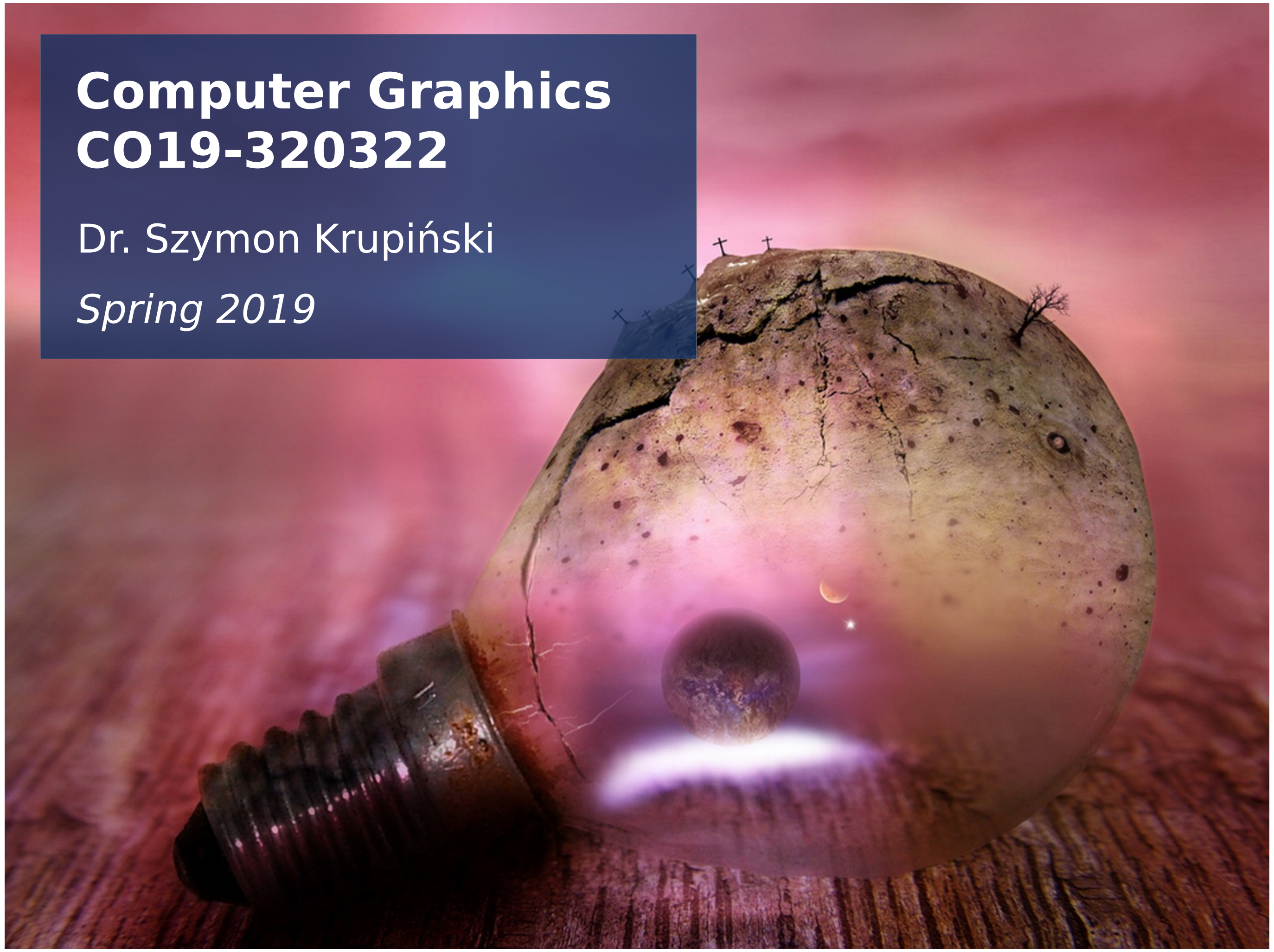
Lecture 8: Rasterisation 2



Computer Graphics
CO19-320322

Dr. Szymon Krupiński

Spring 2019

Last class: programming!

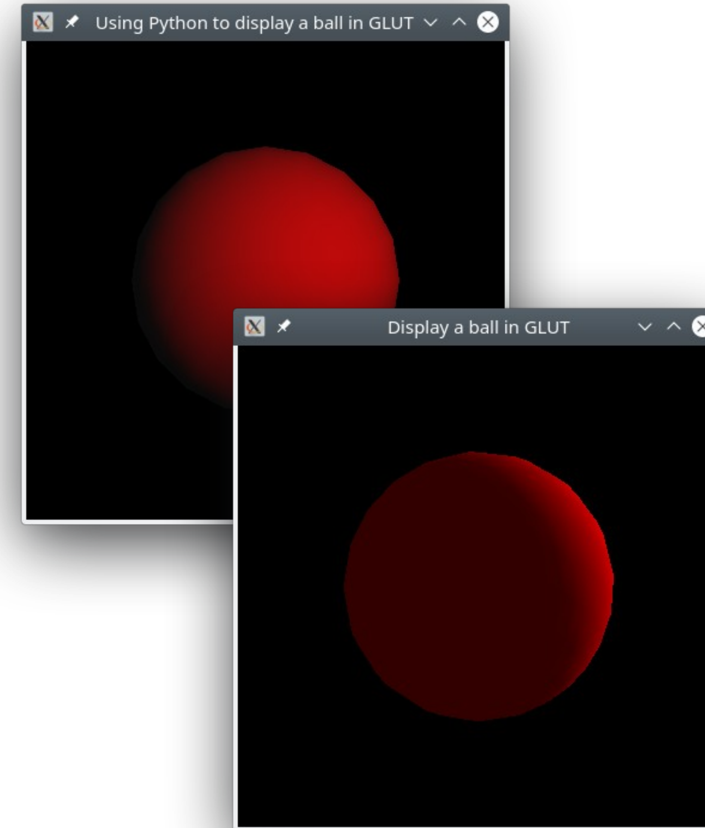
- You have a decent set of basic skills by now
- With the sample programs, you are given a set of recipes

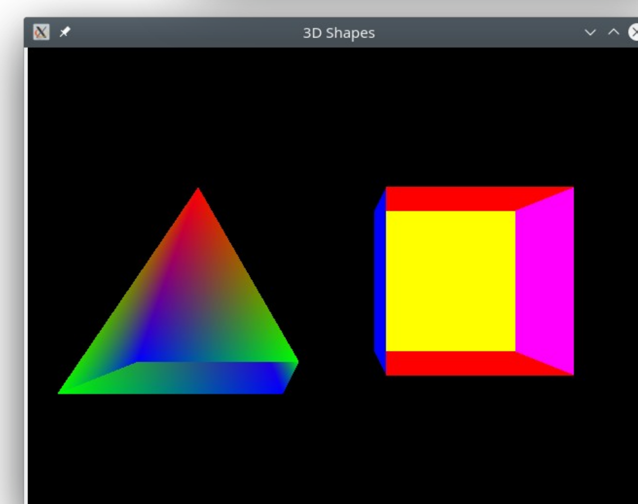
(moodle + http://cs.lmu.edu/~ray/notes/openglexamples/)

- Test them!

  = test your coding environment setup

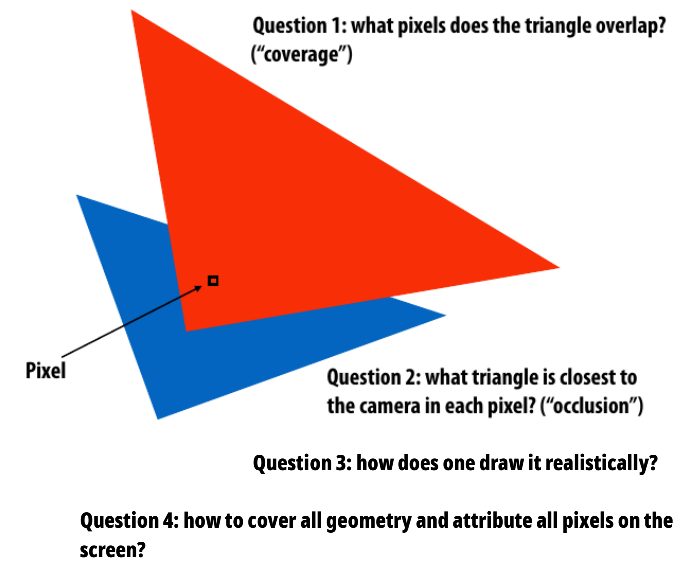
  = test your understanding
- Modify them, play around – it's very important!

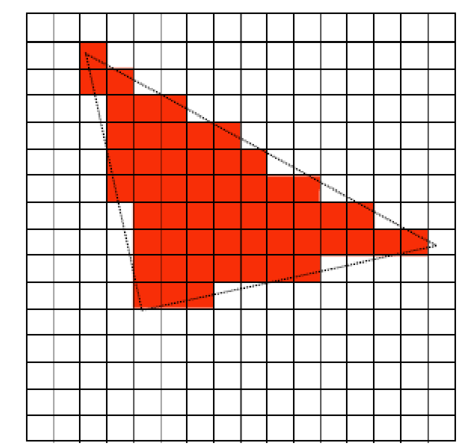


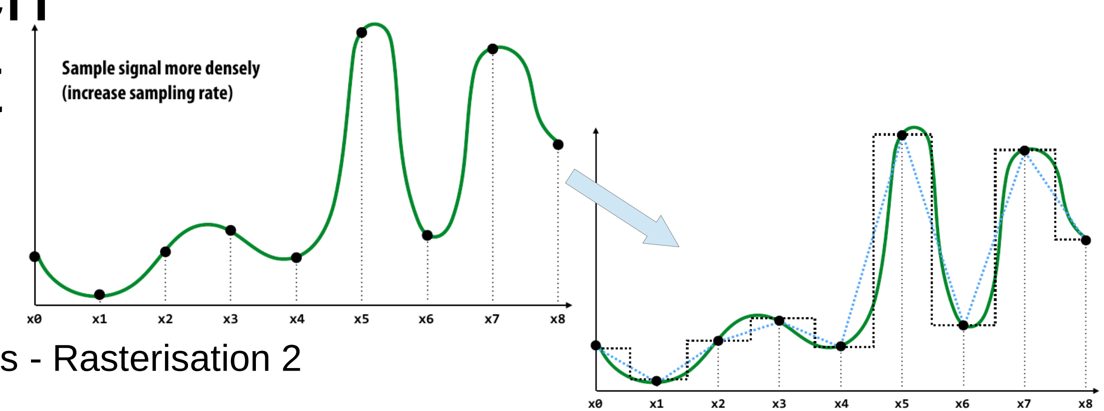


From the last time: rasterisation

- A big part of the CG work is deciding how to colour triangles on the screen
  - ...or pixels, but since so many elements of geometry come as triangles, they are projected on the screen as triangles, too
- 4 “big questions” of how to fill in the image with projected geometry
- We need to sample to decide which geometry each pixel should reflect
- Sampling theory comes in handy!



