Practical AI: Classic computer vision with OpenCV. Image processing

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Agenda

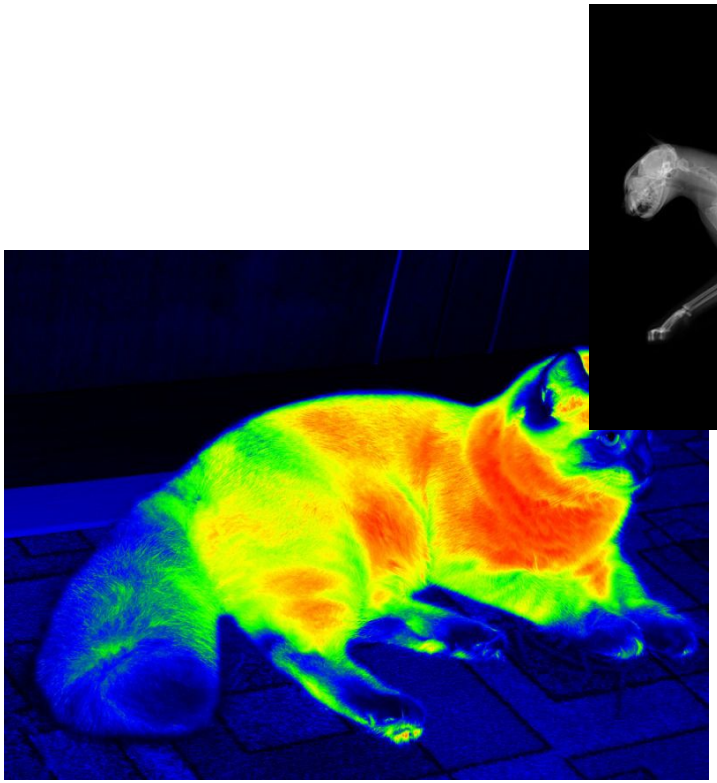
- What is **vision**
  - What is **image**
- Camera
- How to play with images
- What is noise

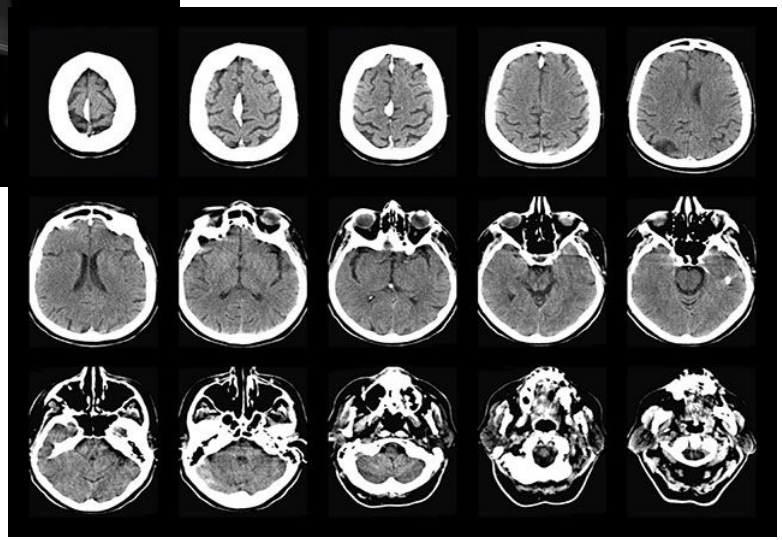
Vision and images

Vision

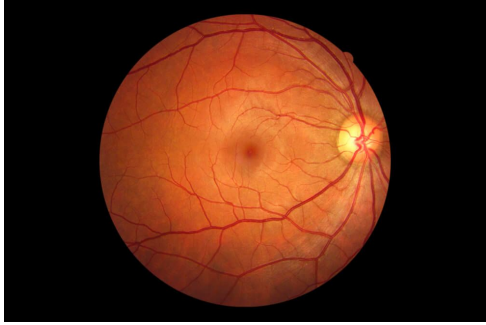
Vision is a sensor system, that receives information using **electromagnetic waves** [of visible spectrum].

In general, X-ray, infrared and CT and can be considered as vision.

