

Analisi di Immagini e Video (Computer Vision)

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Outline

- Image Processing avanzato
 - Canny Edge Detector
 - Hough Transform

Crediti

- Slides adattate da vari corsi
 - Analisi di Immagini (F. Angiulli) – Unical
 - Intro to Computer Vision (J. Tompkin) – CS Brown Edu
 - Computer Vision (I. Gkioulekas), CS CMU Edu

Image Processing, Image Understanding

- Image Processing: $I[x, y] \mapsto I'[x, y]$
- Image Analysis, Computer vision: $I[x, y] \mapsto \text{Features, elements}$

Esempio

- Cosa caratterizza questa immagine?



Esempio

- Cosa caratterizza questa immagine?
 - Linee
 - Cerchi, curve
 - Forme



Esempio



- Cosa caratterizza questa immagine?
 - Linee
 - Cerchi, curve
 - Forme
- In diverse situazioni gli edge points determinati dalla tecnica di edge detection sono sparsi piuttosto che essere raggruppati in linee o curve



Line parameterizations

Forma classica

$$y = mx + b$$

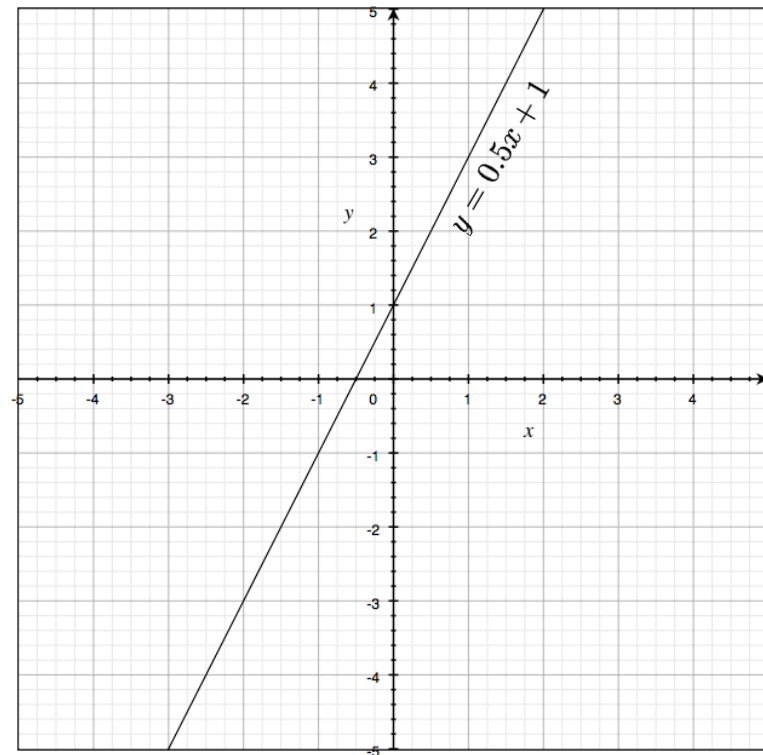
 
slope y-intercept

Cosa sono m e b ?

Forma Classica

$$y = mx + b$$

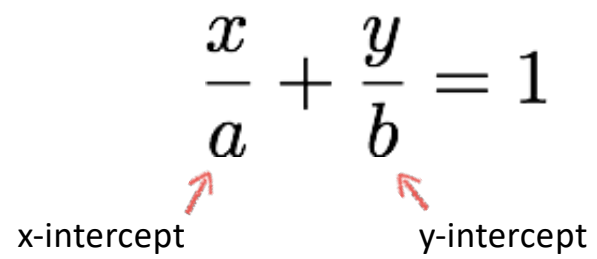
↑ ↑
slope y-intercept



Forma equivalente

$$\frac{x}{a} + \frac{y}{b} = 1$$

x-intercept y-intercept



Cosa sono x e y?

Hough transform

- Framework generico per determinare i parametri di un modello
- I bordi non sono necessariamente connessi
- Le linee possono essere occluse
- **Votazione**

Lo spazio dei parametri

variabili

$$y = mx + b$$

parametri

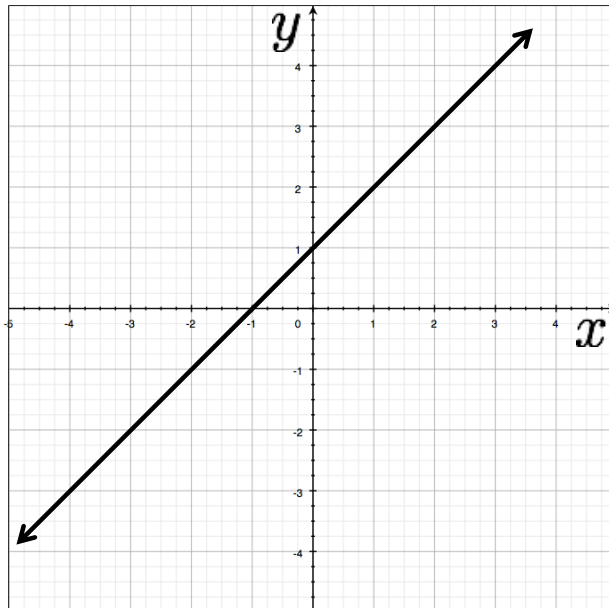


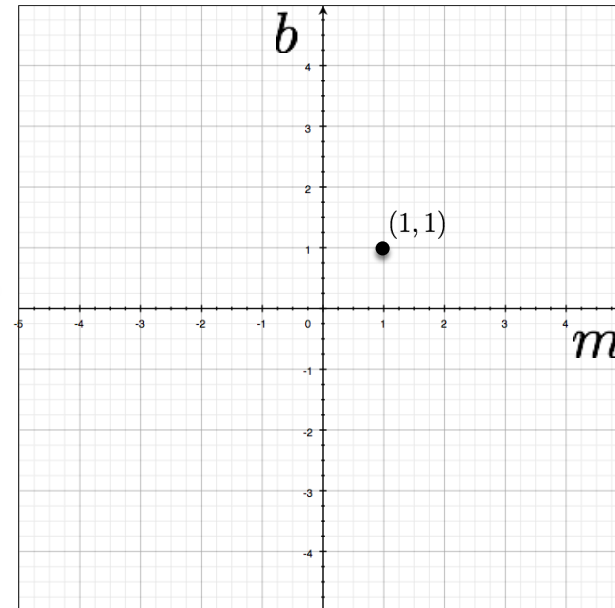
Image space

Una linea
diventa un
punto

variabili

$$y - mx = b$$

parametri



Parameter space

Lo spazio dei parametri

variabili

$$y = mx + b$$

parametri

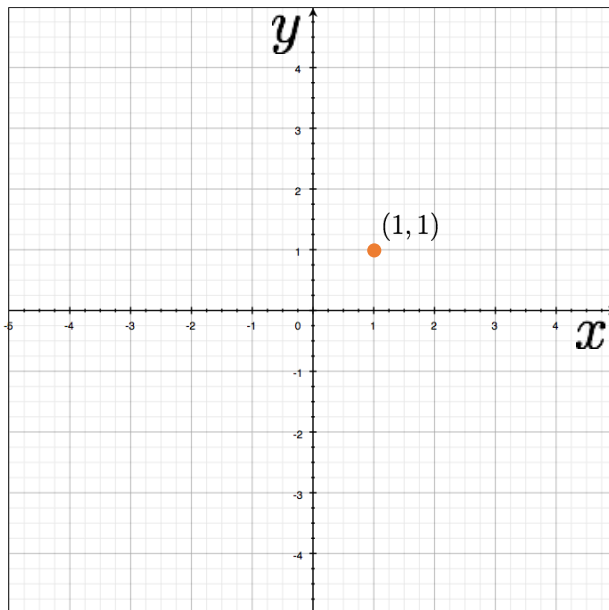


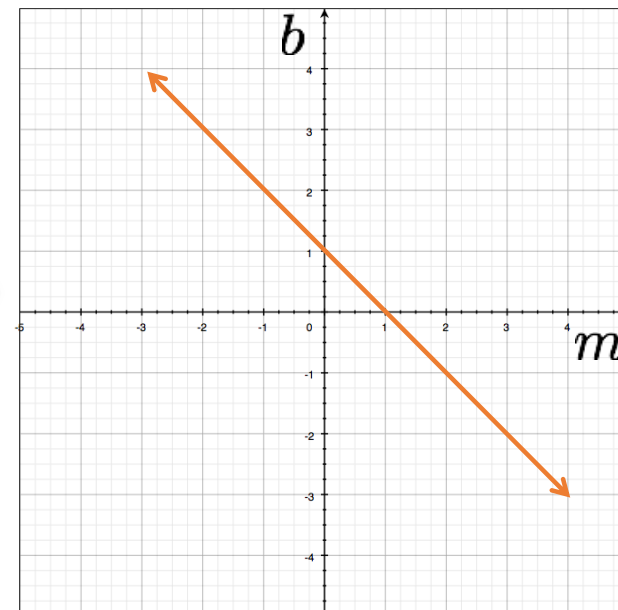
Image space

Un punto
diventa una
linea

variabili

$$y - mx = b$$

parametri



Parameter space

Lo spazio dei parametri

$$y = mx + b$$

Diagram illustrating the equation $y = mx + b$. Green arrows point from the word "variabili" (variables) to y and x , and from the word "parametri" (parameters) to m and b .