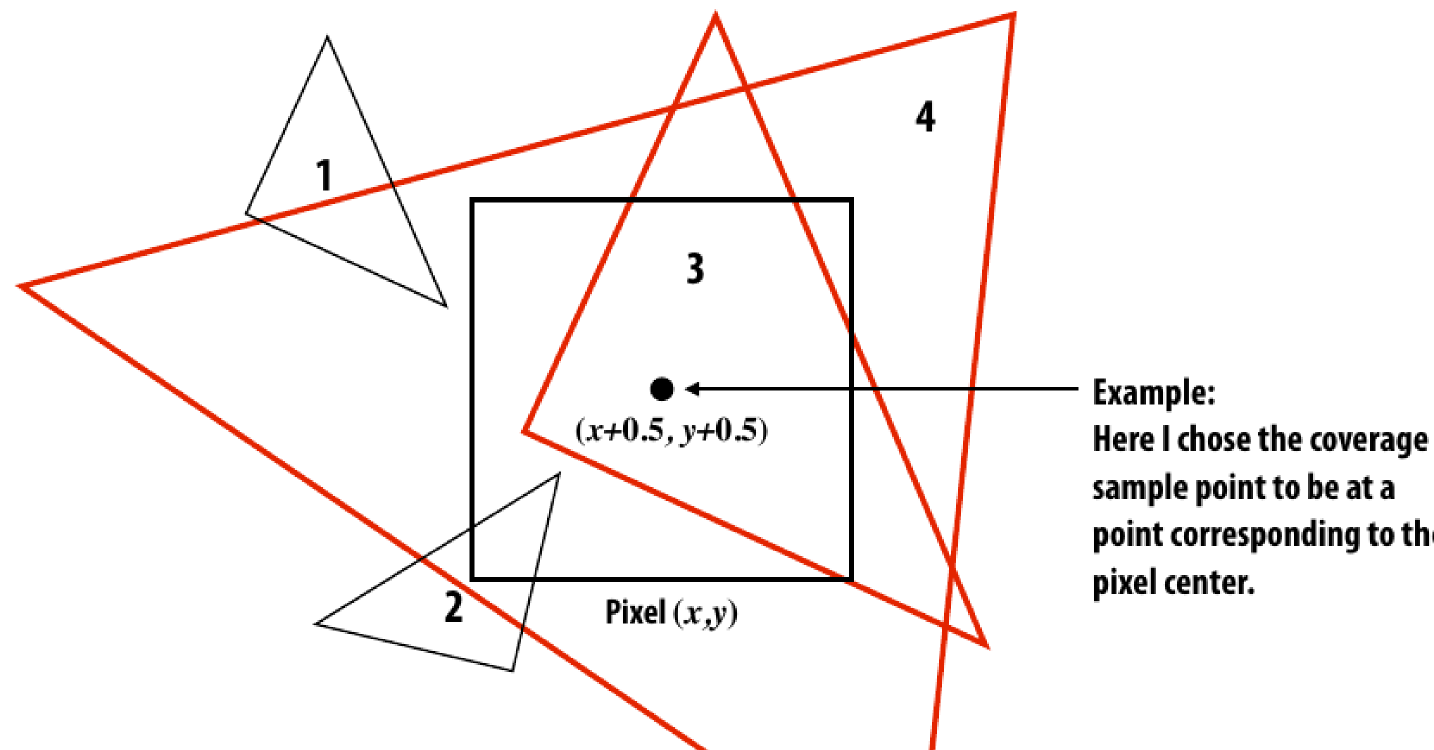




Systematic approach

- Coverage in simple approach:

$$\texttt{coverage(x,y)} = \begin{cases} \texttt{1} & \texttt{if the triangle contains point (x,y)} \\ \texttt{0} & \texttt{otherwise} \end{cases}$$

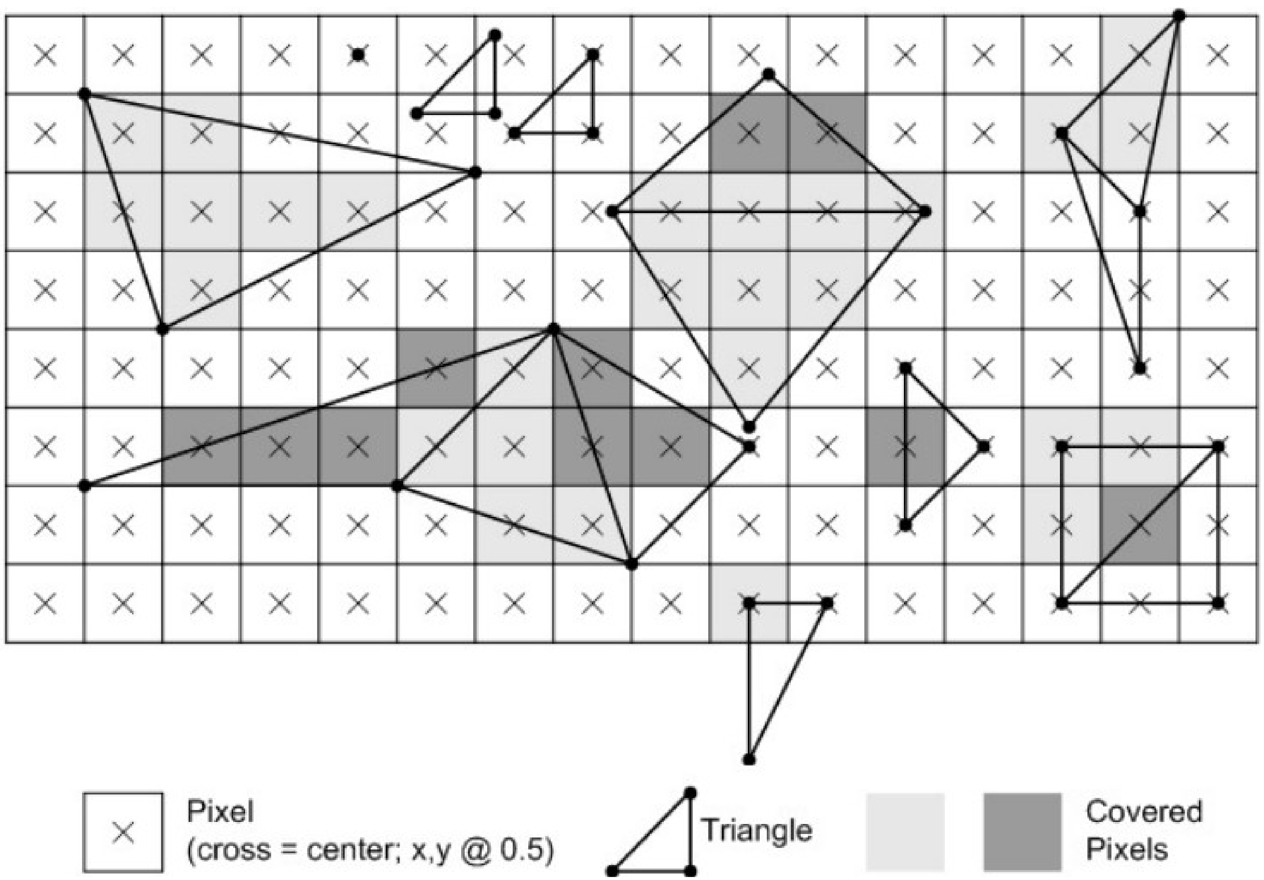


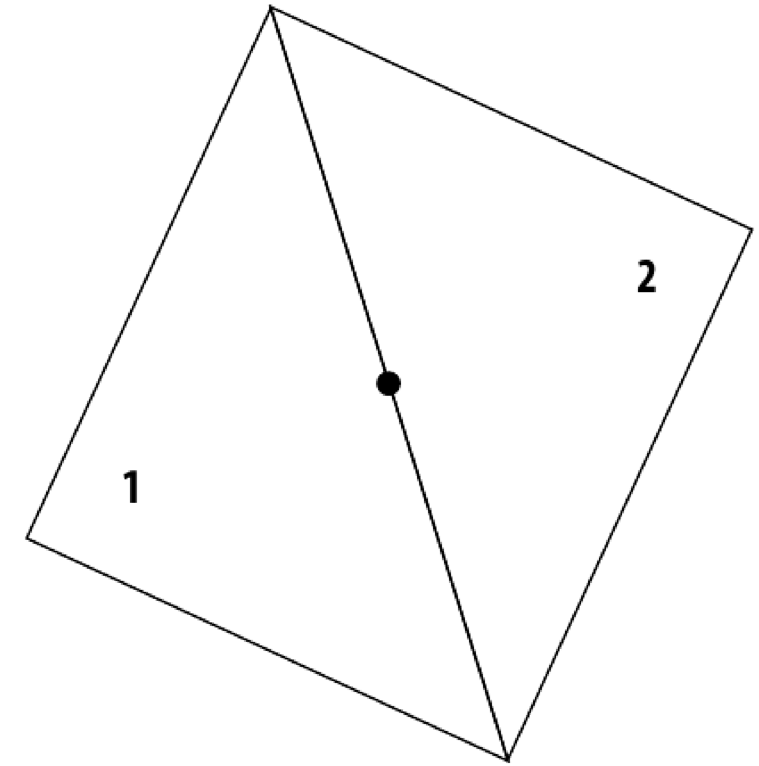
= triangle covers sample, fragment generated for pixel

= triangle does not cover sample, no fragment generated

Systematic approach

- What if the sampling point falls exactly on the edge?
  - We can have rules for that!



