Image Processing Toolkit — Report

Author: Harshit V Shah | Date: Sep 8, 2025

This report accompanies a Streamlit GUI that demonstrates core image processing concepts: color spaces, transformations, filtering, morphology, enhancement, edge detection, and compression. It also includes brief notes on CMOS vs CCD, sampling & quantization, and PSFs.

CMOS vs CCD (Sensors)

CCD (Charge-Coupled Device) sensors transfer accumulated charge across the chip to a single output node—great for low-noise, uniform images but higher power and cost.

CMOS (Complementary Metal–Oxide–Semiconductor) sensors integrate amplification and readout per pixel—lower power, faster readout, on-chip processing; historically noisier but modern CMOS rivals CCD in many applications.

Trade-offs: CCD excels in scientific imaging due to low fixed-pattern noise; CMOS dominates consumer/embedded due to speed, power efficiency, and integration.

Sampling & Quantization

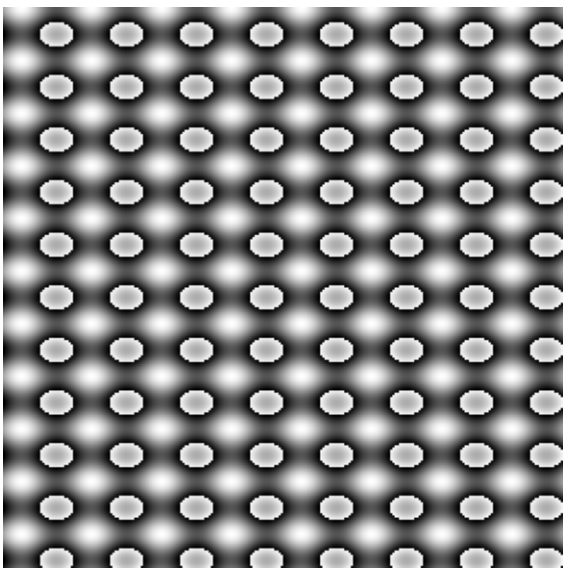
Sampling defines spatial resolution (how many pixels). Quantization defines intensity resolution (how many levels per pixel). Lower sampling causes aliasing/blur; lower bit-depth increases banding and quantization noise.

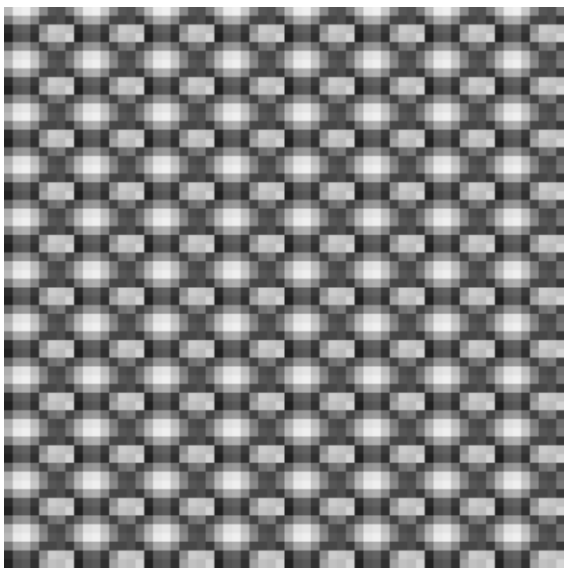
We demonstrate both with a synthetic image: downsample + upsample (stair-steps) and n-bit quantization.

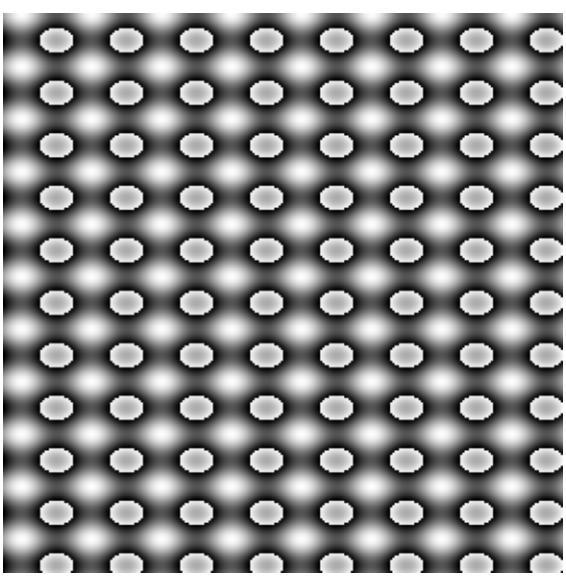
Point Spread Function (PSF)