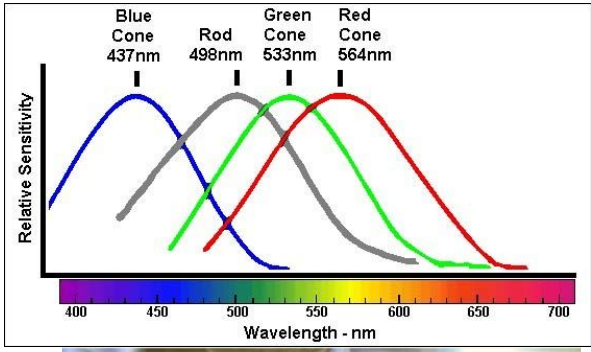




Human vision

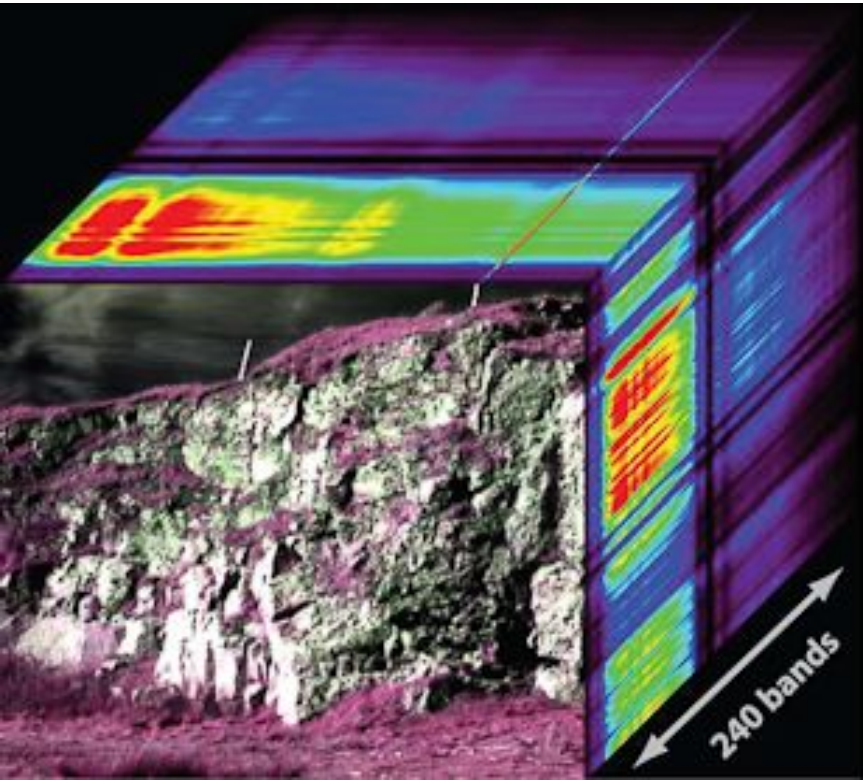


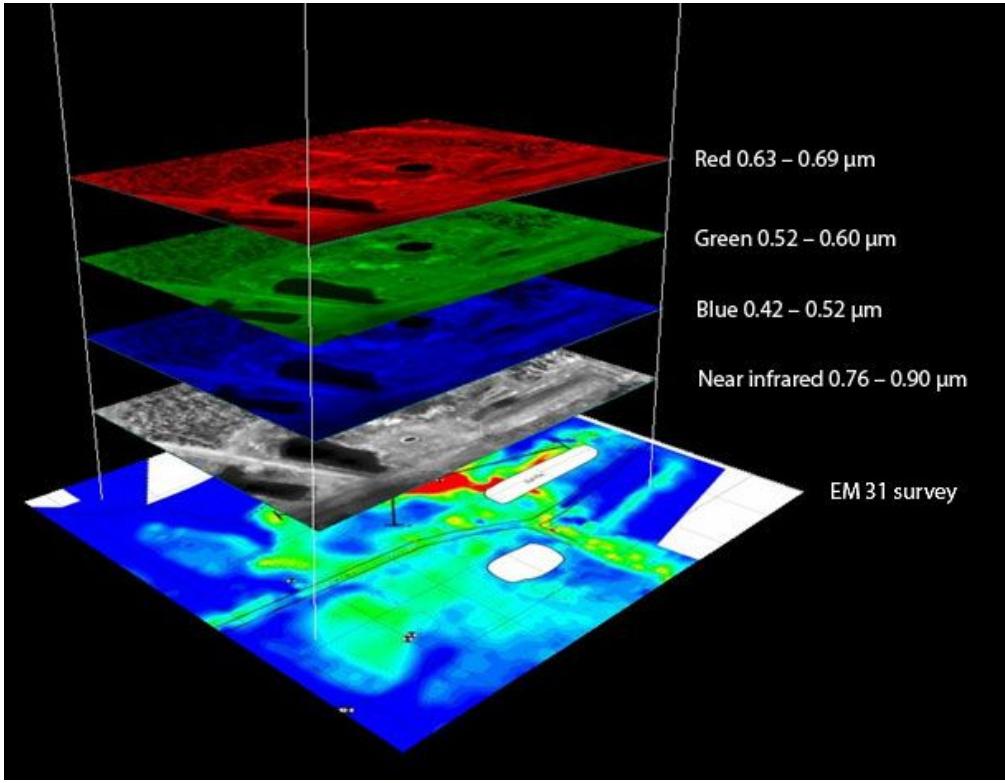
Major facts about vision:



- **Binocular** — allows restore 3D information
- **Retina** — discrete
- **Color** — quantized
  - 4 types of sensor cells:
    - S,M,L-*cone* cells
    - *Rod* cells
- Polarization and phase insensitive
- Supports **focus**
- **Opponent**-process theory and
- **Color constancy**
  - Brain process differences of colors

Multi- and hyperspectral images





What is digital image

Digital image is a *quantized* and *discrete* vector field (similar to human vision). Each vector component describes:

- How much **energy is reflected** in particular spectrum
  - Images, infrared images, ...

OR

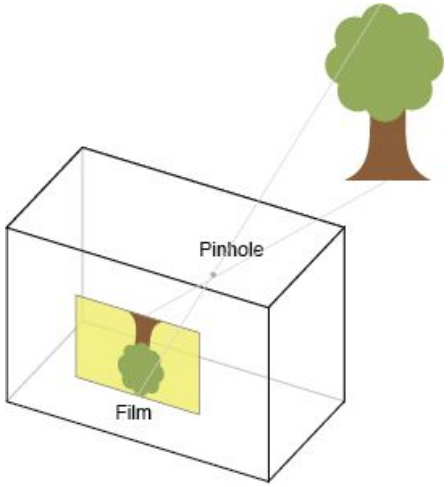
- How much **energy is absorbed**
  - Medical imaging (X-ray, CT)

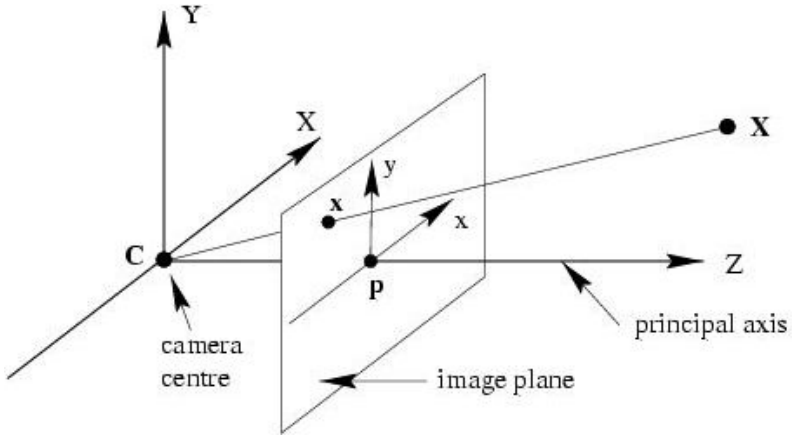
Camera

How image is captured: camera model

Camera = lens + image sensor

Pinhole camera





$$\begin{pmatrix} y_1 \\ y_2 \\ 1 \end{pmatrix} \sim \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \frac{1}{f} & 0 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ 1 \end{pmatrix}$$

Camera model

Normalized model

$$z_c \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = K \begin{bmatrix} R & T \end{bmatrix} \begin{bmatrix} x_w \\ y_w \\ z_w \\ 1 \end{bmatrix}$$

Intrinsic (internal camera params)

