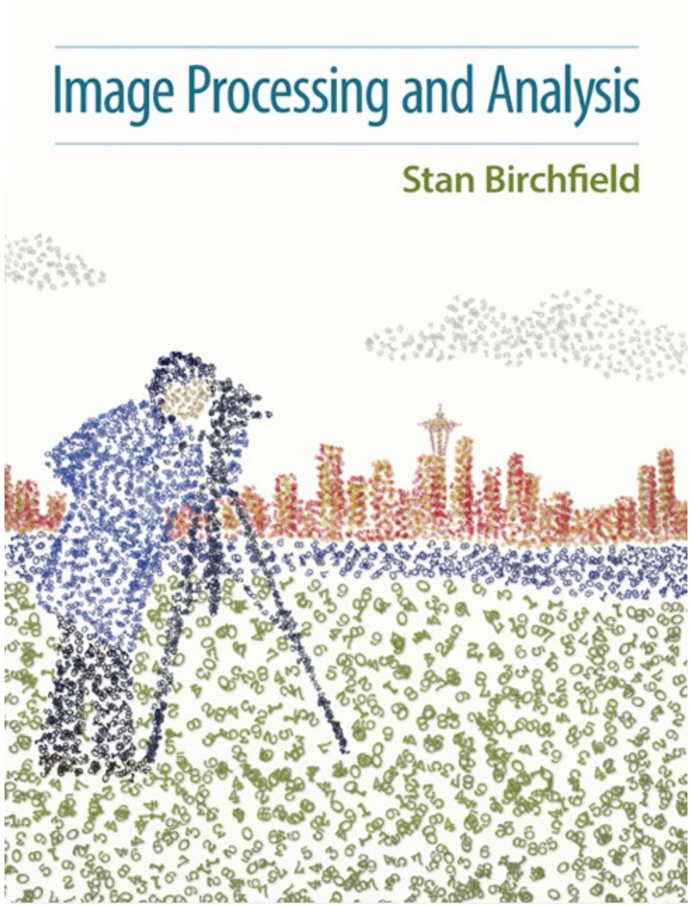
Prof. Kjersti Engan

ELE510 Image processing and computer vision

Point and geometric transformations, (chap 3 Birchfield) 2023

University of Stavanger



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Geometric and point operations (3.1-3.2)

Topic in three points:

1. What defines geometric operations on digital images?
2. What defines point operations on digital images?
3. Some examples of operators

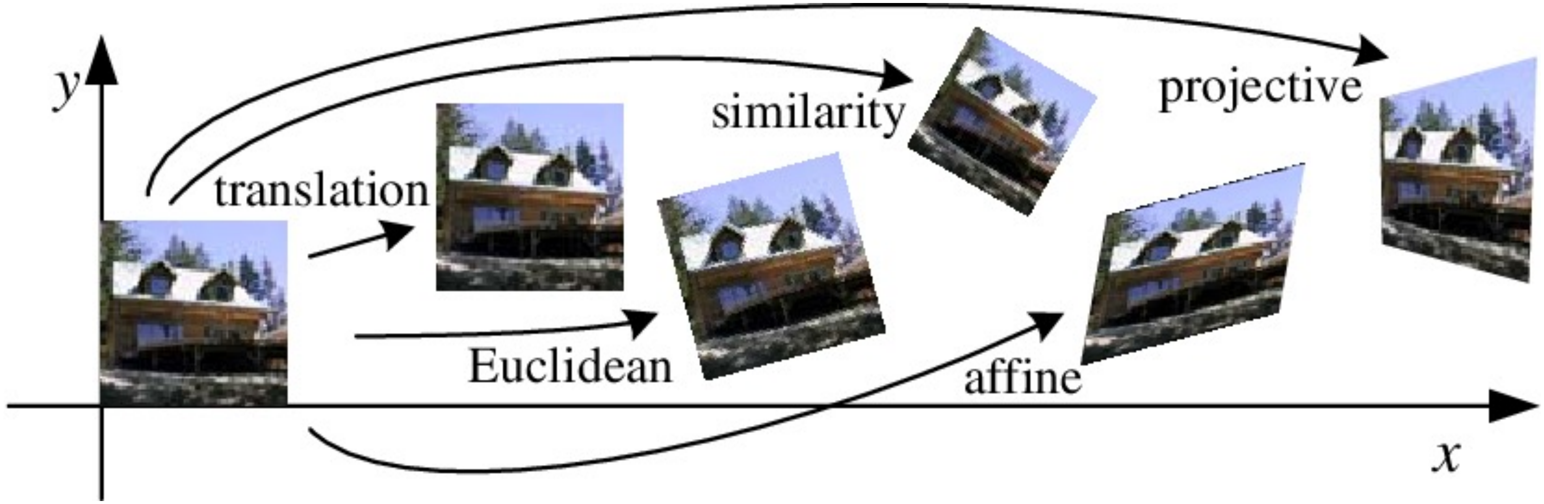
Geometric and point transformation (chap 3)