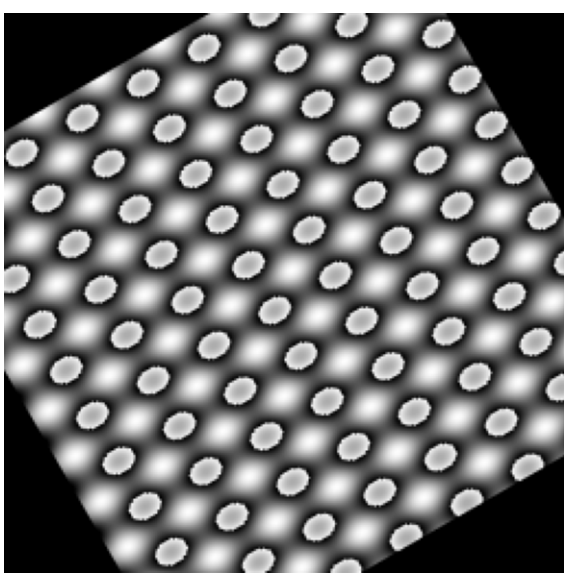
The PSF models the response of an imaging system to a point source. Real optics blur points into small spots—convolution with a PSF blurs the entire image. A common approximation is the Gaussian PSF. We show Gaussian blur and unsharp masking for de-blurring-like enhancement.