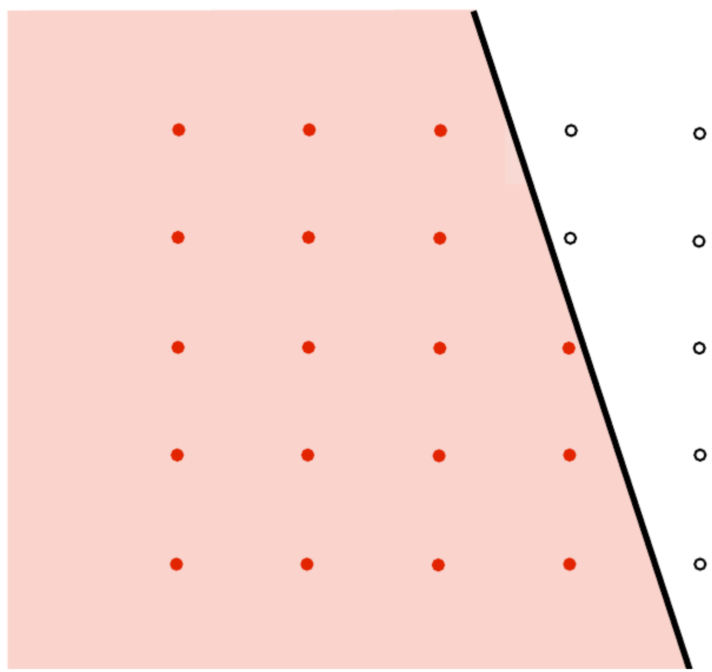


OpenGL (and Microsoft's Direct3D) rendering software rules: coverage = 1for a given triangle if

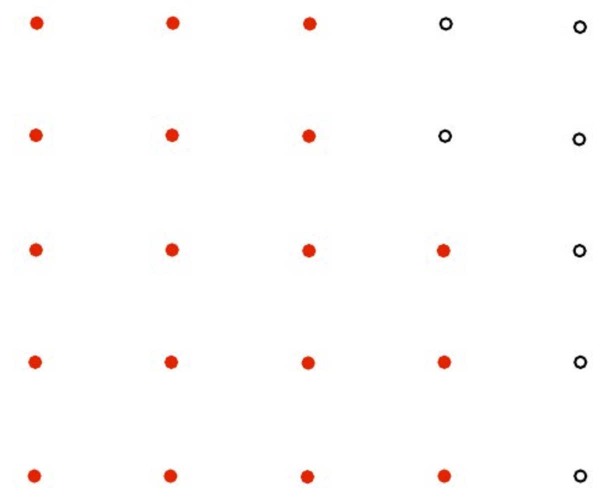
- Top edge: horizontal edge above all other edges
- Left edge: an edge that is not exactly horizontal and is on the left side of the triangle. (triangle can have one or two left edges)

Systematic approach

- Results? If we show the pixel centres as sampling points:

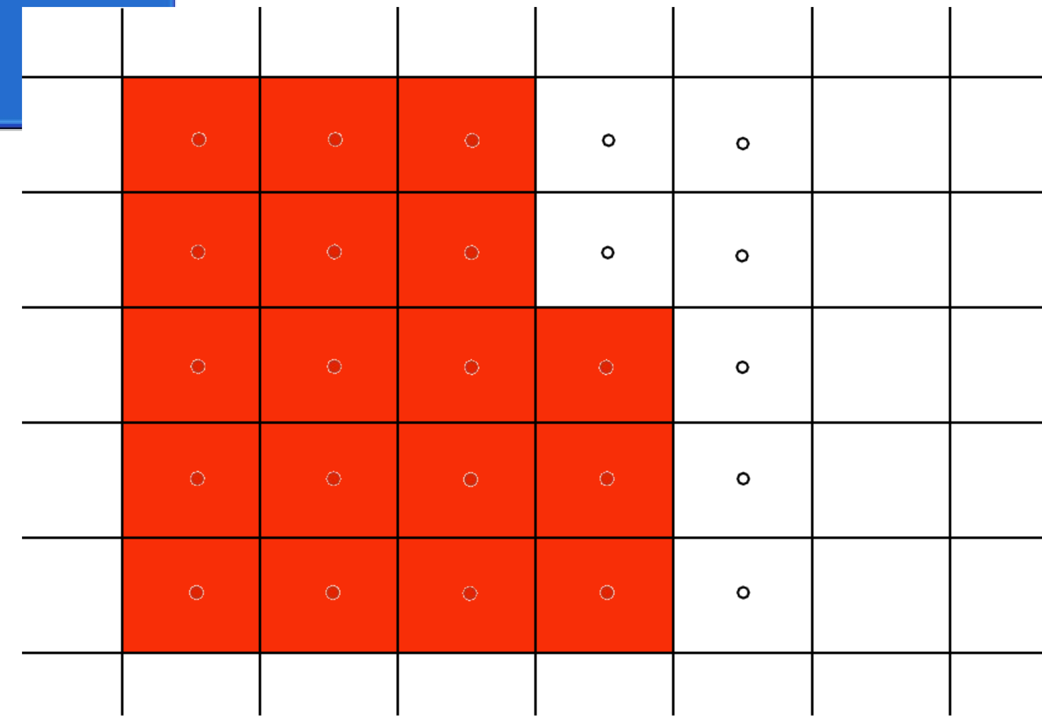


- We obtained the signal:

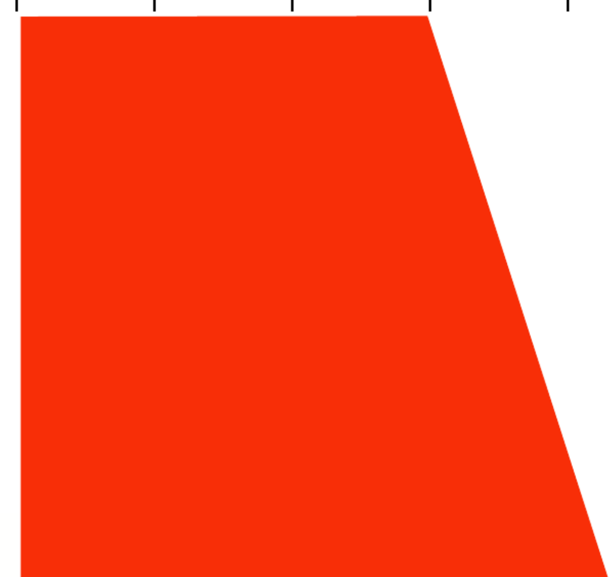


Systematic approach

- Hence, we will display:
  - ouch, this is definitely a “jaggie”



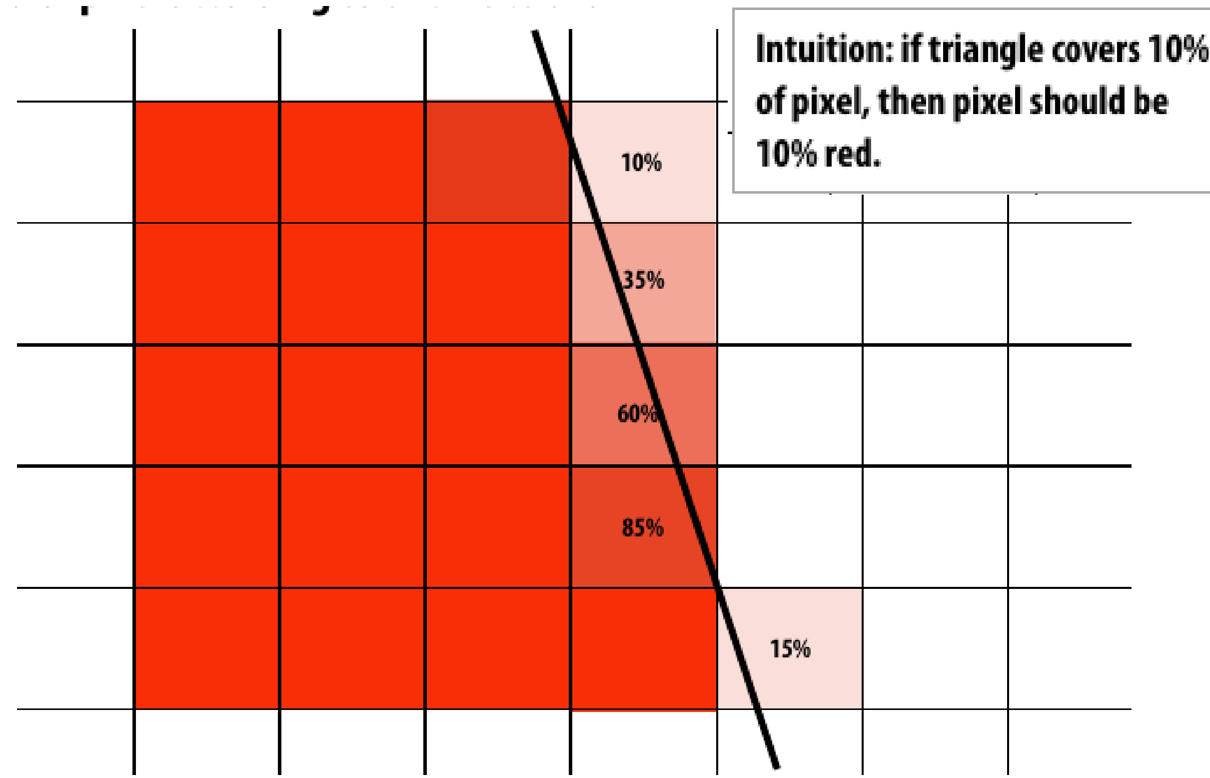
- The original image was:



...where did we go wrong..?

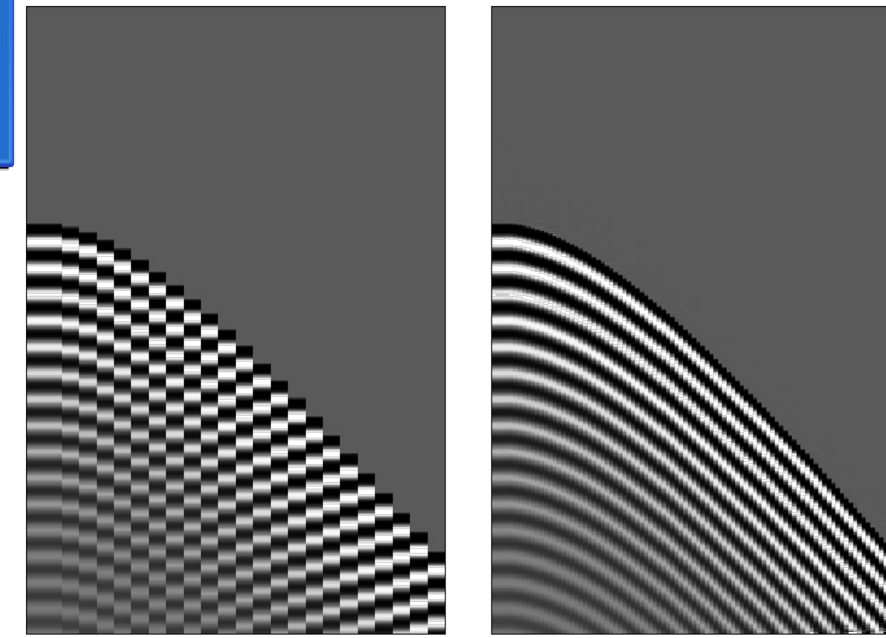
Systematic approach

- Reminder: we have worked out an idea which was looking better but decided that we didn't know
  - how to implement it efficiently
  - How to take into consideration many factors



Lesson from sampling

- We have spoken about sampling and reconstruction
  - bad reconstructions lead to aliasing!
  - We cannot always take more samples (= supersample)
- Nyquist frequency: using sampling frequency f_S the highest frequency we can reconstruct is $0.5 f_S$
- Frequency in the image..?



