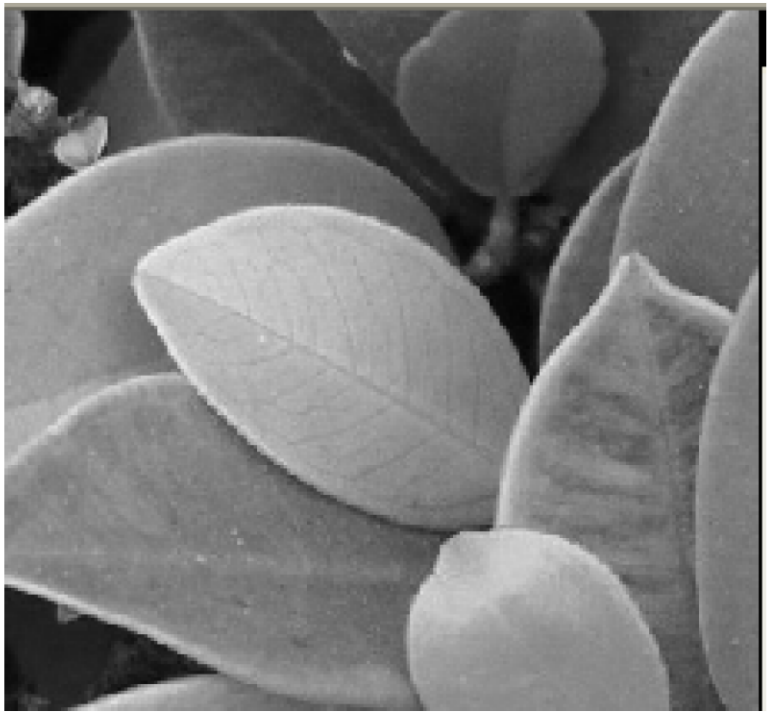
Extending DFT to 2D

Axes

- Frequency
  - Only positive
- Orientation
  - 0 to 180
- Repeats in negative frequency
  - Just as in 1D

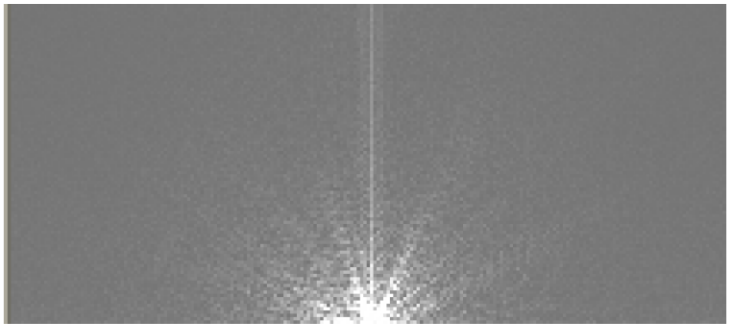
Example

Spatial Domain

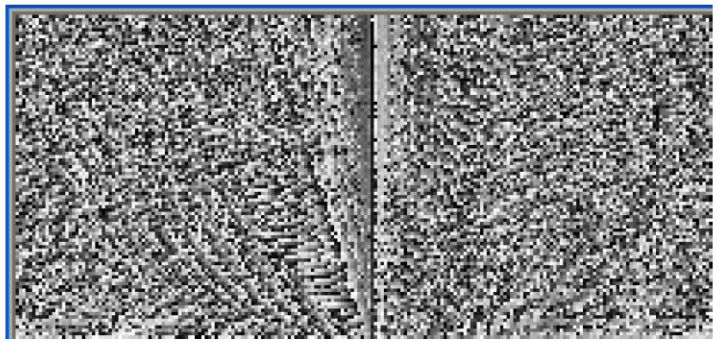


Frequency Domain

Amplitude

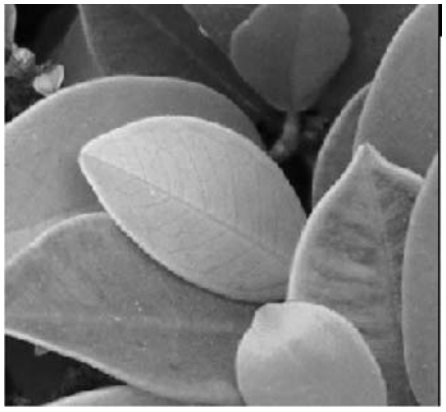


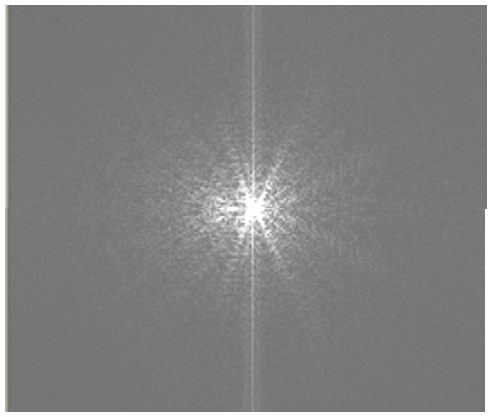
Phase



How it repeats?

- Just like in 1D
  - Even function for amplitude
  - Odd function for phase
- For amplitude
  - Flipped on the bottom





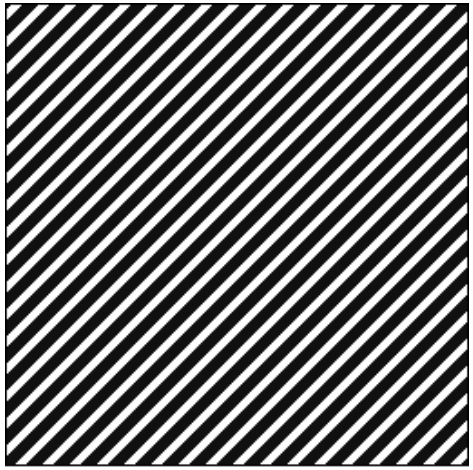
Why all the noise?