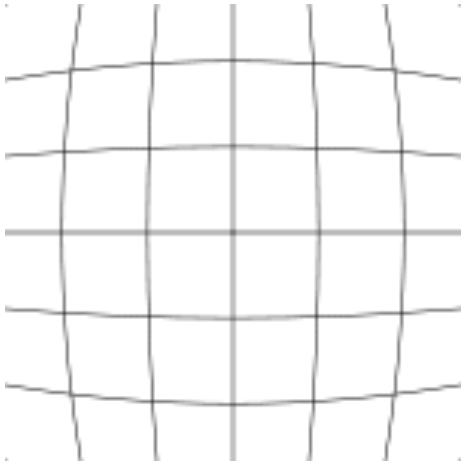
$$K = \begin{bmatrix} \alpha_x & \gamma & u_0 & 0 \\ 0 & \alpha_y & v_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

Excintrisic (rot + transition)

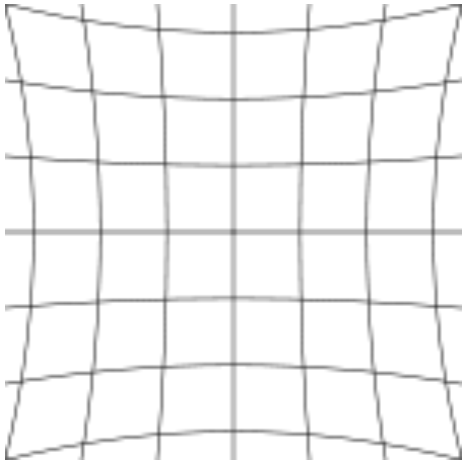
$$\begin{bmatrix} R \mid t \end{bmatrix} = \left[\begin{array}{ccc|c} r_{1,1} & r_{1,2} & r_{1,3} & t_1 \\ r_{2,1} & r_{2,2} & r_{2,3} & t_2 \\ r_{3,1} & r_{3,2} & r_{3,3} & t_3 \end{array}\right]$$

Camera model: lens distortion

Barrel



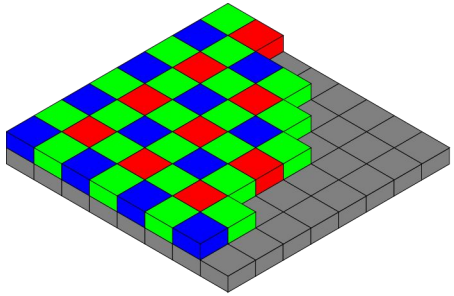
Pincushion



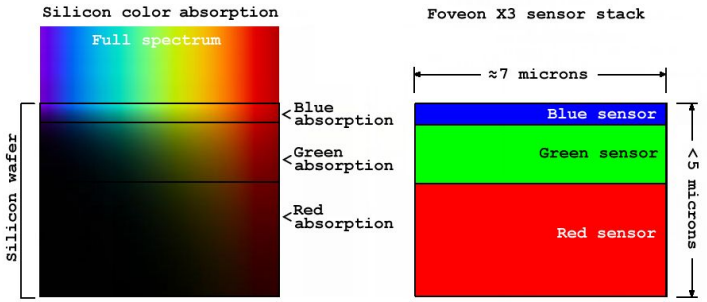
$$x_{\mathrm{u}} = x_{\mathrm{d}} + (x_{\mathrm{d}} - x_{\mathrm{c}})(K_1 r^2 + K_2 r^4 + \cdots) + (P_1(r^2 + 2(x_{\mathrm{d}} - x_{\mathrm{c}})^2) + 2P_2(x_{\mathrm{d}} - x_{\mathrm{c}})(y_{\mathrm{d}} - y_{\mathrm{c}}))(1 + P_3 r^2 + P_4 r^4 \cdots)$$

Camera model: image sensor

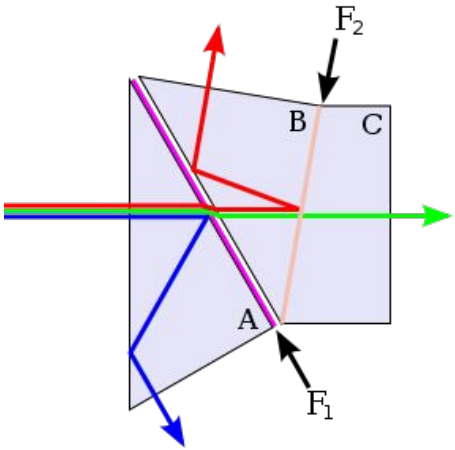
Bayer filter



Layered sensors



3-CCD



[Classic] computer vision major idea

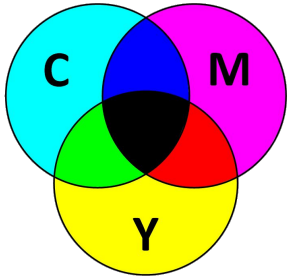
CV is about <u>implementing good models</u> of processes and objects.