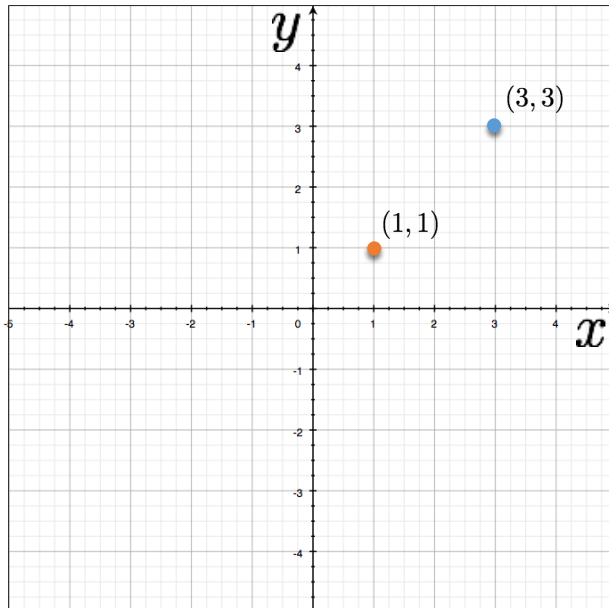
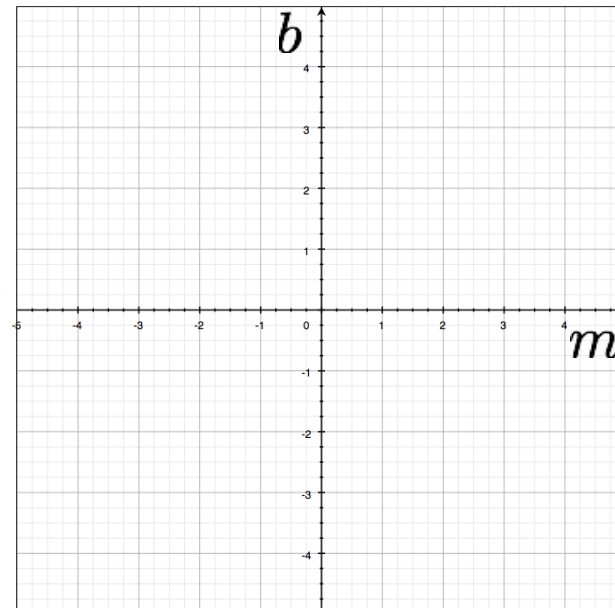


Image space

Cosa sono
due punti?

$$y - mx = b$$

Diagram illustrating the equation $y - mx = b$. Green arrows point from the word "variabili" (variables) to y and x , and from the word "parametri" (parameters) to m and b .



Parameter space

Lo spazio dei parametri

$$y = mx + b$$

Diagram illustrating the equation $y = mx + b$. Green arrows point from the word "variabili" (variables) to y and x , and from the word "parametri" (parameters) to m and b .

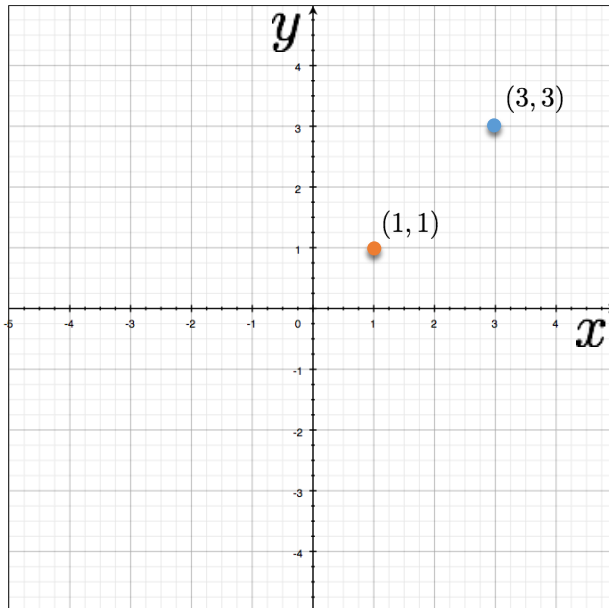
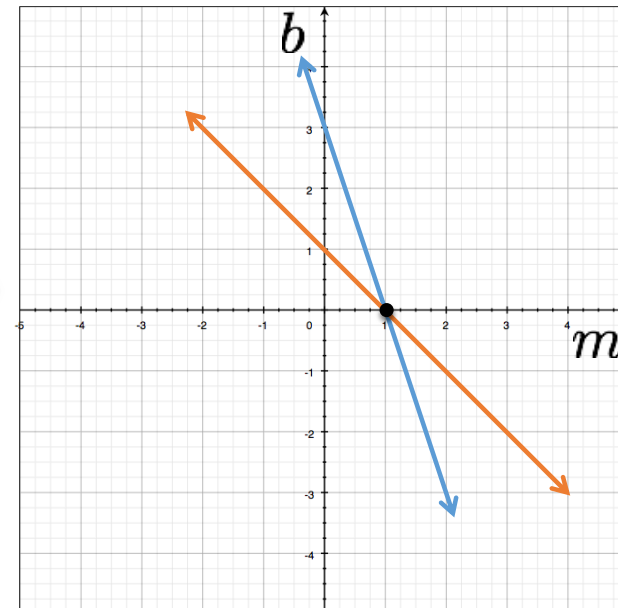


Image space

Cosa sono
due punti?

$$y - mx = b$$

Diagram illustrating the equation $y - mx = b$. Green arrows point from the word "variabili" (variables) to y and x , and from the word "parametri" (parameters) to m and b .



Parameter space

Lo spazio dei parametri

$$y = mx + b$$

Diagram illustrating the equation $y = mx + b$. Green arrows point from the word "variabili" (variables) to y and x , and from the word "parametri" (parameters) to m and b .

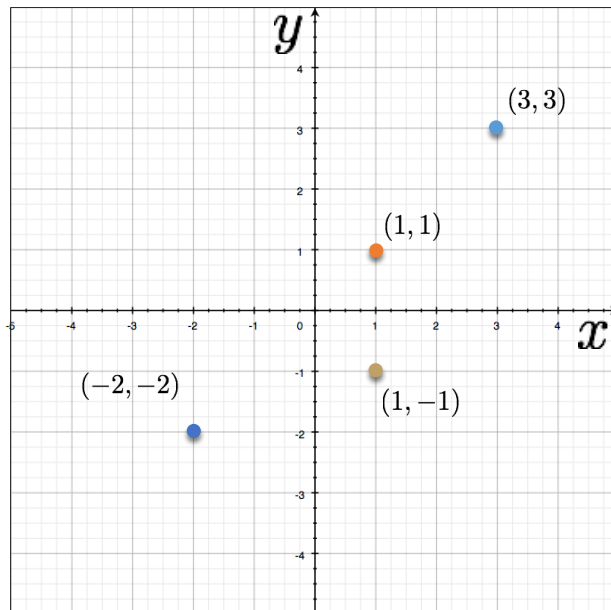
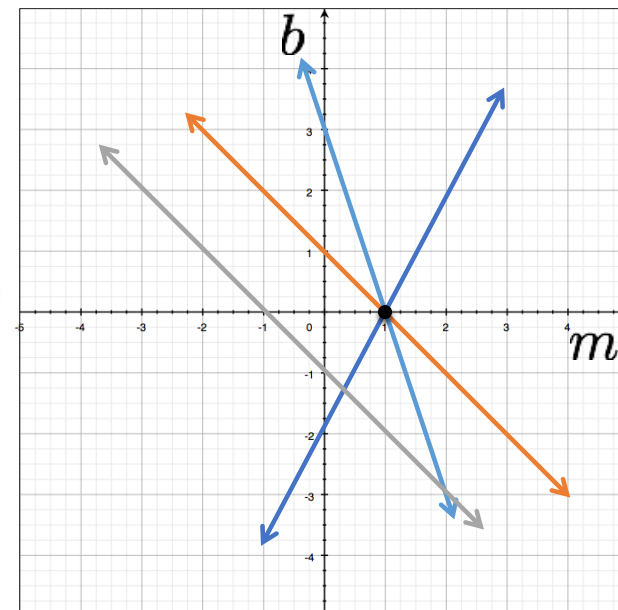


Image space

Cosa sono 4 punti?

$$y - mx = b$$

Diagram illustrating the equation $y - mx = b$. Green arrows point from the word "variabili" (variables) to y and m , and from the word "parametri" (parameters) to b .



Parameter space

Qual è la linea più compatibile con i dati?

