ECSE 6320 Final Project
Image Compression Formats

In this project we will compare 3 common image compression techniques using difference types of images.
1. JPEG
2. JPEG2000 (JP2)
3. HEIF

2. Test 1
2-1. Test Setup
In this part the program will load a high-resolution photography image. The purpose is to access the ability to compress daily images and align with human perception.

We will measure:
(1) Compression Time
(2) Compression Ratio (output size / original size)
(3) Peak Signal-to-Noise Ratio (PSNR)
(4) Structural Similarity Index Measure (SSIM)

2-2. Test Results
The results are shown from Table 1 to Table 3

Time(s)	0.282	0.302	0.315	0.320	0.342	0.350	0.419
Ratio	0.241	0.322	0.392	0.432	0.539	0.588	0.900
SSIM	0.869	0.898	0.914	0.923	0.935	0.945	0.964
MSE	62.416	45.624	36.303	29.923	25.184	20.084	15.697
PSNR(dB)	30.178	31.539	32.531	33.371	34.120	35.102	36.173

Table 1: JPEG Test Result

Time(s)	4.484	4.530	4.529	4.511	4.531	4.530
Ratio	0.217	0.232	0.377	0.488	0.643	0.787
SSIM	0.852	0.874	0.897	0.912	0.929	0.936
MSE	66.347	52.663	40.788	33.309	26.358	21.059
PSNR(dB)	29.913	30.916	32.025	32.905	33.922	34.896

Table 2: JPEG2000 Test Result

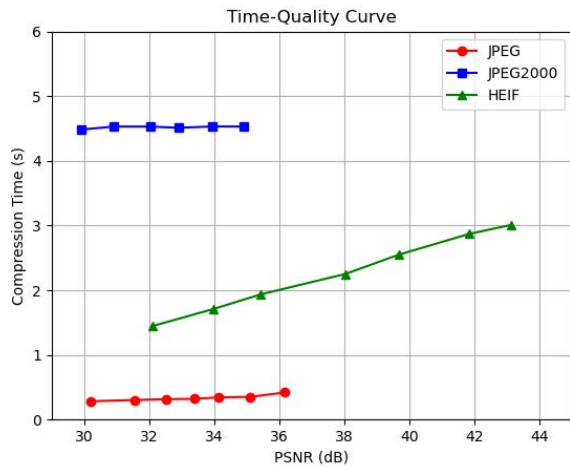| Time(s)	1.445	1.708	1.934	2.251	2.550	2.872	3.008
Ratio	0.178	0.266	0.352	0.536	0.653	0.796	0.887
SSIM	0.909	0.937	0.953	0.974	0.982	0.989	0.992
MSE	40.132	26.117	18.678	10.237	7.002	4.244	3.168
PSNR(dB)	32.096	33.962	35.418	38.029	39.678	41.853	43.123

Table 3: HEIF Test Result
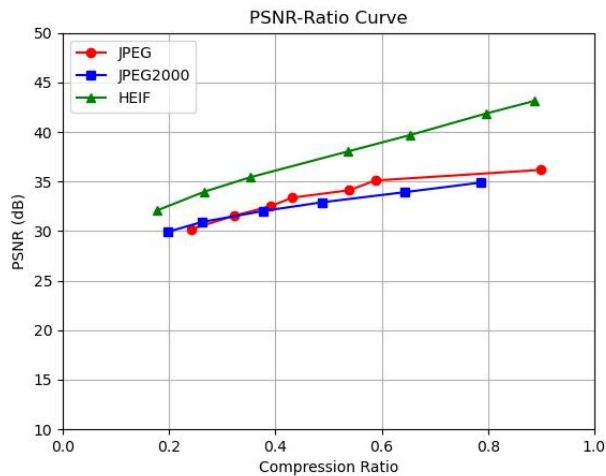
Figure 1: Time-Quality Curve
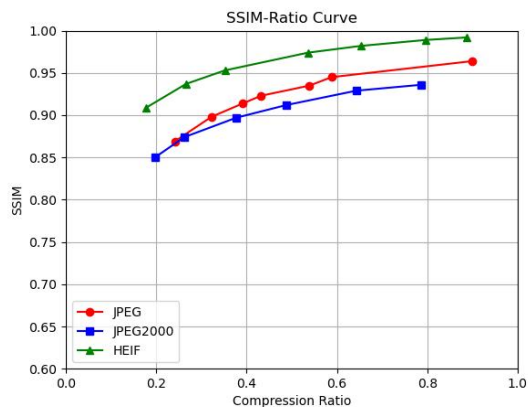

Figure 2: PSNR-Ratio Curve

Figure 3: SSIM Curve

2-3. Analysis

JPEG is the fastest compression method.