- Geometric transformations:
  - changing a pixels location without changing its value

- Point transformations:
  - change a pixels value without changing the location
  - Independent of pixel coordinates and values of other pixels

(3.1) Geometric transformations

- Simple geometric transformations: Output pixel only dependent on a single input pixel
- Changes a pixels location without changing its value



https://towardsdatascience.com/image-geometric-transformation-in-numpy-and-opencv-936f5cd1d315

(3.1) Geometric transformations

- Simple geometric transformations: Output pixel only dependent on a single input pixel
- Changes a pixels location without changing its value

- (x,y) : coordinates of input pixel. Input image : I(x,y)
- (x´,y´) : coordinates of output pixel. Output image :I´(x´,y´)

- Forward mapping: compute destination coordinates from source
- Invers mapping; compute source coordinates from destination – often preferred to be sure there are no ambiguities (not multiple answers to a destination coodrdinate).
- For some mappings (but not all) they are equivalent.

Flipping and flopping

- The simplest geometric transformation is to reflect the image about a horizontal or vertical axis passing through the center of the image.
  - If the axis is horizontal, the transformation **flips** the image upside down.
  - If the axis is vertical, the transformation **flops** the image to produce a right-to-left mirror image.

$$\begin{bmatrix} 128 & 78 & 174 \\ 181 & 48 & 77 \\ 109 & 49 & 138 \end{bmatrix} \xrightarrow{\text{FLOP}} \begin{bmatrix} 174 & 78 & 128 \\ 77 & 48 & 181 \\ 138 & 49 & 109 \end{bmatrix}$$

$\downarrow$ FLIP

$$\begin{bmatrix} 109 & 49 & 138 \\ 181 & 48 & 77 \\ 128 & 78 & 174 \end{bmatrix}$$

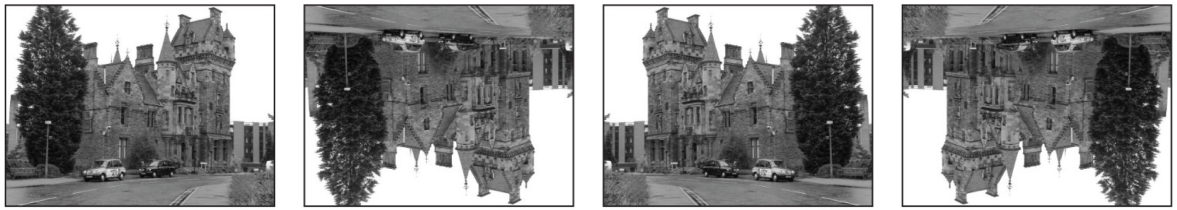


Image Flip Flop Flip-flop

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(x,y) : coordinates of input pixel. Input image : I(x,y)
(x´,y´) : coordinates of output pixel. Output image :I´(x´,y´)

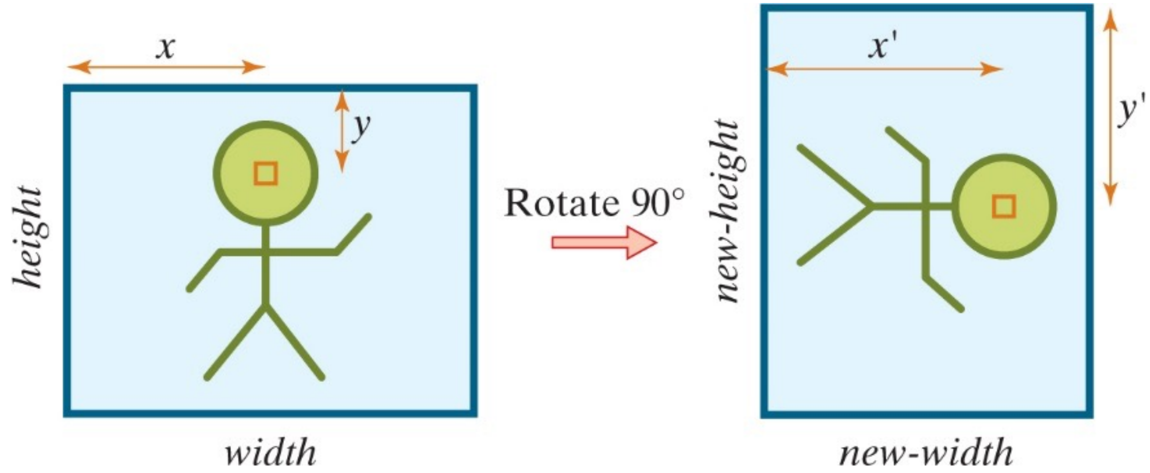
Forward mapping: relationship between I´ and I as a function of (x,y)
Inverse mapping: relationship between I´ and I as a function of (x',y')