- Values much bigger than 255
- DC is often 1000 times more than the highest frequencies
- Difficult to show all in only 255 gray values

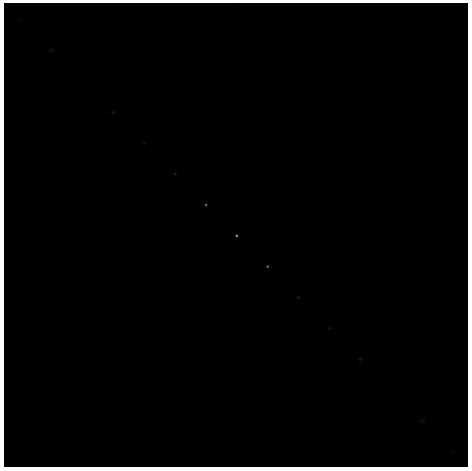
Mapping

- Numerical value = ***i***
- Gray value = ***g***
- Linear Mapping is ***g = ki***
- Logarithmic mapping is ***g = k log (i)***
  - Compresses the range
  - Reduces noise
  - May still need thresholding to remove noise

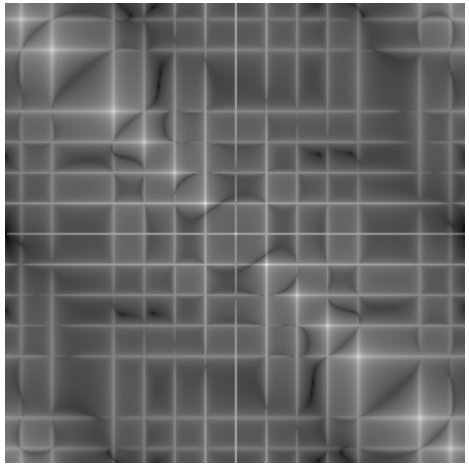
Example



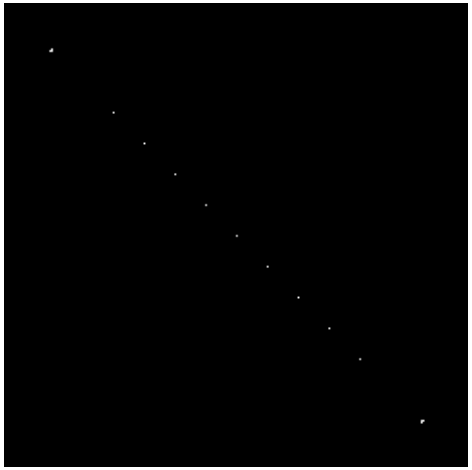
Original



DFT Magnitude

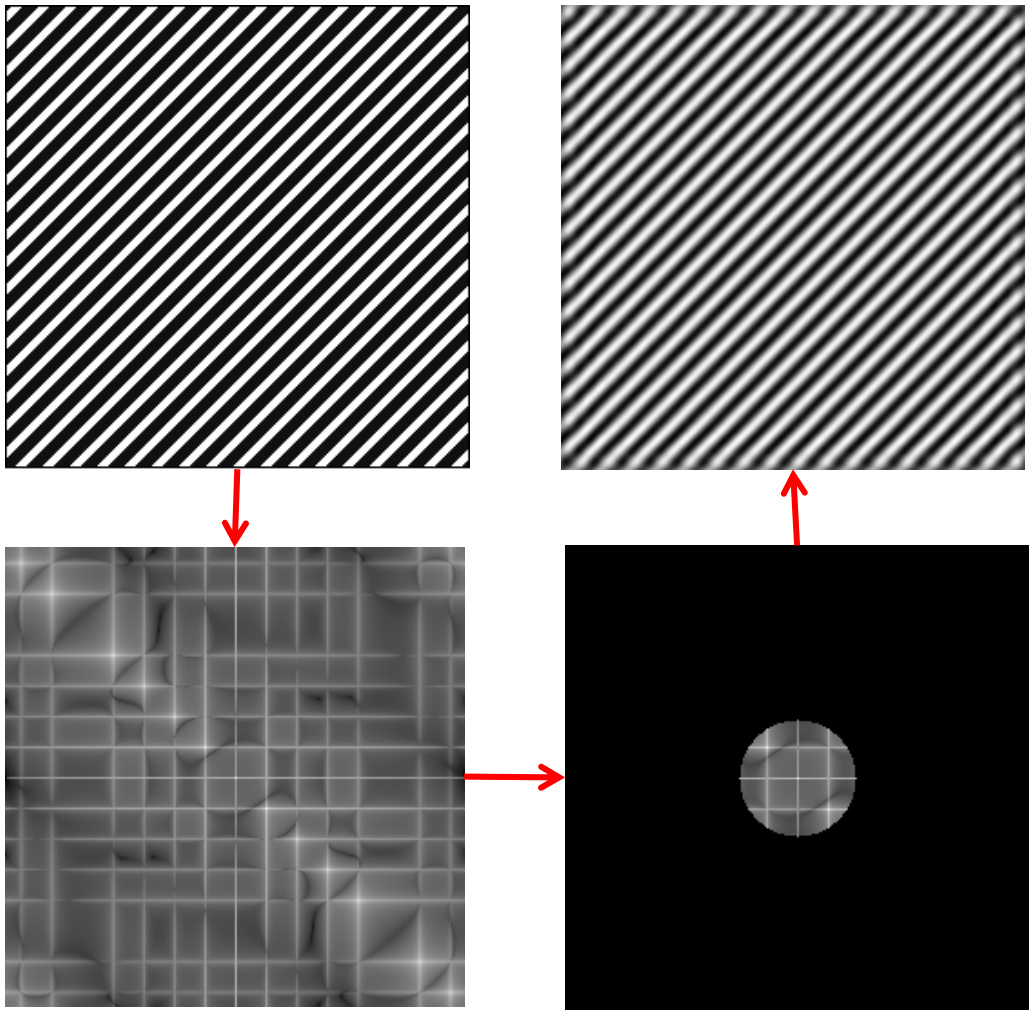


In Log scale

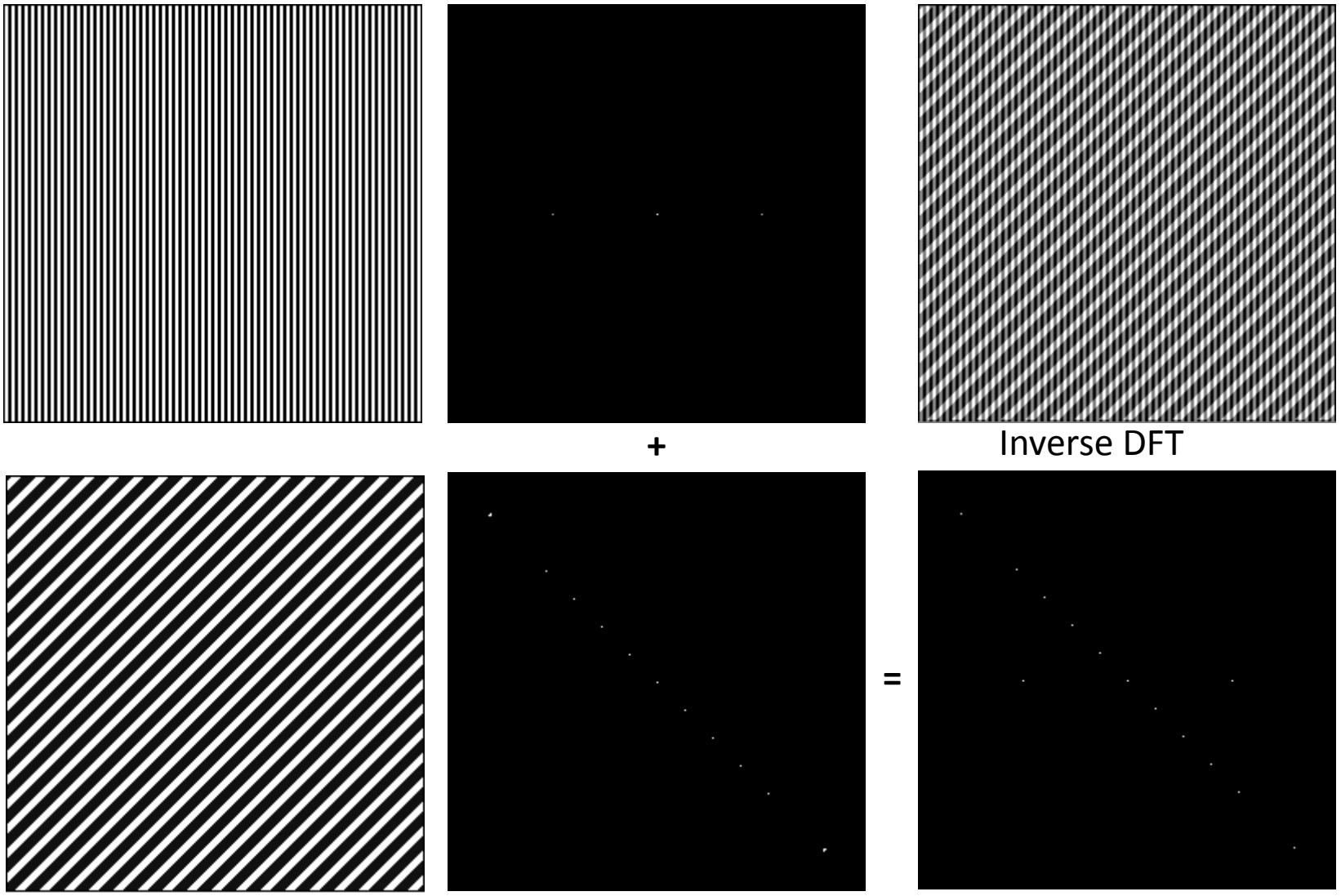


Post Thresholding

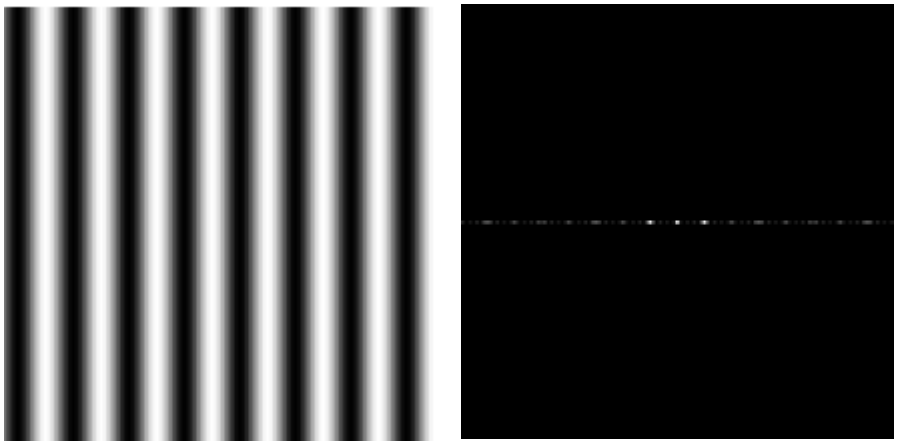
