Processamento de Sinais para Biolog*s

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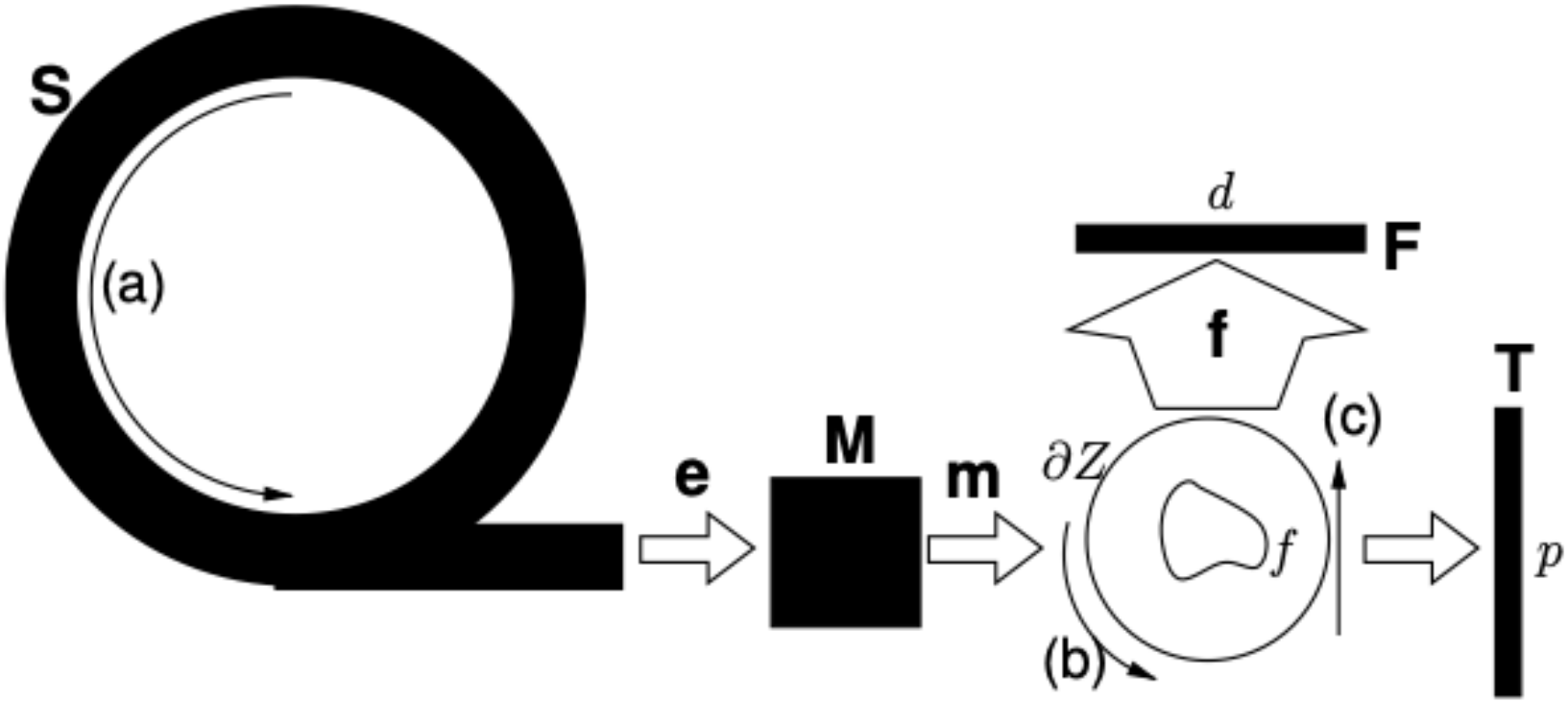
Download:

https://github.com/exmiqueles/fofurasIB

Parte 2:
Algumas definições

What is this lecture about?



