

Digital Images summary

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2D data types: images



Spatial coordinates x, y .

2D data types: images

- **Still images/pictures:** spatial 2D signals of the form $f(x, y): \mathbb{R}^2 \rightarrow \mathbb{R}$, having:

- domain \mathbb{R}^2 and codomain \mathbb{R} .
- two spatial coordinates x, y .

- **Image sampling/digitization** transforms continuous coordinates images to **digital images**:

$$f(i, j): \mathbb{Z}^2 \rightarrow [0, \dots, 2^B - 1].$$

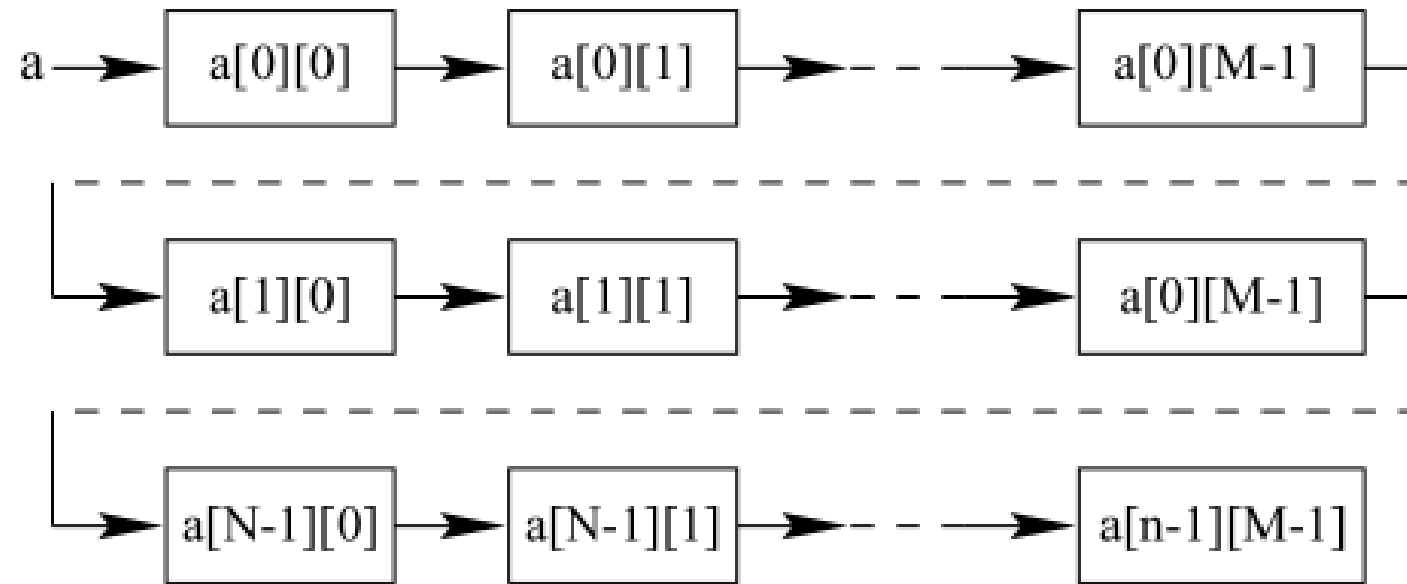
Digital Image Representation

Digital image representation by an $N \times M$ matrix \mathbf{i} :

$$\mathbf{i} = \begin{bmatrix} i(1,1) & i(1,2) & \dots & i(1,M) \\ i(2,1) & i(2,2) & \dots & i(2,M) \\ \vdots & \vdots & \dots & \vdots \\ i(N,1) & i(N,2) & \dots & i(N,M) \end{bmatrix}.$$

- Matrix elements (image pixels):
 - integers in the range $[0, \dots, 255]$ for 8 bit images.
 - unsigned character representation in the C language.

