



Definiciones y herramientas básicas

Unidad 1

BME423 · Procesamiento de imágenes médicas

Alejandro Veloz

Ingeniería Biomédica

¿Qué es una imagen?

¿Qué es una imagen?

Es una función

$$f : \underbrace{E \subseteq \mathbb{R}^d}_{\text{coordenadas}} \rightarrow \underbrace{I \subseteq \mathbb{R}^c}_{\text{color, intensidad}}$$

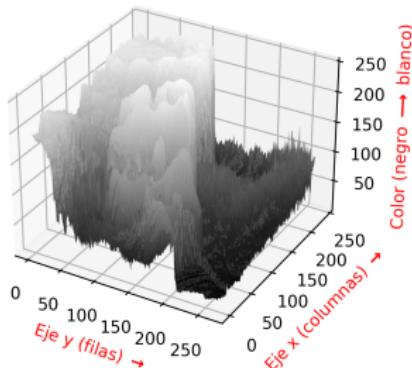


- $d = 2$, en caso de una imagen 2D típica
- $d = 3$, para una imagen volumétrica (por ejemplo, MRI, CT)
- $c = 1$, para una imagen en escala de grises
- $c = 3$, para una imagen RGB

¿Qué es una imagen?

Es una función

$$f : \underbrace{E \subseteq \mathbb{R}^d}_{\text{coordenadas}} \rightarrow \underbrace{I \subseteq \mathbb{R}^c}_{\text{color, intensidad}}$$



- $d = 2$, en caso de una imagen 2D típica
- $d = 3$, para una imagen volumétrica (por ejemplo, MRI, CT)
- $c = 1$, para una imagen en escala de grises
- $c = 3$, para una imagen RGB

¿Qué es una imagen?

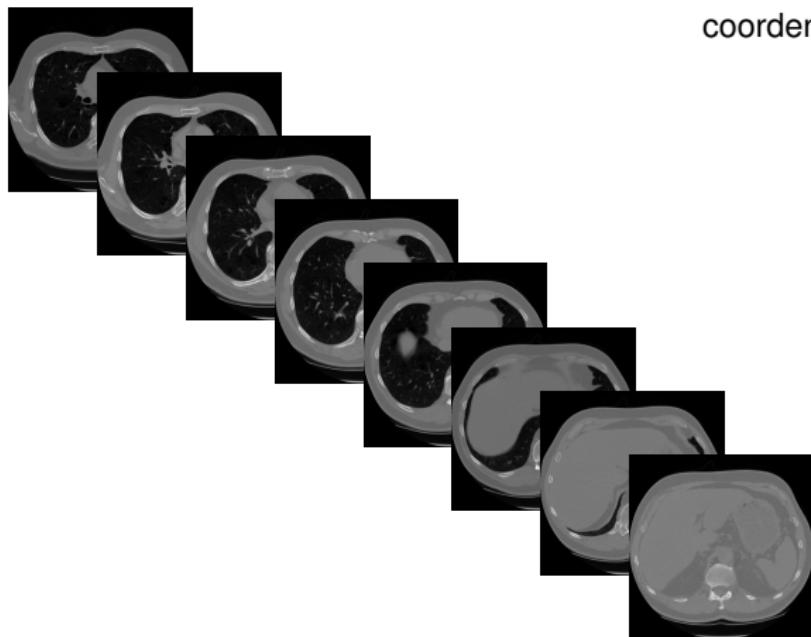
Imagen RGB (Red-Green-Blue)

$$f : \underbrace{E \subseteq \mathbb{R}^2}_{\text{coordenadas}} \rightarrow \underbrace{I \subseteq \mathbb{R}^3}_{\text{color}}$$



¿Qué es una imagen?