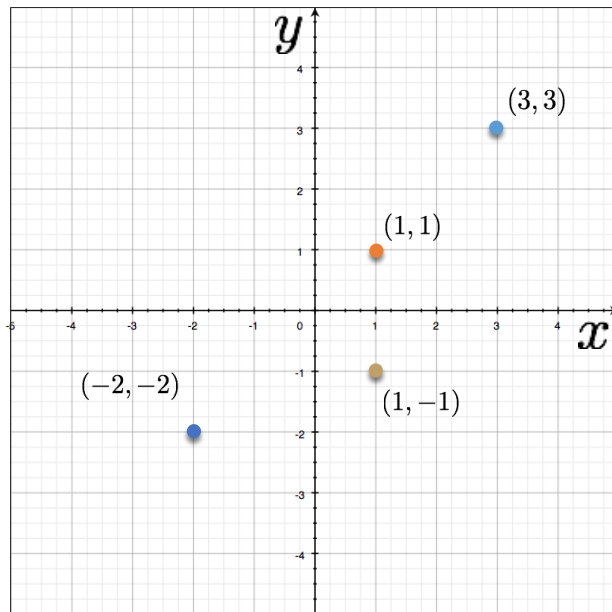
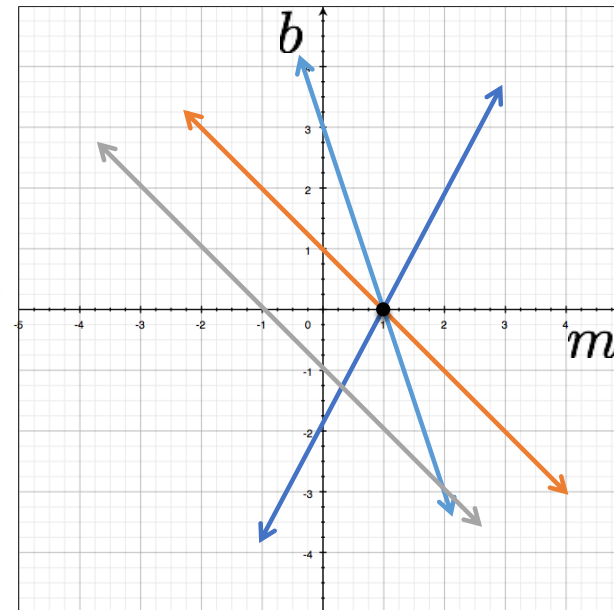


Image space



Parameter space

Tollerante al rumore?

Perché non va bene

- I parametri m e b hanno un range potenzialmente infinito
- Se dovessimo accumulare le incidenze, quanti accumulatori ci servirebbero?

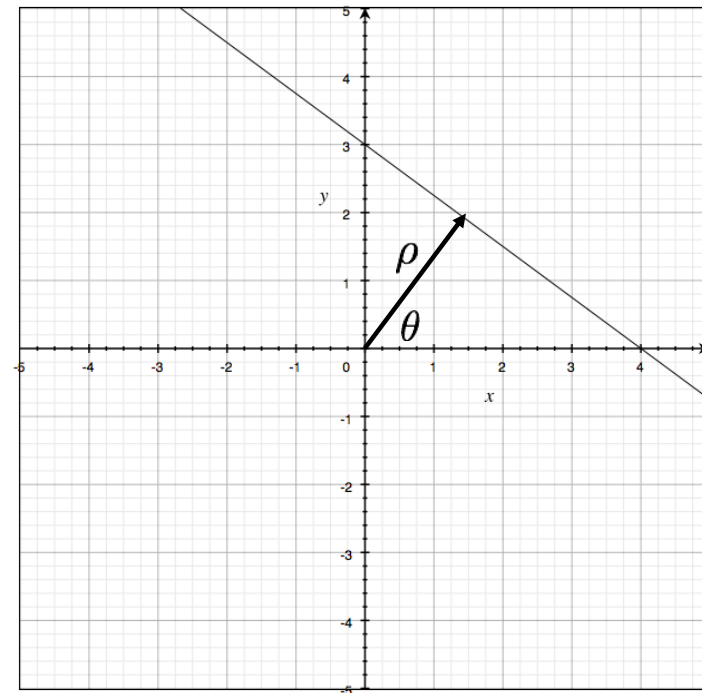
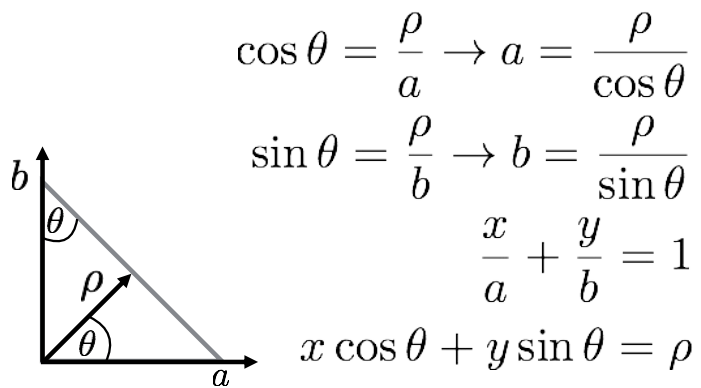
Coordinate polari

$$x \cos \theta + y \sin \theta = \rho$$

Cosa sono ρ e θ ?

Coordinate polari

$$x \cos \theta + y \sin \theta = \rho$$



Coordinate polari

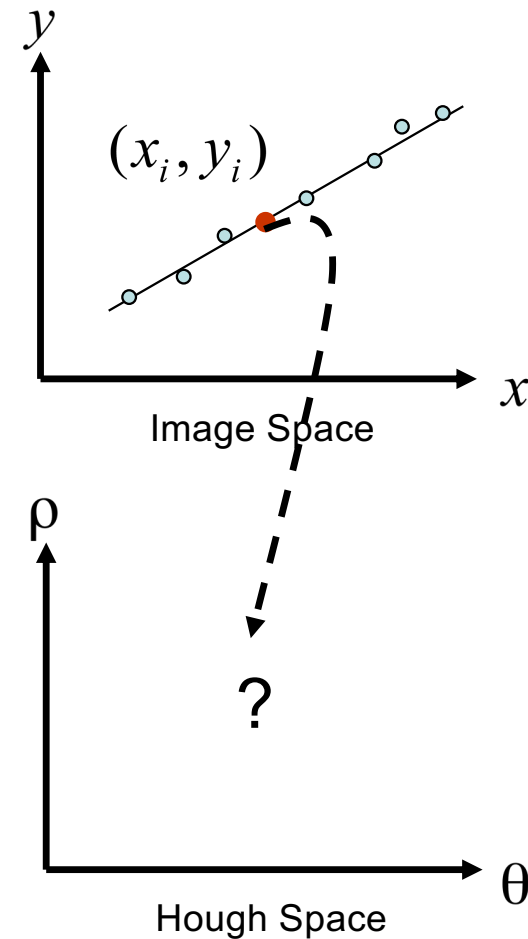
- Usiamo la forma normale

$$x \cos \theta + y \sin \theta = \rho$$

- Parametri con range controllabile

$$0 \leq \theta \leq 2\pi$$

$$0 \leq \rho \leq \rho_{\max}$$



Lo spazio dei parametri

variabili

$$y = mx + b$$

parametri

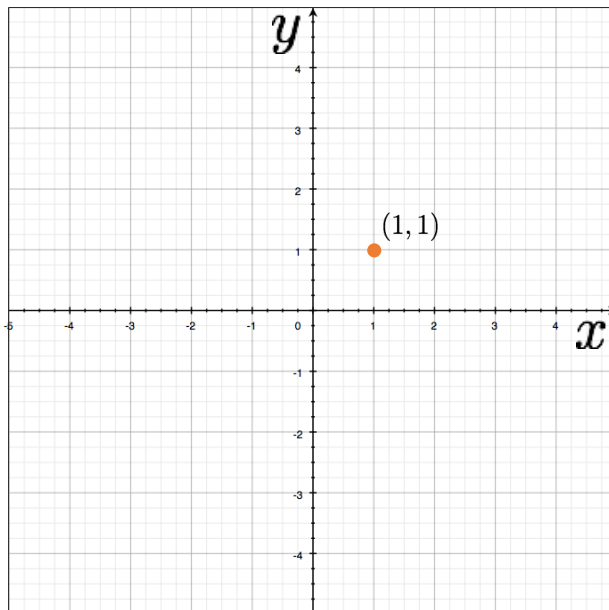


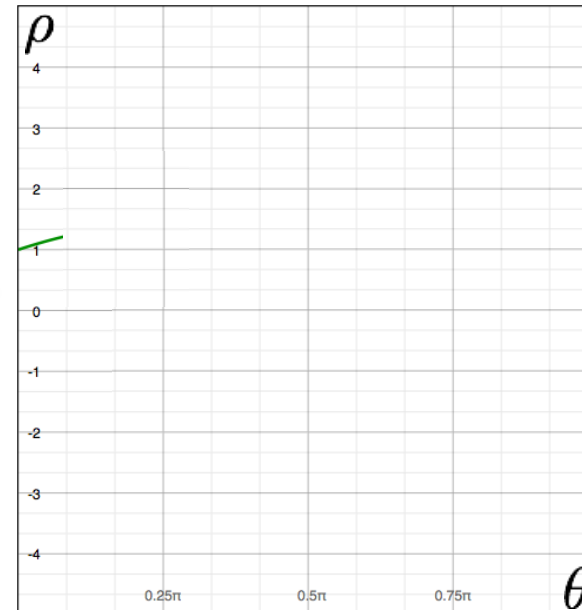
Image space

Cos'è un
punto?