Sampling, Rotation Examples

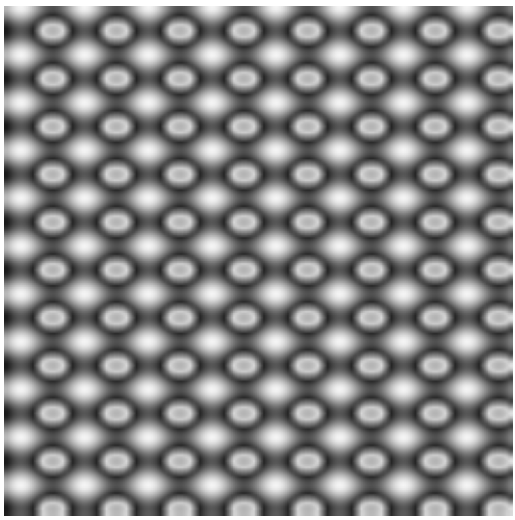


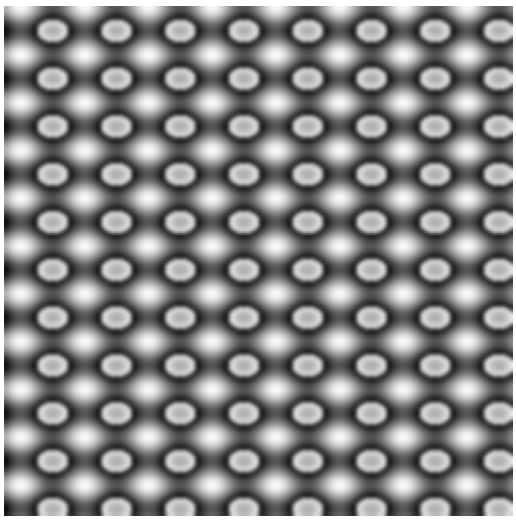


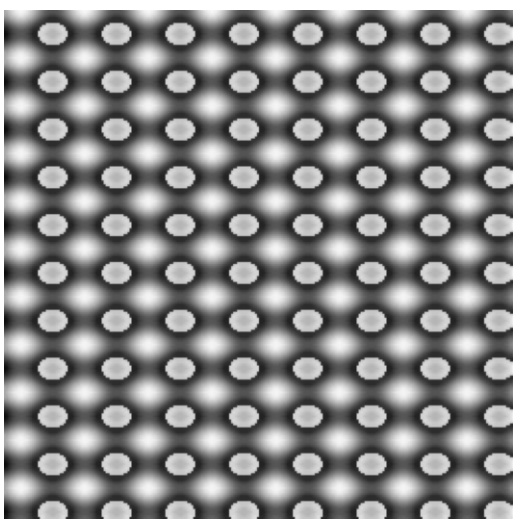


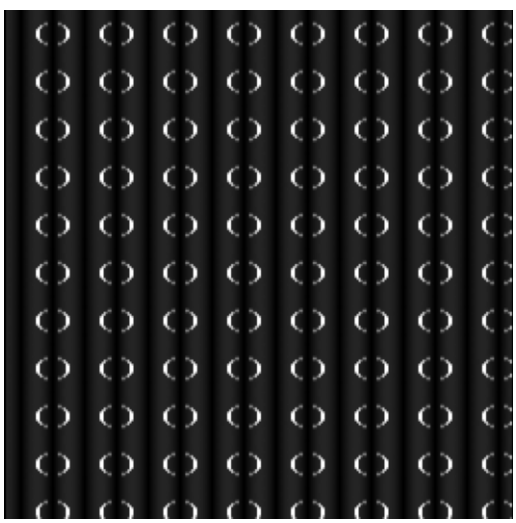


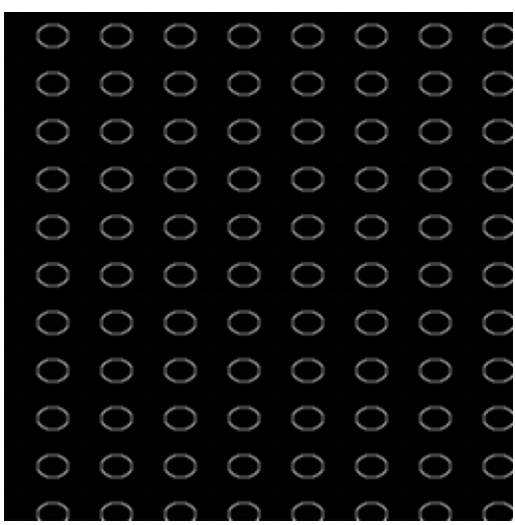
Filtering & Edge Detection

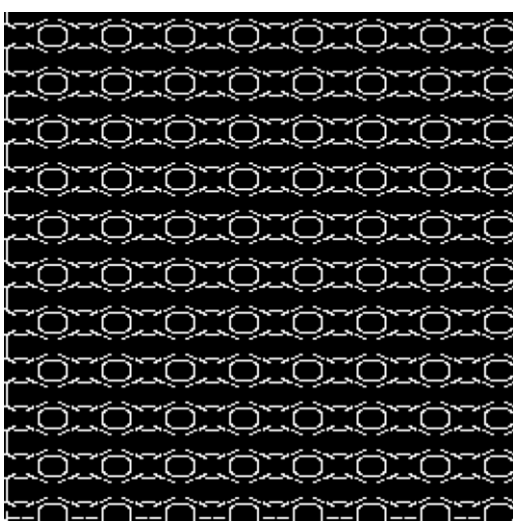




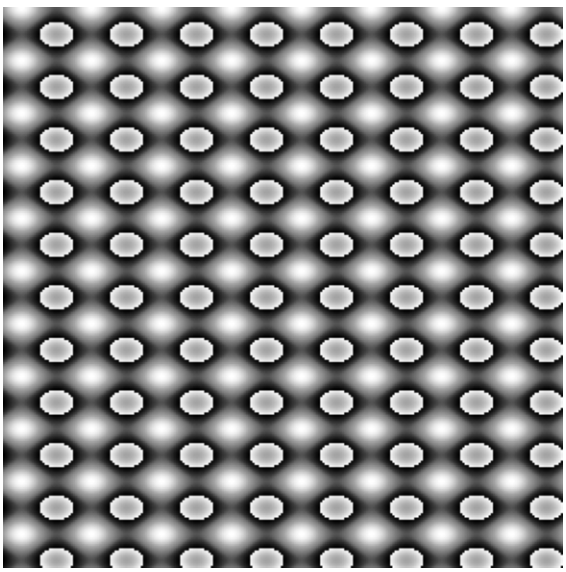


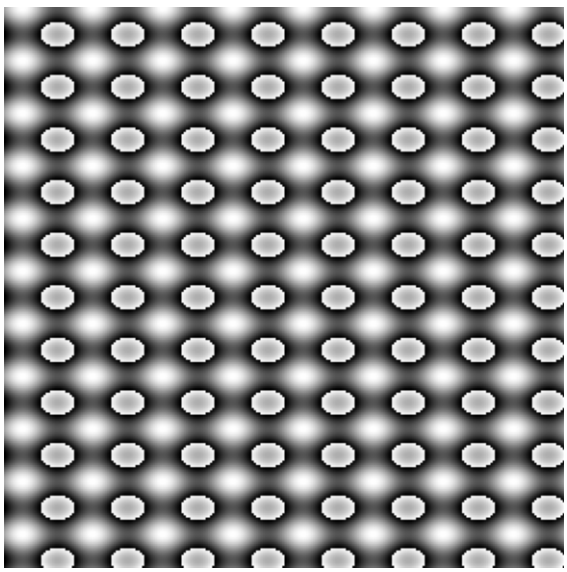


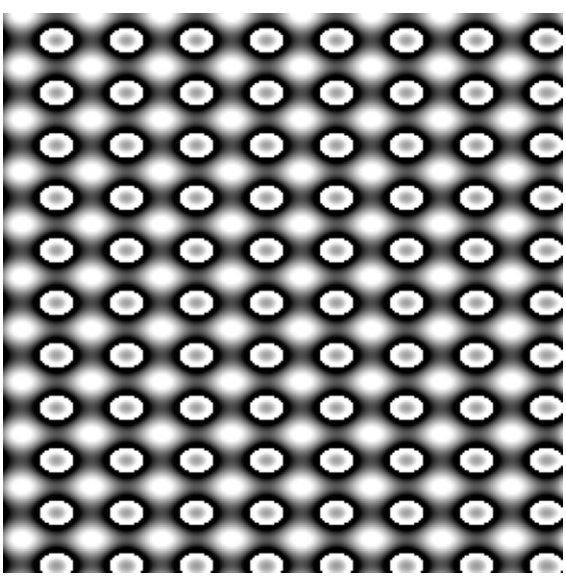




Enhancement







Compression — Size Comparison

PNG: 103.10 kB | BMP: 192.05 kB | JPG(q85): 26.51 kB

Note: JPG is lossy; PNG/BMP are lossless.