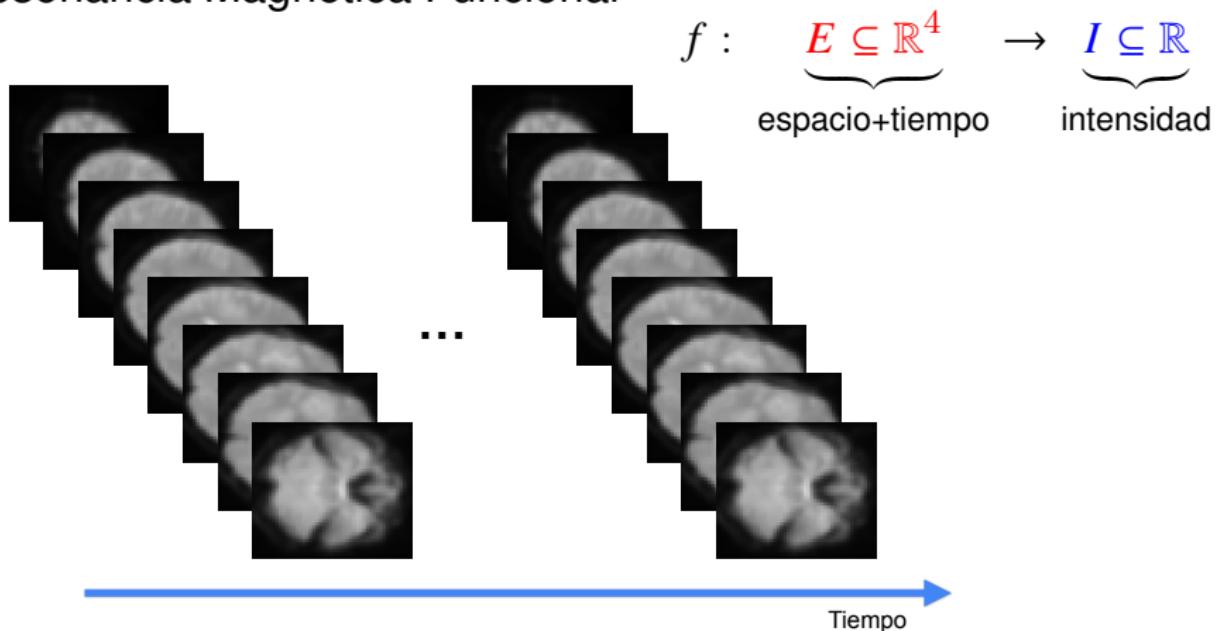
Volumen CT



$$f : \underbrace{E \subseteq \mathbb{R}^3}_{\text{coordenadas}} \rightarrow \underbrace{I \subseteq \mathbb{R}}_{\text{intensidad}}$$

¿Qué es una imagen?

Resonancia Magnética Funcional



¿Qué es una imagen?

Imágenes multiespectrales, multimodales, etc.

Ej. MRI (T1, T2, T1+contraste)

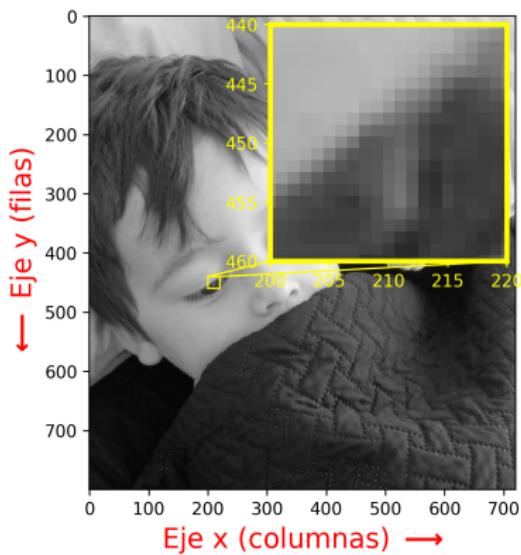
$$f : \underbrace{E \subseteq \mathbb{R}^2}_{\text{espacio}} \rightarrow \underbrace{I \subseteq \mathbb{R}^3}_{\text{intensidades en cada espectro}}$$



Pixel / Voxel

Una imagen 2D tiene una representación matricial

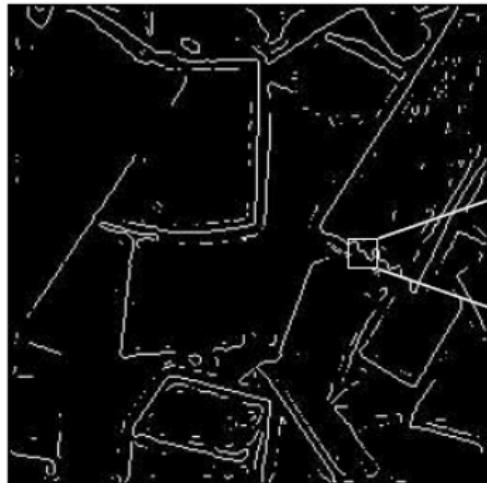
$$\mathbf{I} = [I_{ij}] \in \mathbb{R}^{m \times n}, i = \{1, \dots, m\}, j = \{1, \dots, n\}$$



