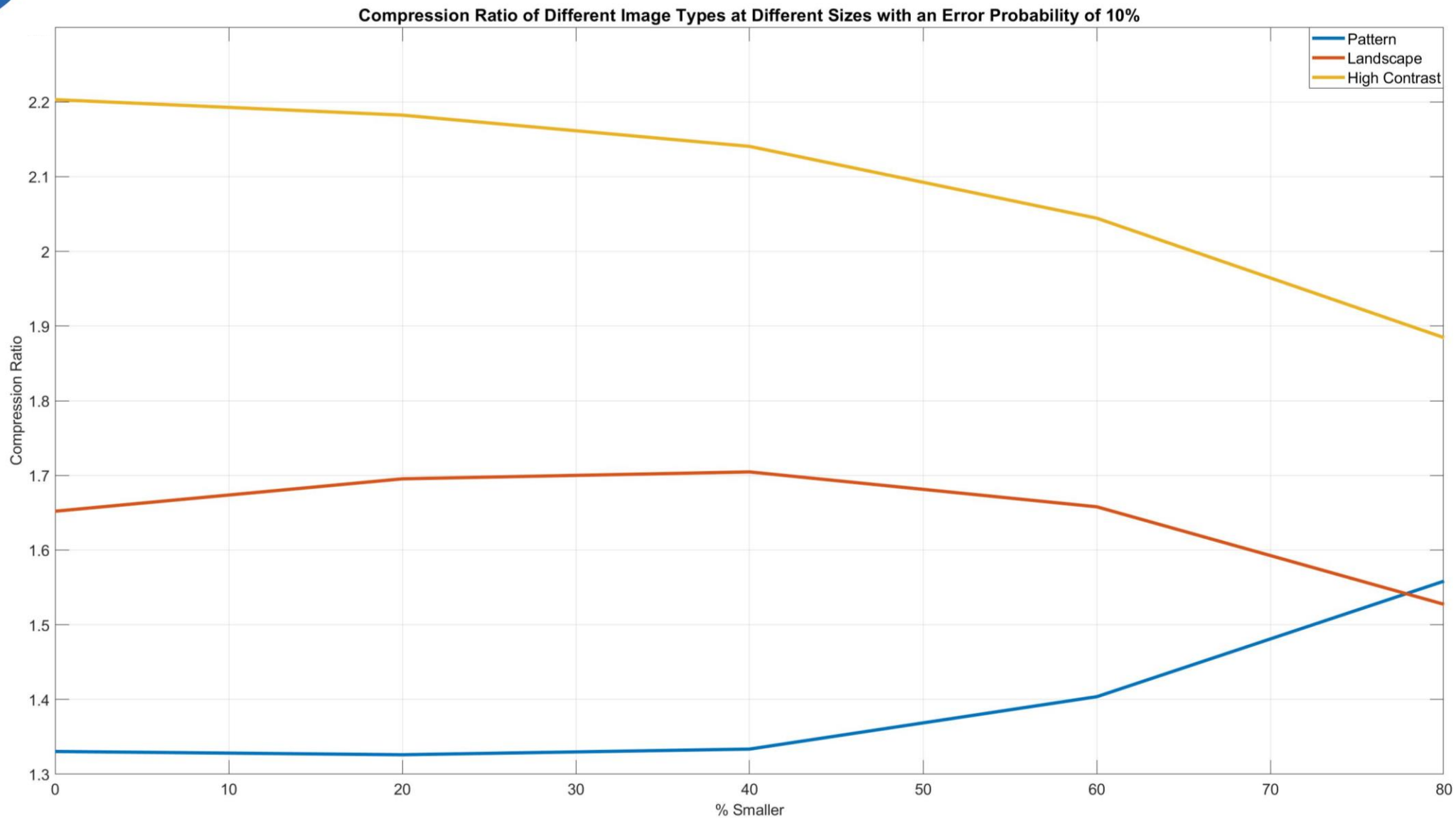
Results (Average Compression Ratio)