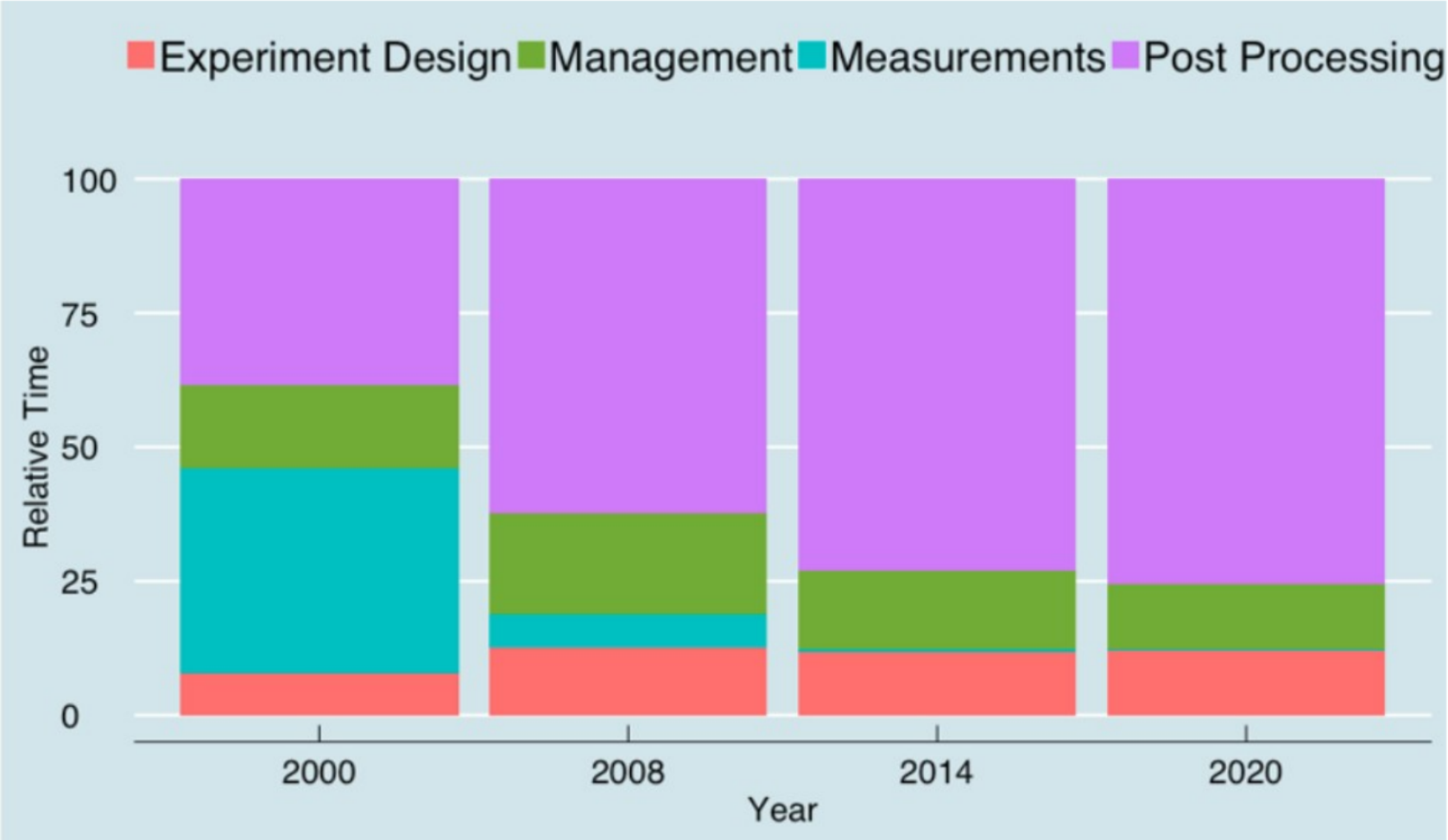
GCC team

(a) Segmentation
(b) Reconstruction
(c) HPC

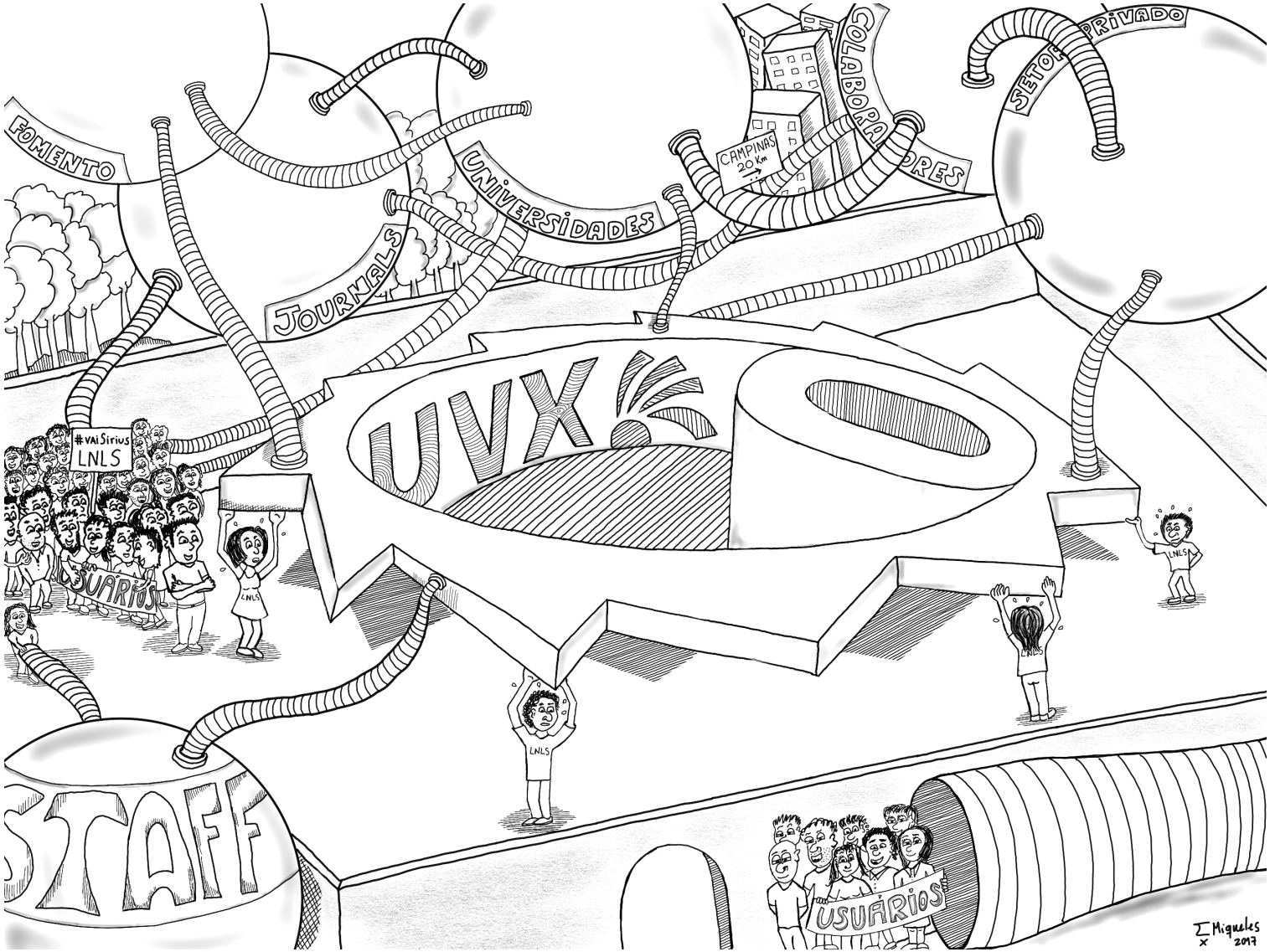
My part ...

1. Applied Mathematics
2. General computer stuff
3. Patience

Scientific Computing



Users dynamics



An image

32×32

An image

512×512

Resolution?

Good resolution: image S

Bad resolution: image S

Resolution: in practice

Good resolution: image S

Bad resolution: image S

Notation

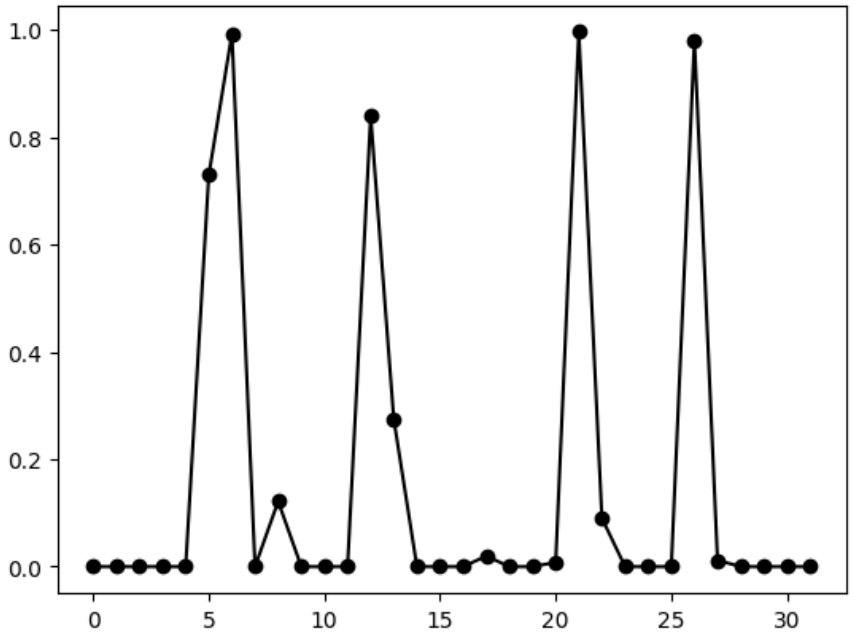
Image (or matrix) S:

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.95	0.84	0.00	0.02	0.97	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.06	0.98	0.00	0.00	0.70	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.09	0.12	0.00	0.00	0.69	0.28	0.17	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.98	0.00	0.01	0.97	0.01	0.00	0.00	0.82	0.69	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.02	0.00	0.00	0.97	0.00	0.00	0.00	0.99	0.91	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.75	0.03	0.02	0.96	0.97	0.03	0.89	0.00	0.00	0.01	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.01	0.00	0.00	0.00	0.00	0.87	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37
0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97
0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.02	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.35	0.00	0.00	0.00	0.99	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.87	0.00	0.00	1.00	0.00	0.00	0.00	0.68	0.13	0.00	0.00	0.00	0.80	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.73	0.99	0.00	0.12	0.00	0.00	0.00	0.84	0.27	0.00	0.00	0.00	0.02	0.00	0.00	0.01
0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.01	1.00	0.00	0.01	0.00	0.76	0.39	0.01	0.00	0.01	0.12	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.26	0.94	0.02	0.04	0.00	0.01	0.01	1.00	0.00	0.00	0.78	0.73
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A profile

(a)

(b) Row 23



Symbol

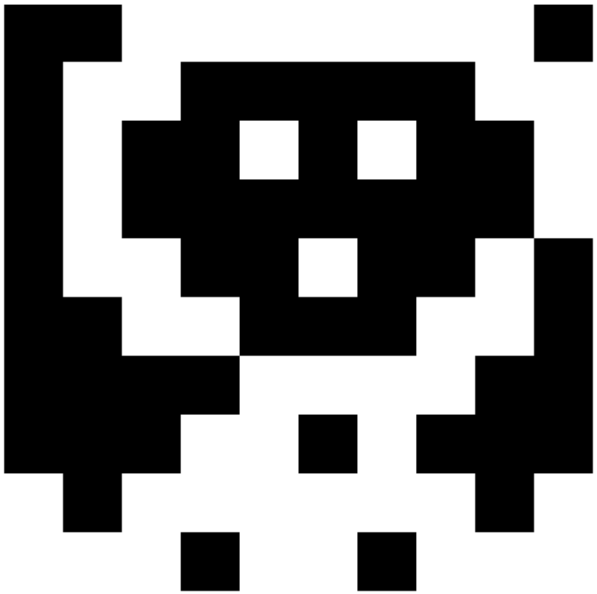
$$S = (S_{ij}) \in \mathbb{R}^{32\times 32}$$

Image $\Longleftrightarrow$ Matrix

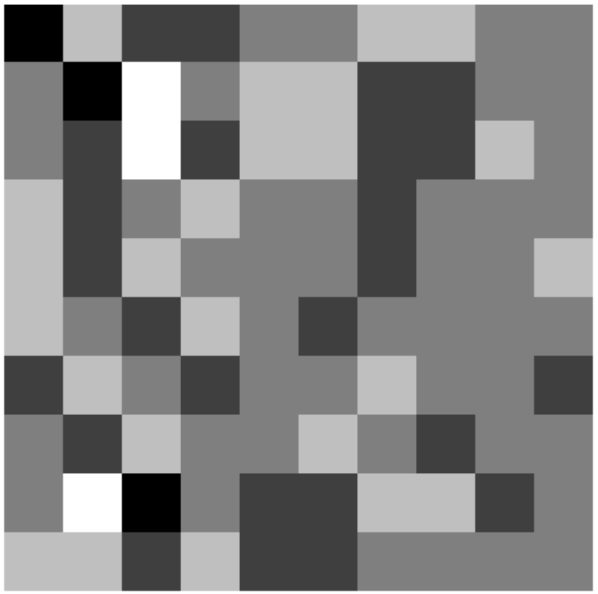
Generally

$S \in \mathbb{F}^{n \times n}$ $\quad$ $\mathbb{F} \in \{\mathbb{R}, \mathbb{C}, \mathbb{Z}, \mathbb{N}\}$ ... $\quad$ (*mathematically known as "a field"*)