- A cada I_{ij} se le llama **Picture element (Pixel)**
- **Convención:** El punto $(0, 0)$ (aunque no siempre) está en la parte superior izquierda
- En algunas modalidades de imagen (MRI, CT) el Pixel tiene cierto "ancho de corte", dando como resultado un "Pixel 3D" denominado **Voxel (Volume element)**

Imagen binaria

$$f : \underbrace{E \subseteq \mathbb{R}^d}_{\text{coordenadas}} \rightarrow \underbrace{I \subseteq \{0,1\}}_{V \text{ ó } F}$$



1	1	0	0	0	0
0	0	1	0	0	0
0	0	1	0	0	0
0	0	0	1	0	0
0	0	0	1	1	0
0	0	0	0	0	1

Escala de grises

$$f : \underbrace{E \subseteq \mathbb{R}^d}_{\text{coordenadas}} \rightarrow \underbrace{I \subseteq \mathbb{R}}_{\text{intensidad}}$$



230	229	232	234	235	232	148
237	236	236	234	233	234	152
255	255	255	251	230	236	161
99	90	67	37	94	247	130
222	152	255	129	129	246	132
154	199	255	150	189	241	147
216	132	162	163	170	239	122

Imagen RGB

$$f : \underbrace{E \subseteq \mathbb{R}^d}_{\text{coordenadas}} \rightarrow \underbrace{I \subseteq \mathbb{R}^3}_{\text{color RGB}}$$



49	55	56	57	52	53
58	60	60	58	55	57
58	58	54	53	55	56
83	78	72	69	68	69
88	91	91	84	83	82
69	76	83	78	76	75
61	69	73	78	76	76

Red

64	76	82	79	78	78
93	93	91	91	86	86
88	82	88	90	88	89
125	119	113	108	111	110
137	136	132	128	126	120
105	108	114	114	118	113
96	103	112	108	111	107

Green

66	80	77	80	87	77
81	93	96	99	86	85
83	83	91	94	92	88
135	128	126	112	107	106
141	129	129	117	115	101
95	99	109	108	112	109
84	93	107	101	105	102

Blue

Espacio RGB

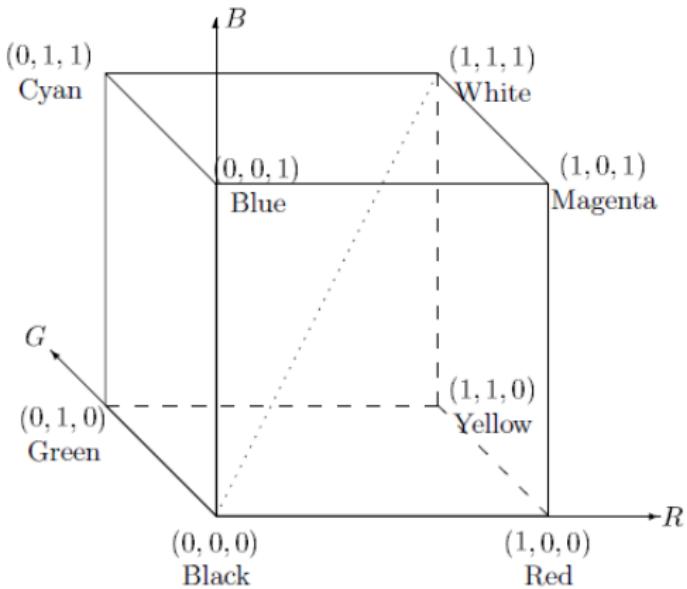


Imagen indexada

$$f : \underbrace{E \subseteq \mathbb{R}^d}_{\text{coordenadas}} \rightarrow \underbrace{I \subseteq \mathbb{R}^3}_{\text{color RGB}}$$