Input Output

Image sampling

- Fourier analysis

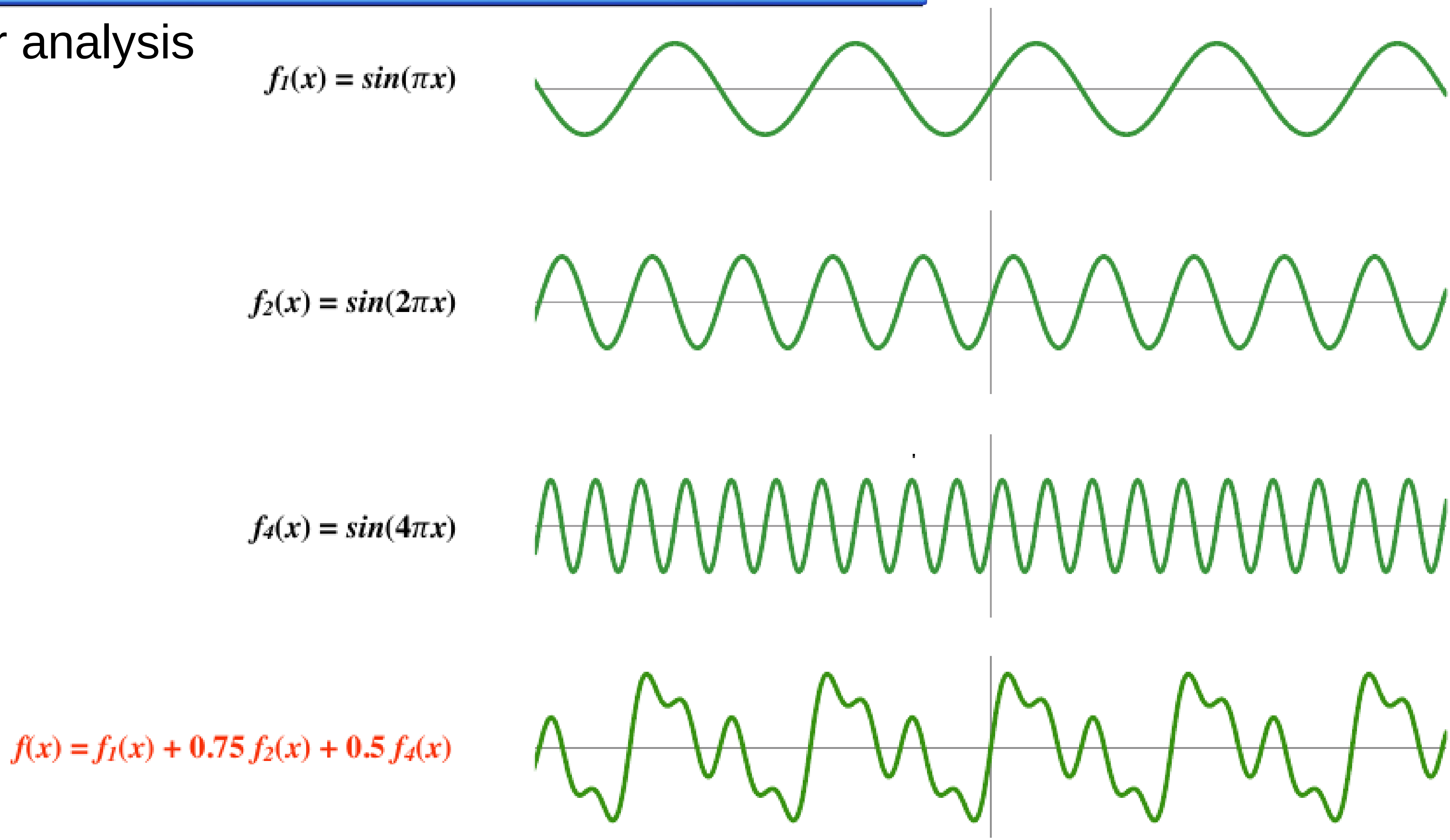
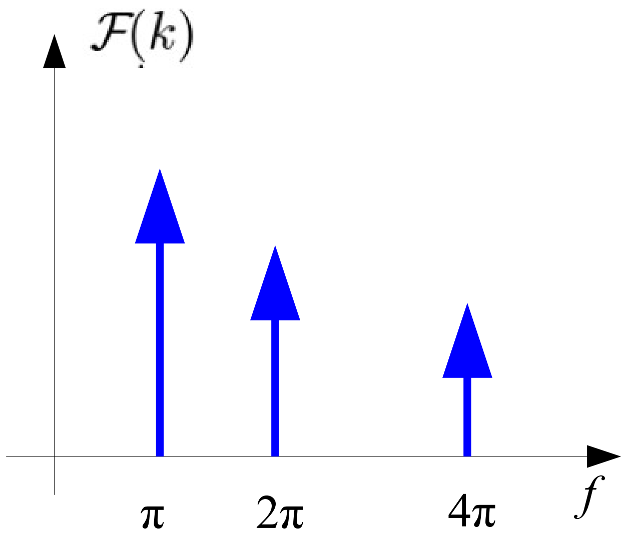
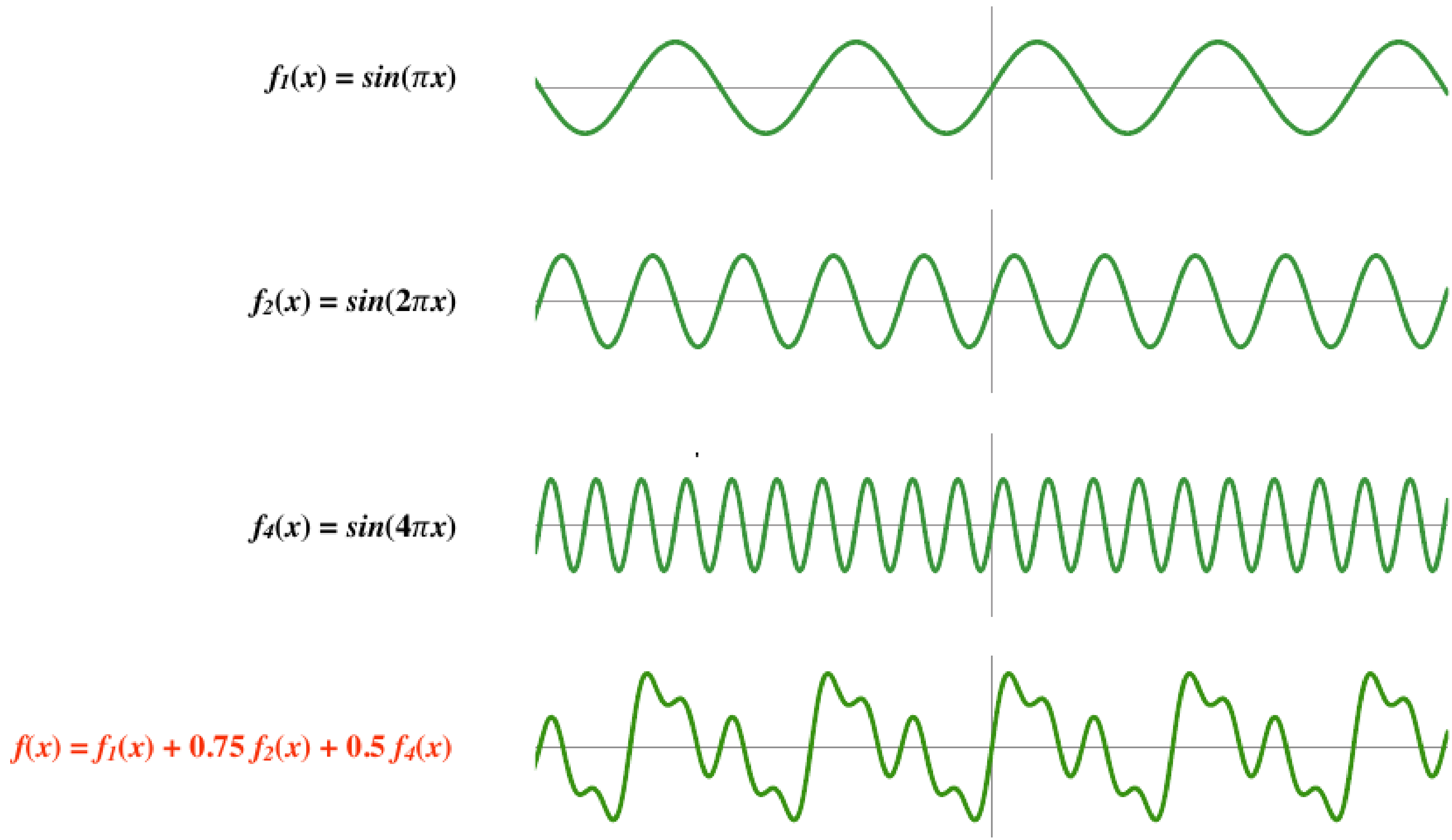