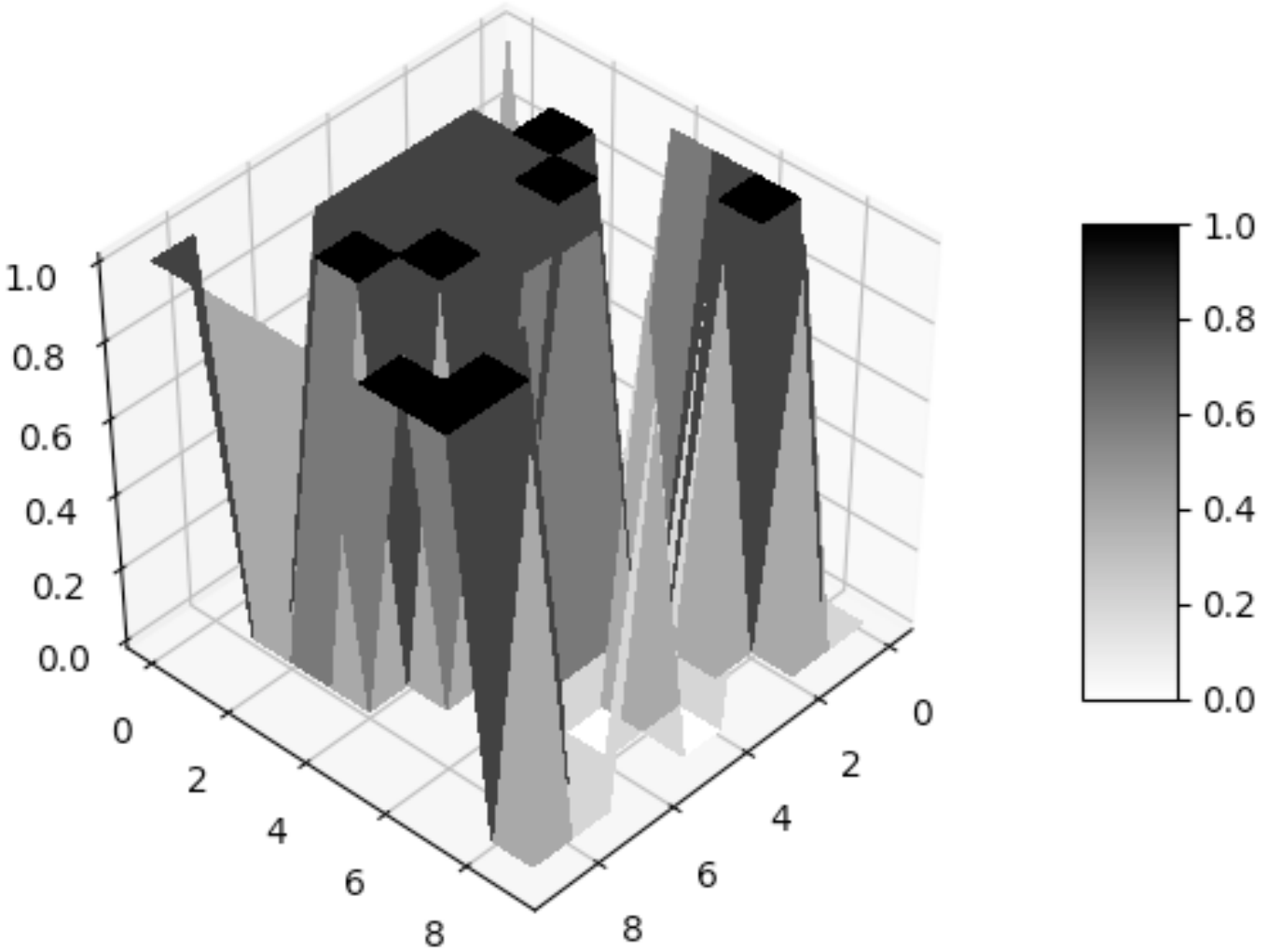
(a) $P \in [0, 1]^{10 \times 10}$



(b) $P^{-1} \in \mathbb{R}^{10 \times 10}$

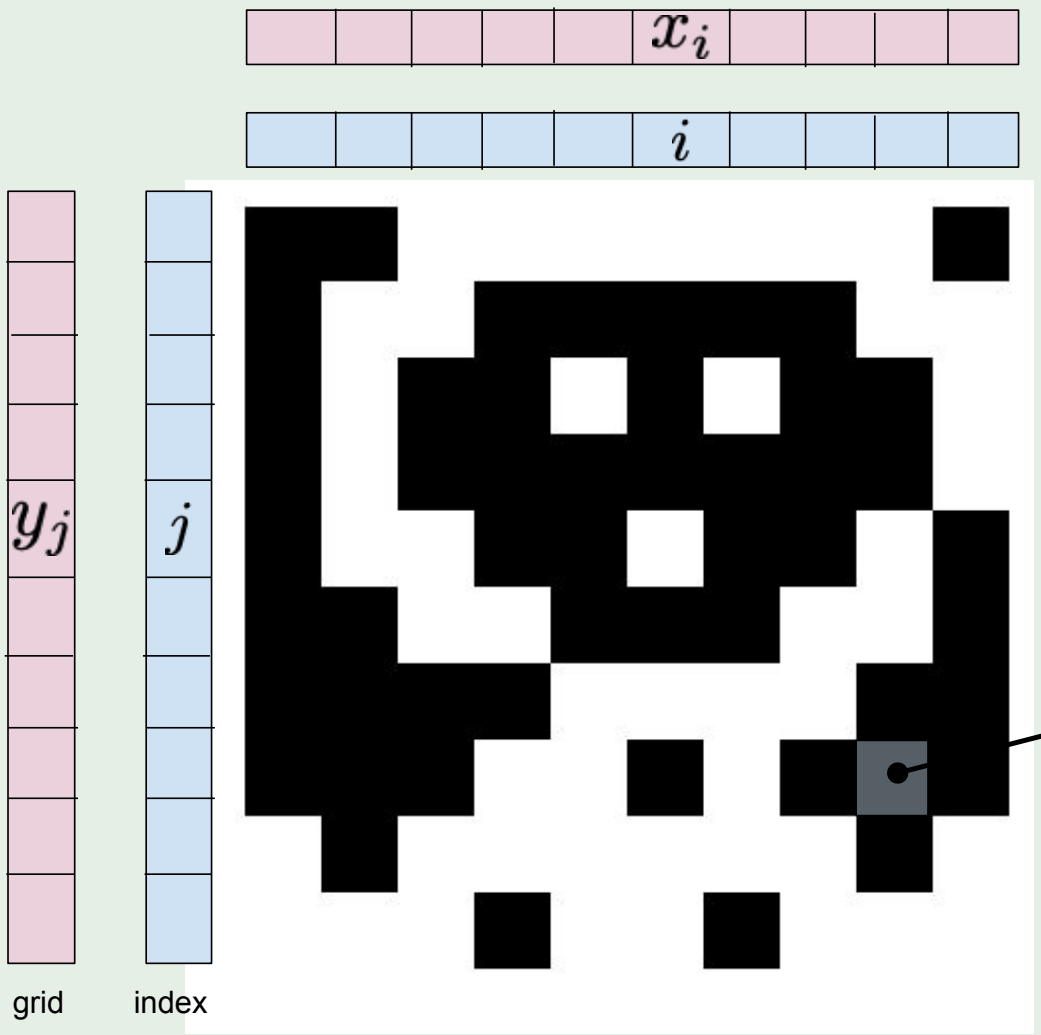


Surface $\Longleftrightarrow$ Image $\Longleftrightarrow$ Matrix



Surface $\Longleftrightarrow$ Image $\Longleftrightarrow$ Matrix

You said surface?? ☺



Exist a function $p(x, y)$