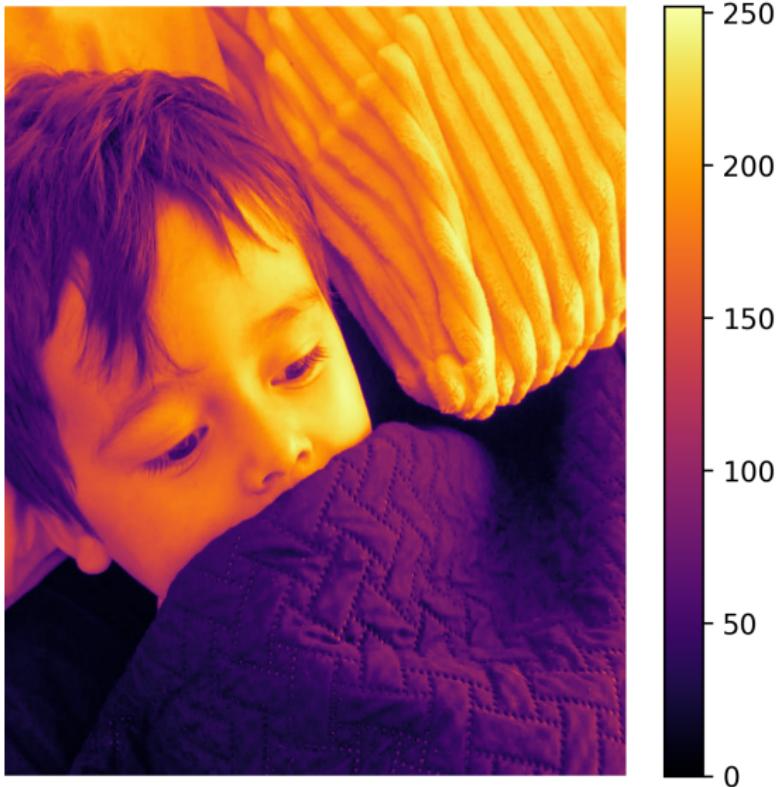
4	5	5	5	5	5
5	4	5	5	6	6
5	5	5	0	8	9
5	5	5	5	11	11
5	5	5	8	16	20
8	11	11	26	33	20
11	20	33	33	58	37

Indices

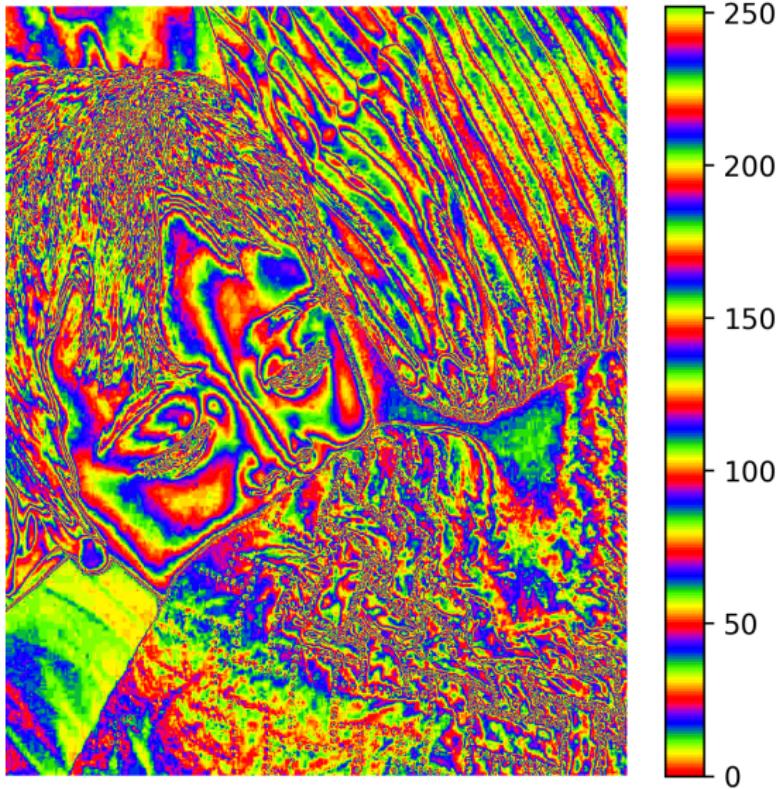
0.1211	0.1211	0.1416
0.1807	0.2549	0.1729
0.2197	0.3447	0.1807
0.1611	0.1768	0.1924
0.2432	0.2471	0.1924
0.2119	0.1963	0.2002
0.2627	0.2588	0.2549
0.2197	0.2432	0.2588