Digital Image Representation

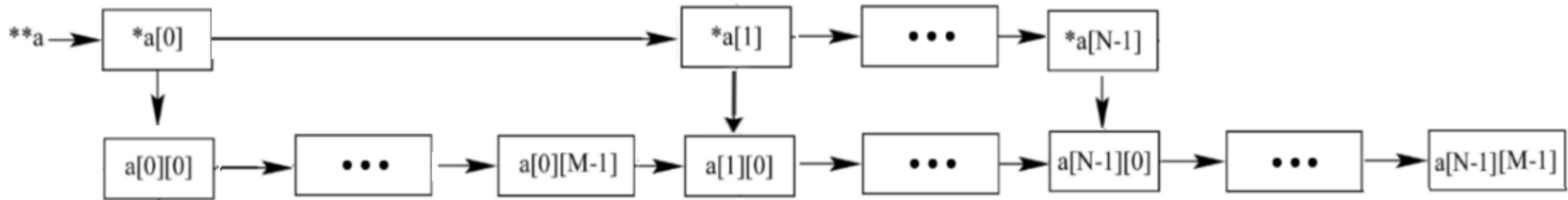


2D image storage.

Digital Image Representation

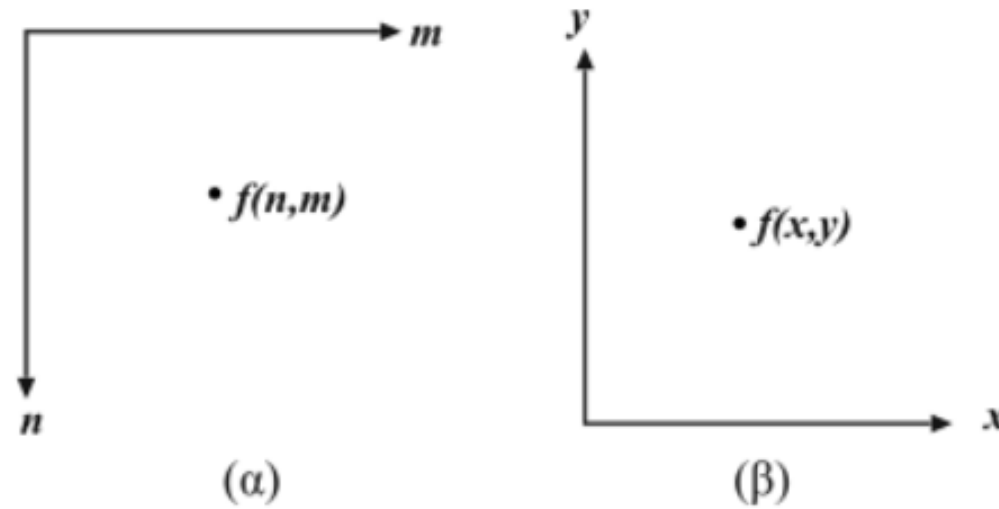
The entire two-dimensional array can be memory allocated in one memory block.

- Pointers point to image row first elements.



Single block image memory allocation.

Digital Image Representation



a) 2D matrix coordinates; b) Cartesian coordinates.

Elementary digital image processing operations

- Image addition, subtraction:

$$c[i][j] = a[i][j] \pm b[i][j].$$

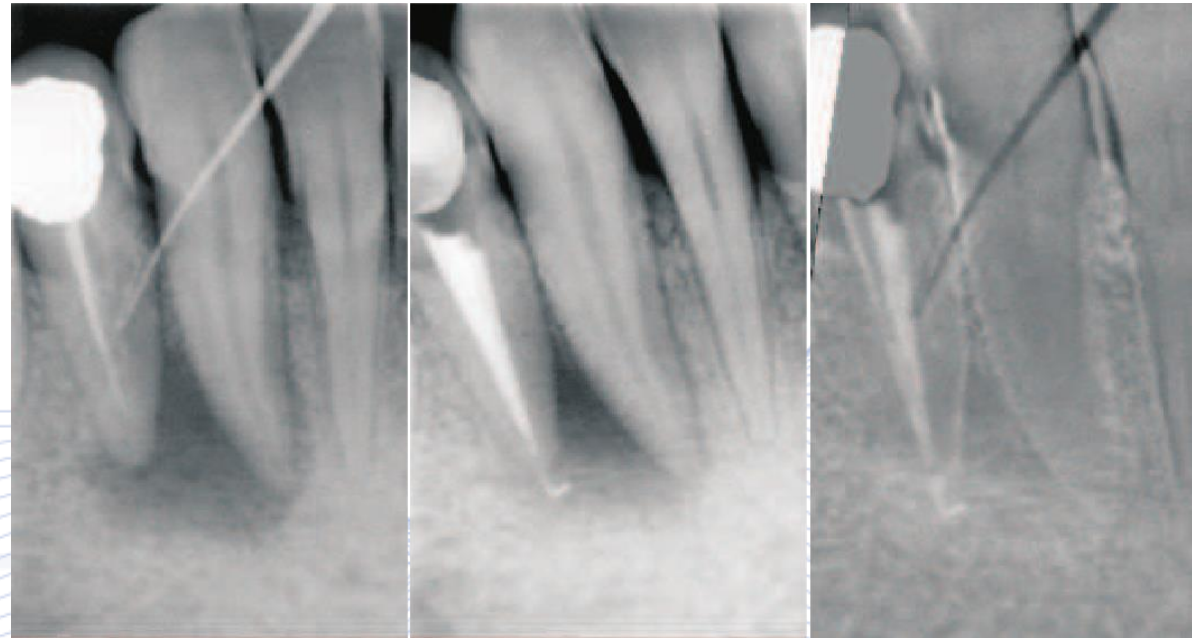
- Multiplication of an image by a constant:

$$b[i][j] = c \cdot a[i][j].$$

- Point nonlinear transformations of the form:

$$b[i][j] = h(a[i][j]).$$

Elementary digital image processing operations



Subtractive radiography (image registration and subtraction).

2D Image registration

- 2D image registration and mosaicking (averaging in overlapping parts).



Elementary digital image processing operations

- Clipping:

$$b[i][j] = \begin{cases} c_{max}, & \text{if } a[i][j] > c_{max}. \\ a[i][j], & \text{if } c_{min} \leq a[i][j] \leq c_{max}. \\ c_{min}, & \text{if } a[i][j] < c_{min}. \end{cases}$$

- It is needed to retain pixel values in the range $[0, \dots, 2^B - 1]$.
- Thresholding:

$$b[i][j] = \begin{cases} a_1, & \text{if } a[i][j] < T. \\ a_2, & \text{if } a[i][j] \geq T. \end{cases}$$

Elementary digital image processing operations



(a)



(b)

a) Original image; b) Image thresholding.

Elementary digital image processing operations

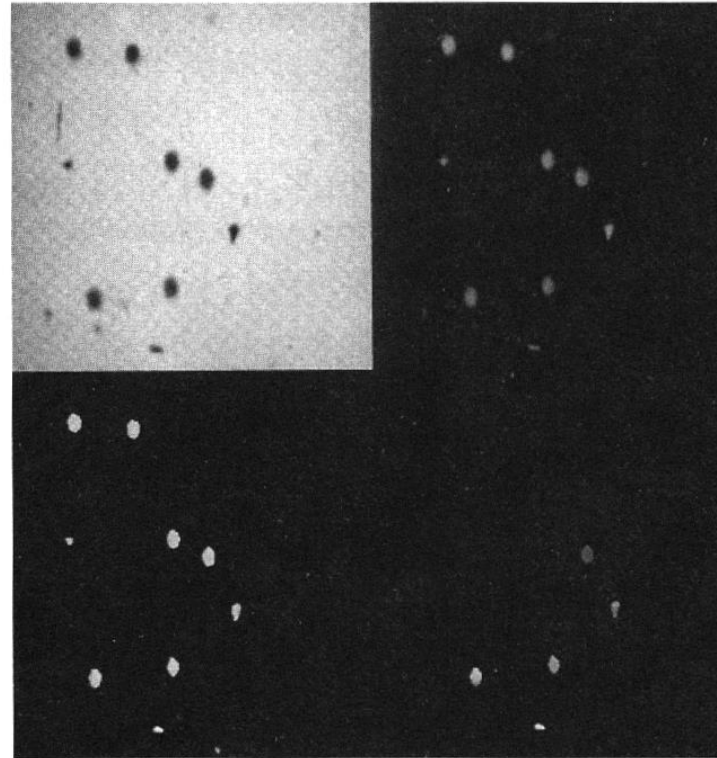


Image negation.