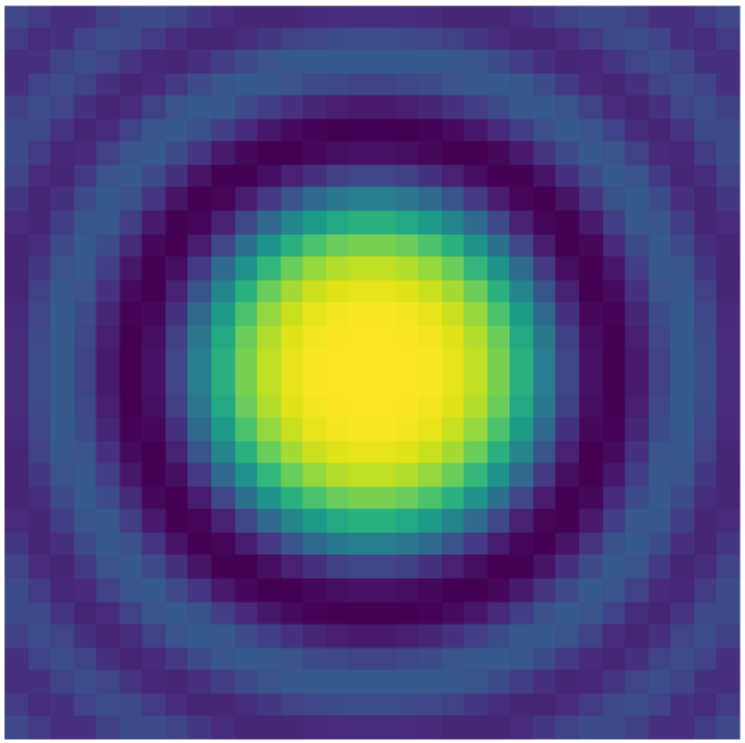
$$P_{ji} = p(x_i, y_j)$$

Surface $\Longleftrightarrow$ Image $\Longleftrightarrow$ Matrix

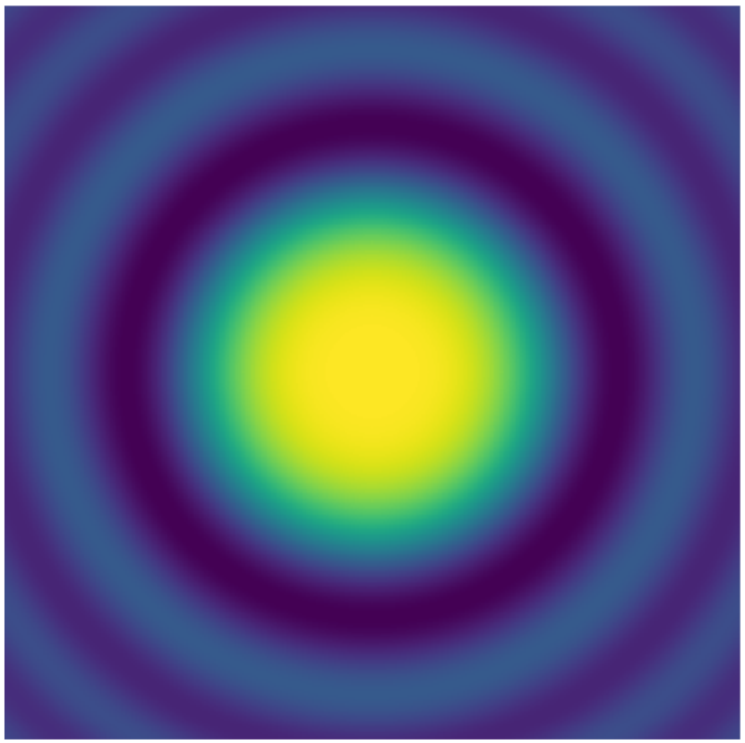
2D Functions

$$p(x,y) = \frac{\sin(10(x^2+y^2))}{10(x^2+y^2)}, \quad x_i = -1 + i \underbrace{\frac{2}{n}}_{\Delta x}, \quad y_j = -1 + j \underbrace{\frac{2}{n}}_{\Delta y}$$