JPEG2000 is the slowest method. Due to the characteristics of DWT, compression time for JPEG2000 is independent of the target quality. Both JPEG and HEIF take longer for outputs in higher quality.

In terms of quality, as a new technique HEIF offers the best performance, which is 40-50% more efficient than JPEG. JPEG2000 performs slightly worse than expected. One possible explanation is that JPEG2000 is not optimized for cinematic images, and today's JPEG/HEIF encoders are well

optimized for this purpose.

3. Test 2
3-1. Test Setup
In this part the program will load a X-ray image. The purpose is to access the ability to preserve subtle grayscale gradients and critical fine details like edge clarity. This feature is critical in specialized areas like medical imaging.

We will measure:

(1) Compression Time

(2) Compression Ratio (output size / original size)

(3) Gradient Difference Metric (GDM)

3-2. Test Results

Time(s)	0.151	0.207	0.155	0.164	0.220
Ratio	0.1227	0.146	0.1729	0.193	0.1971
GDM	25.5718	23.8709	22.0565	20.3618	19.6285

Table 4: JPEG Test Result

Time(s)	0.9481	0.9385	0.9281	0.946	0.936
Ratio	0.1205	0.1314	0.1445	0.1606	0.181
GDM	12.4399	11.617	10.7917	10.2407	9.5445

Table 5: JPEG2000 Test Result

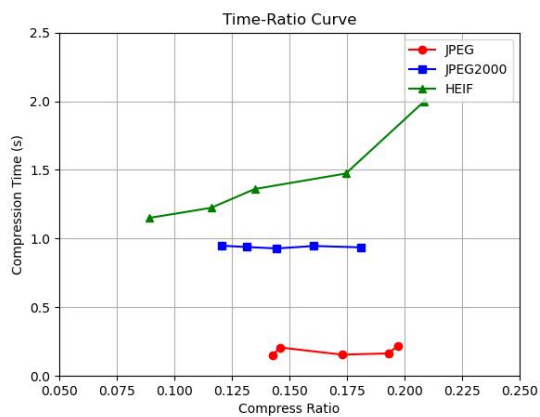| Time(s)	1.150	1.224	1.361	1.4734	1.9981
Ratio	0.089	0.116	0.135	0.1745	0.2085
GDM	13.4771	11.55	9.2318	8.3282	6.9846

Table 6: HEIF Test Result
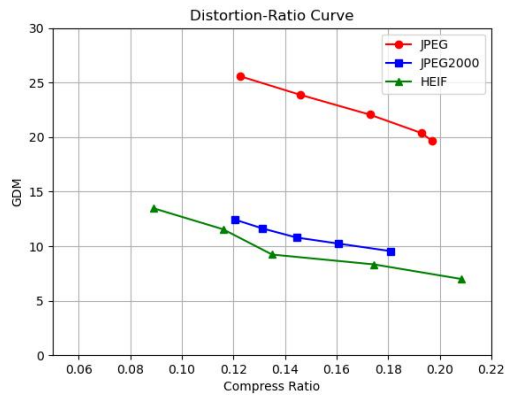

Figure 4: Time-Ratio Curve

Figure 5: Distortion-Ratio Curve

3-3. Analysis

JPEG2000 and HEIF performs much better than JPEG in terms of preserving subtle gradients and edge clarity. HEIF is 22-40% more efficient than JPEG2000 given the same target GDM.

4. Conclusion

JPEG is still one of the most commonly used format in modern computers due to its quick compression, making it suitable for daily use (e.g. web page, regular image display).

JPEG2000 is capable of preserving gradient details. With other features like ROI encoding, resolution scalability, it has been commonly used for specialized applications like medical imagery and satellite imagery. However the complication of wavelet transform, illustrated in long compression time, makes it not widely used in daily life.

HEIF which was released just several years ago shows the best performance in both tests. HEIF is ideal for high quality visuals like 4k+ photography, and more cameras are adapting this new format.