parametri

$$x \cos \theta + y \sin \theta = \rho$$

variabili



Parameter space

Lo spazio dei parametri

variabili

$$y = mx + b$$

parametri

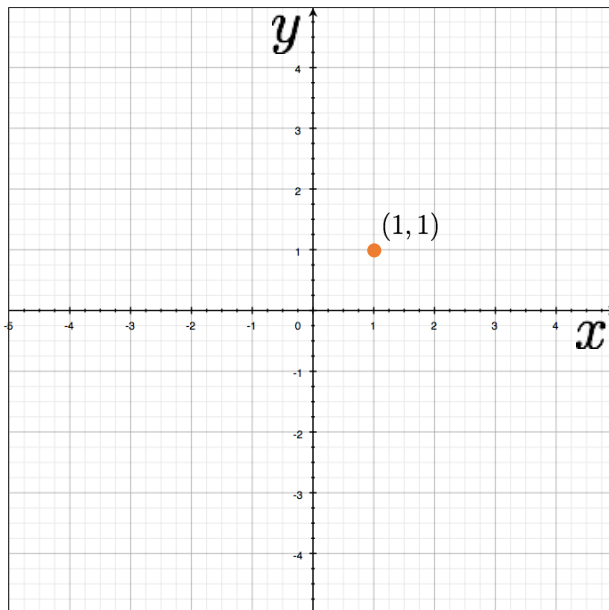


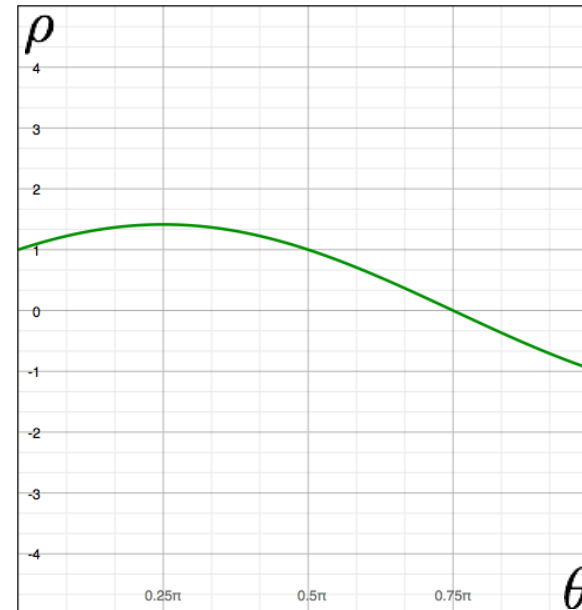
Image space

Un'onda

parametri

$$x \cos \theta + y \sin \theta = \rho$$

variabili



Parameter space

Lo spazio dei parametri

variabili

$$y = mx + b$$

parametri

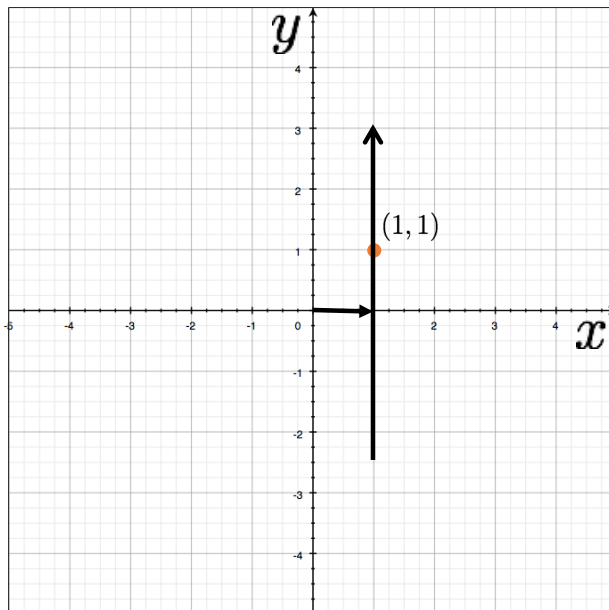


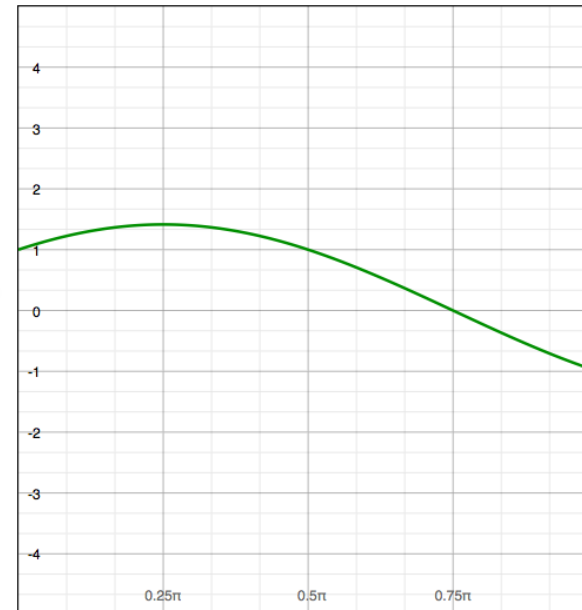
Image space

Cos'è una
linea?