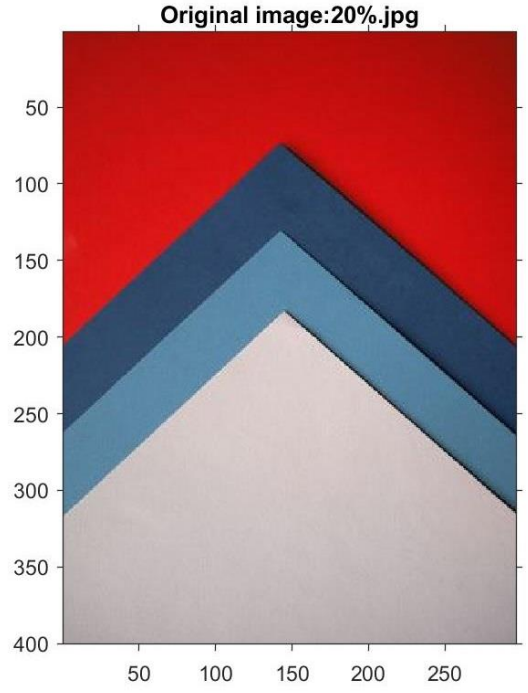


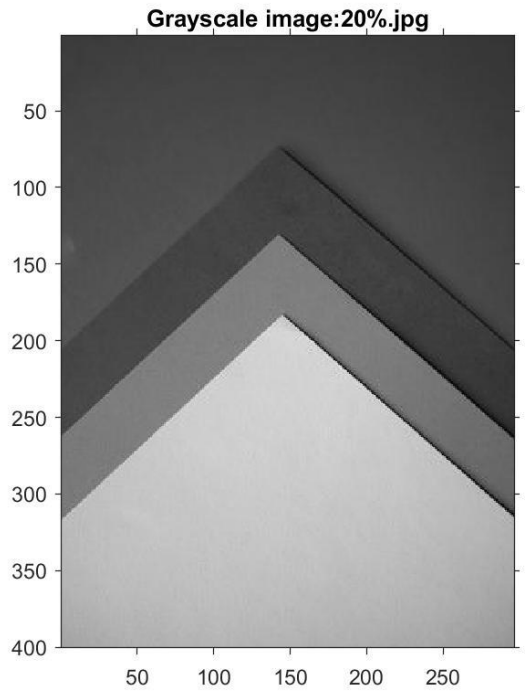
Results (Same Image at Different Resolutions)

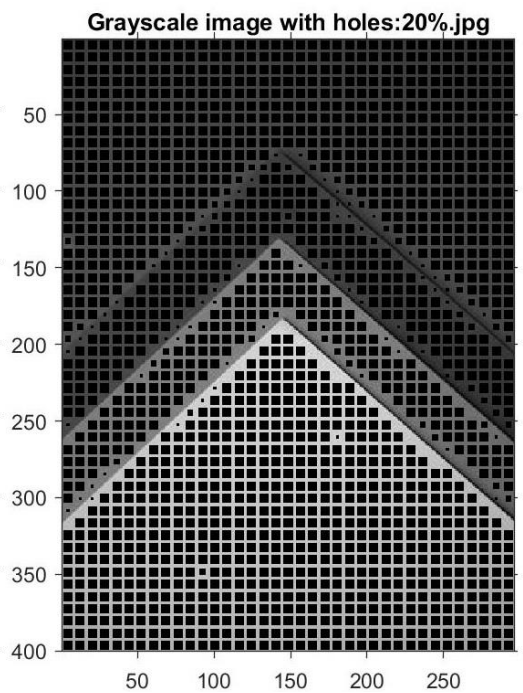
- Tests:
  - effect of ***Holes***-only algorithm on the compression ratio
- Average image size:
  - 2000x1100 pixels
  - Decreasing in size
- Chance of error being introduced:
  - 10%
  - Bit flip

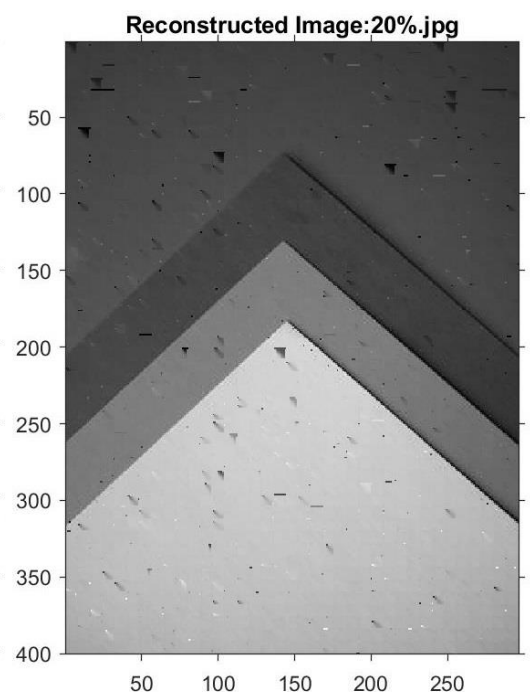
Results (Same Image at Different Resolutions)