Image sampling

- Fourier analysis

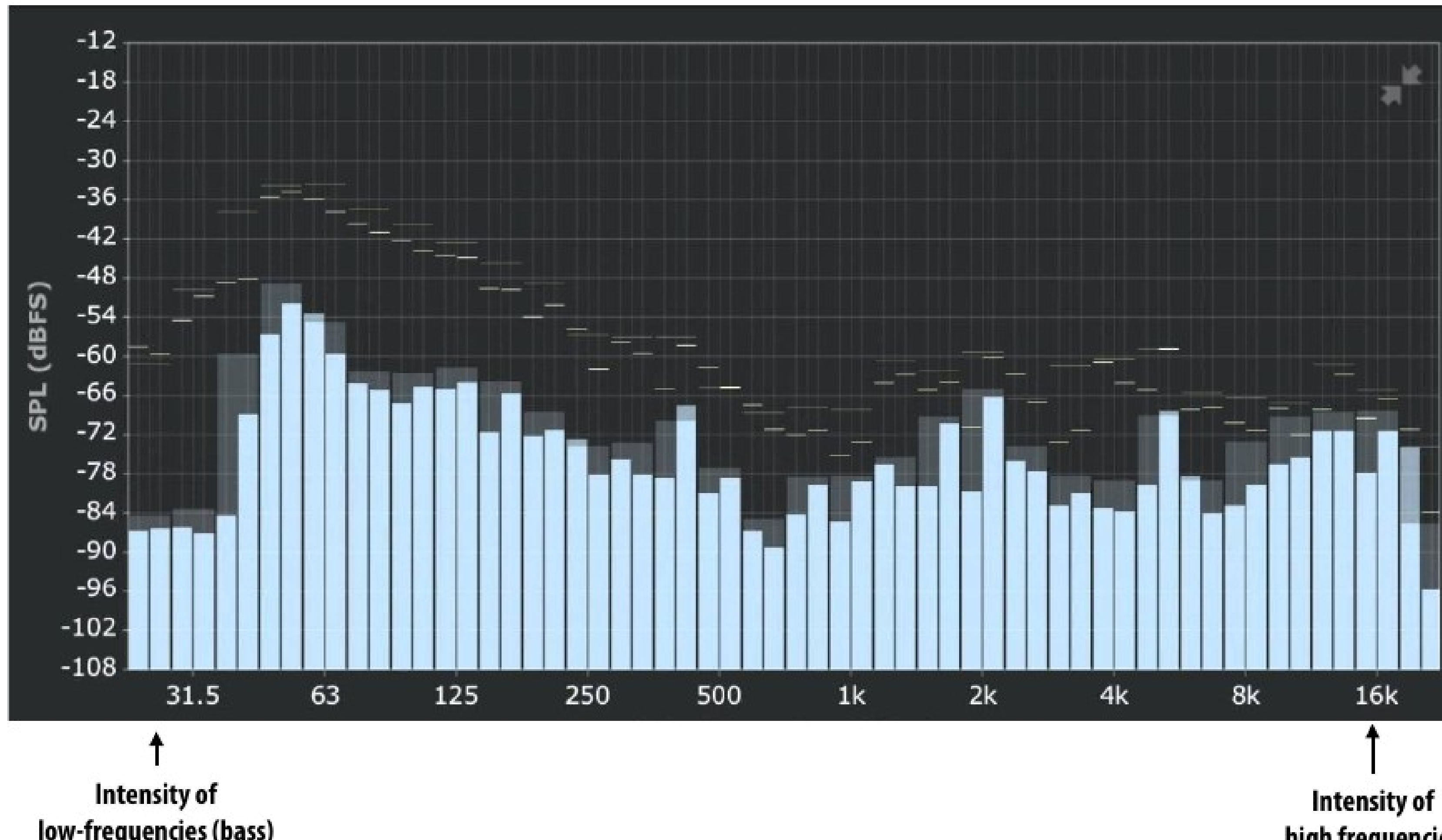


- Splitting a function into frequency components
- Works well even for non ideal signals



Fourier analysis

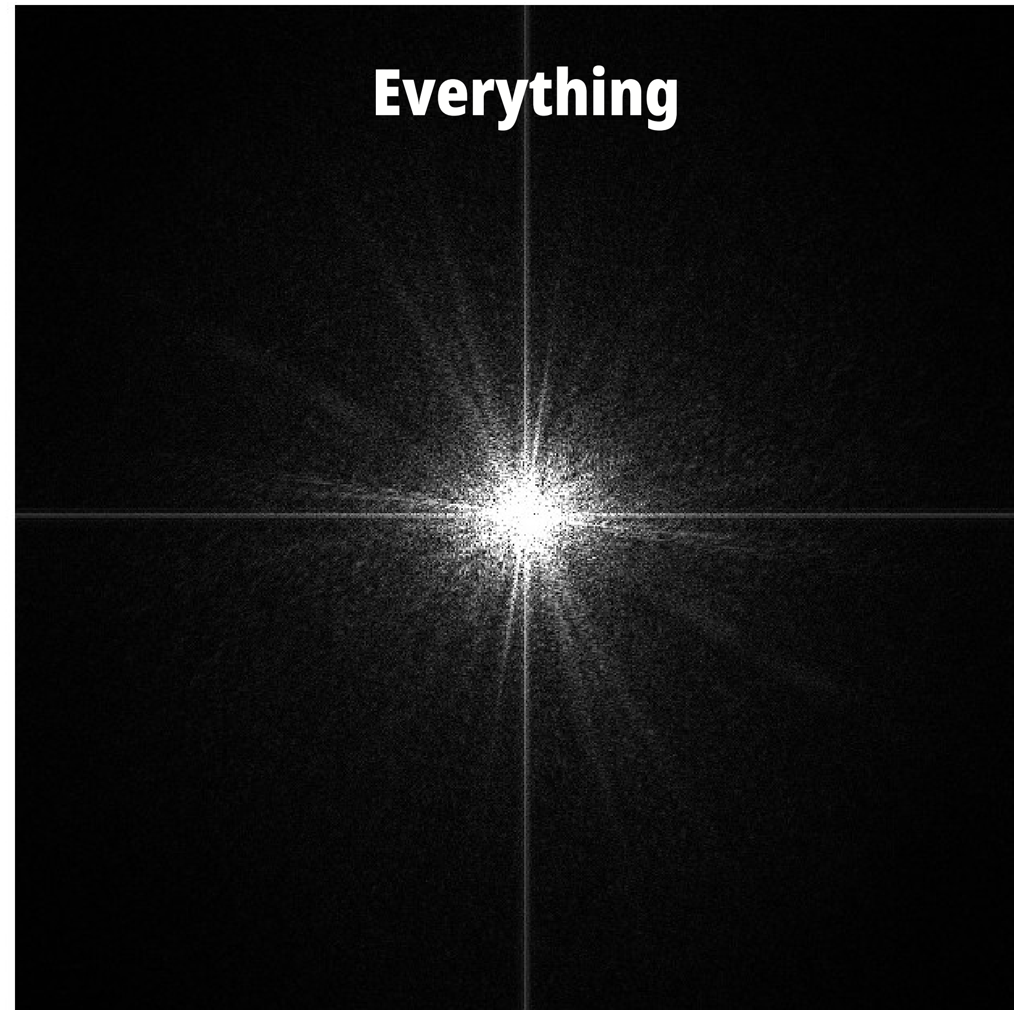
- Example: sound spectrum analyser:



Very fast implementations exists for discrete signals like FDFT (Fast discrete Fourier transform)!