parametri

$$x \cos \theta + y \sin \theta = \rho$$

variabili



Parameter space

Lo spazio dei parametri

variabili

$$y = mx + b$$

parametri

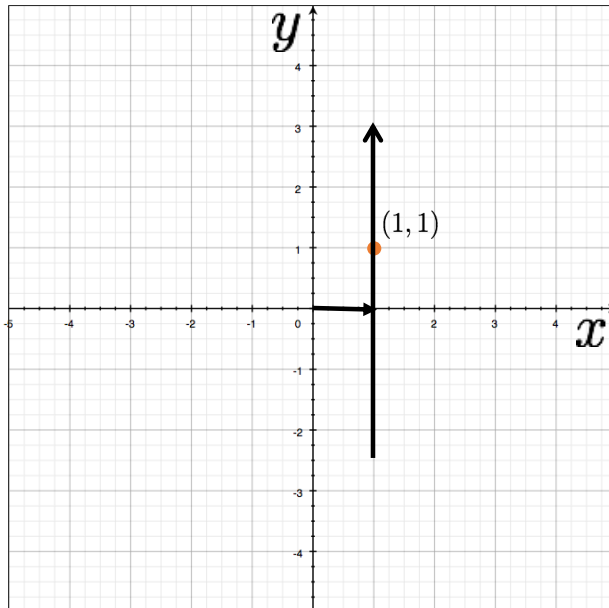


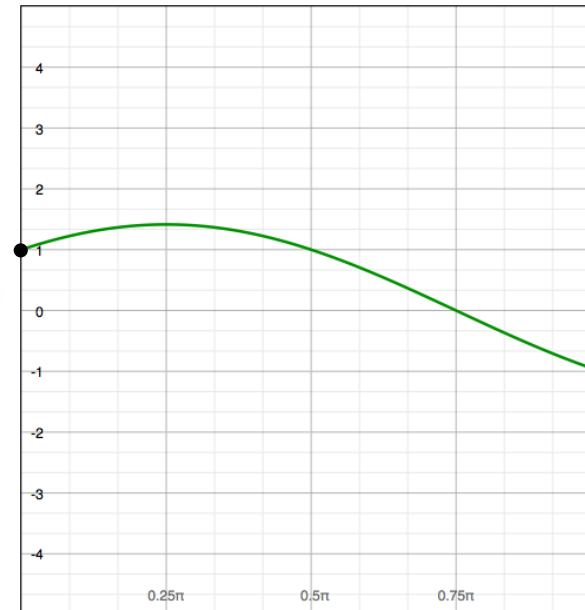
Image space

Una linea
diventa un
punto

parametri

$$x \cos \theta + y \sin \theta = \rho$$

variabili



Parameter space

Lo spazio dei parametri

variabili

$$y = mx + b$$

parametri

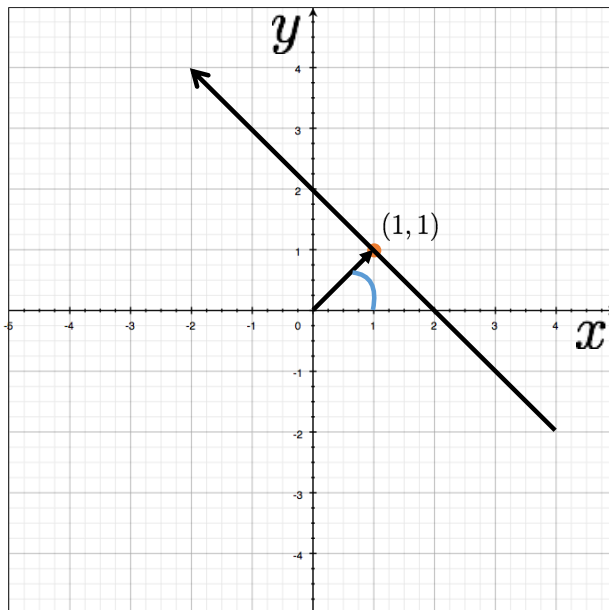


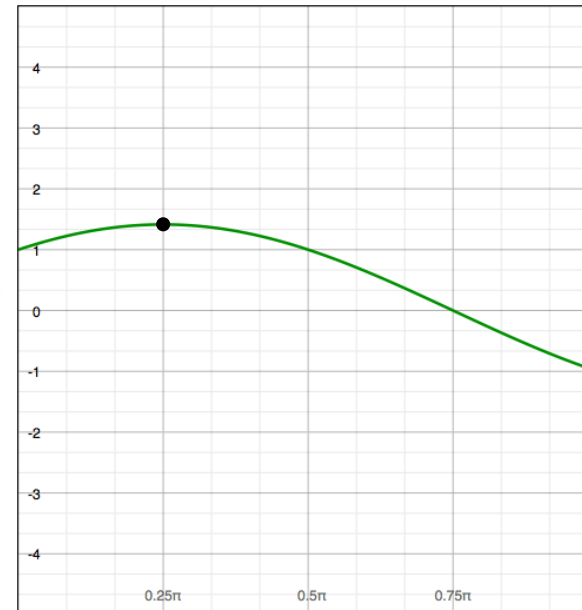
Image space

Una linea
diventa un
punto

parametri

$$x \cos \theta + y \sin \theta = \rho$$

variabili



Parameter space

Lo spazio dei parametri

variabili

$$y = mx + b$$

parametri

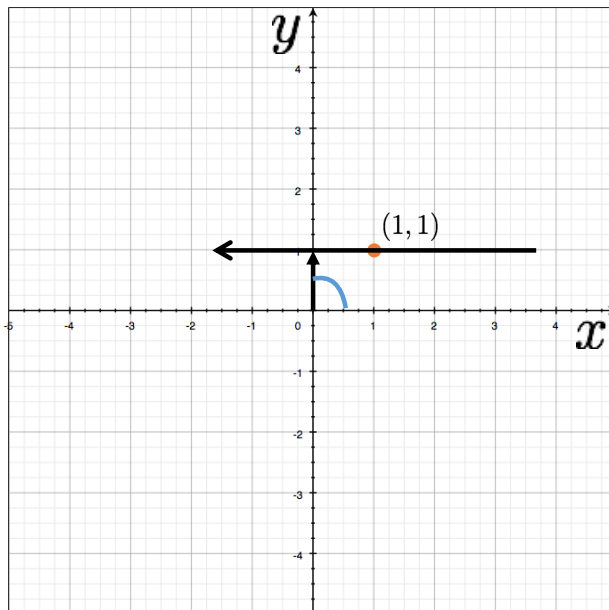


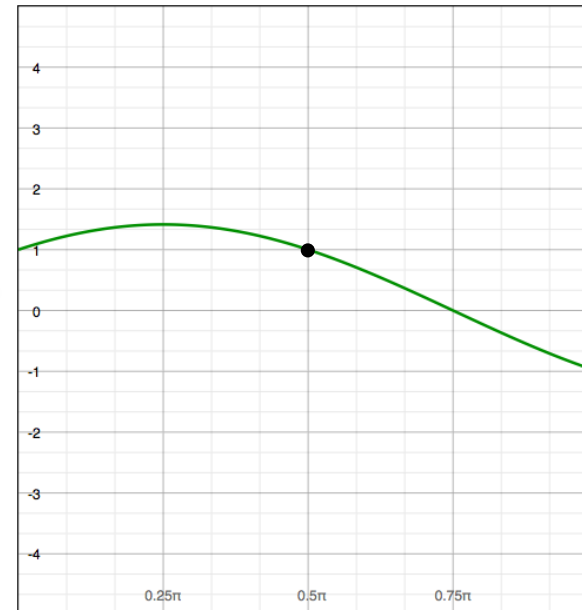
Image space

Una linea
diventa un
punto

parametri

$$x \cos \theta + y \sin \theta = \rho$$

variabili



Parameter space

Lo spazio dei parametri

variabili

$$y = mx + b$$

parametri

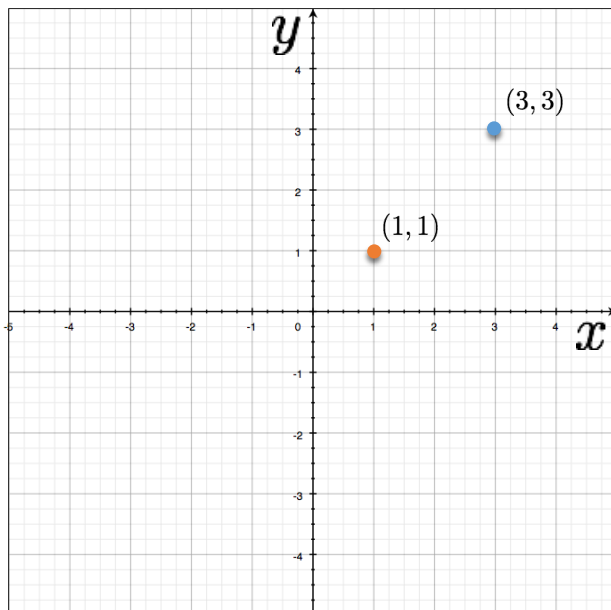


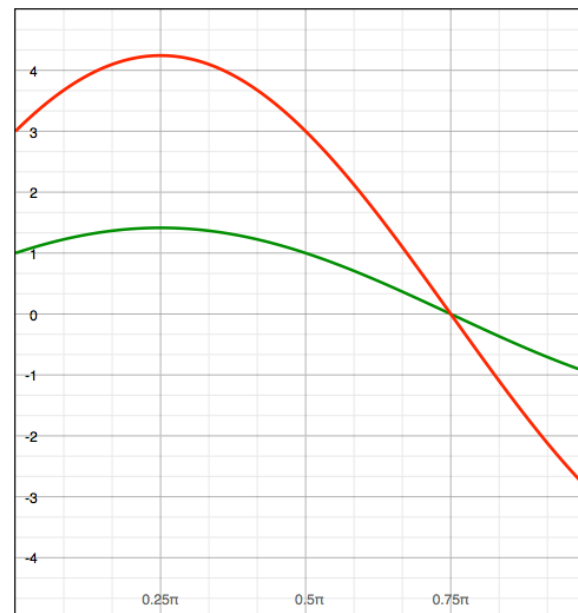
Image space

Due punti
diventano?

parametri

$$x \cos \theta + y \sin \theta = \rho$$

variabili



Parameter space

Lo spazio dei parametri

variabili

$$y = mx + b$$

parametri

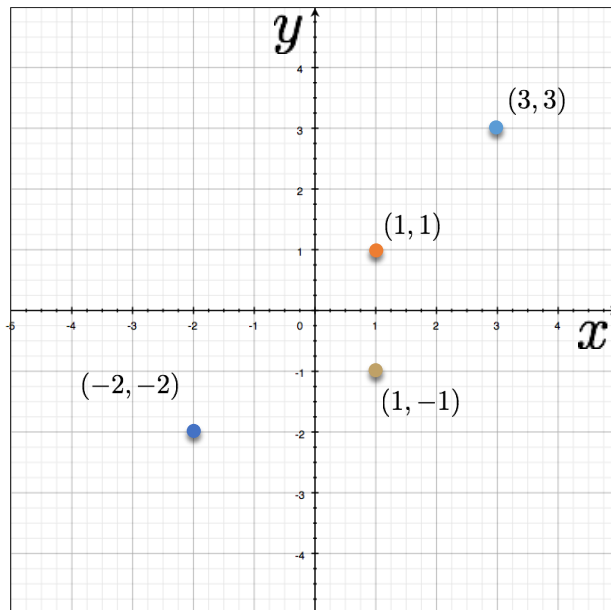


Image space

Quattro
punti
diventano?