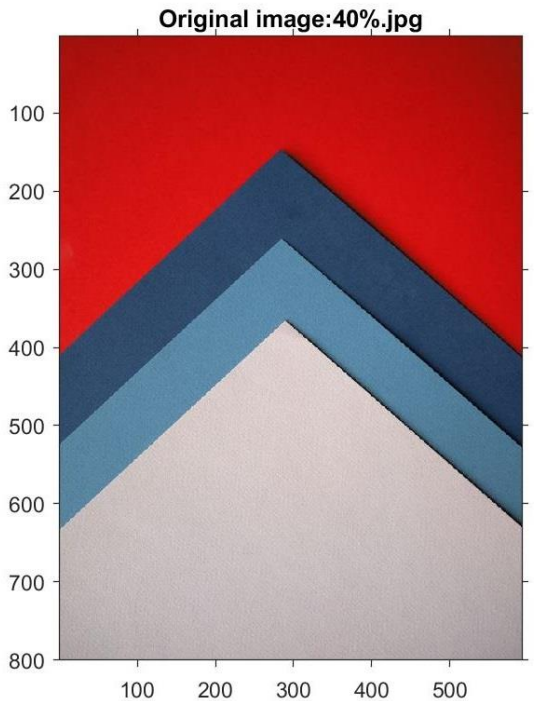


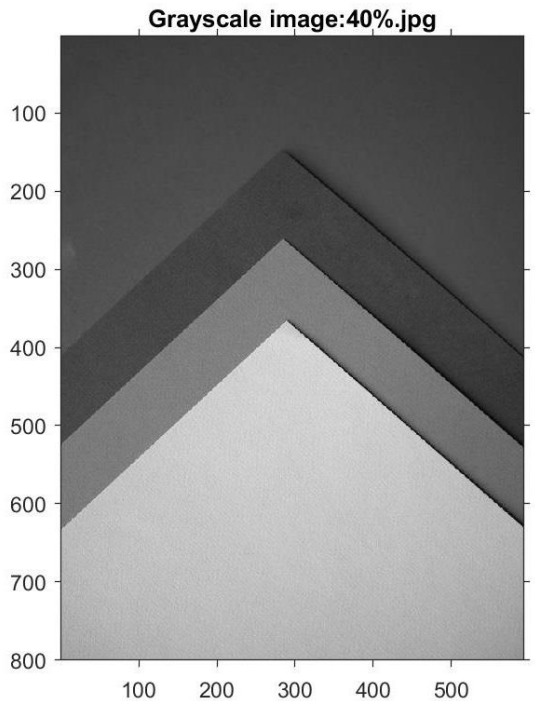

Original image:20%.jpg

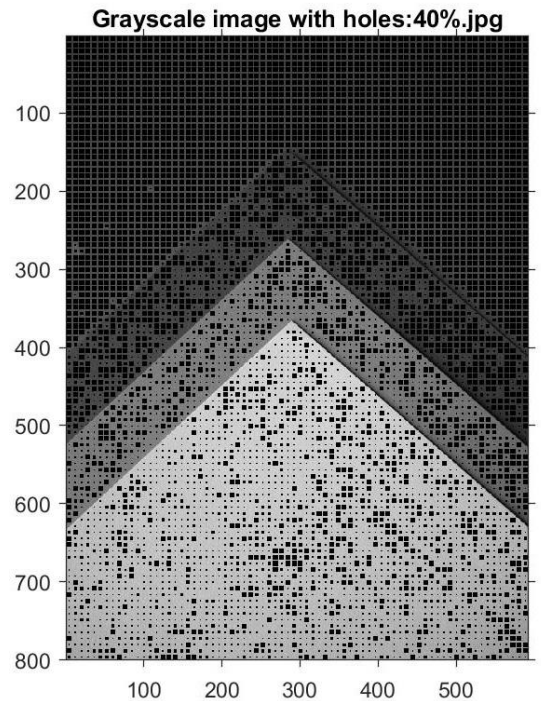

Grayscale image:20%.jpg

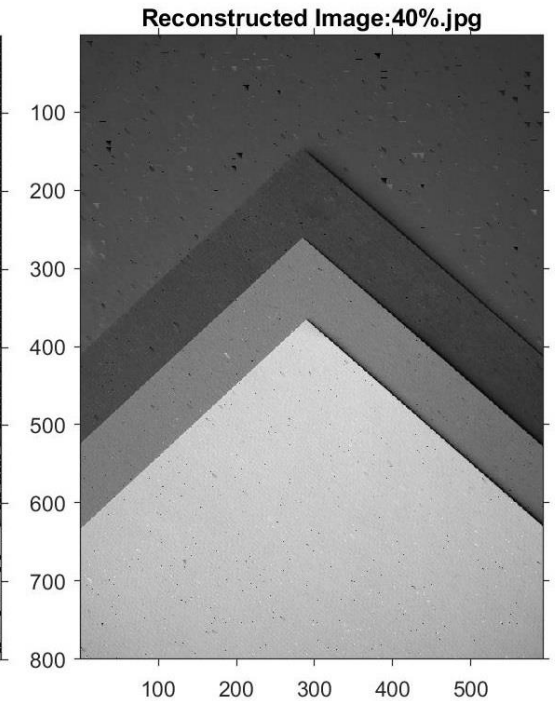

Grayscale image with holes:20%.jpg

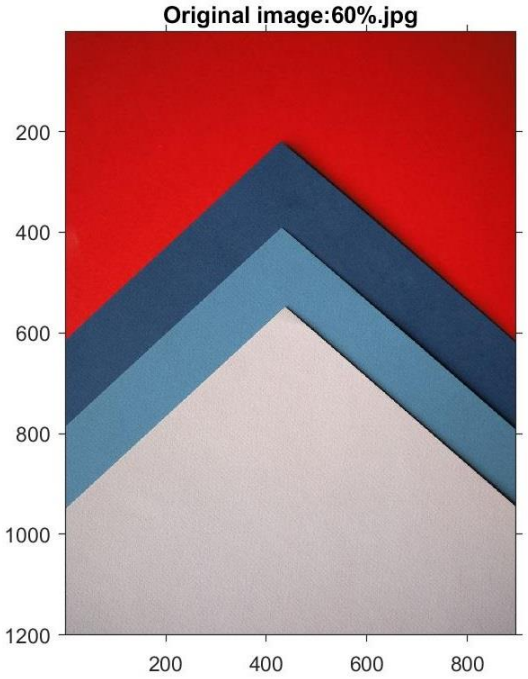

Reconstructed Image:20%.jpg

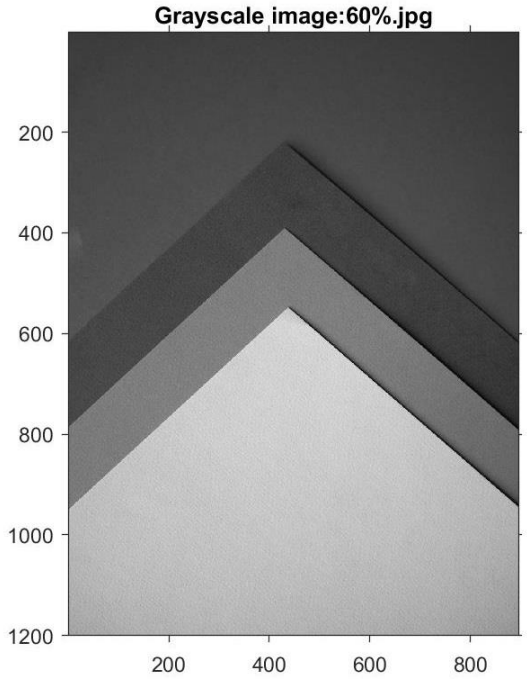

Original image:40%.jpg

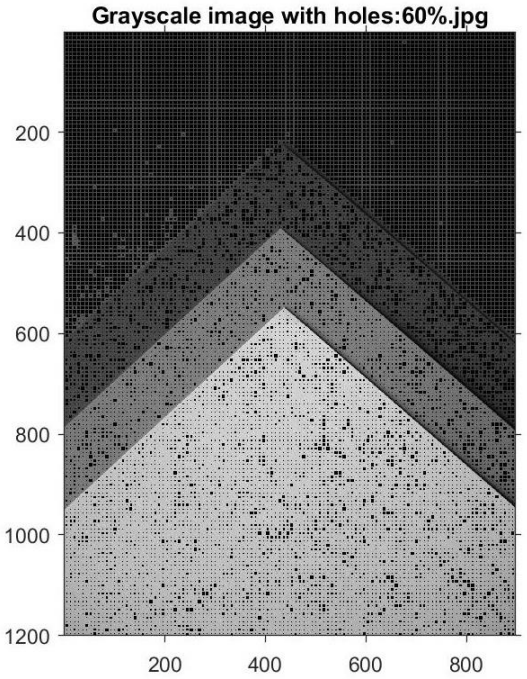

