Images

Course: Computer Vision

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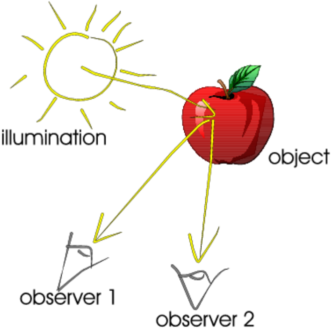
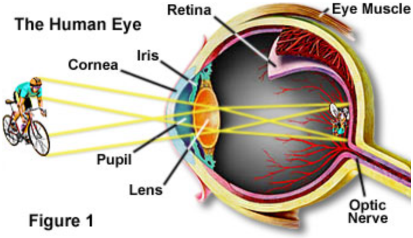
Outline

Light reflection

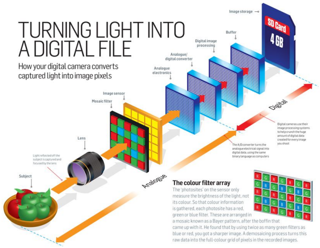
- At the surface of an object, light is reflected in all directions.
- A few beams might hit on sensors (eye, film, CMOS, CCD).

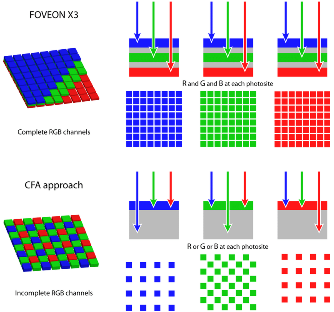




Capturing light

There different types of sensors.





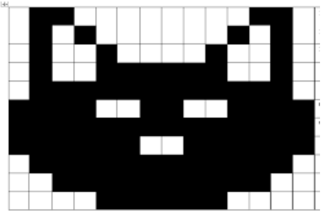
Regardless, we often think of images as a 3-dimensional array.

$$[nrows \times ncols \times nchannels]$$

Outline

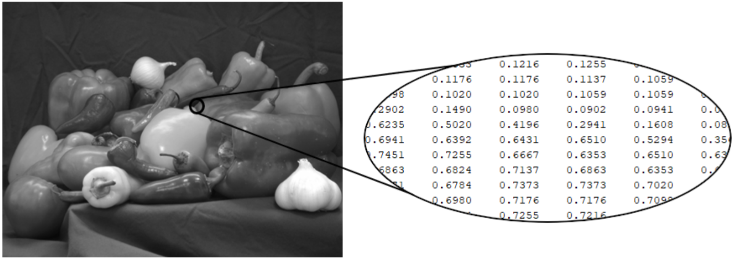
Binary images

Shape: $[nrows \times ncols \times 1]$.
Each pixel has a value of either 0 or 1.
Light vs no-light.



Gray-scale images

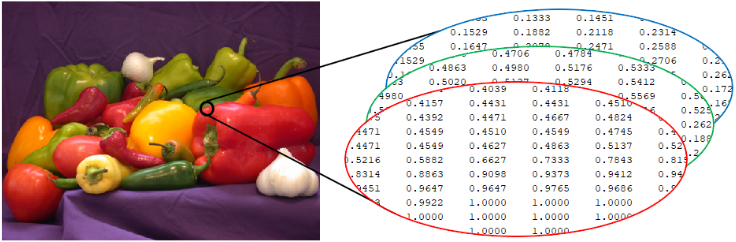
Shape: $[nrows \times ncols \times 1]$.
Each pixel has a real value between 0 and 1.
Amount (intensity) of light.



Most commonly used in computer vision.

Color images

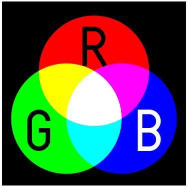
Shape: $[nrows \times ncols \times 3]$.
Each pixel is a vector of length 3 (red, green and blue channels).
Each element on a vector has a real value between 0 or 1.
(or an integer value between 0 and 255).
Amount of light withing a range of the visible spectrum.

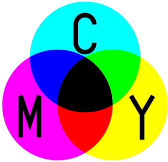


Often used in recent applications based on deep learning methods.