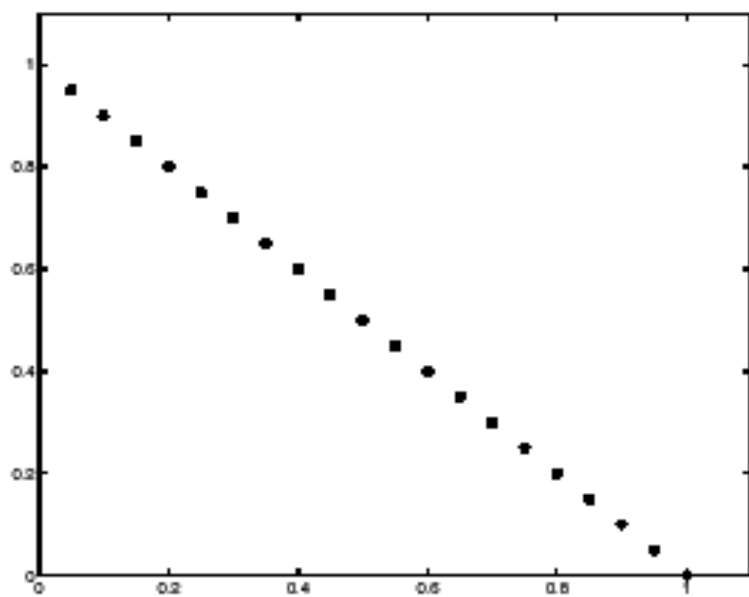
parametri

$$x \cos \theta + y \sin \theta = \rho$$

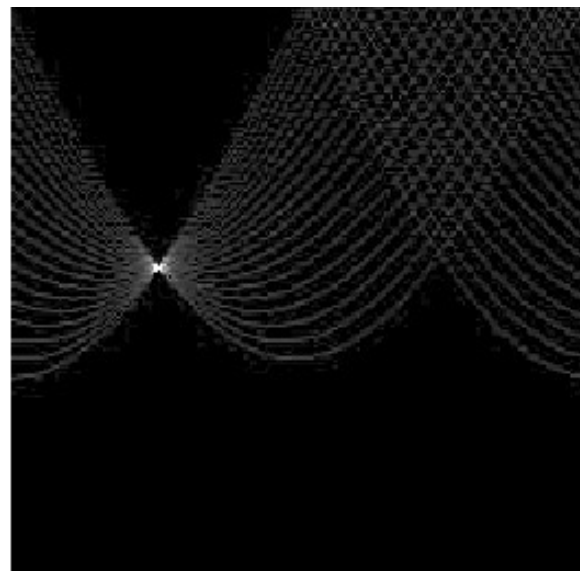
variabili



Parameter space

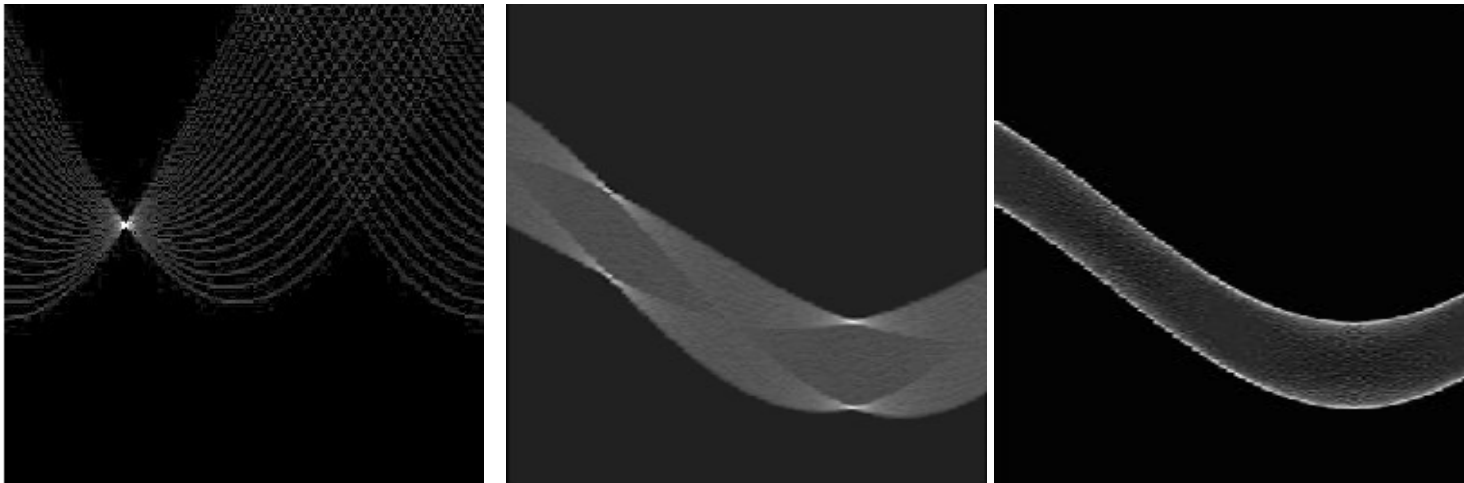


Immagine



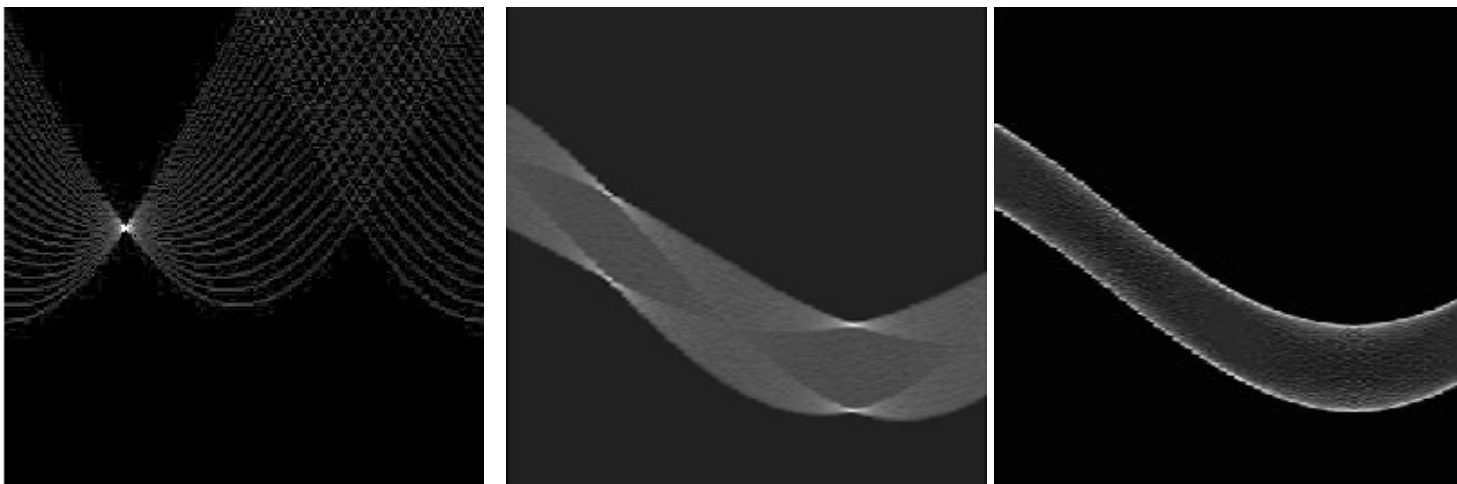
Voti

Lo spazio dei parametri



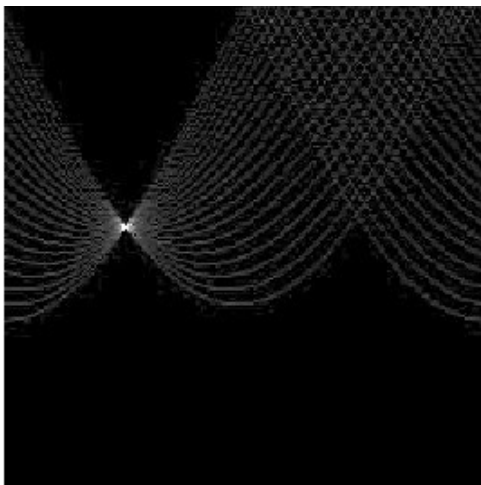
Qual è la forma?