Elementary digital image processing operations

Geometric image transforms:

- **2D Image translation:**

$$b[i][j] = a[i + k][j + l].$$

- **2D Image rotation.** If the image point $a(x, y)$ is rotated by θ degrees, its new coordinates (x', y') are given by:

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}.$$

Elementary digital image processing operations

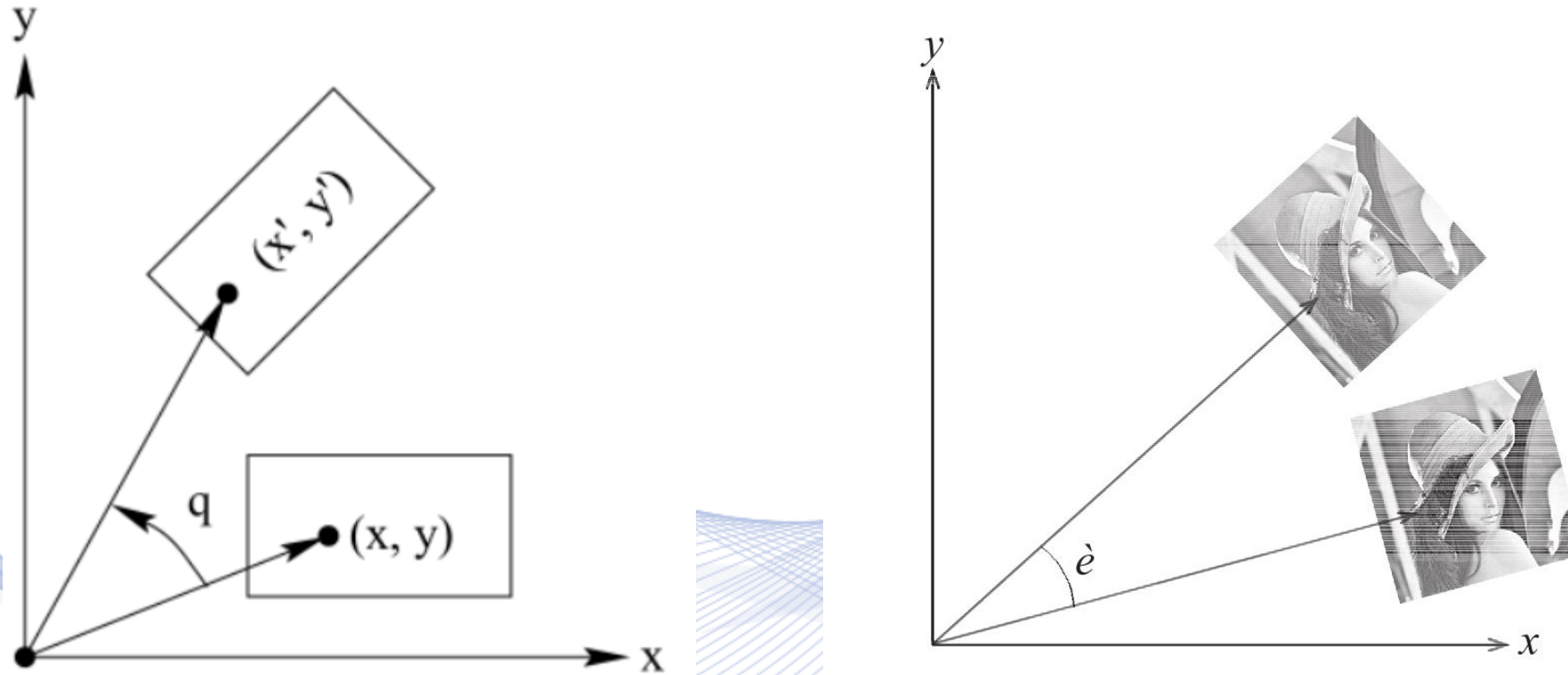


Image rotation.

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Q & A

Thank you very much for your attention!

**More material in
<http://icarus.csd.auth.gr/cvml-web-lecture-series/>**

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