Grayscale image:40%.jpg

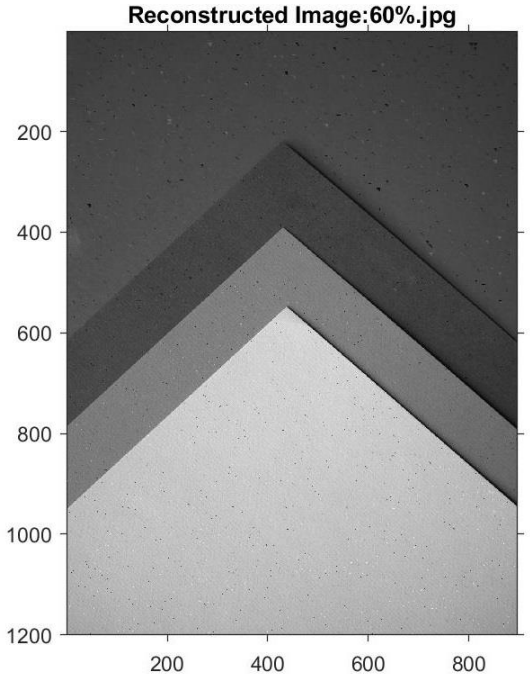

Grayscale image with holes:40%.jpg

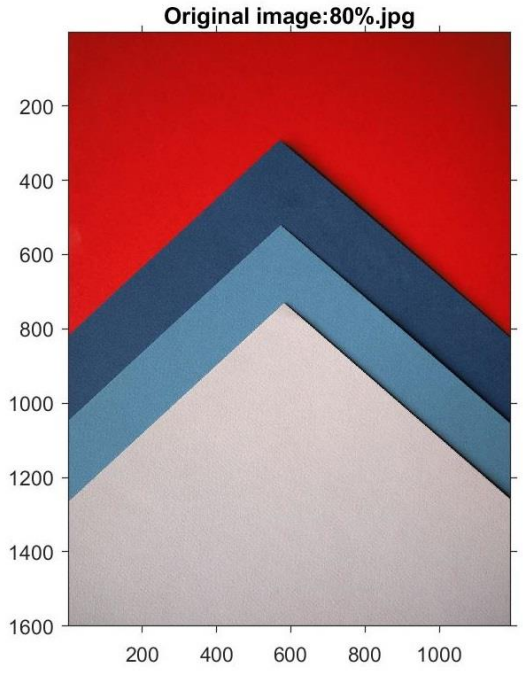

Reconstructed Image:40%.jpg

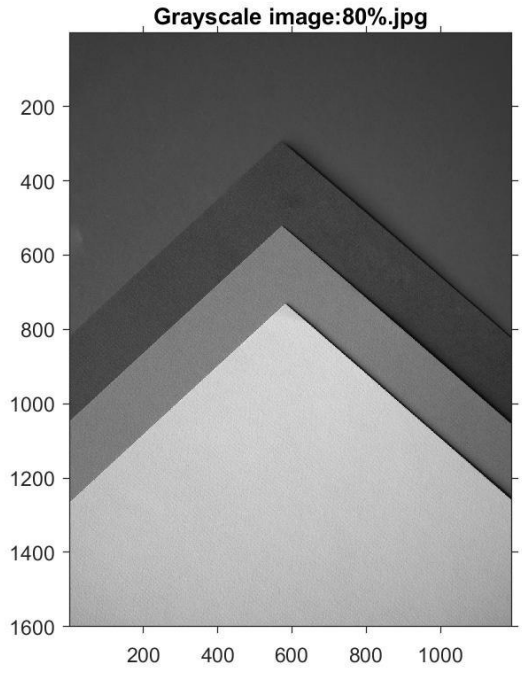

Original image:60%.jpg
200
400
600
800
1000
1200
200
400
600
800

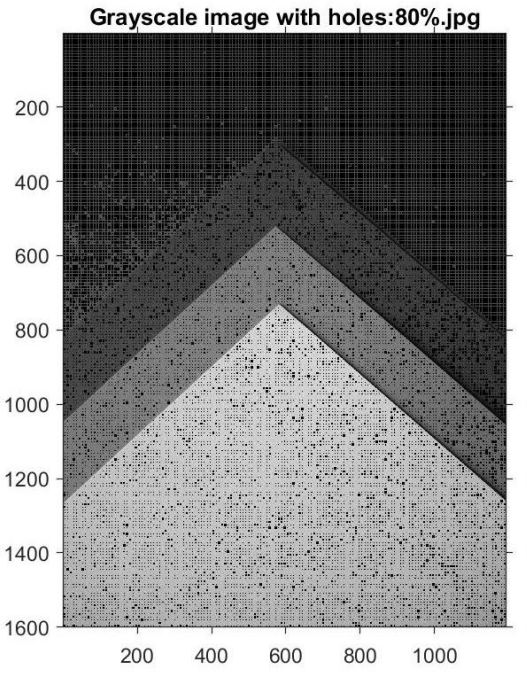

Grayscale image:60%.jpg
200
400
600
800
1000
1200
200
400
600
800

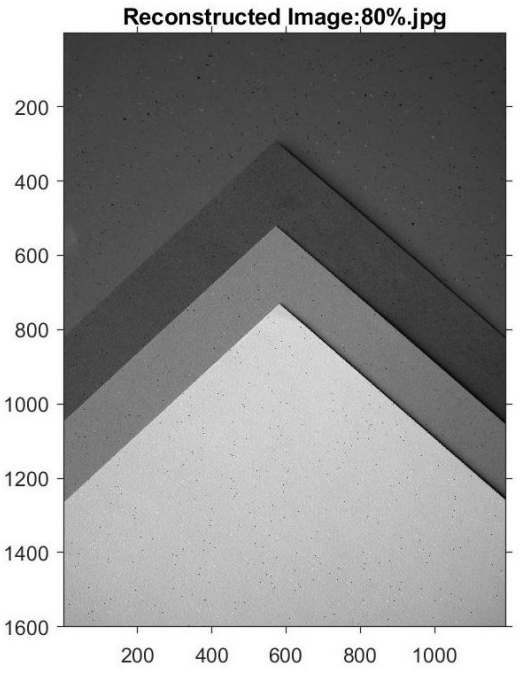