Low Pass Filter Example

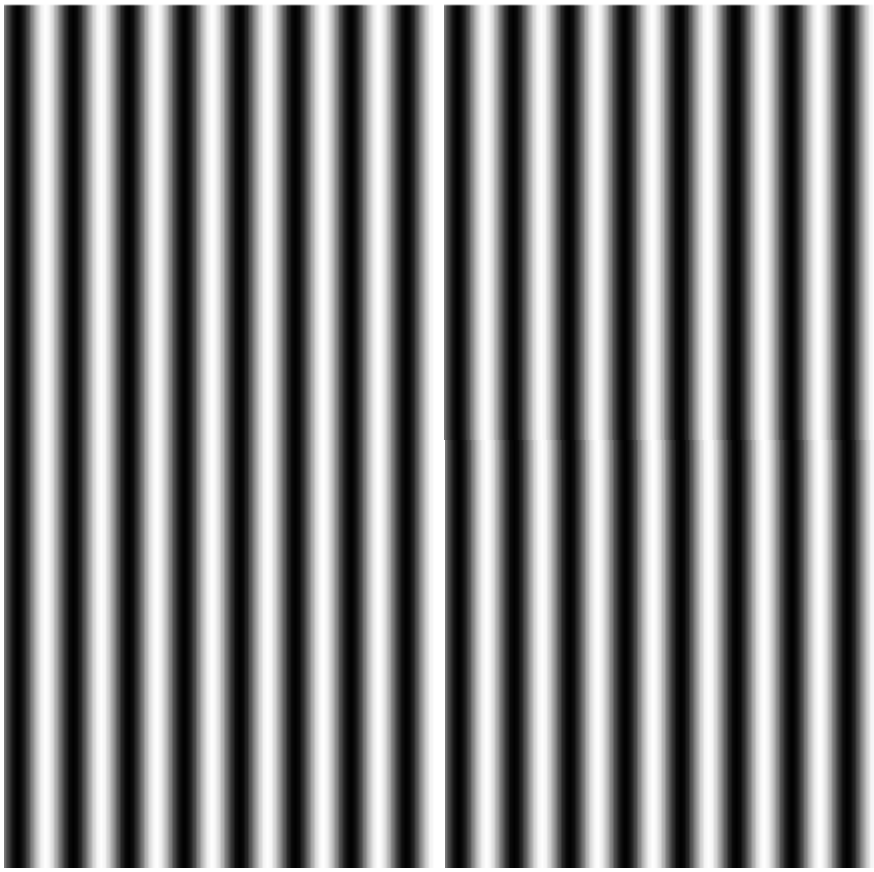


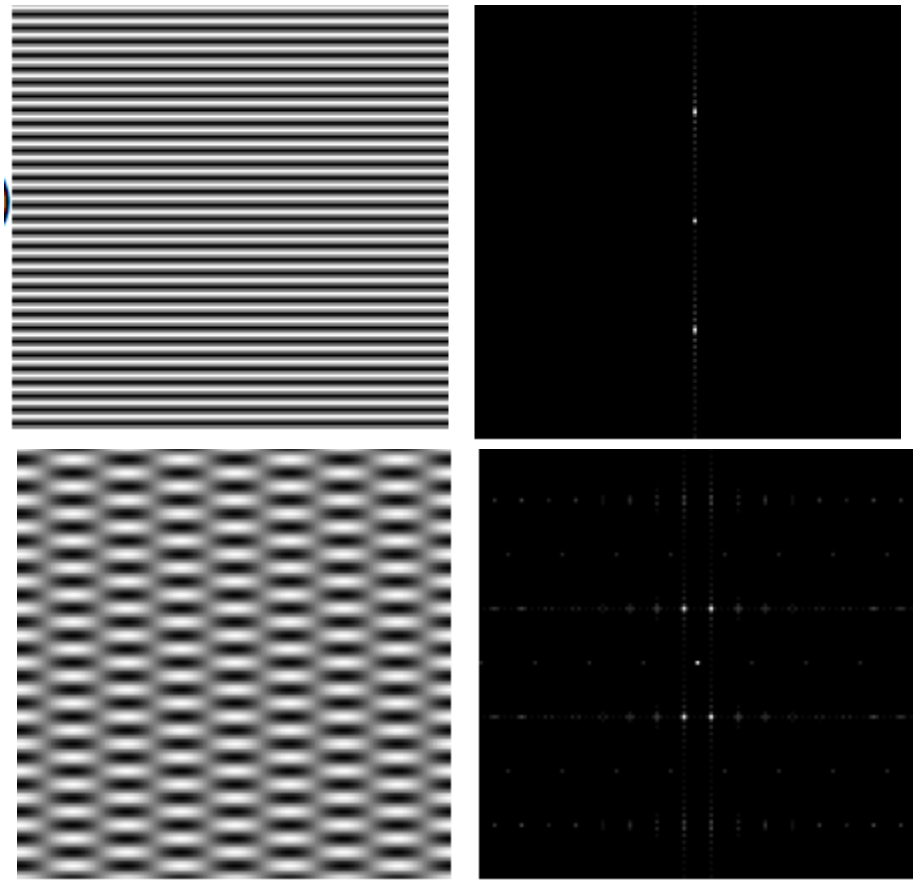
Additivity

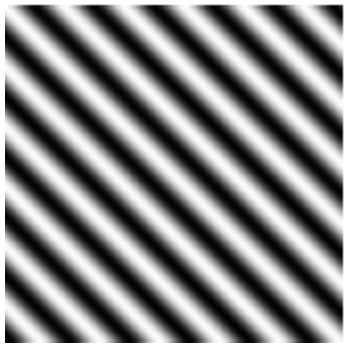
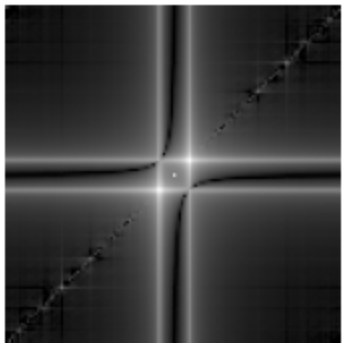
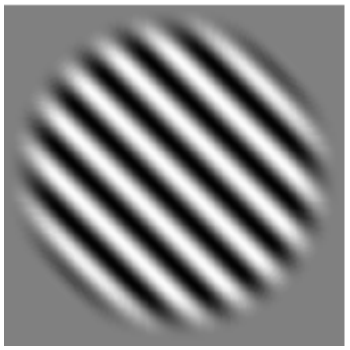
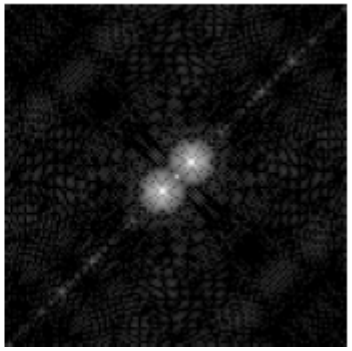
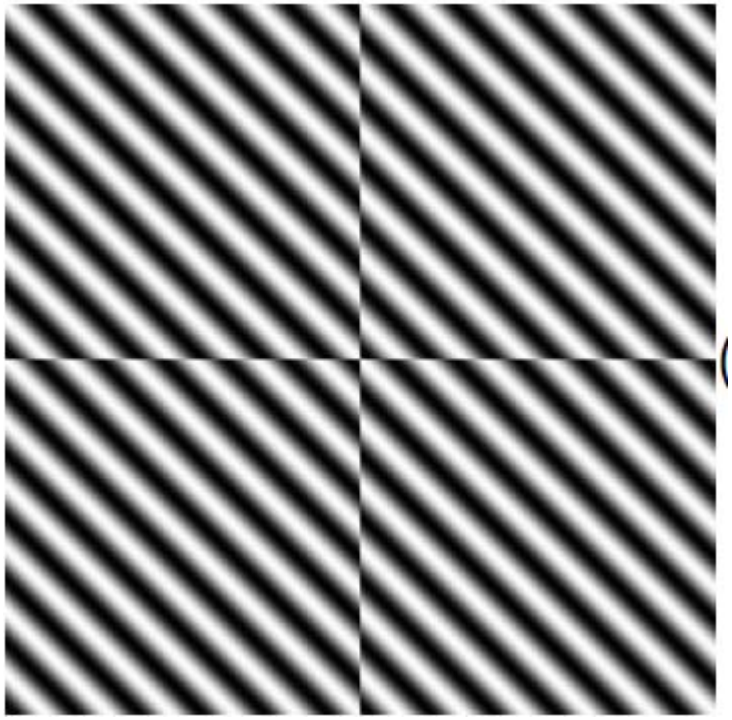