Lo spazio dei parametri

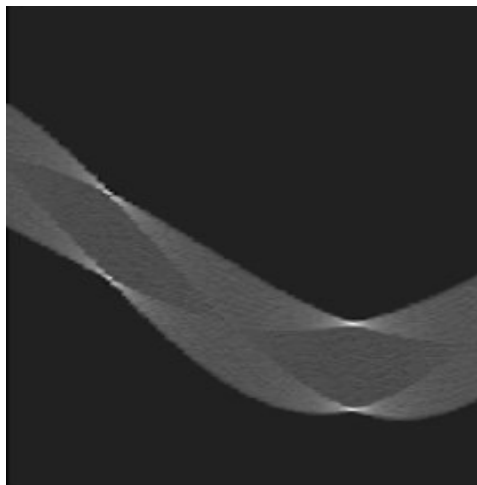


linea

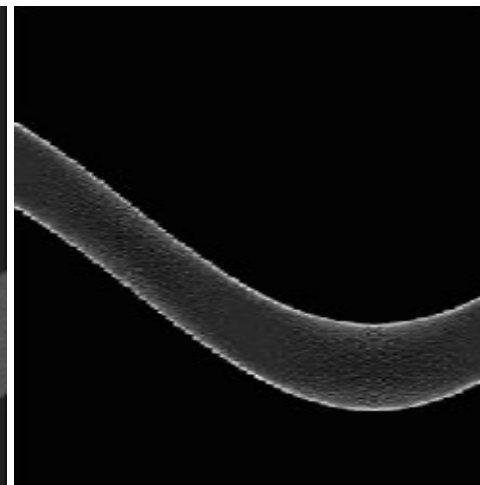
Lo spazio dei parametri



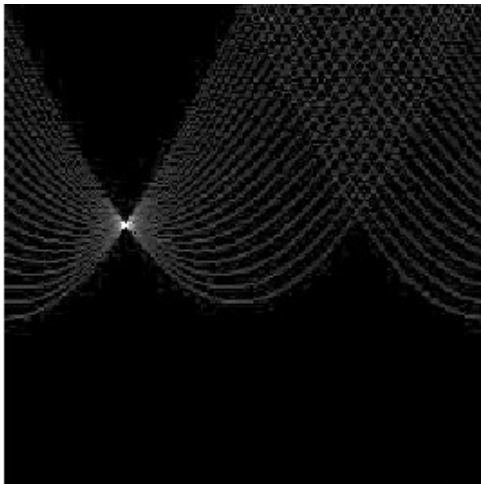
line



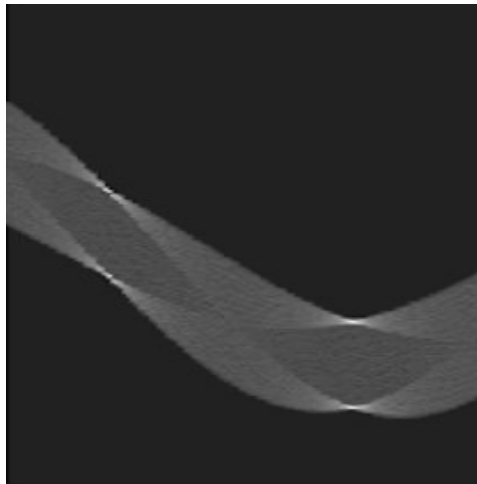
Rettangolo



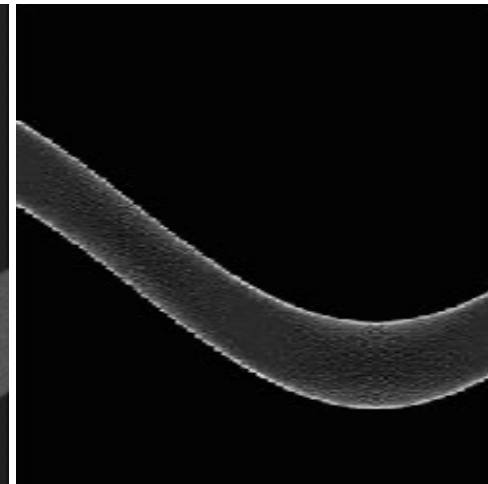
Lo spazio dei parametri



line



rectangle

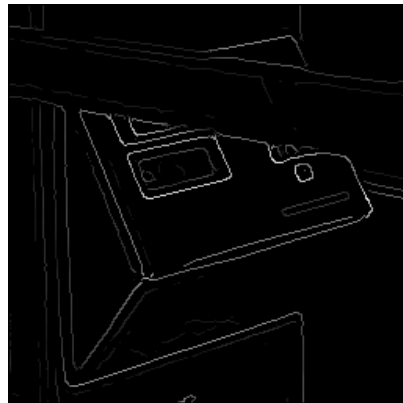


Cerchio

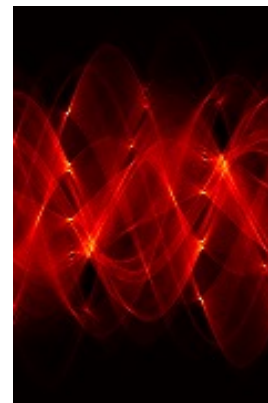
Esempio



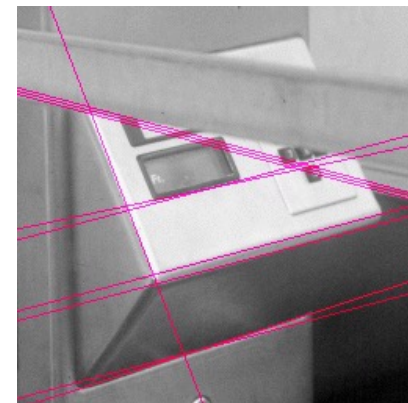
Original



Edges



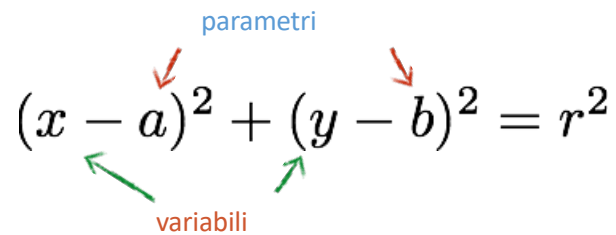
parameter space



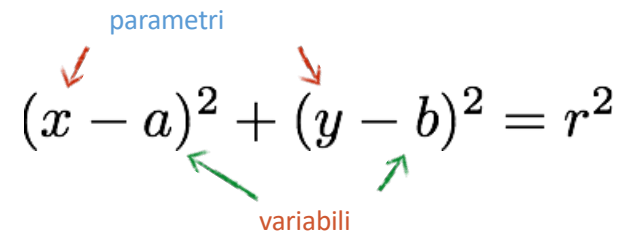
Hough Lines

Possiamo individuare cerchi direttamente?

- L'equazione del cerchio

$$(x - a)^2 + (y - b)^2 = r^2$$


The diagram shows the equation $(x - a)^2 + (y - b)^2 = r^2$. Above the equation, the word "parametri" is written in blue. Two red arrows point from "parametri" to the variables a and b . Below the equation, the word "variabili" is written in red. Two green arrows point from "variabili" to the variables x and y .

$$(x - a)^2 + (y - b)^2 = r^2$$


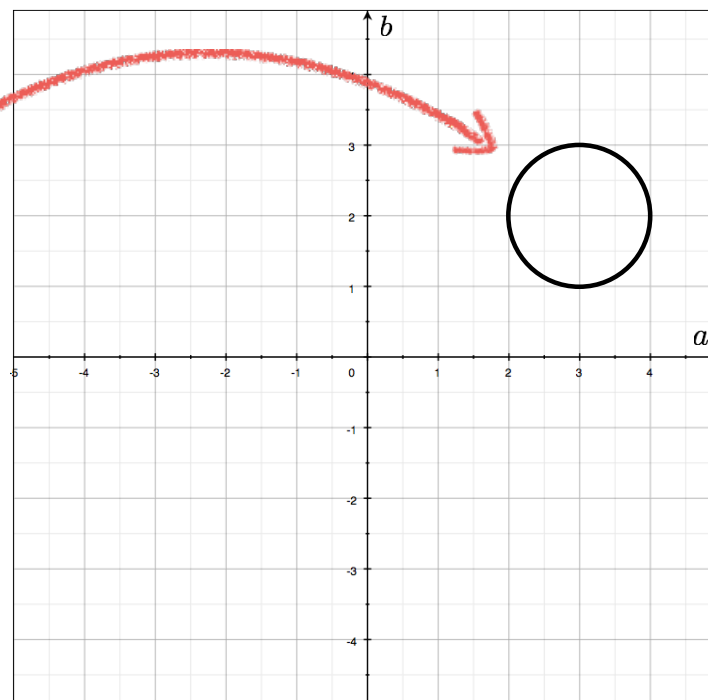
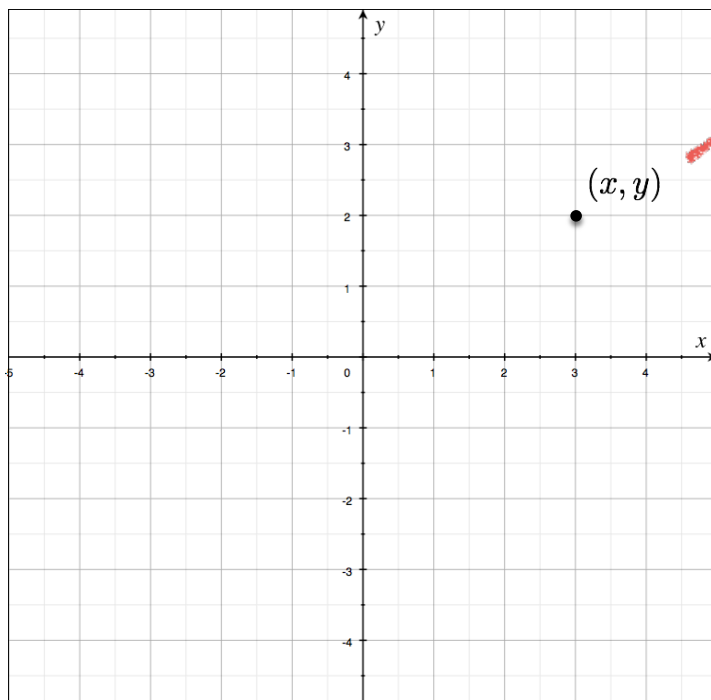
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$$(x - a)^2 + (y - b)^2 = r^2$$