Grayscale image with holes:60%.jpg
200
400
600
800
1000
1200
200
400
600
800

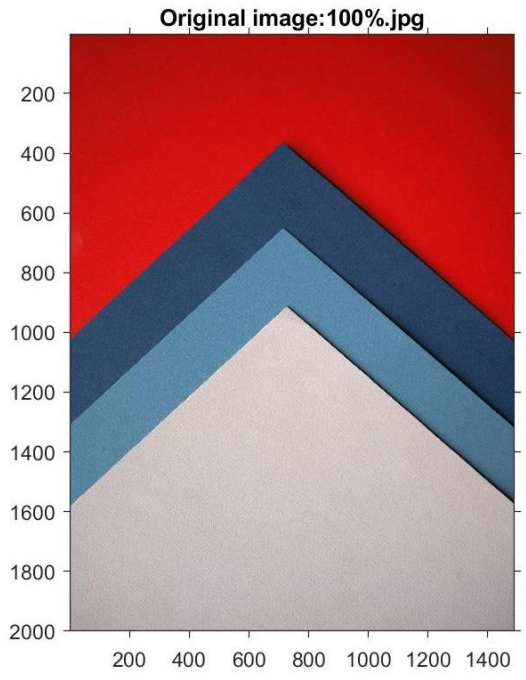

Reconstructed Image:60%.jpg
200
400
600
800
1000
1200
200
400
600
800

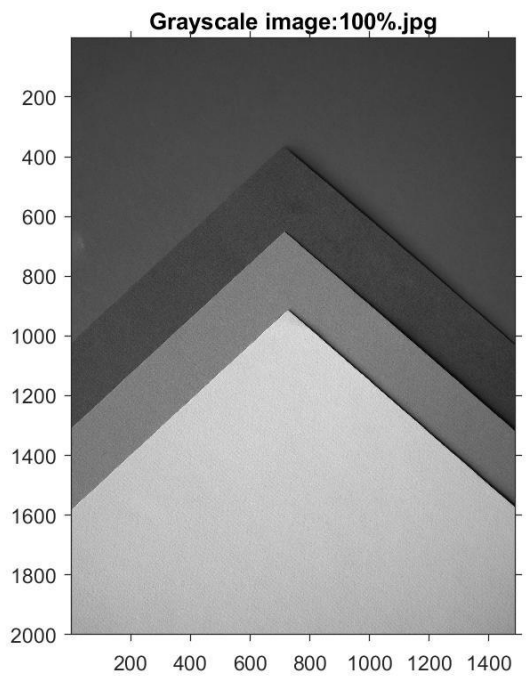

Original image:80%.jpg
200
400
600
800
1000
1200
1400
1600
200
400
600
800
1000

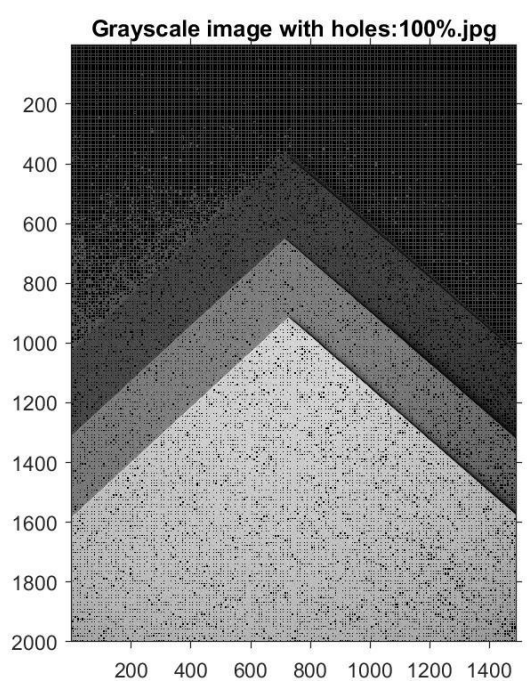

Grayscale image:80%.jpg
200
400
600
800
1000
1200
1400
1600
200
400
600
800