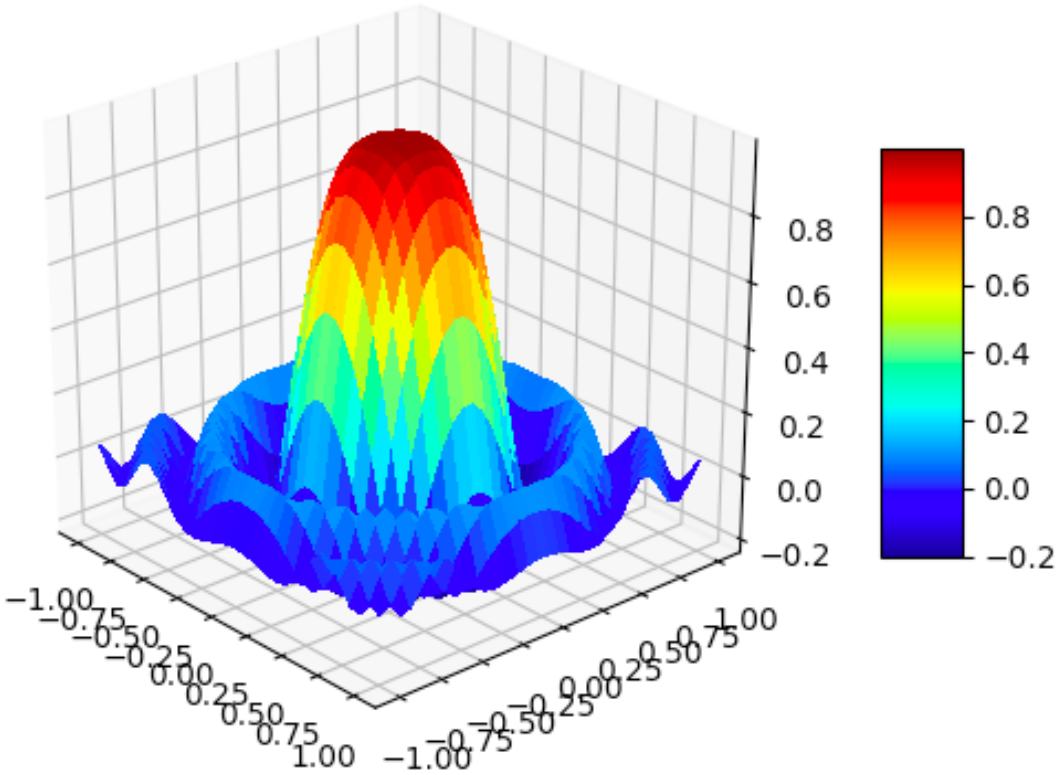
(a) $n = 32$



(b) $n = 512$



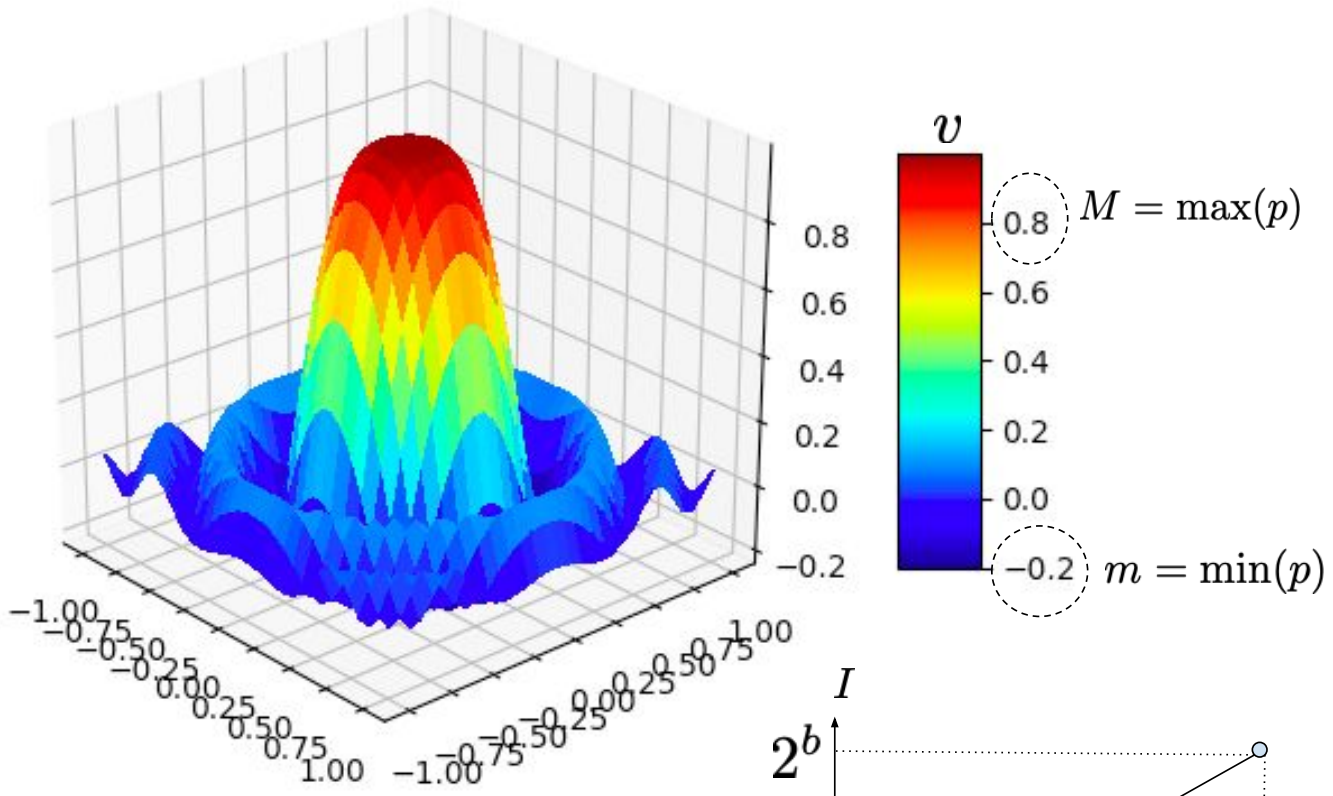
Surface $\Longleftrightarrow$ Image $\Longleftrightarrow$ Matrix