Nuances

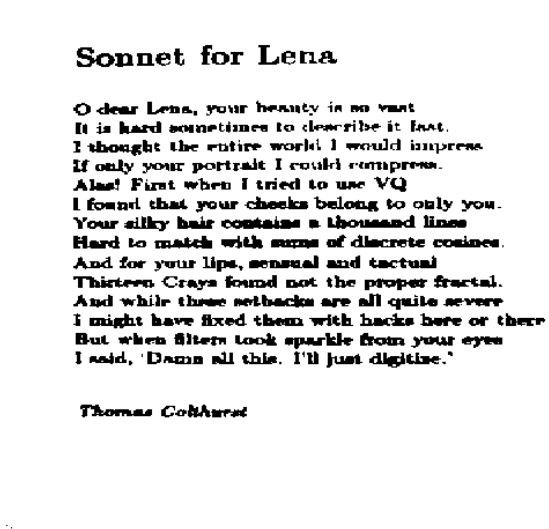


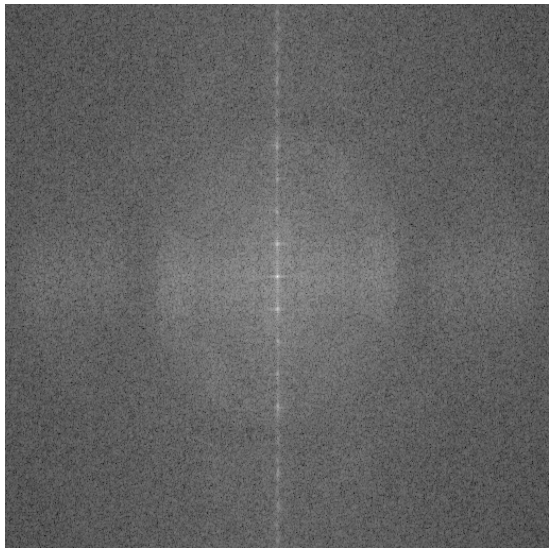


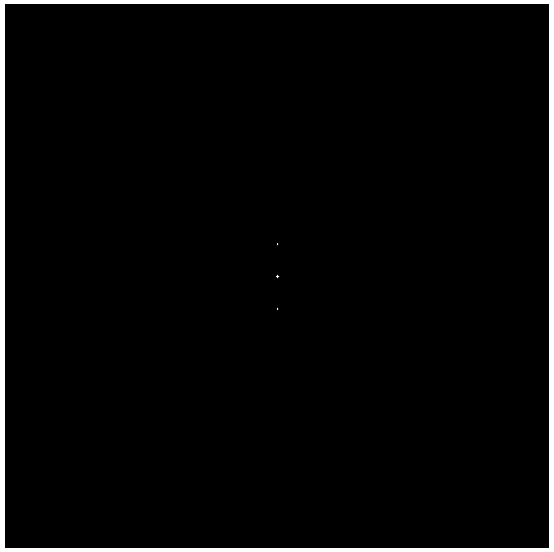


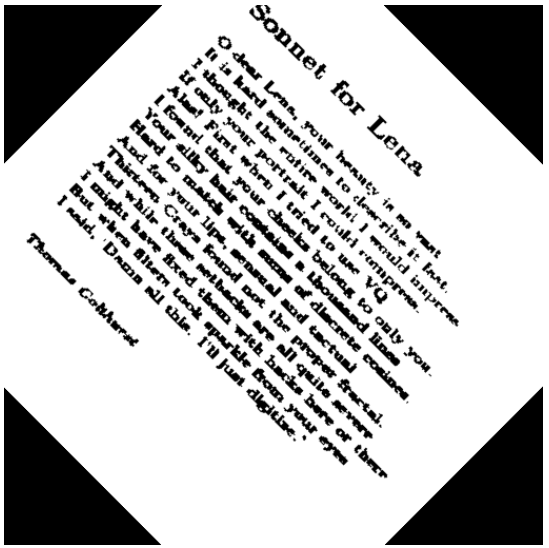






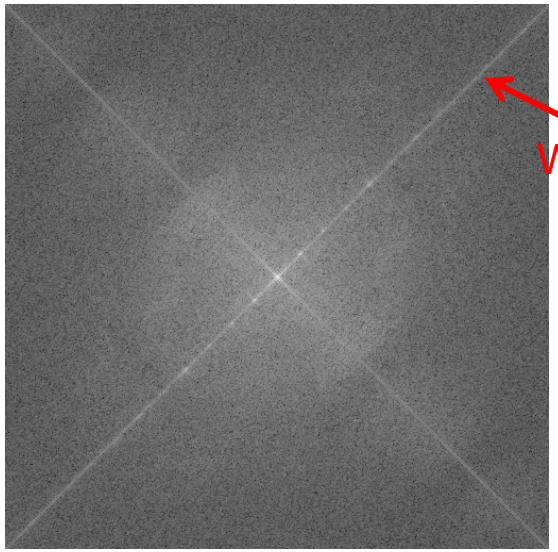

Rotation



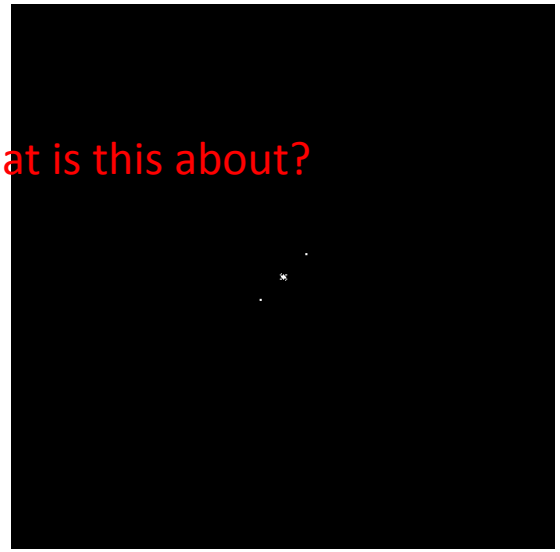


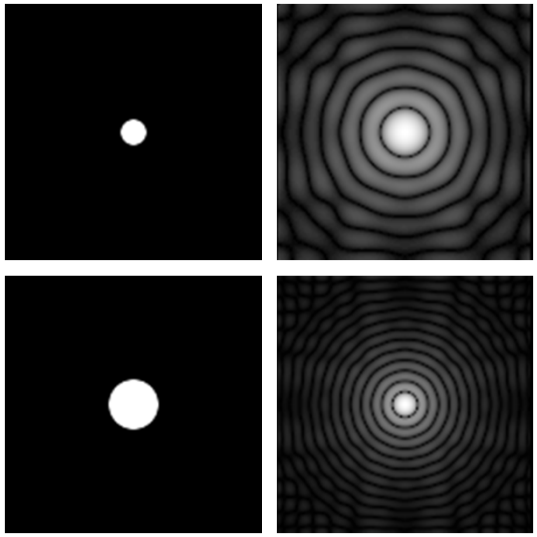


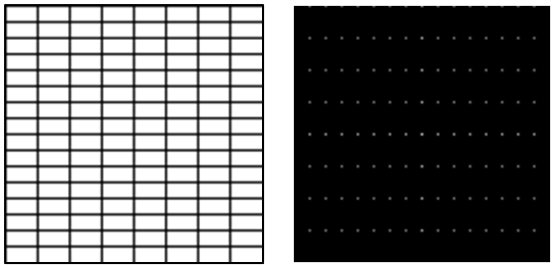


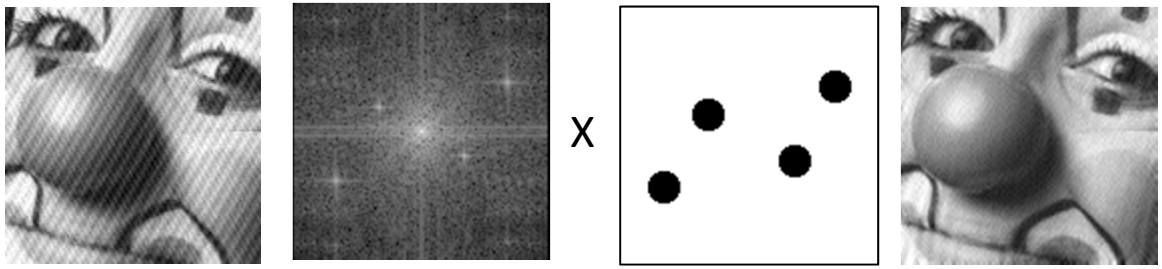


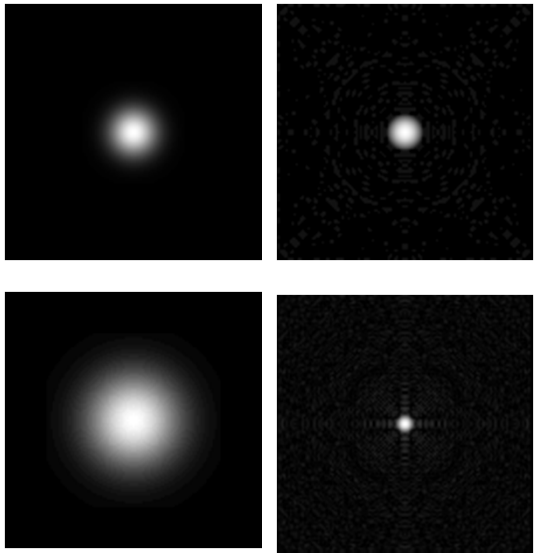
What is this about?