Colour map

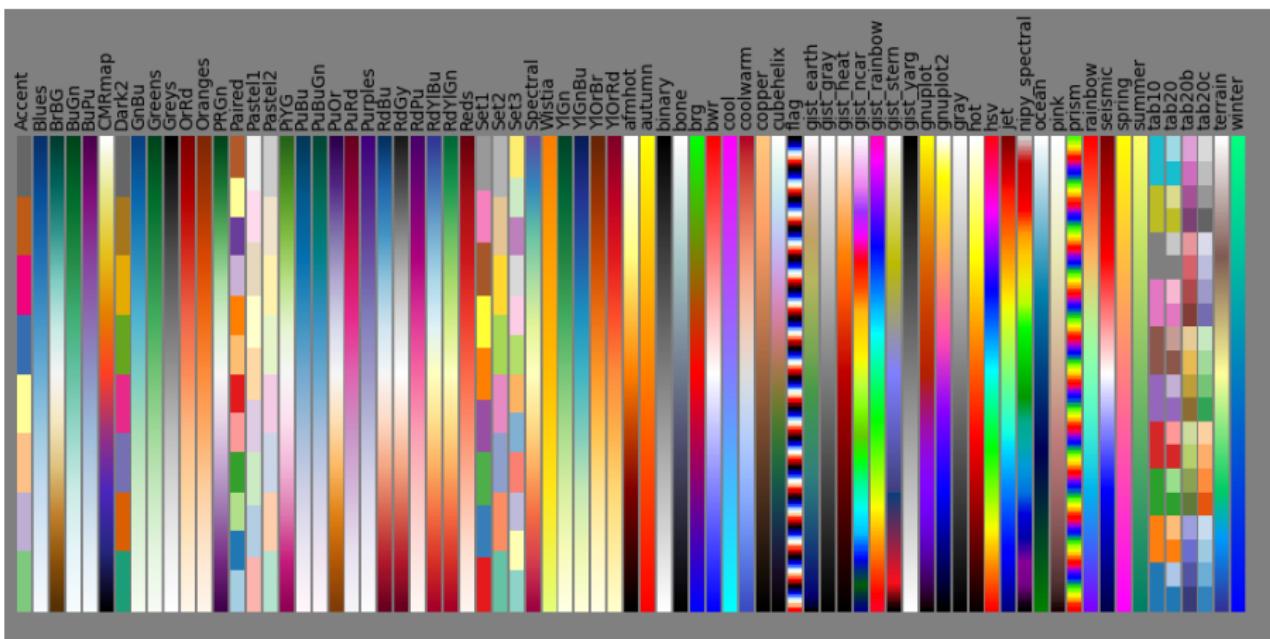
Colormap *Inferno*



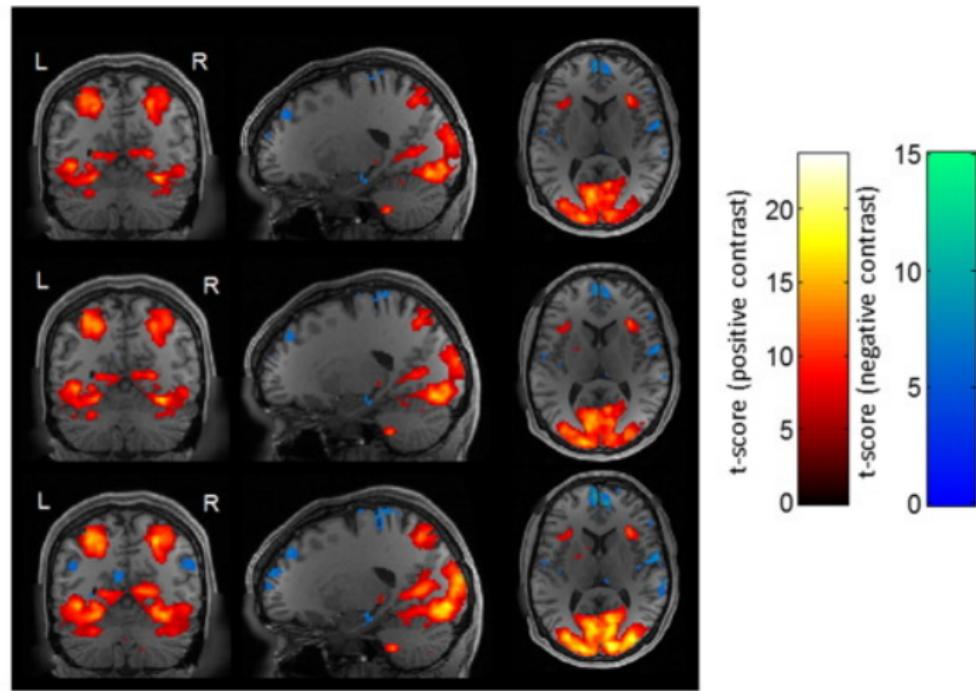
Colormap Prism



Colormaps



fMRI - mapa activación



Escala de grises

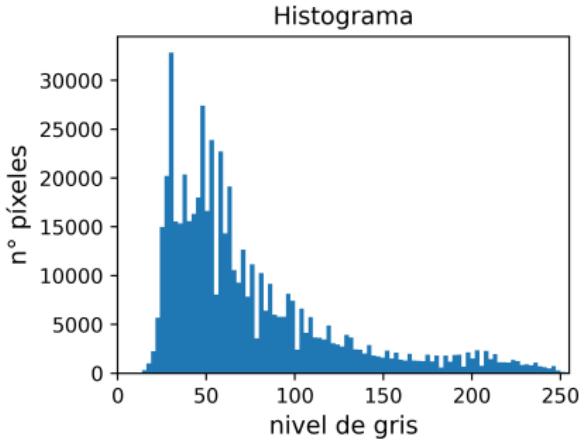
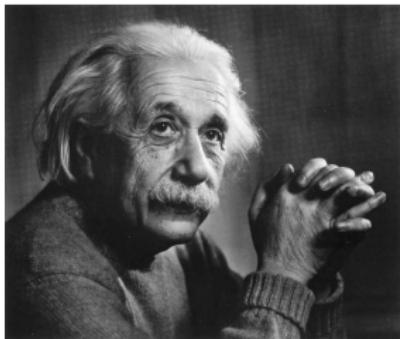
- El nivel de gris de la imagen en la coordenada (x, y) es $GL = f(x_0, y_0)$, donde:

$$L_{\min} \leq \underbrace{f(x, y)}_{\text{nivel de gris, GL}} \leq L_{\max}$$

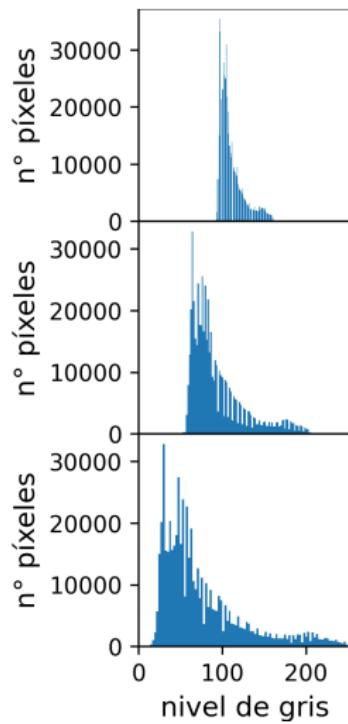
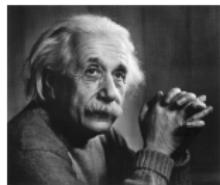
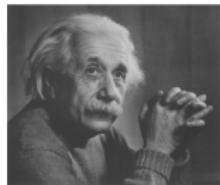
- El intervalo $[L_{\min}, L_{\max}]$ se llama **escala de grises**
- Es común desplazar dicho intervalo a $[0, L - 1]$, donde $GL = 0$ es negro y $GL = L - 1$ es blanco
- El rango en el que se distribuyen las intensidades en el intervalo $[0, L - 1]$ se conoce como **rango dinámico**

Escala de grises

- Una imagen tiene un alto rango dinámico si sus niveles de gris cubren una alta porción de la escala de grises, lo que se traduce en un alto contraste.