parametri
variabili

$$(x - a)^2 + (y - b)^2 = r^2$$

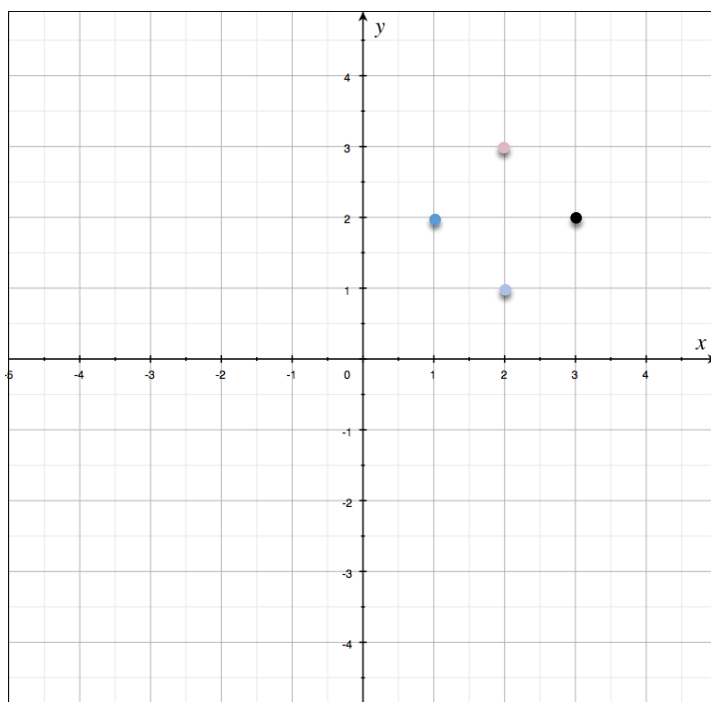
parametri
variabili



$$(x - a)^2 + (y - b)^2 = r^2$$

parametri

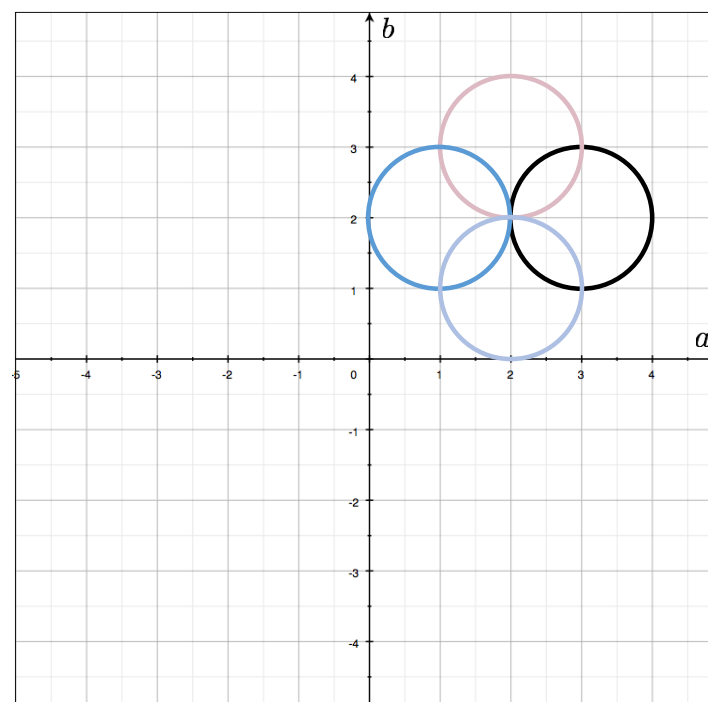
variabili

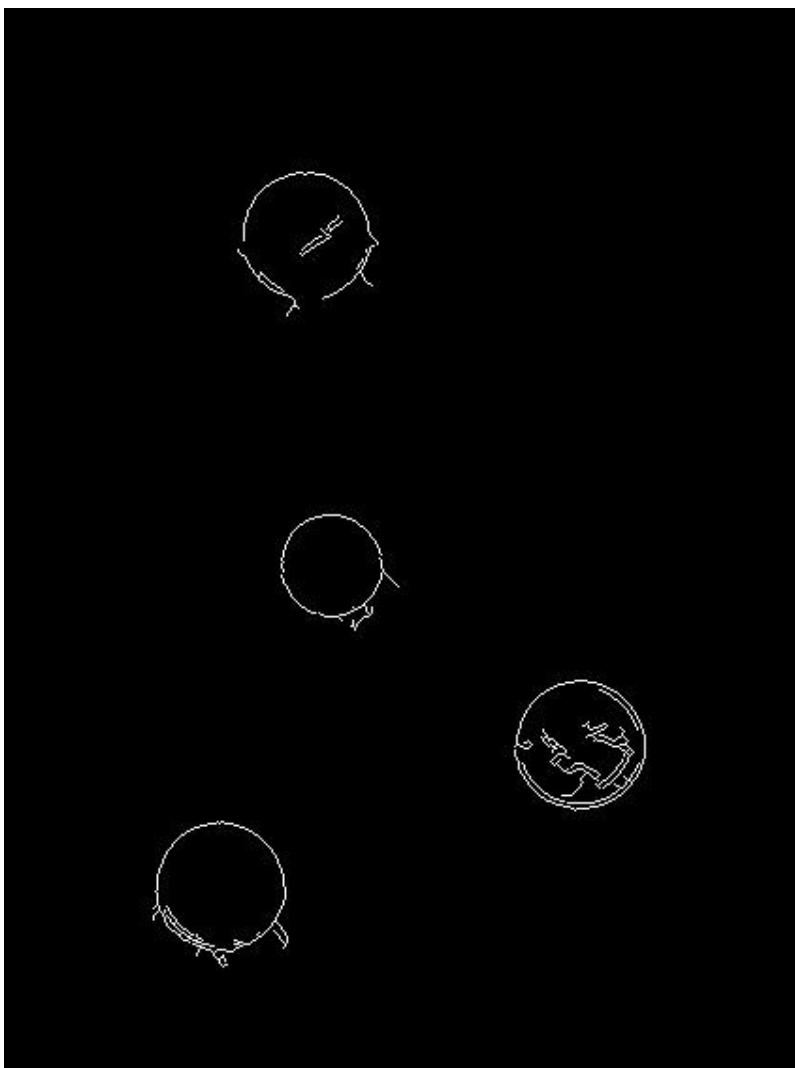
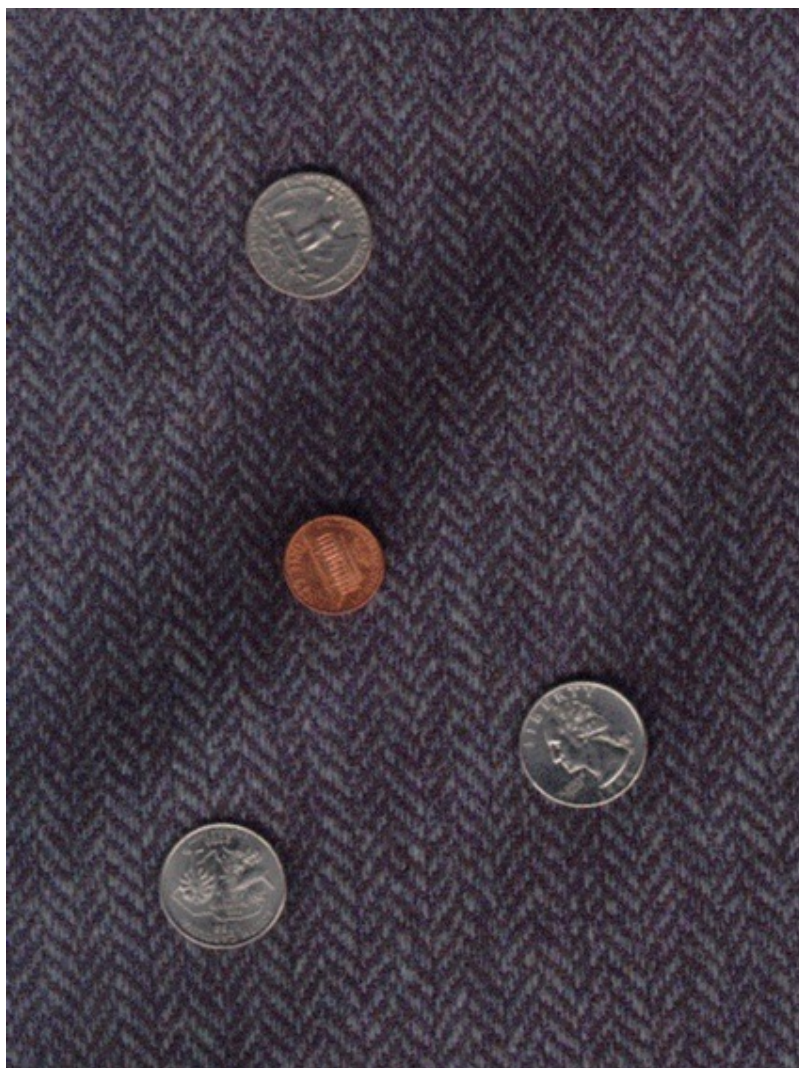


$$(x - a)^2 + (y - b)^2 = r^2$$

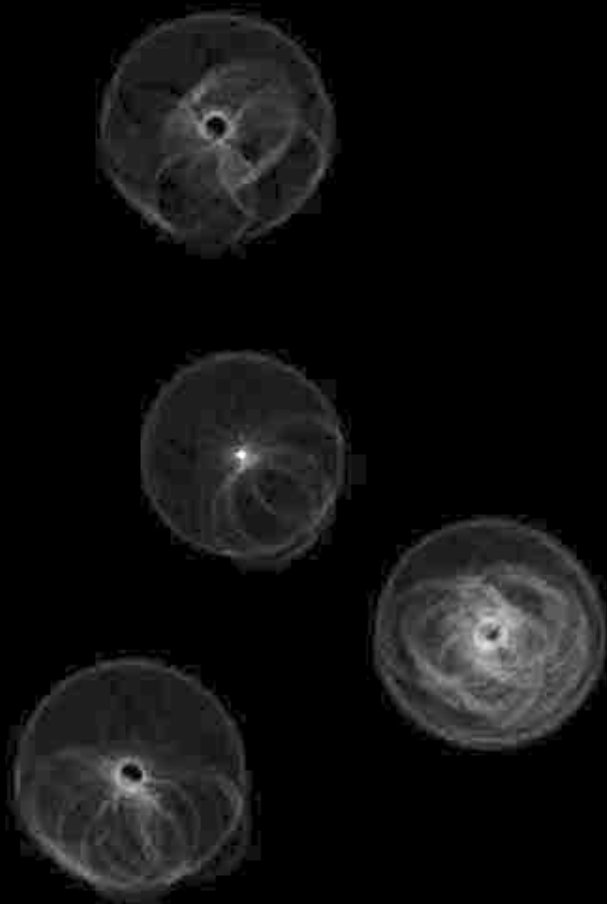
parametri

variabili





Raggio piccolo



Raggio grande