1000

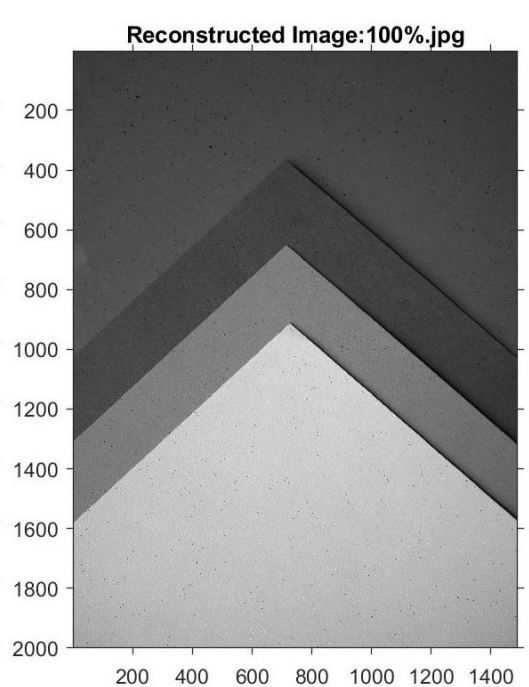

Grayscale image with holes:80%.jpg
200
400
600
800
1000
1200
1400
1600
200
400
600
800
1000


Reconstructed Image:80%.jpg
200
400
600
800
1000
1200
1400
1600
200
400
600
800
1000


Original image:100%.jpg
200
400
600
800
1000
1200
1400
1600
1800
2000
200 400 600 800 1000 1200 1400


Grayscale image:100%.jpg
200
400
600
800
1000
1200
1400
1600
1800
2000
200 400 600 800 1000 1200 1400