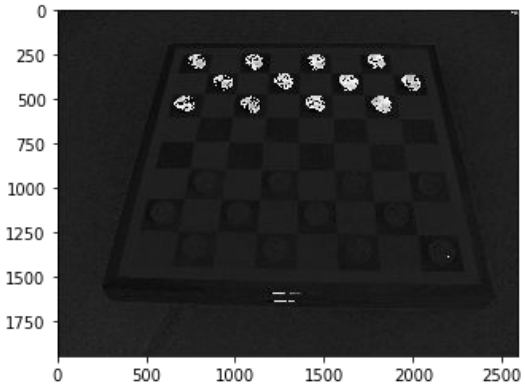
- Sometimes model is obvious.
- Sometimes you need to “play” with images.

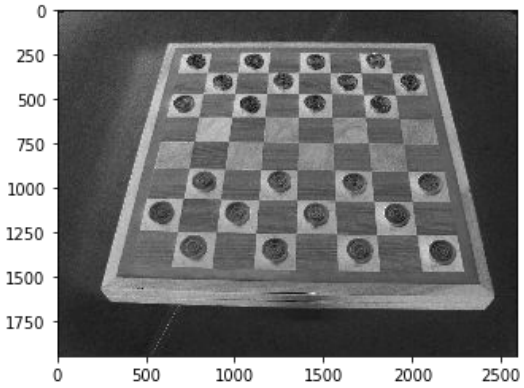
How to play?

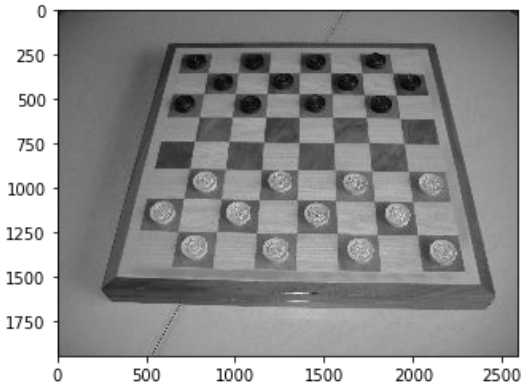
CV techniques: representation

- **Brightness/Lightness** holds information about about of reflected energy
  - Grayscale images
- **Multispectral** images splits energy by frequency
  - RGB/BGR images, CMYK (**C**yan, **M**agenta, **Y**ellow, blac**K**)
- **Spectral differences** can be more precise
  - HSB/HSV images