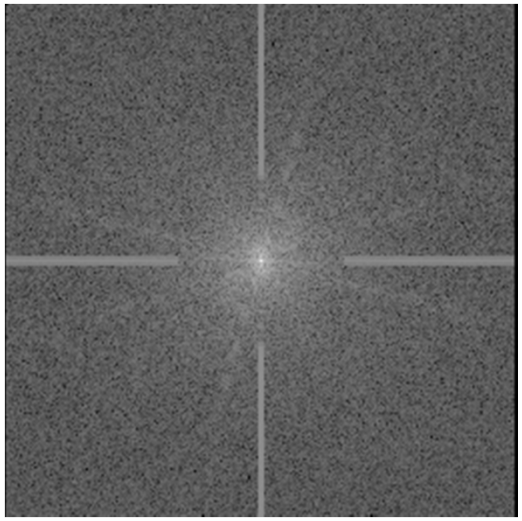




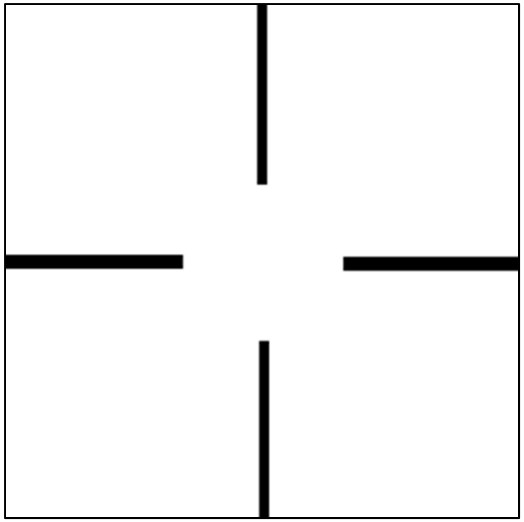



X

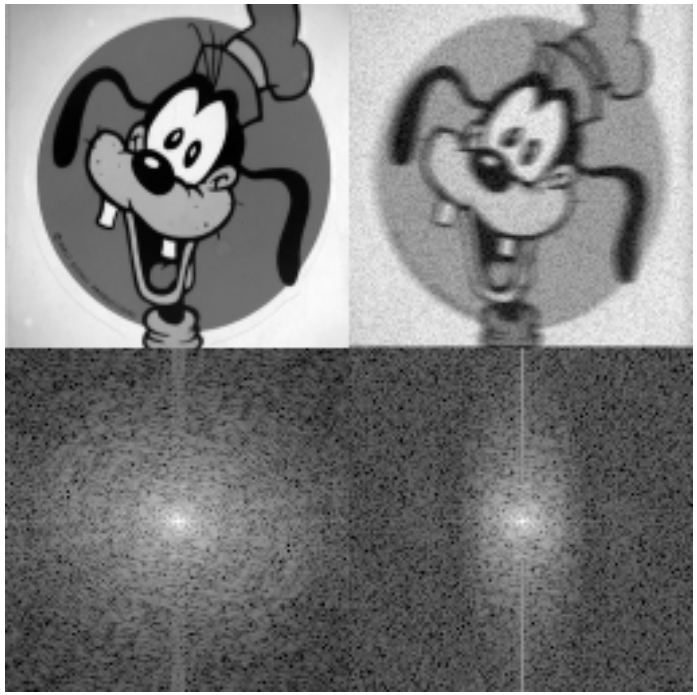


X

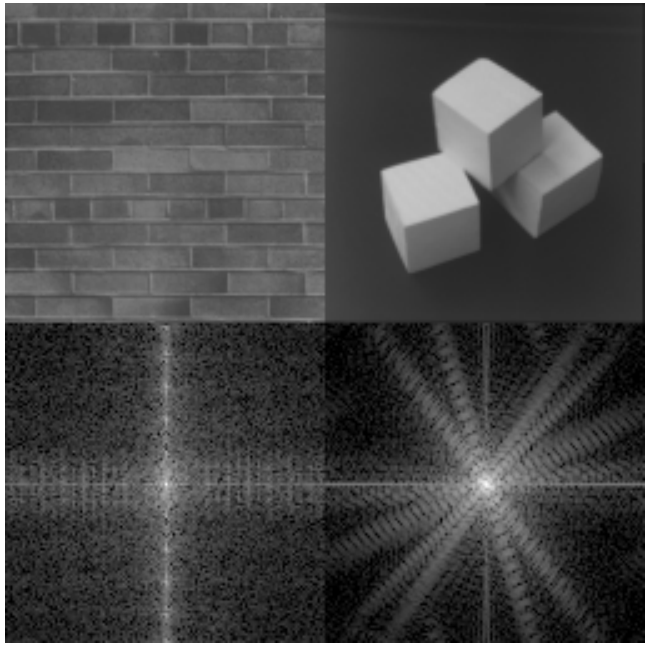



More examples: Blurring



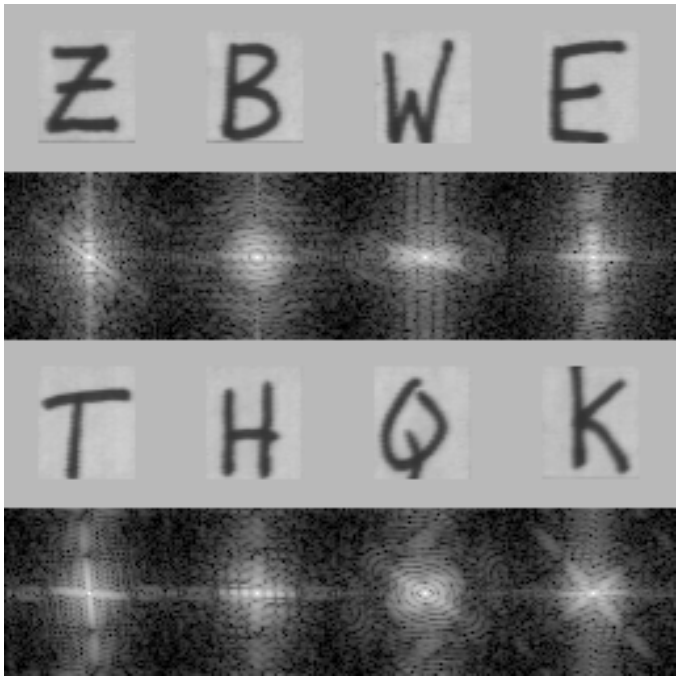
- Note energy reduced at higher frequencies
- What is direction of blur?
  - Horizontal
- Noise also added
  - DFT more noisy

More examples: Edges