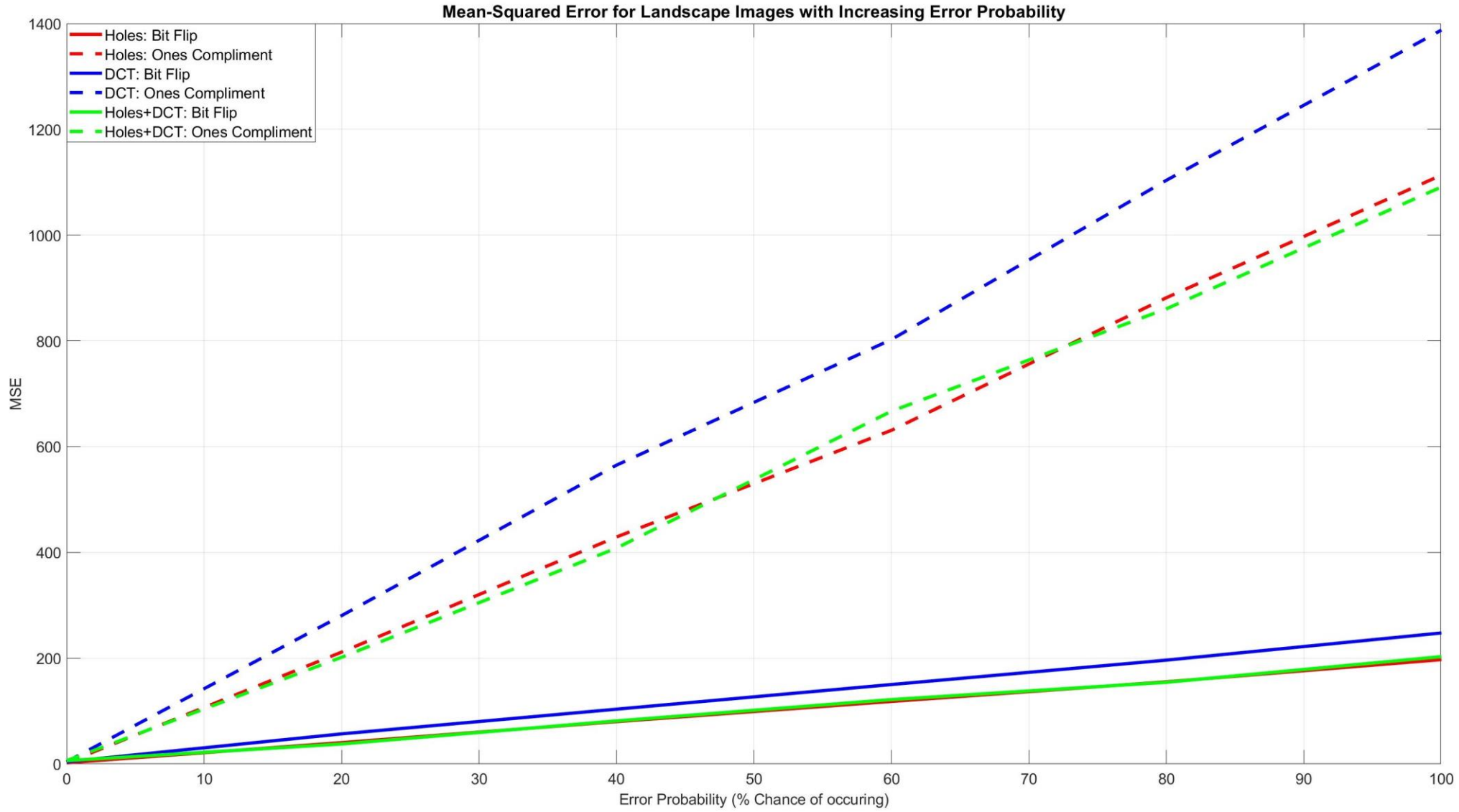

Grayscale image with holes:100%.jpg
200
400
600
800
1000
1200
1400
1600
1800
2000
200 400 600 800 1000 1200 1400


Reconstructed Image:100%.jpg
200
400
600
800
1000
1200
1400
1600
1800
2000
200 400 600 800 1000 1200 1400

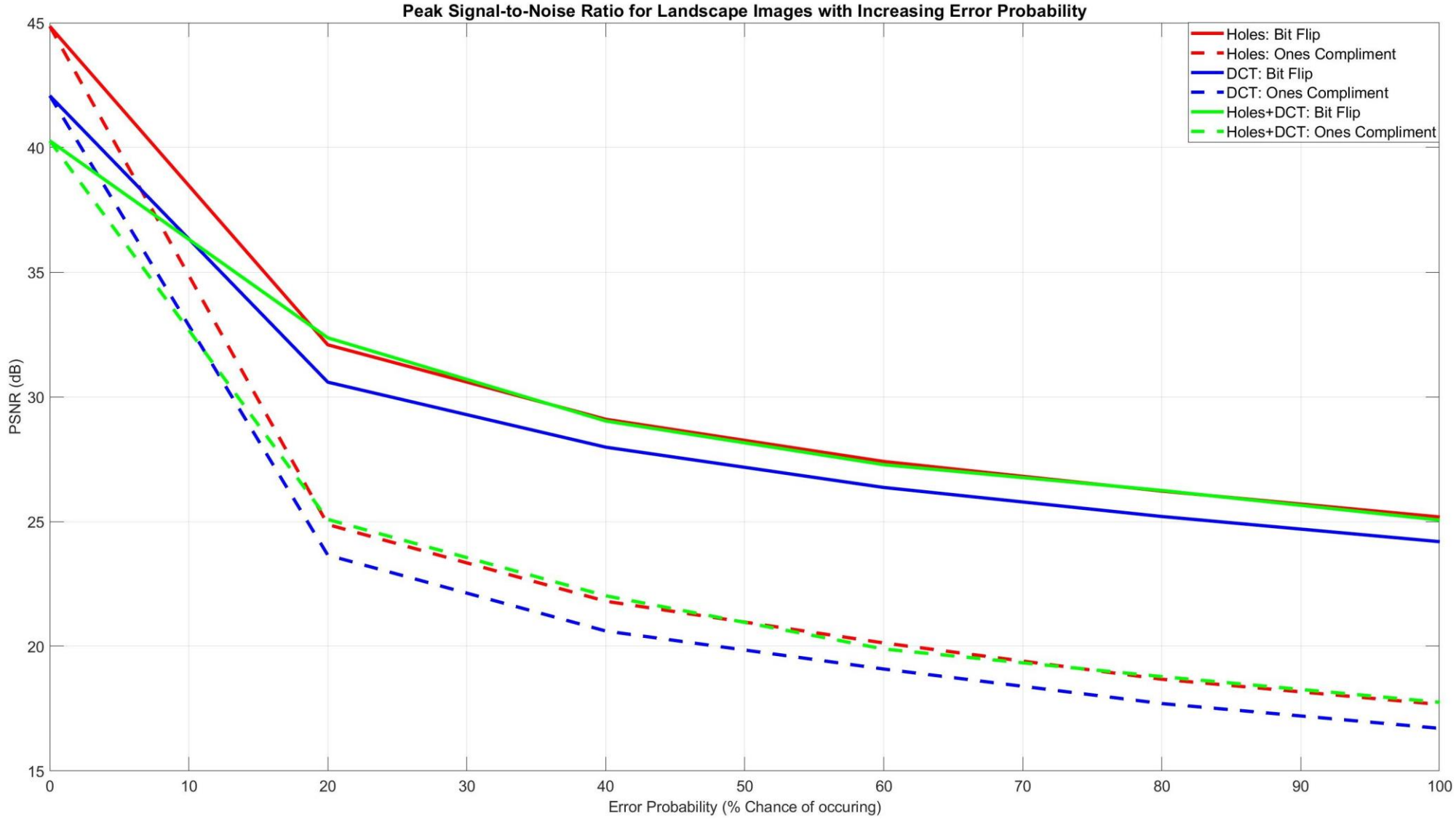
Results (PSNR & MSE)