Rango dinámico y contraste



Muestreo y cuantización

- Sampling: Discretización de las coordenadas (x, y) . El tamaño de una imagen corresponde a la **resolución espacial**
- Cuantización: Discretización de la amplitud $f(x, y)$. Si codificamos **cada Pixel** con k bits, tenemos 2^k niveles de grises

Muestreo

1155×1162



577×581



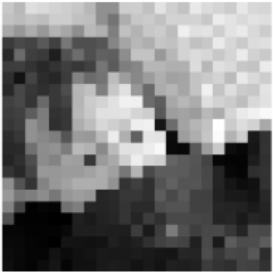
231×232



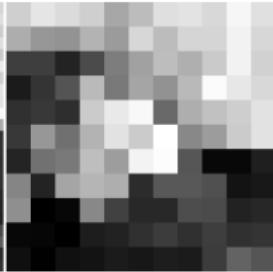
115×116



23×23



11×11



Cuantización

8 bits



7 bits



6 bits



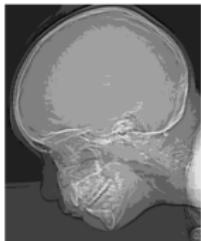
5 bits



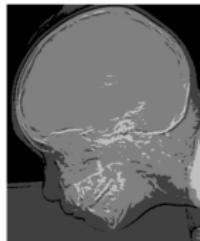
4 bits



3 bits



2 bits

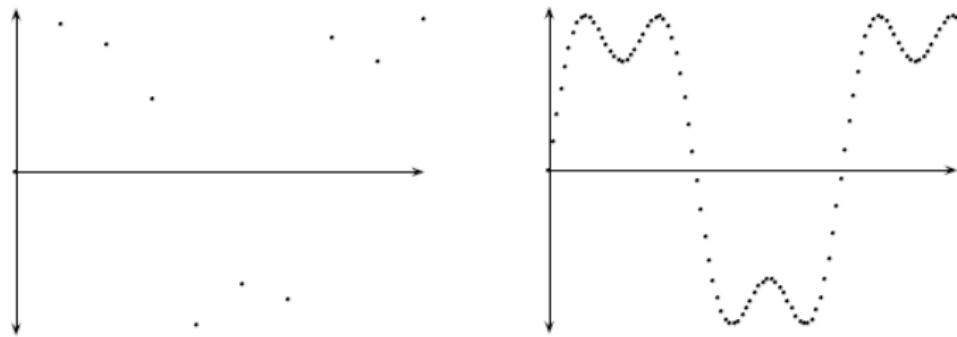


1 bit

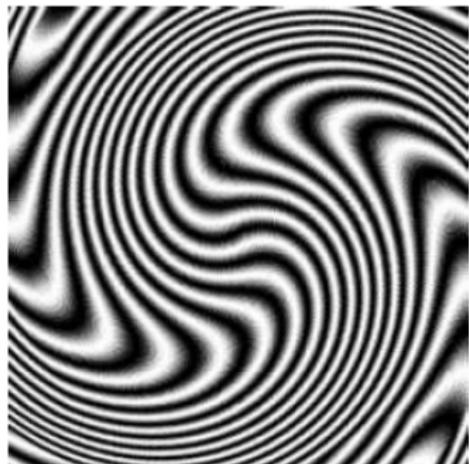


Aliasing

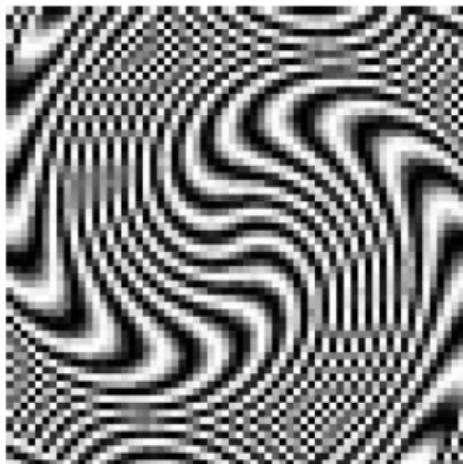
$$y = \sin(x) + \frac{1}{3} \sin(3x)$$



Aliasing



Correct sampling; no aliasing

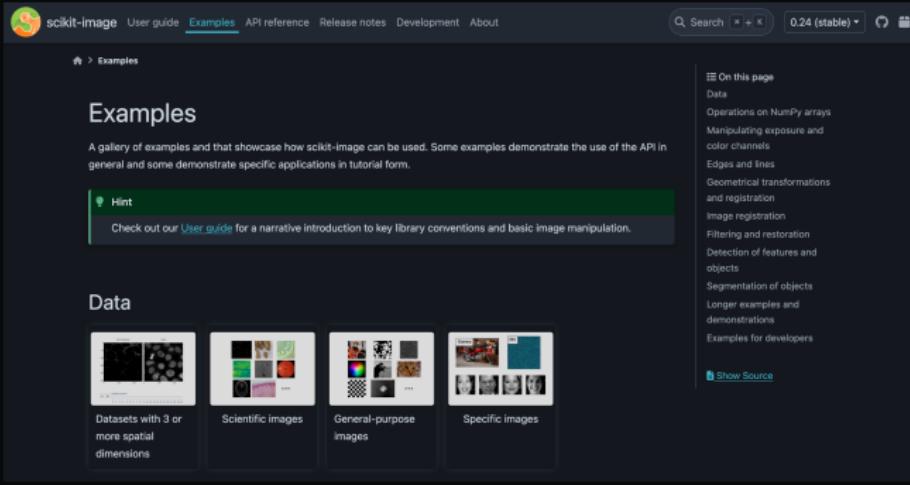


An undersampled version with aliasing

Algunas herramientas



Algunas herramientas

A screenshot of the scikit-image Examples page. The top navigation bar includes links for User guide, Examples (which is underlined), API reference, Release notes, Development, and About. A search bar and a version selector (0.24 (stable)) are also present. The main content area has a breadcrumb trail: Home > Examples. Below this, a section titled "Examples" is shown with a sub-section "Data". Under "Data", there are four categories: "Datasets with 3 or more spatial dimensions", "Scientific Images", "General-purpose Images", and "Specific Images", each with a small thumbnail image. To the right of the main content, a sidebar titled "On this page" lists various topics: Operations on NumPy arrays, Manipulating exposure and color channels, Edges and lines, Geometrical transformations and registration, Image registration, Filtering and restoration, Detection of features and objects, Segmentation of objects, Longer examples and demonstrations, and Examples for developers. A "Show Source" button is located at the bottom of the sidebar.

scikit-image User guide Examples API reference Release notes Development About