Frequencies in image

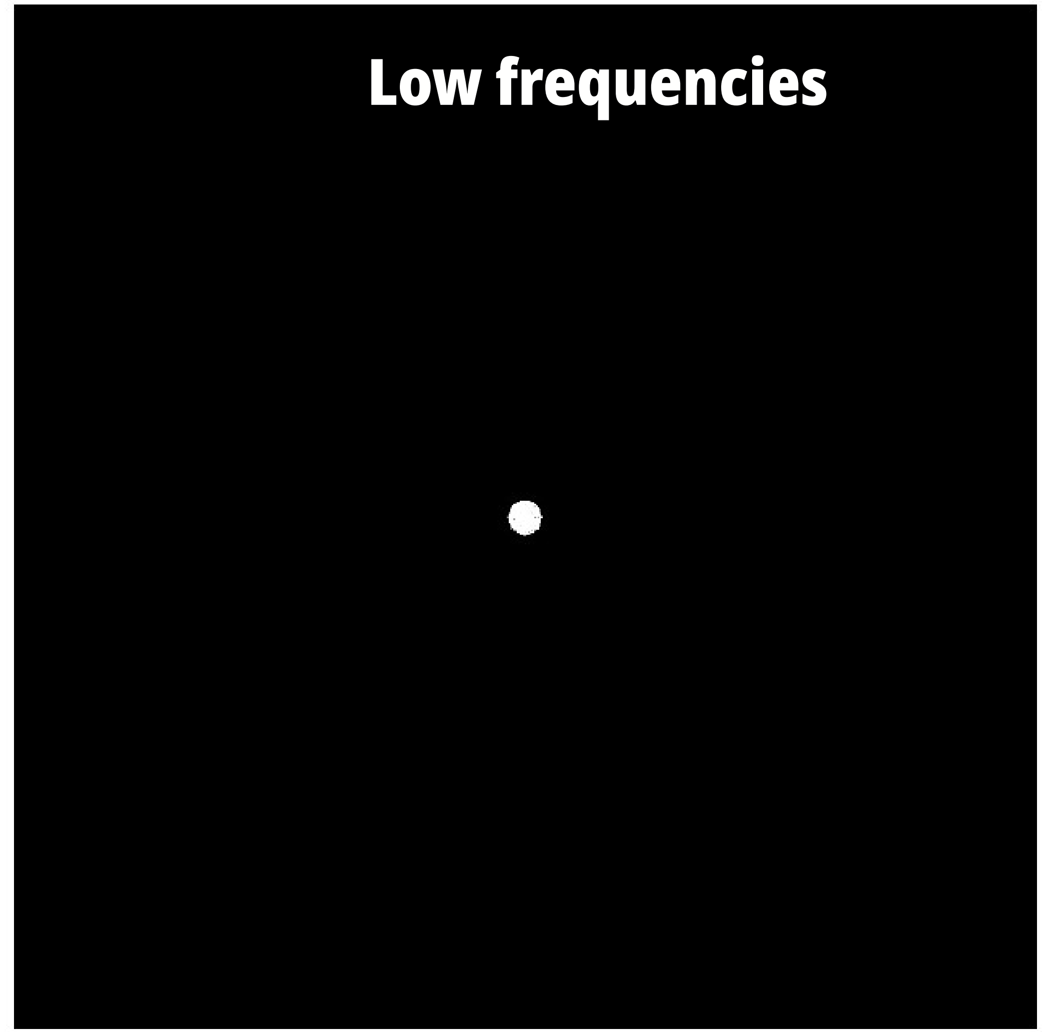
Spatial domain result



Spectrum

Frequencies in image

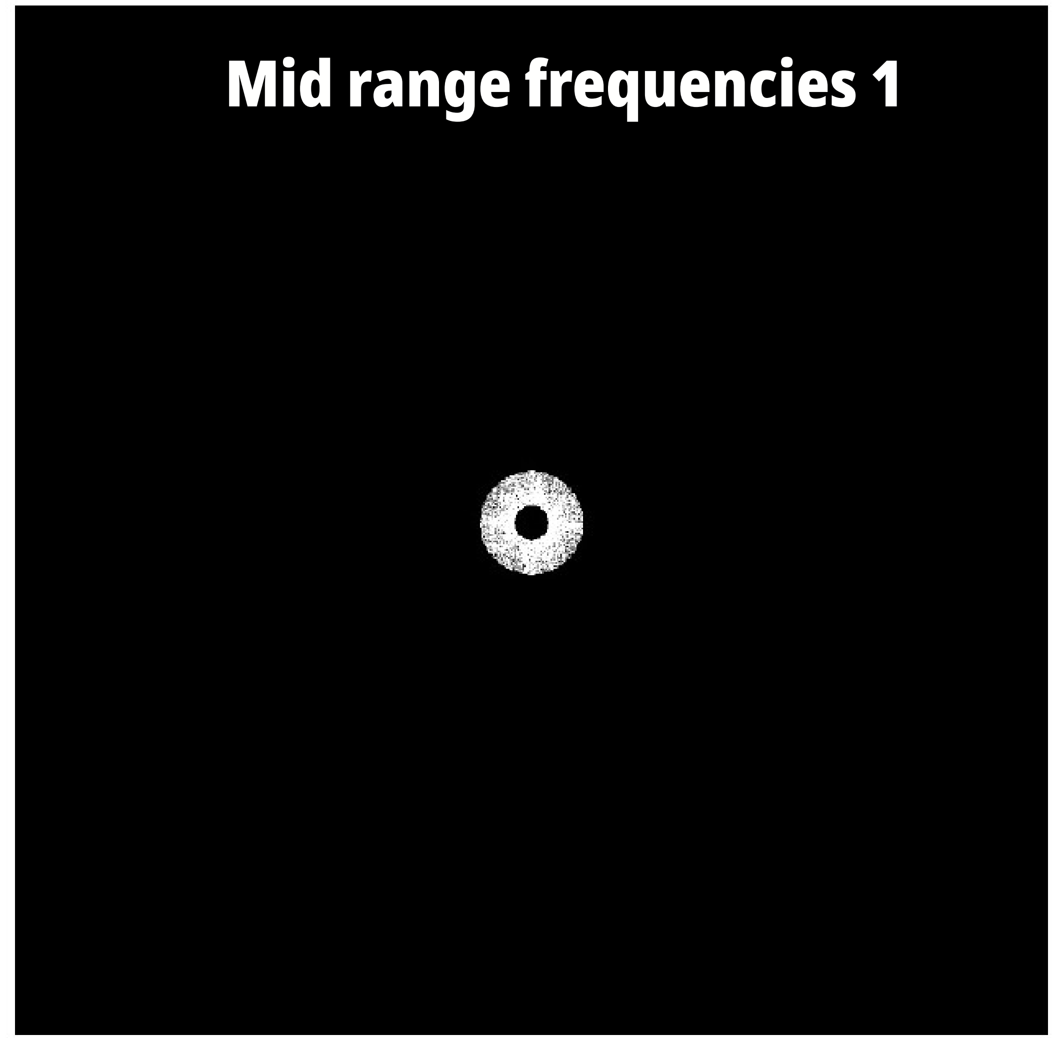
Spatial domain result



Spectrum (after low-pass filter)
All frequencies above cutoff have 0 magnitude

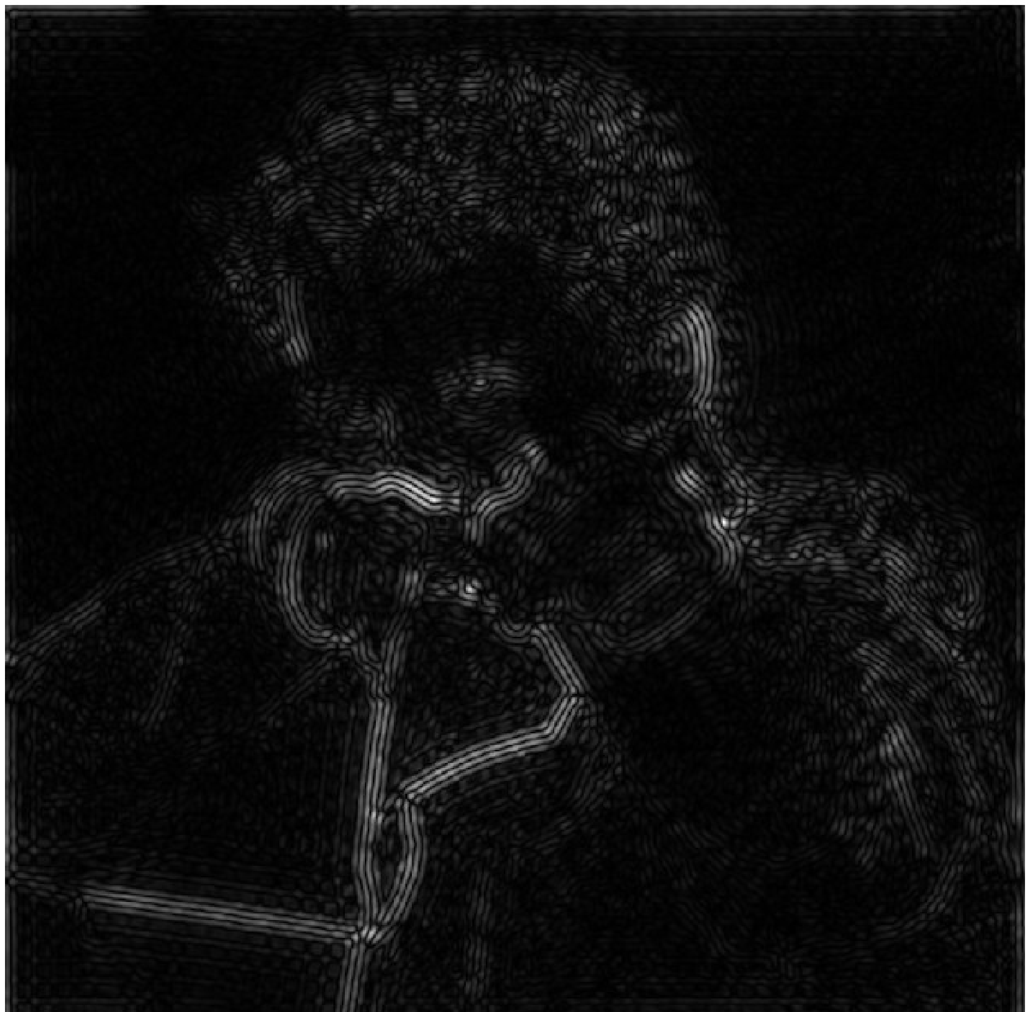
Frequencies in image

Spatial domain result

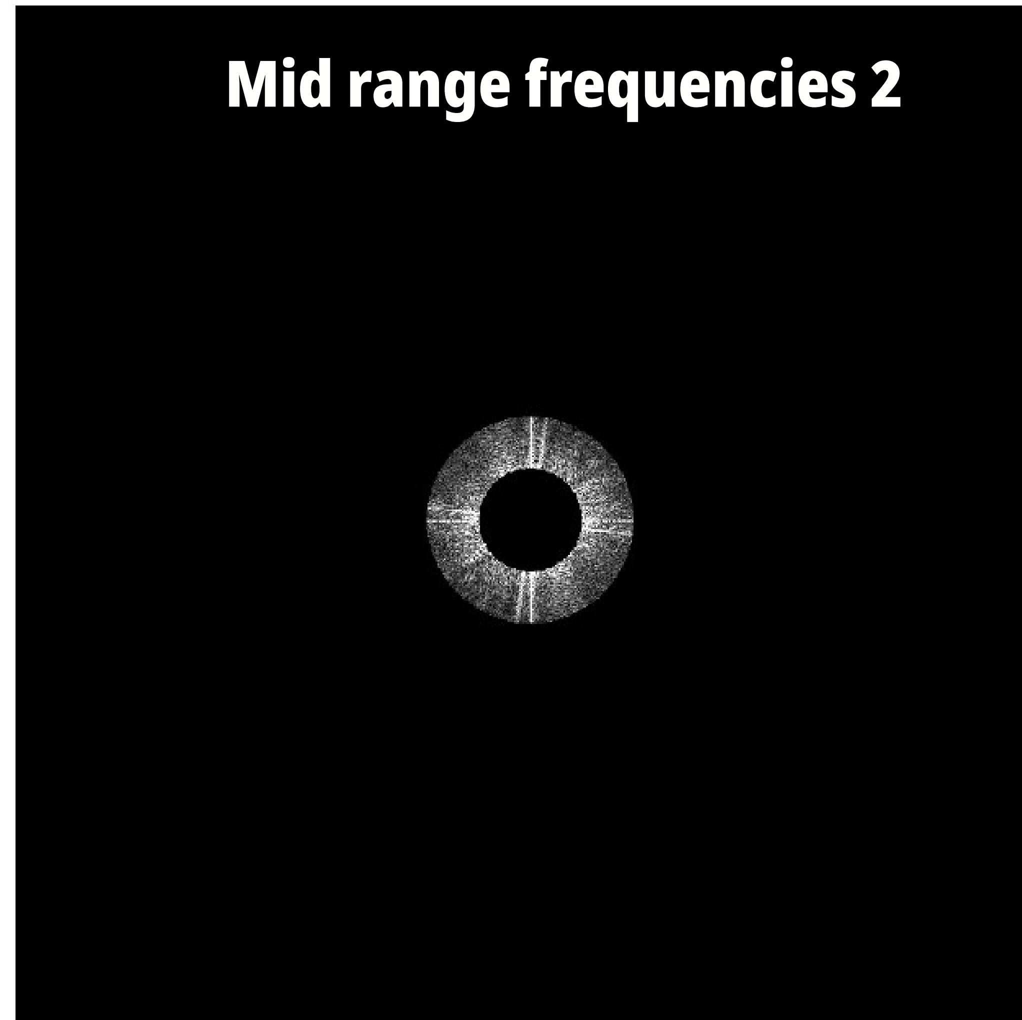


Spectrum (after band-pass filter)