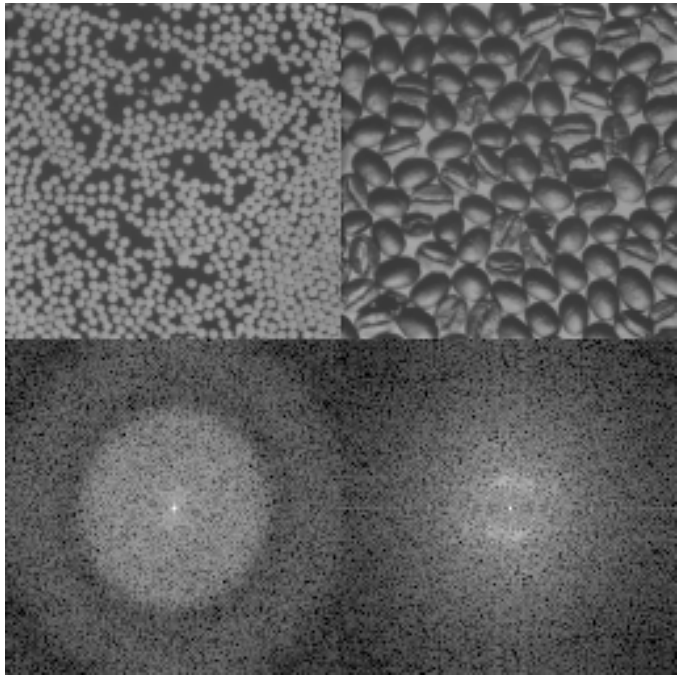
- Two direction edges on left image
  - Energy concentrated in two directions in DFT
- Multi-direction edges
  - Note how energy concentration synchronizes with edge direction

More examples: Letters



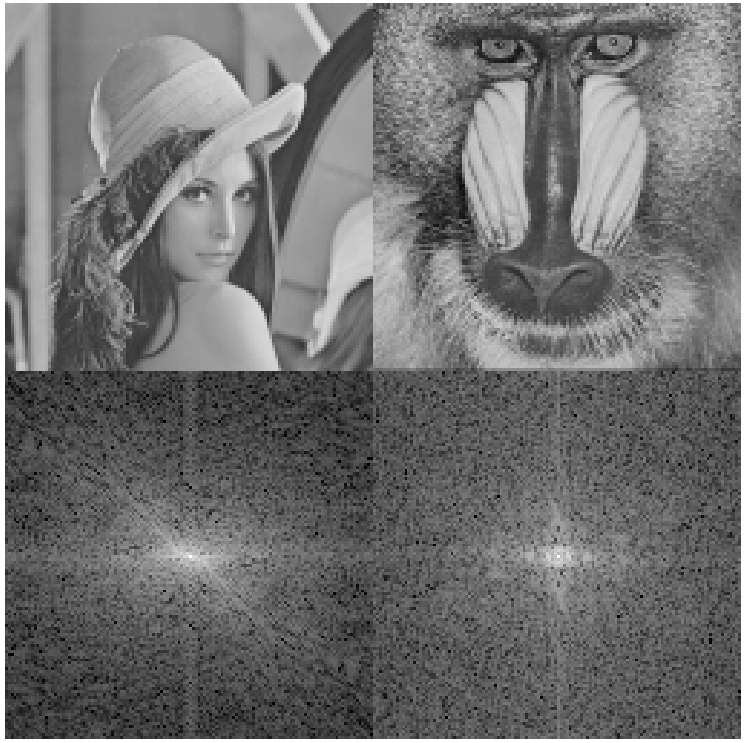
- DFTs quite different
  - Specially at low frequencies
- Bright lines perpendicular to edges
- Circular segments have circular shapes in DFT