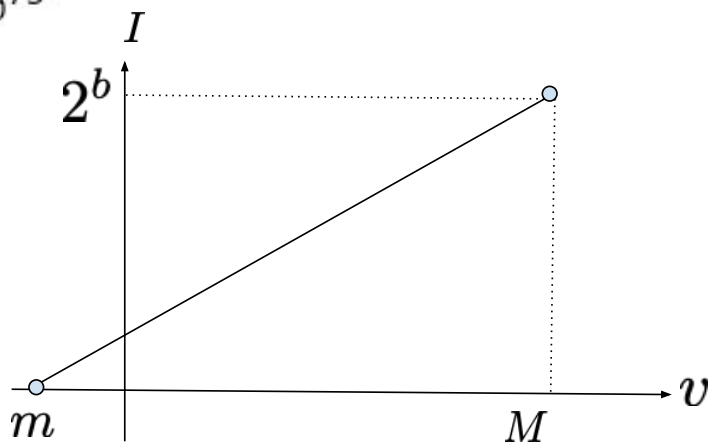
Warning

$$\dim(p) = 2, \qquad \text{graph}(f) \in \mathbb{R}^3$$

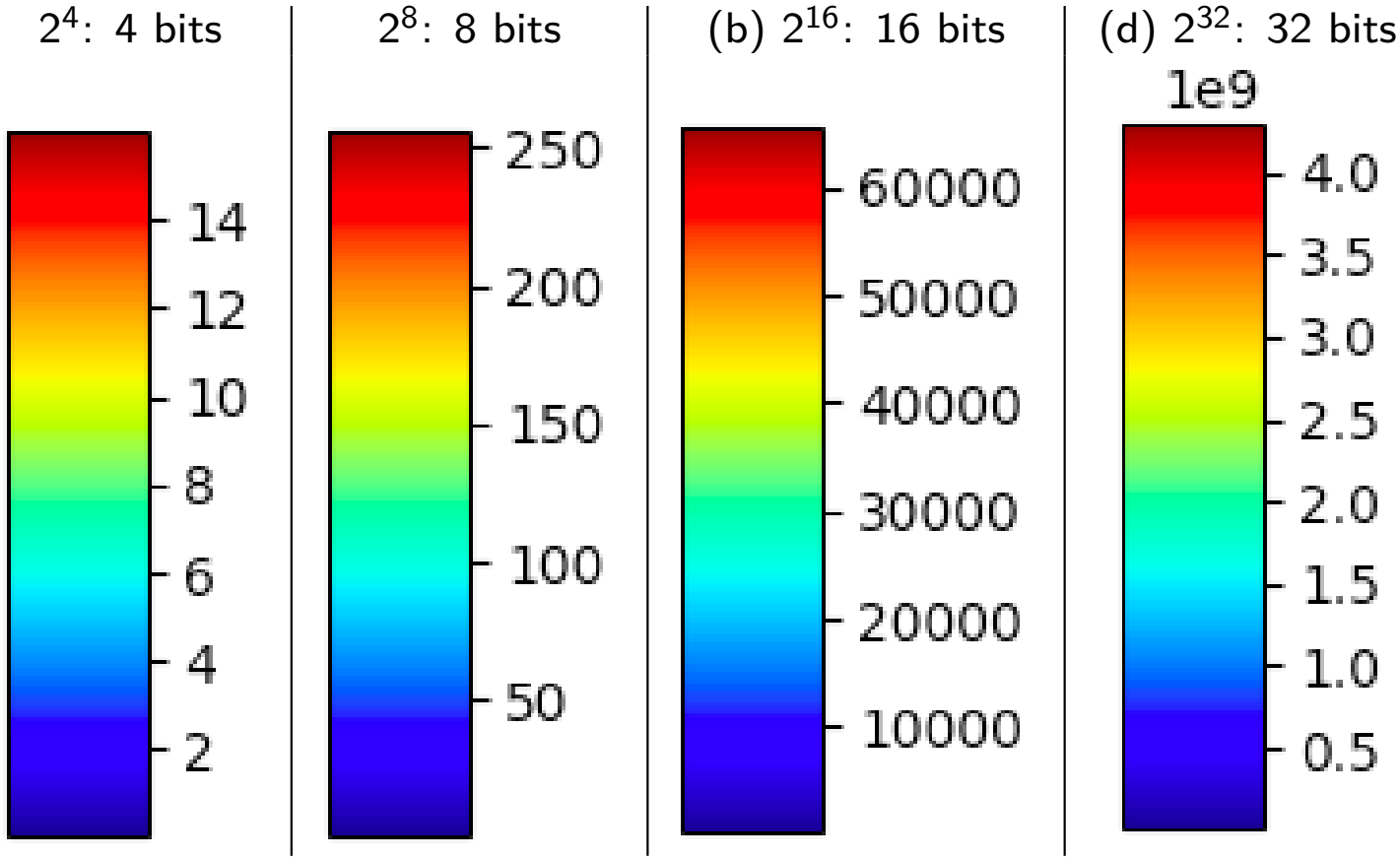
Bit depth



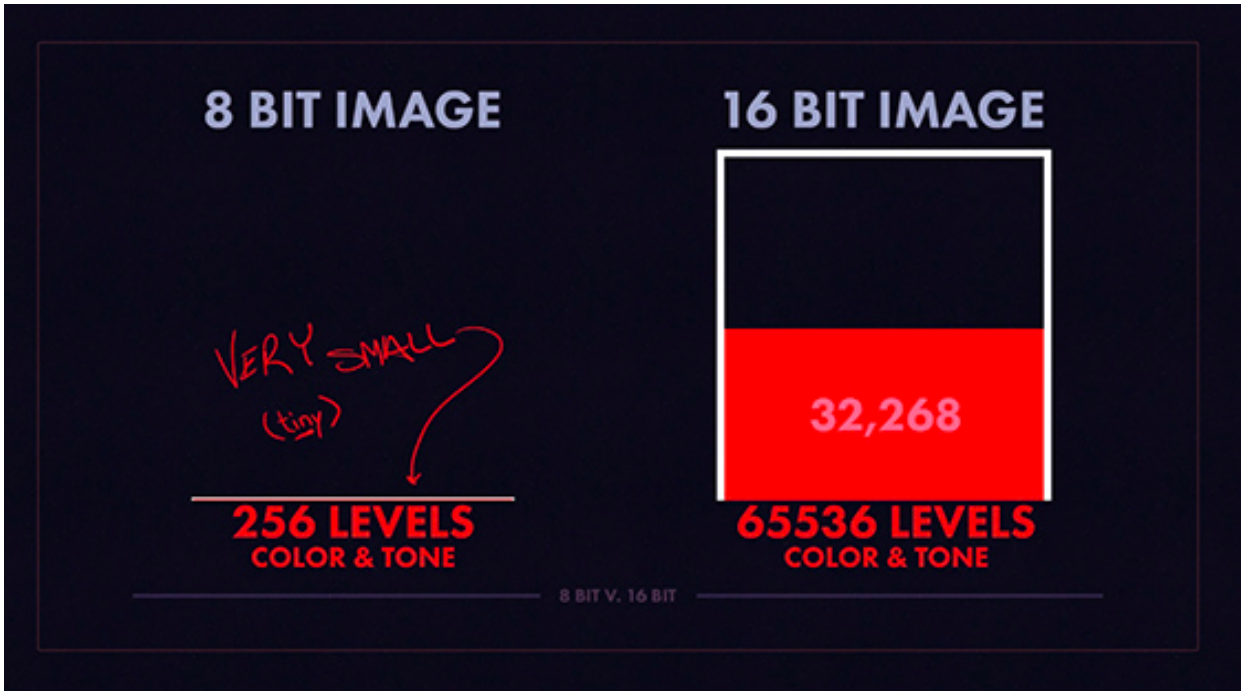
$$I(v) = \left(\frac{2^b}{M - m}\right)(v - m)$$



Bit depth


2^4: 4 bits
14
12
10
8
6
4
2
2^8: 8 bits
250
200
150
100
50
(b) 2^{16}: 16 bits
60000
50000
40000
30000
20000
10000
(d) 2^{32}: 32 bits
1e9
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5