Frequencies in image

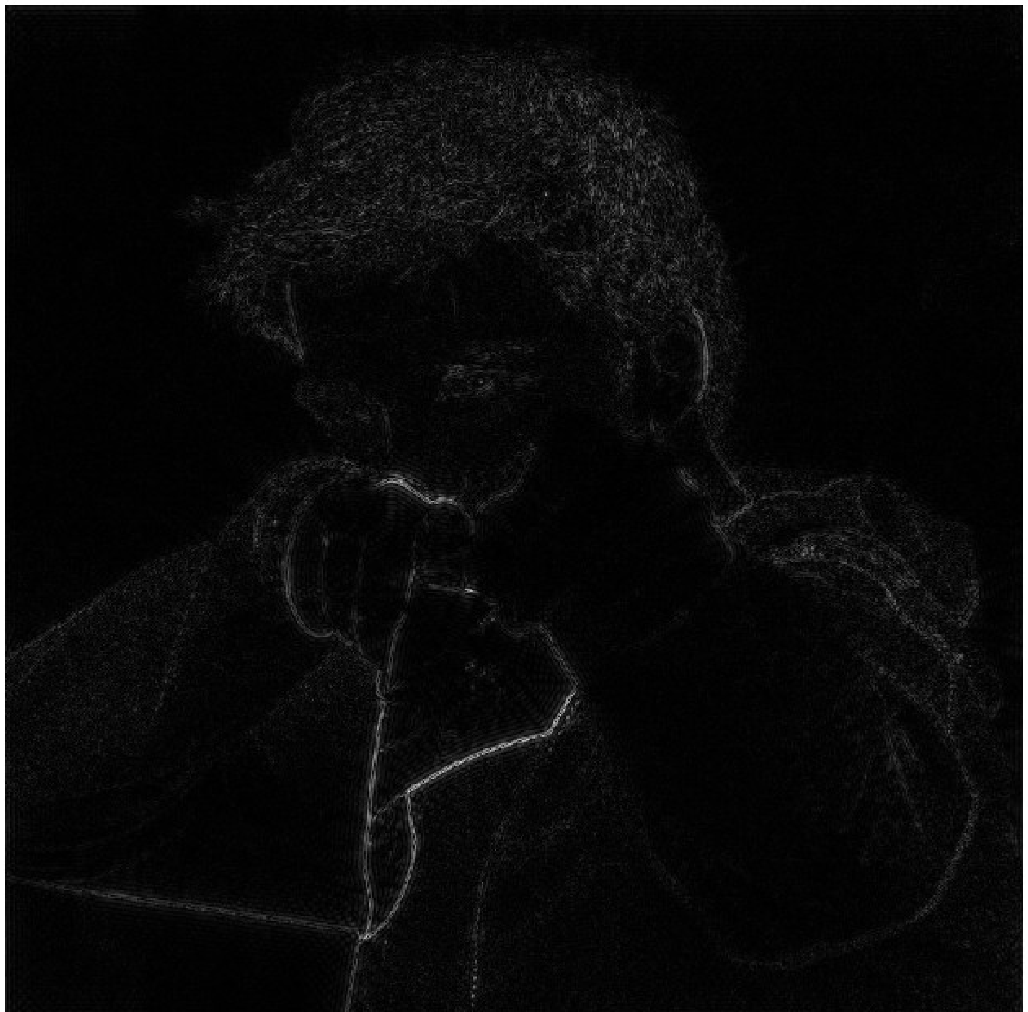


Spatial domain result

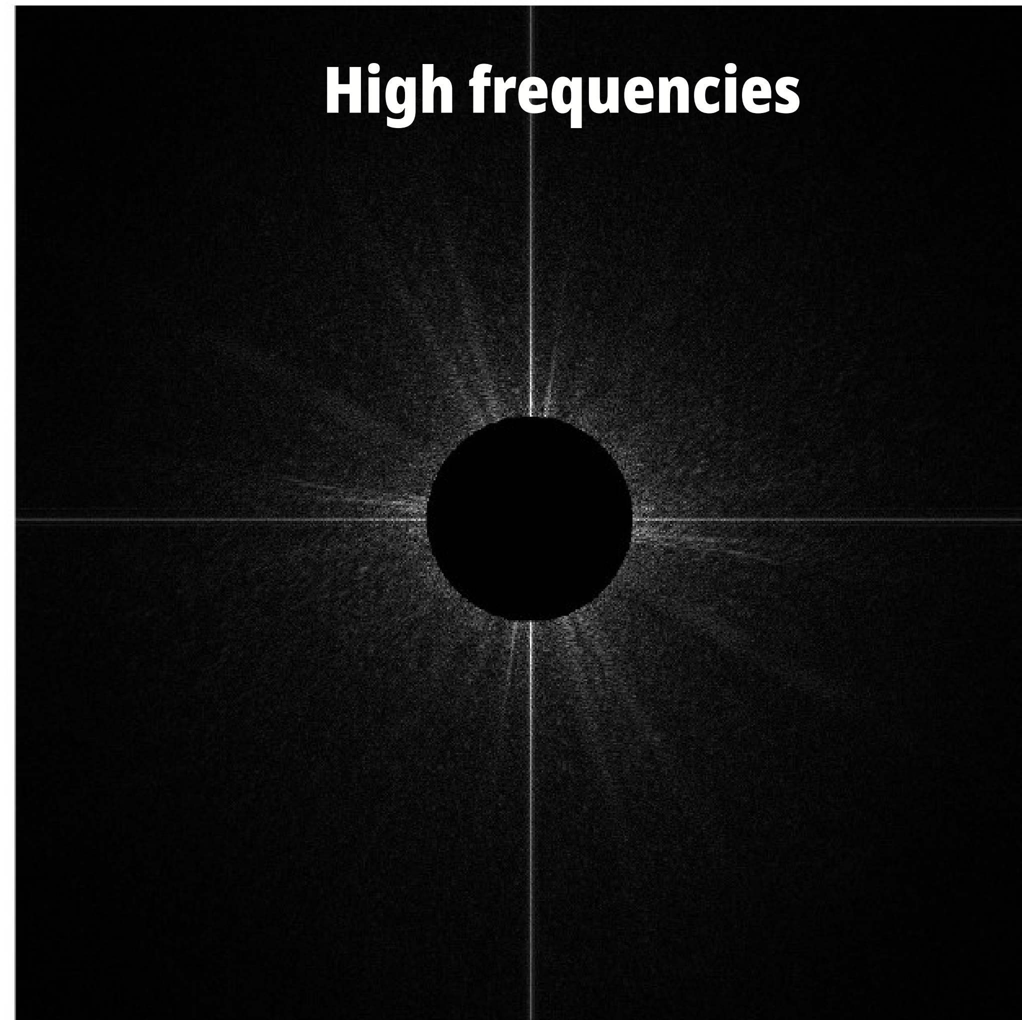


Spectrum (after band-pass filter)

Frequencies in image



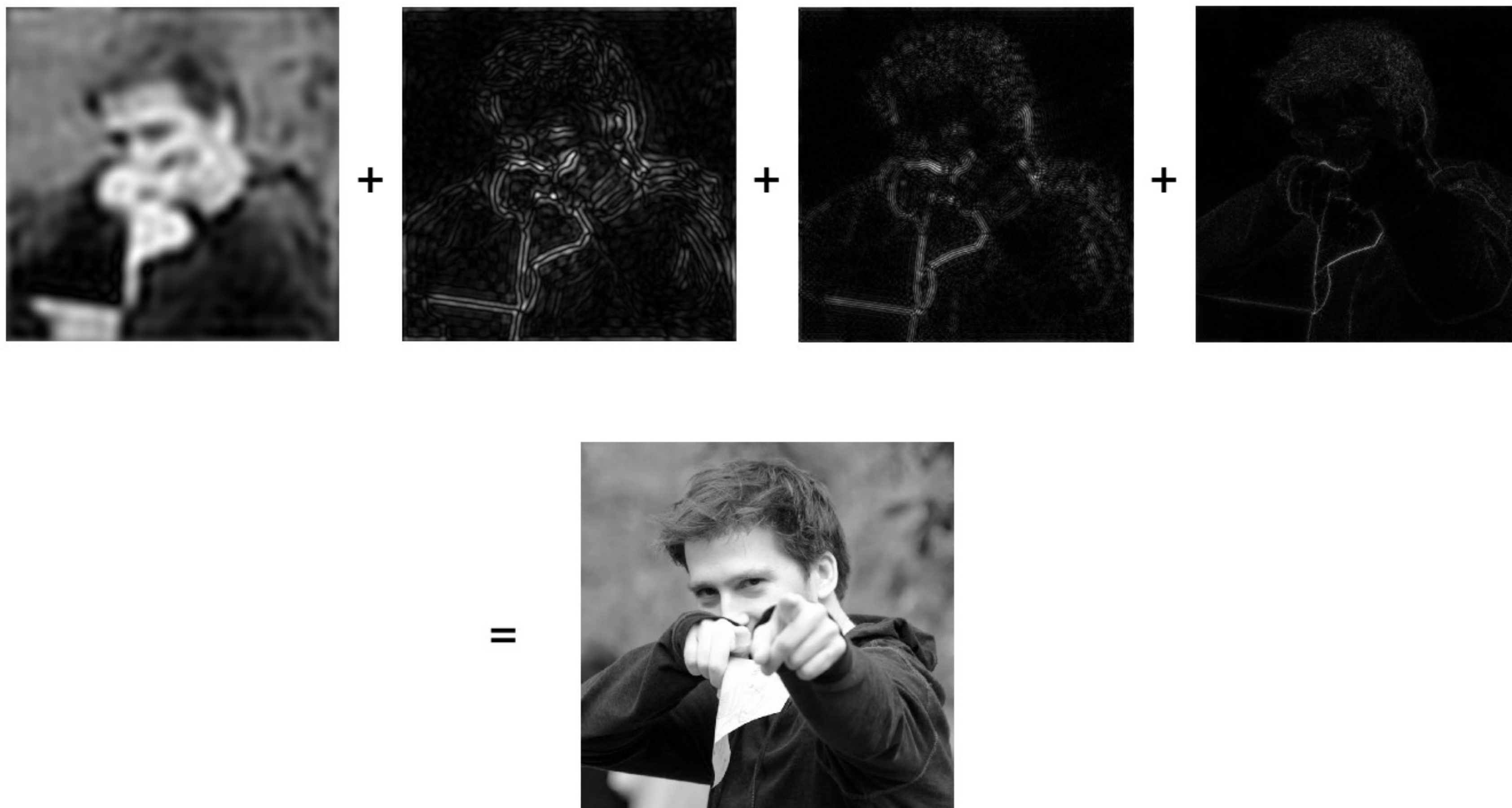
Spatial domain result
(strongest edges)



Spectrum (after high-pass filter)
All frequencies below threshold
have 0 magnitude

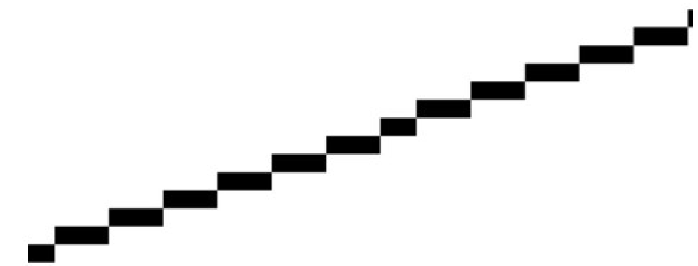
Frequencies in image

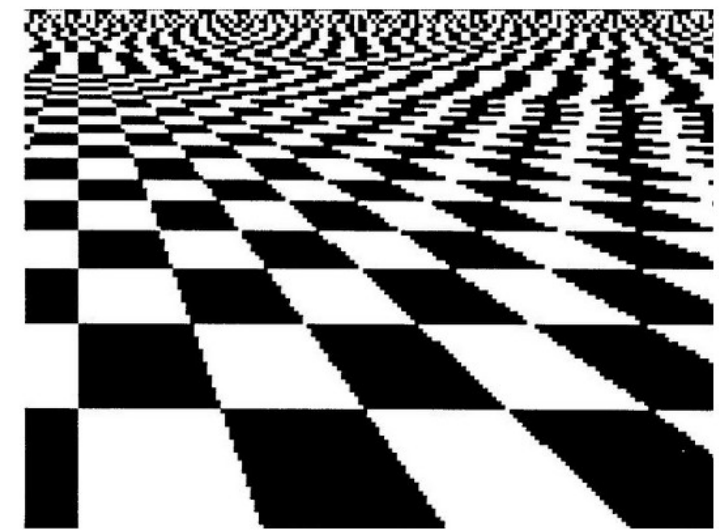
- The sum is the image itself!