More examples: Collections



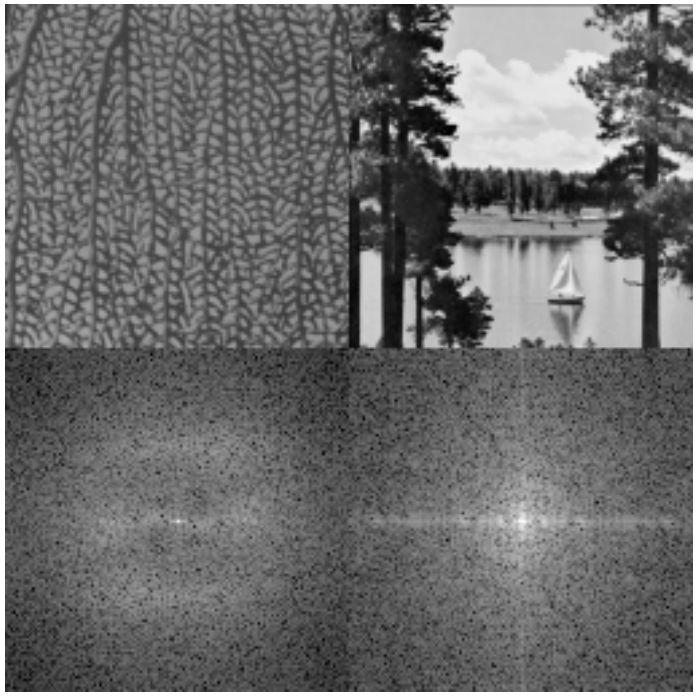
- Concentric circle
  - Due to pallets symmetric shape
  - DFT of one pallet
    - Similar
- Coffee beans have no symmetry
  - Why the halo?
  - Illumination

More examples: Natural Images



- Natural Images
- Why the diagonal line in Lena?
  - Strongest edge between hair and hat
- Why higher energy in higher frequencies in Mandril?
  - Hairs

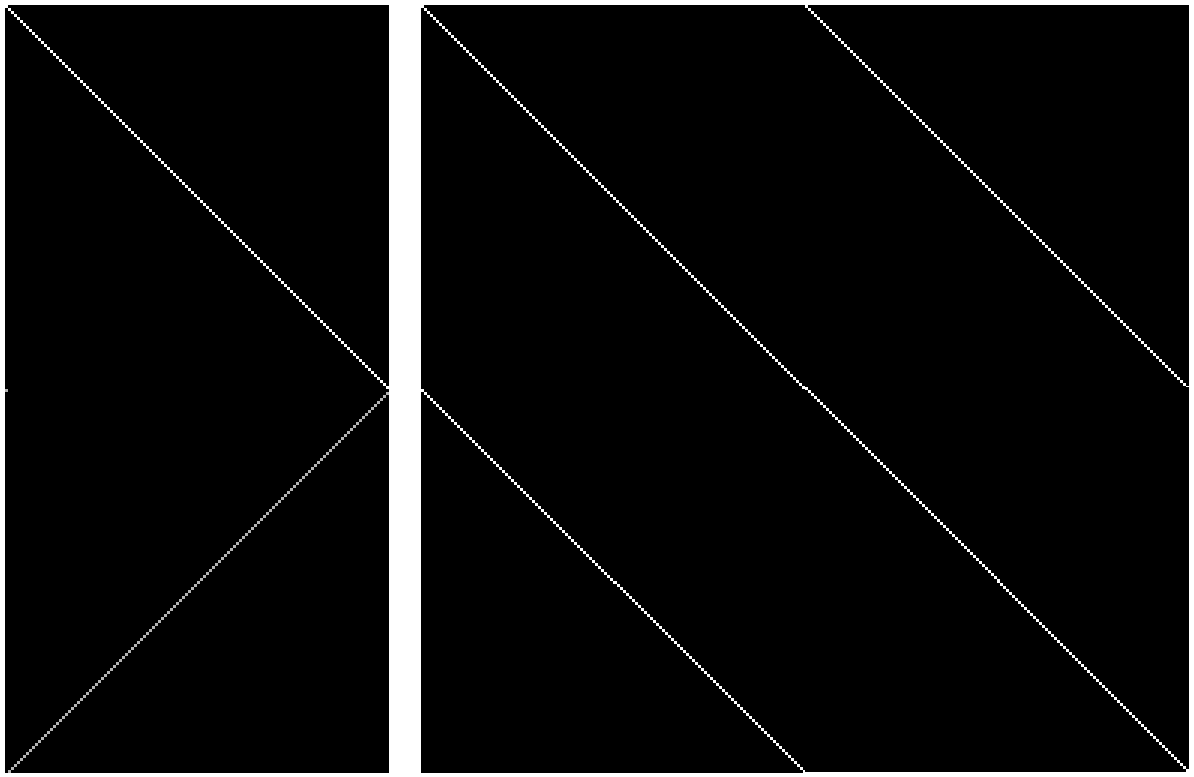
More examples: Natural Images



- Why high energy half way out towards maximum?
  - 2 pixels wide holes
  - Frequency half way to maximum
- Why horizontal energy concentration?
  - Tree Trunks
- Why a little lower vertical energy concentration?
  - Boundary between lake and land

More examples

Spatial

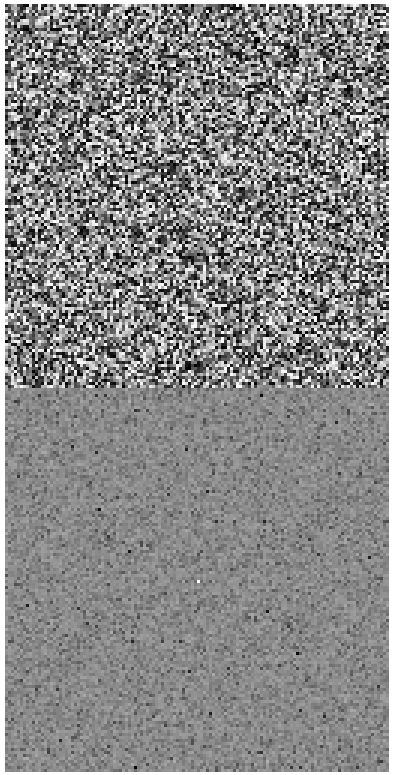


Frequency

- Repeatation makes perfect periodic signal
- Therefore perfect result perpendicular to it

More examples

Spatial



Frequency

- Just a gray telling all frequencies
- Why the bright white spot in the center?