Find Forward mapping flip – inverse mapping flip

Rotating by a multiple of 90 degrees

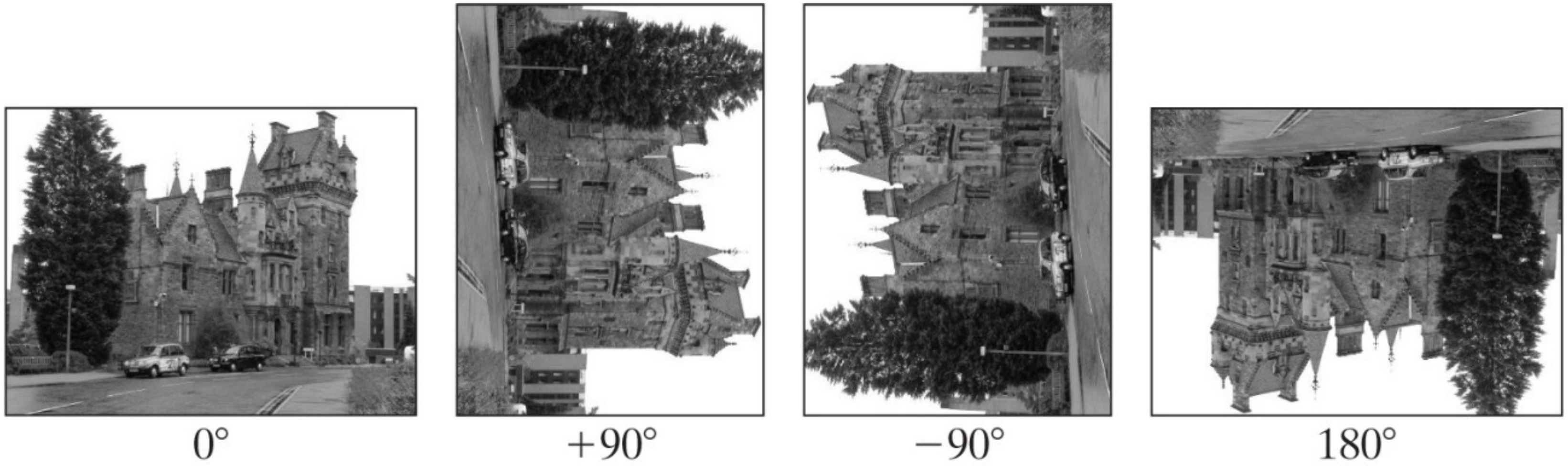
$$I'(height - 1 - y, x) = I(x, y) \qquad I'(x', y') = I(y', height - 1 - x')$$

Figure 3.4 To rotate an image clockwise by 90 degrees, the pixel (x, y) in the input image is mapped to (x', y') in the output image. From the drawing, it is easy to see that $x' = new\text{-}width - 1 - y = height - 1 - y$, and $y' = x$.



Rotating by a multiple of 90 degrees

Figure 3.3 An image rotated by 0, +90, −90, and 180 degrees.



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Cropping an Image

Figure 3.5 An image and an automobile cropped out of the region of the image indicated by the red rectangle.

ALGORITHM 3.4 Crop an image

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CropImage(I, left, top, right, bottom)

Input:  image I, rectangle with corners (left, top) and (right−1, bottom−1)
Output: cropped image I′ of size new-width × new-height

new-width ← right − left
new-height ← bottom − top
I′ ← AllocateImage(new-width, new-height)
for (x′, y′) ∈ I′ do
   I′(x′, y′) ← I(x′ + left, y′ + top)
return I′
```

Downsampling and upsampling

- **Downsample** an image to produce a smaller image than the original (should be smoothed first):

$$I'(x, y) = I(2x, 2y) \qquad \text{(downsample by two)}$$

- **Upsample** an image to produce a larger image than the original (interpolation should be done):

$$I'(x, y) = I\left(\left\lfloor \frac{x}{2} \right\rfloor, \left\lfloor \frac{y}{2} \right\rfloor\right) \qquad \text{(upsample by two)}$$

Figure 3.6 LEFT: An image and the result of downsampling by a factor of 2 and 4, respectively, in each direction. RIGHT: A cropped region and the result of upsampling by a factor of 2 and 4, respectively, in each direction.