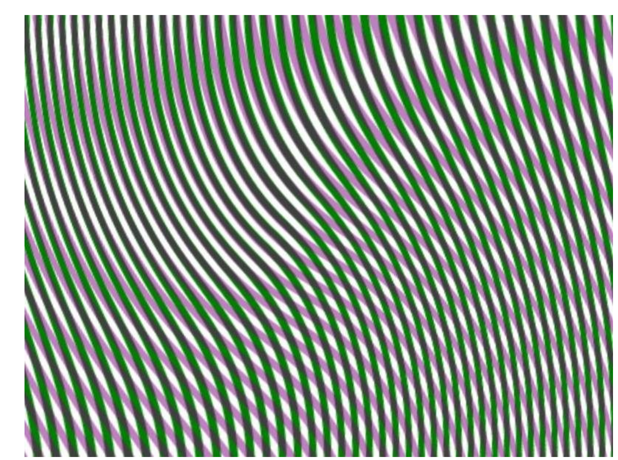


Frequencies in image

- Reconstruction based on undersampled set results in image artifacts
  - “jaggies”
  - “roping” or “shimmering” of images when animated
  - Moiré patterns in textured areas

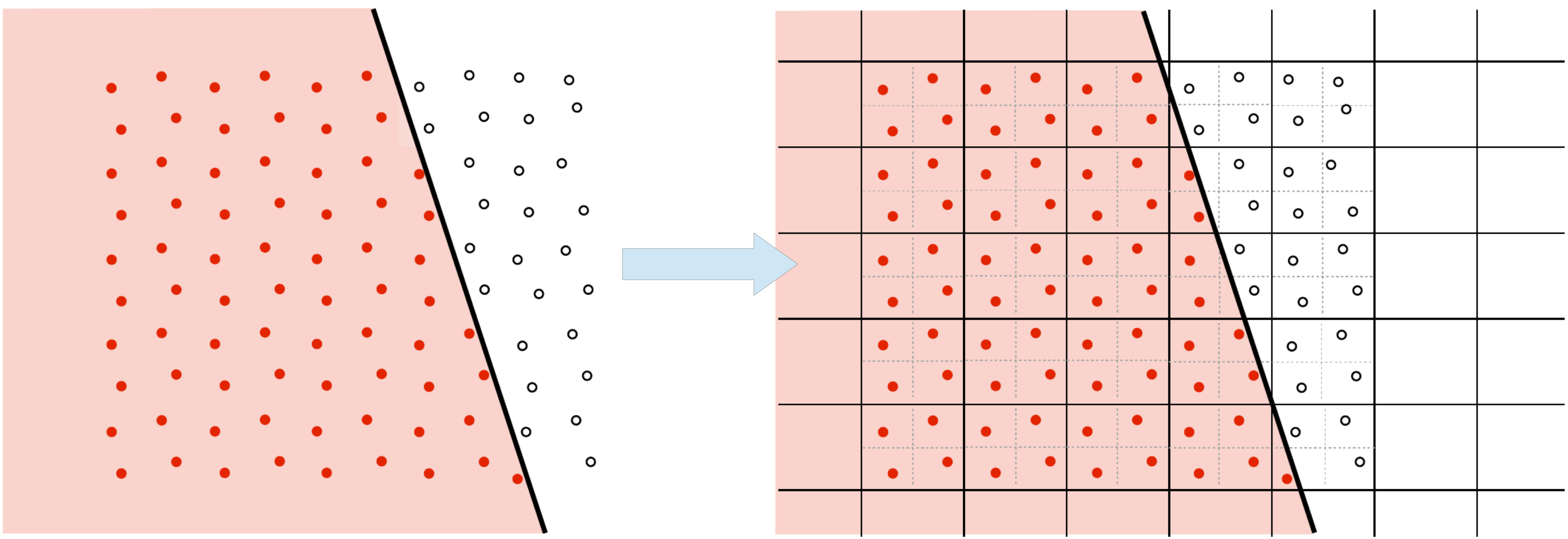






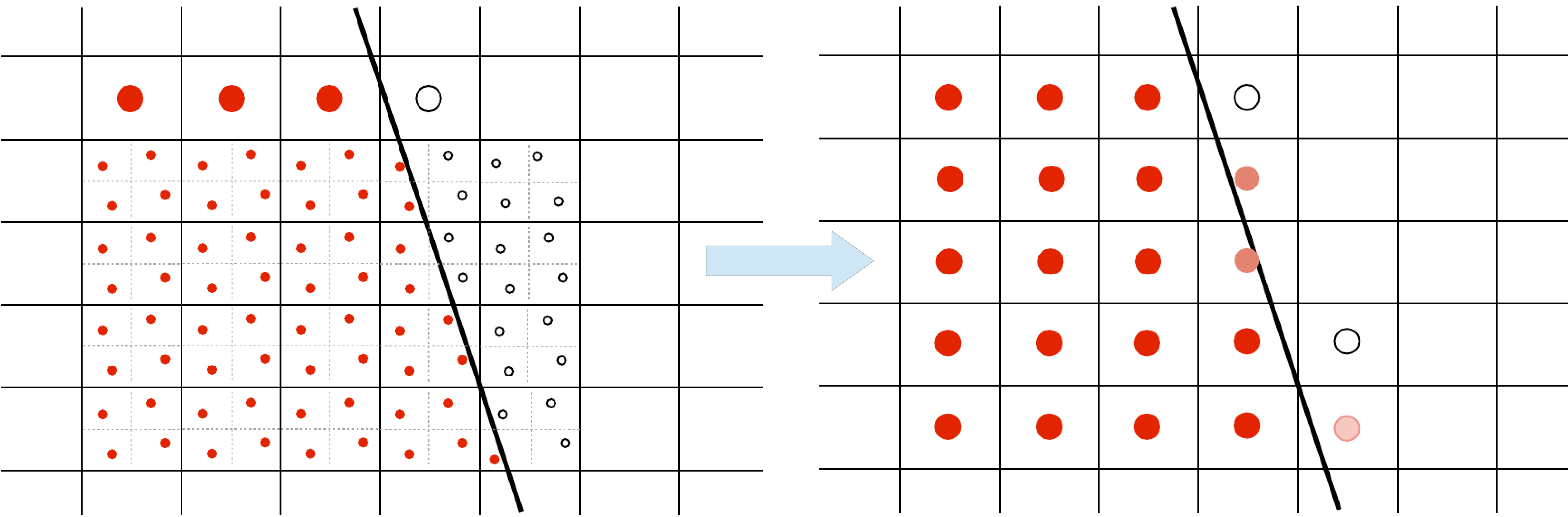
Supersampling

- The supersampling solution:
  - Increase the number of sampling points per pixel



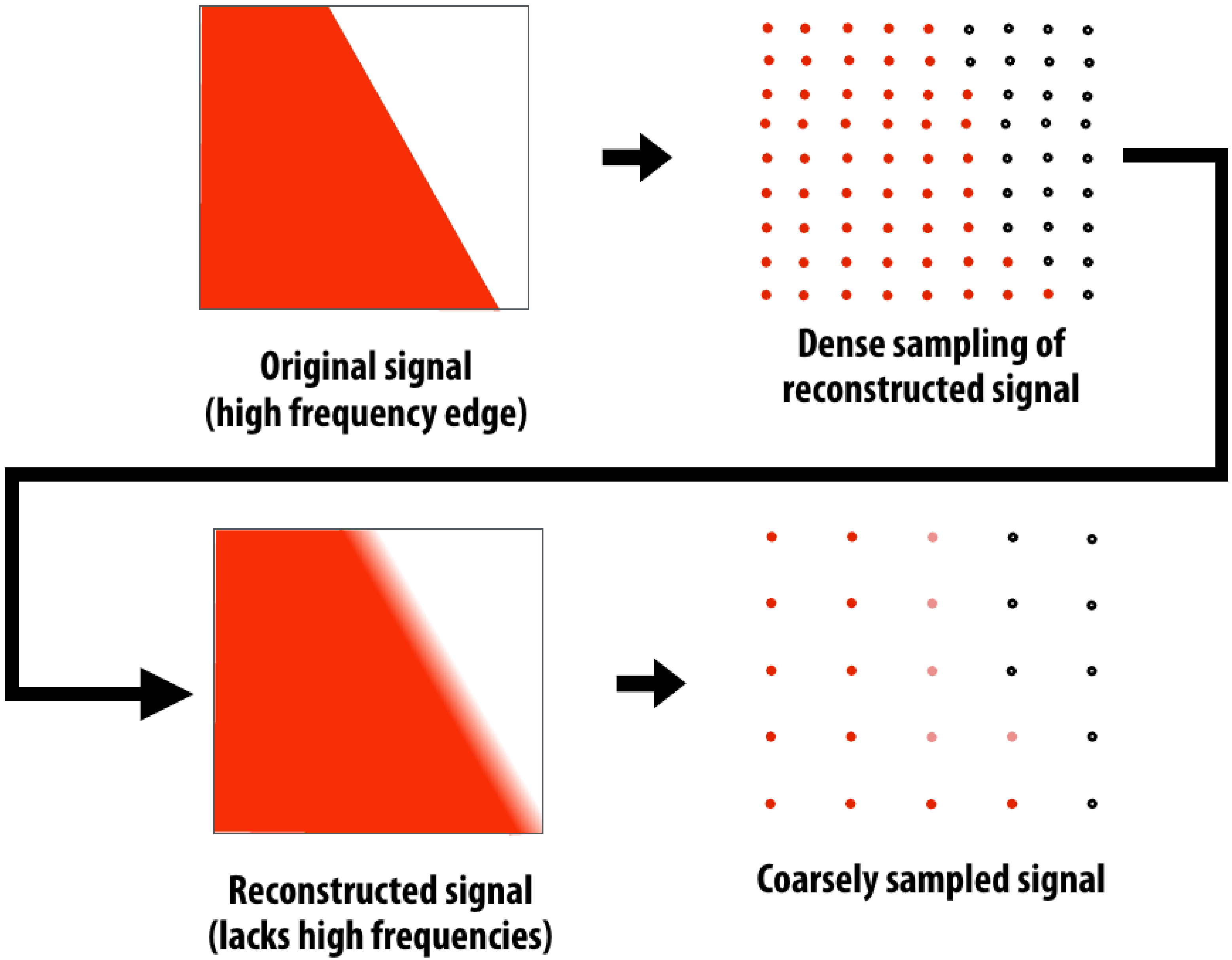
Supersampling

– New sample points can contribute vote to approximate coverage



Supersampling

- Result:



Thank you!

- Questions?