Bit depth

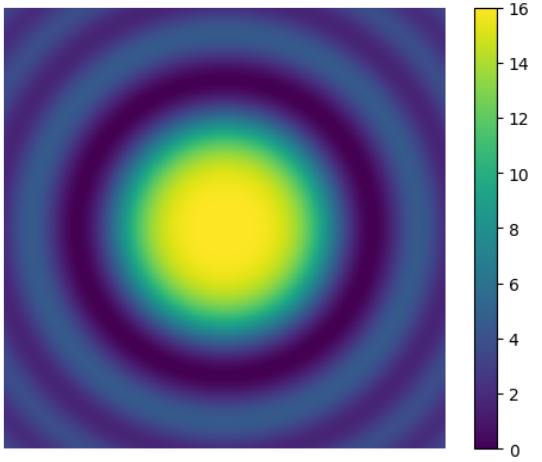


Importance

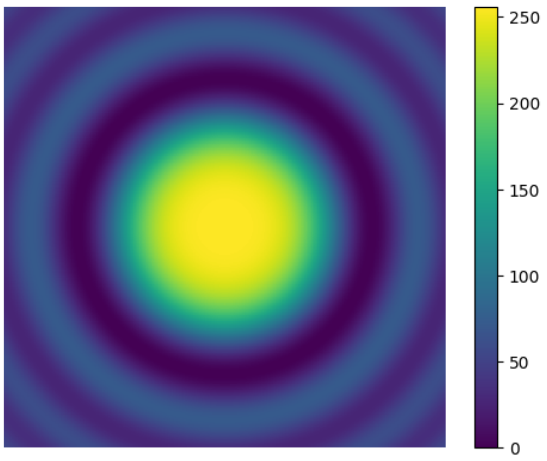
1. Image segmentation
2. Data analysis

Bit depth

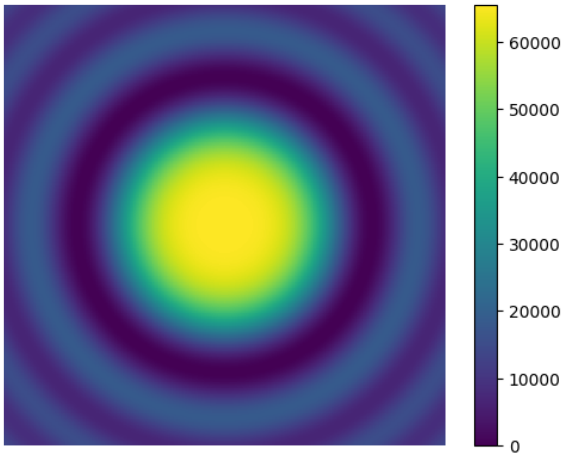
2^4



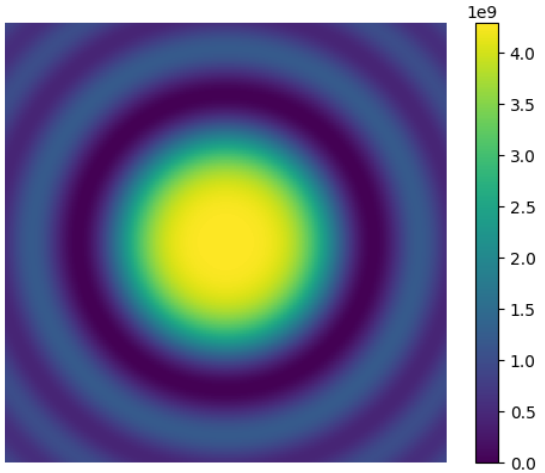
2^8



2^{16}

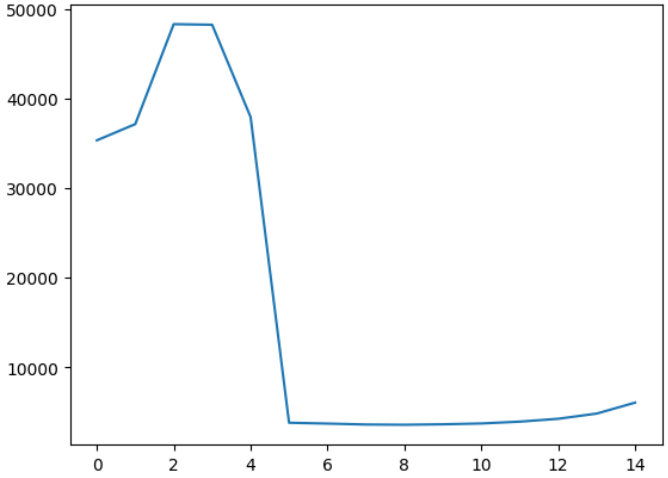


2^{32}

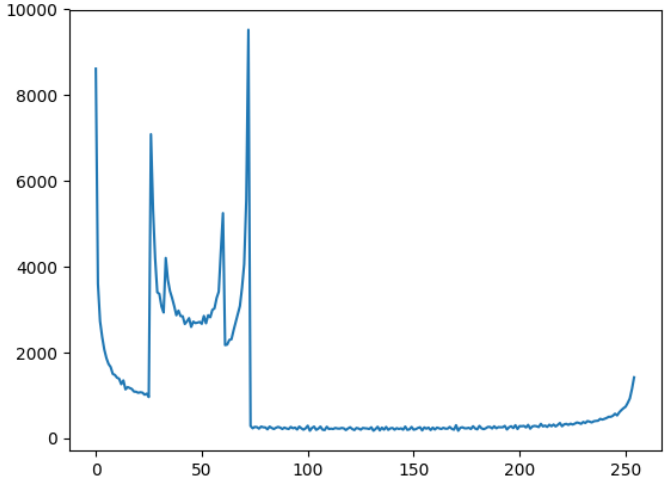


Bit depth

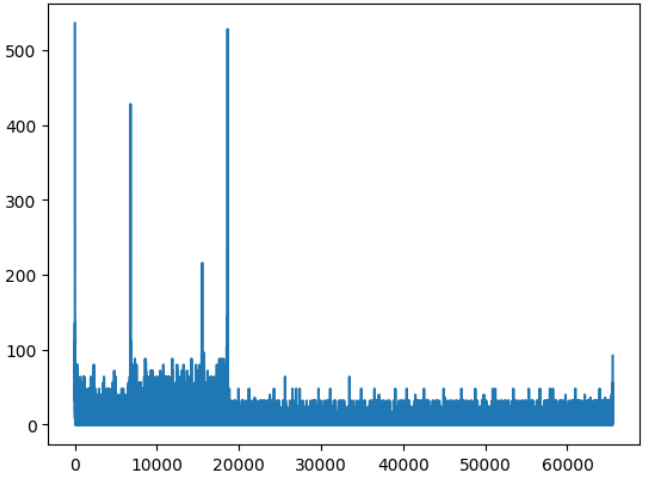
2^4



2^8



2^{16}



2^{32}

☹

Disk space (DS)

Formula

DS = (bit depth) × (rows) × (columns) **bits**

☺

1 bit = $\frac{1}{8}$ Bytes

General formula

$$DS = \frac{bn^2}{8}\text{Bytes} = \begin{cases} \frac{bn^2}{8\times 1024} = \frac{bn^2}{2^{13}} & \text{KB} \\ \frac{bn^2}{8\times 1024^2} = \frac{bn^2}{2^{23}} & \text{MB} \\ \frac{bn^2}{8\times 1024^3} = \frac{bn^2}{2^{33}} & \text{GB} \end{cases}$$

... megabytes

	$b = 4$	$b = 8$	$b = 16$	$b = 32$
$n = 512$	0.125	0.250	0.500	1.000
$n = 1024$	0.500	1.000	2.000	4.000
$n = 2048$	2.000	4.000	8.000	16.000
$n = 3072$	4.500	9.000	18.000	36.000
$n = 10000$	47.684	95.367	190.735	381.470