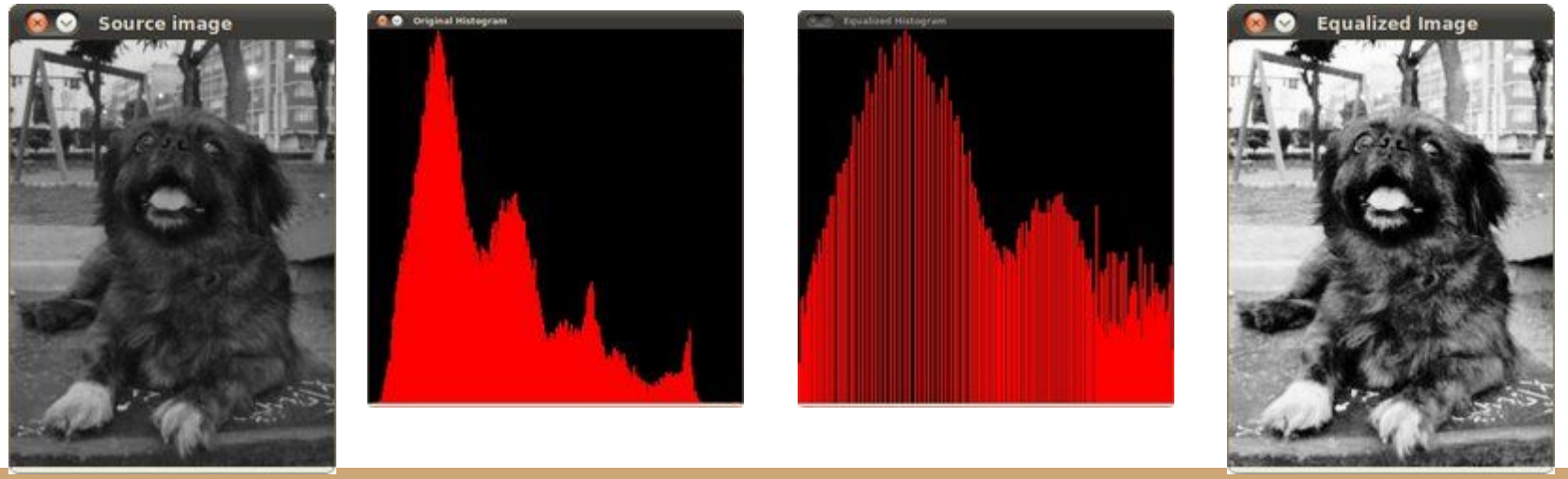




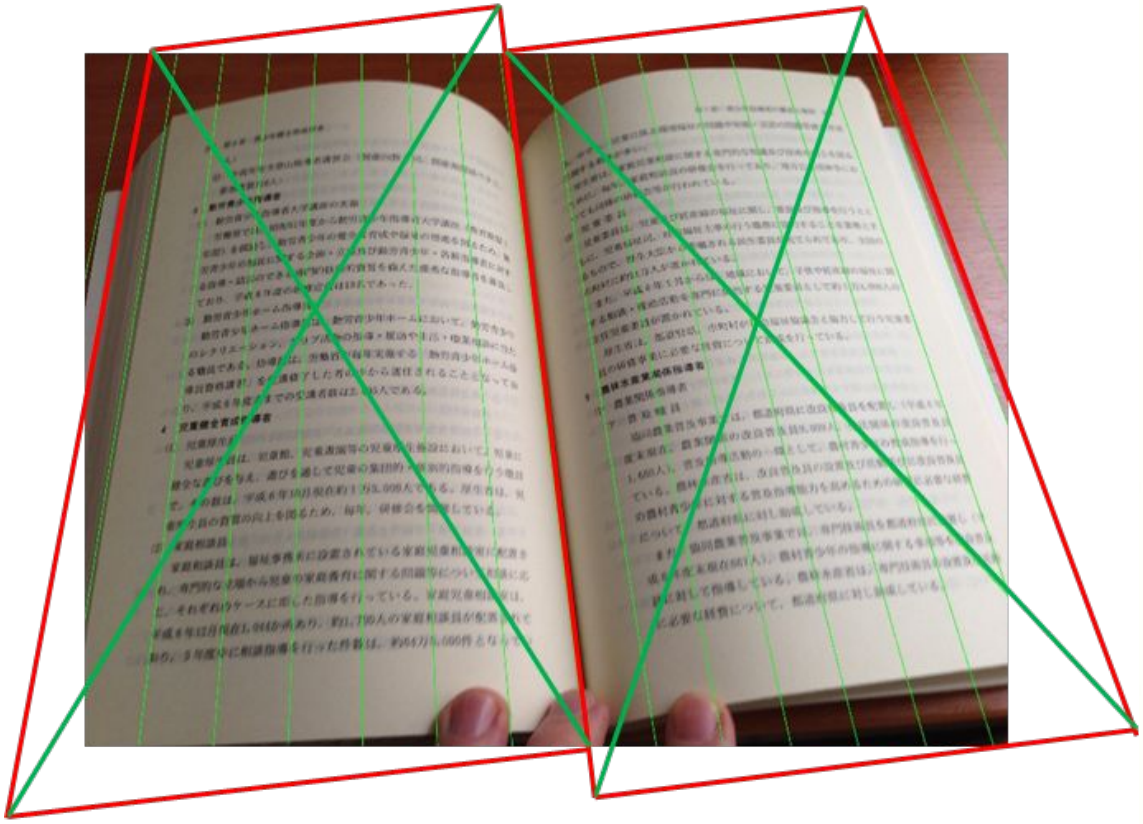
CV techniques: normalization

Changing the range of pixel intensity values. Doesn't bring any new information, but makes images more friendly to us, humans.