- Tests:
  - effect of increasing error probability on different image types
- Average image size:
  - 1200x800 pixels
- Chance of error being introduced:
  - Increasing from 0% to 100%
  - Bit flip and Ones compliment introduction

Results (MSE)

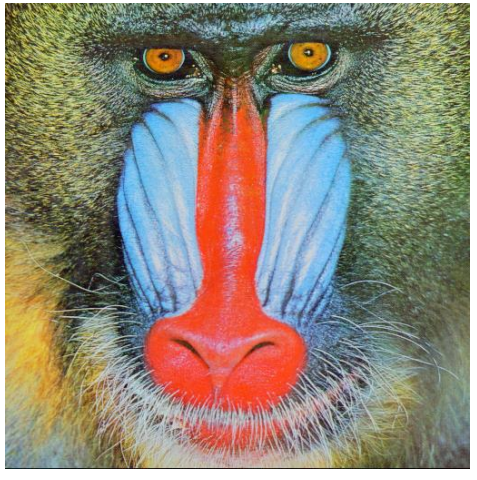
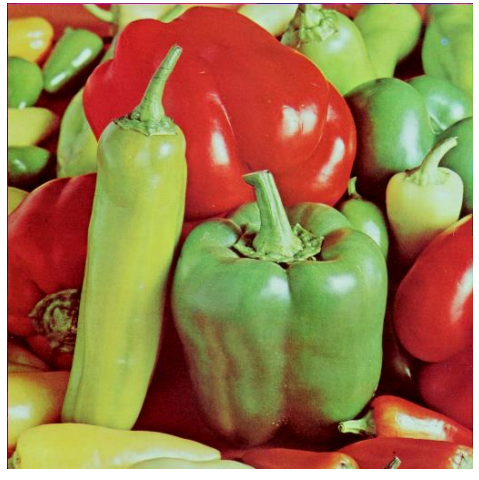

Mean-Squared Error for Landscape Images with Increasing Error Probability
Holes: Bit Flip
Holes: Ones Compliment
DCT: Bit Flip
DCT: Ones Compliment
Holes+DCT: Bit Flip
Holes+DCT: Ones Compliment
MSE
Error Probability (% Chance of occuring)
0
200
400
600
800
1000
1200
1400
0
10
20
30
40
50
60
70
80
90
100

Results (PSNR)



Results (Comparison with DCT & DWT)

- Tests:
  - How does the ***holes*** only algorithm perform against DCT and DWT technique
- Image size:
  - Known images
- Chance of error being introduced:
  - 10%
  - Bit flip introduction

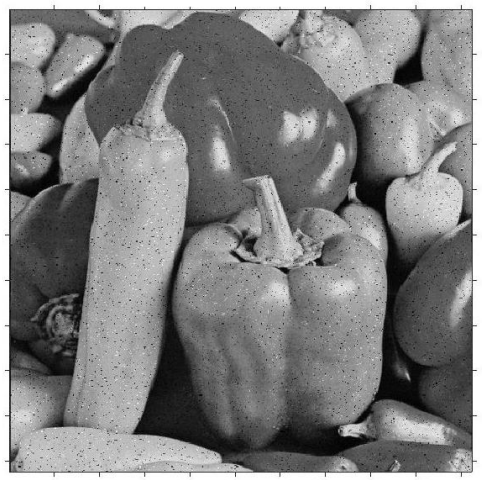
Results (Comparison with DCT & DWT)

Averaged Results with 10% Error			
Method	**Compression ratio**	**PSNR**	**MSE**
Holes	1,15	33,20	31,71
DCT	1,09	53,02	225,81
DWT	2,57	25,22	244,60

Peppers: Original

Peppers: Holes

Peppers: DCT



Peppers: DWT

Future Work

- Serial programming used → long processing time
- Parallel programming
- Run Length Encoding → drawbacks
- Better encoding scheme
- Distance value of 6 → hard coded values
- Neural networks (GAN)
  - Lower resolution → higher resolution

Conclusion

- All objectives met within project specifications
- Created algorithm:
  - Functional image compression scheme
  - Maintains image quality
- All images from *Unsplash.com*

Thank You!

Kishan Narotam

Nitesh Nana

Supervisor: Professor Fambirai Takawira