Search 0.24 (stable)

Home > Examples

Examples

A gallery of examples and that showcase how scikit-image can be used. Some examples demonstrate the use of the API in general and some demonstrate specific applications in tutorial form.

Hint

Check out our [User guide](#) for a narrative introduction to key library conventions and basic image manipulation.

Data

- Datasets with 3 or more spatial dimensions
- Scientific Images
- General-purpose Images
- Specific Images

On this page

- Operations on NumPy arrays
- Manipulating exposure and color channels
- Edges and lines
- Geometrical transformations and registration
- Image registration
- Filtering and restoration
- Detection of features and objects
- Segmentation of objects
- Longer examples and demonstrations
- Examples for developers

Show Source

Algunas herramientas



[About Keras](#)

[Getting started](#)

[Developer guides](#)

[Keras 3 API documentation](#)

[Keras 2 API documentation](#)

[Code examples](#)

Computer Vision

Natural Language Processing

Structured Data

Timeseries

Generative Deep Learning

Audio Data

Reinforcement Learning

Graph Data

Quick Keras Recipes

KerasTuner: Hyperparameter
Tuning

Search Keras documentation...



▶ [Code examples](#)

Code examples

Our code examples are short (less than 300 lines of code), focused demonstrations of vertical deep learning workflows.

All of our examples are written as Jupyter notebooks and can be run in one click in [Google Colab](#), a hosted notebook environment that requires no setup and runs in the cloud. Google Colab includes GPU and TPU runtimes.

= Good starter example

= Keras 3 example

Computer Vision

Image classification

[Image classification from scratch](#)

[Simple MNIST convnet](#)

[Image classification via fine-tuning with EfficientNet](#)

[Image classification with Vision Transformer](#)

[Classification using Attention-based Deep Multiple Instance Learning](#)

[Image classification with modern MLP models](#)

[A mobile-friendly Transformer-based model for image classification](#)