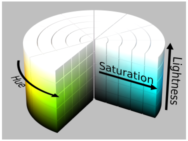
Other color spaces

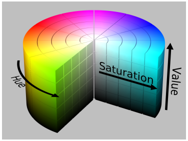
RGB and CMYK



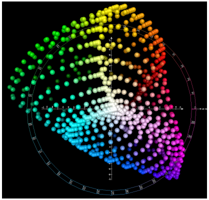


HSL and HSV





CIELab



rgb2gray conversion

Convert RGB images (I^C) into gray-scale space (I^G).

$$I^G(y,x) = \frac{I^C(y,x,R) + I^C(y,x,G) + I^C(y,x,B)}{3}$$

Weighted method (more precise):

$$I^G(y,x) = 0.3I^C(y,x,R) + 0.59I^C(y,x,G) + 0.11I^C(y,x,B)$$

Q: Can we go back?

gray2bw conversion

Convert gray-scale images (I^G) into binary space (I^B).

$$I^B(y,x) = I^G(y,x) > \tau$$

where τ is a threshold to be adjusted.

Q: Can we go back?

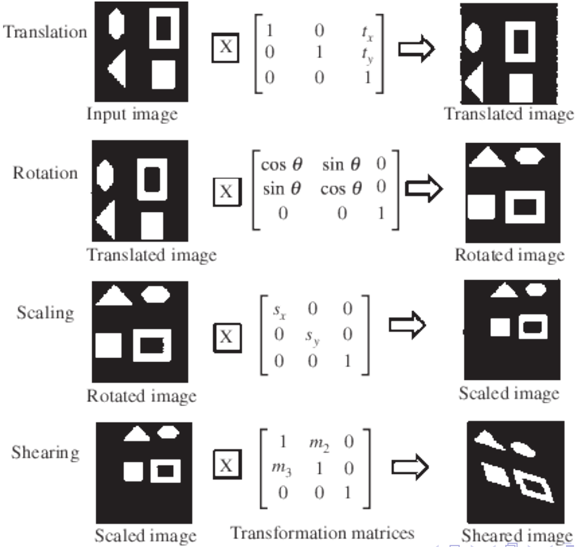
Outline

Intro

Image transforms are commonly applied through the use of:

- Homogeneous coordinates.
- 3-by-3 transform matrices.

Affine


Translation
Input image
X
1 0 t_x
0 1 t_y
0 0 1
Translated image
Rotation
Translated image
X
cos θ sin θ 0
sin θ cos θ 0
0 0 1
Rotated image
Scaling
Rotated image
X
s_x 0 0
0 s_y 0
0 0 1
Scaled image
Shearing
Scaled image
X
1 m_2 0
m_3 1 0
0 0 1
Sheared image
Transformation matrices

Shifting (translate)

Consider a triangle whose vertices are

$$X = \begin{bmatrix} 0 & 3 & 4 \\ 0 & 5 & 2 \end{bmatrix},$$

using the matrix transform T, we can move the triangle as follows,

$$T = \begin{bmatrix} -3 & -3 & -3 \\ -1 & -1 & -1 \end{bmatrix}, \qquad X + T = \begin{bmatrix} -3 & 0 & 1 \\ -1 & 4 & 1 \end{bmatrix}.$$

Or,

$$x' = \bar{x} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ tx & ty & 1 \end{bmatrix},$$

where, $\bar{x}$ is the homogeneous coordinate representation of x, and tx and ty are the translation units in the horizontal and vertical directions, respectively.

Identity

The trivial case is the identity transform.

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

Just yielding a copy of the input image.

Reflection

Mirrored image.

About x-axis

$$\begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

About y-axis

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Resize

Downscale or upscale.

$$\begin{bmatrix} sx & 0 & 0 \\ 0 & sy & 0 \\ 0 & 0 & 1 \end{bmatrix},$$

where, sx and sy are the scaling factors for the x and y axis, respectively.

Skew

Skew transform.

$$\begin{bmatrix} 1 & yk & 0 \\ xk & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix},$$

where, xk and yk are the distortion factors for the x and y directions, respectively.

Rotation

Rotation by an angle θ.

$$\begin{bmatrix} \cos(\theta) & \sin(\theta) & 0 \\ -\sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

Non-affine

Change of perspective.

$$\begin{bmatrix} sx & kx & p0 \\ sy & ky & p1 \\ tx & ty & p2 \end{bmatrix},$$

where,pn represents the change of perspective across n-th axis.

Outline

Operations

- Addition.
- Mean.
- Subtraction.

See code.

Recap

- Image formation.
- Color spaces.
- Transforms.
- Operations.

Q&A

Thank you!

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