Close concept is called histogram equalization: making intensity histogram more uniform. It highlights details in homogenous objects.



https://habrahabr.ru/company/abbyy/blog/312570/



人）

キ 中高年安全登山指導者講習会（開催回数3回，開催期間延べ9日，参加者数116人）

3 勤労青少年指導者

(1) 勤労青少年指導者大学講座の実施

労働省では，昭和51年度から勤労青少年指導者大学講座（教育期間1年間）を開設し，勤労青少年の健全な育成や福祉の増進を図るため，勤労青少年の福祉に関する企画・立案及び勤労青少年・各種指導者に対する指導・助言のできる専門的技術的資質を備えた優秀な指導者を養成しており，平成6年度の研修定員は13名であった。

(2) 勤労青少年ホーム指導員

勤労青少年ホーム指導員は，勤労青少年ホームにおいて，勤労青少年のレクリエーション，クラブ活動の指導・援助や生活・職業相談に当たる職員である。指導員は，労働省が毎年実施する「勤労青少年ホーム指導員資格講習」を受講修了した者の中から選任されることとなっており，平成6年度末までの受講者数は2,495人である。

4 児童健全育成指導者

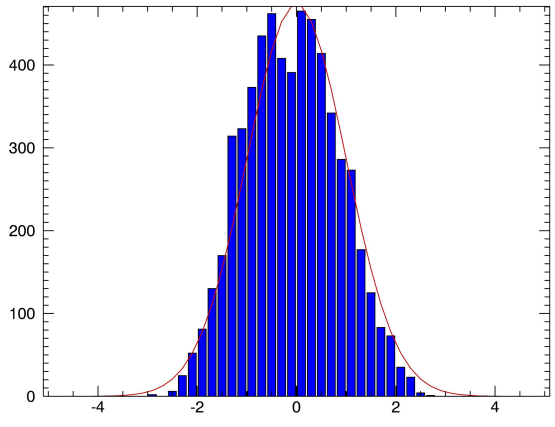
(1) 児童厚生員

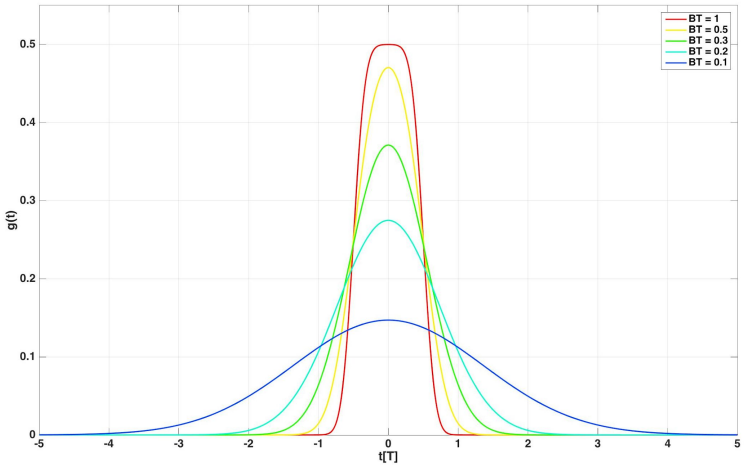
児童厚生員は，児童館，児童遊園等の児童厚生施設において，児童に健全な遊びを与え，遊びを通して児童の集団的・個別的指導を行う職員で，その数は，平成6年10月現在約1万3,000人である。厚生省は，児童厚生員の資質の向上を図るため，毎年，研修会を開催している。

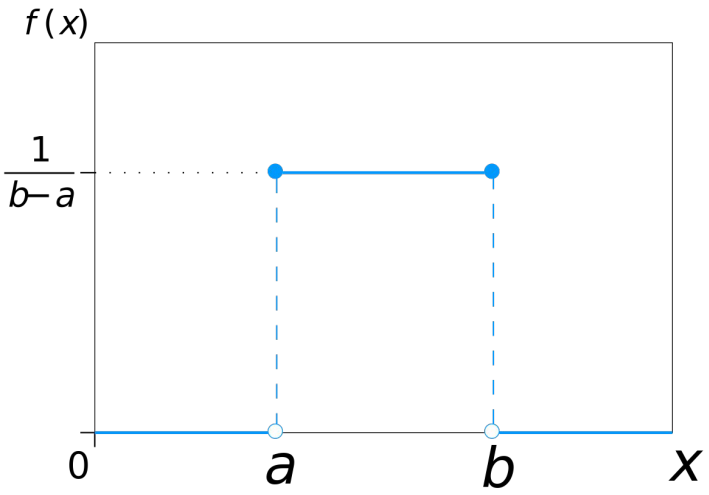
(2) 家庭相談員

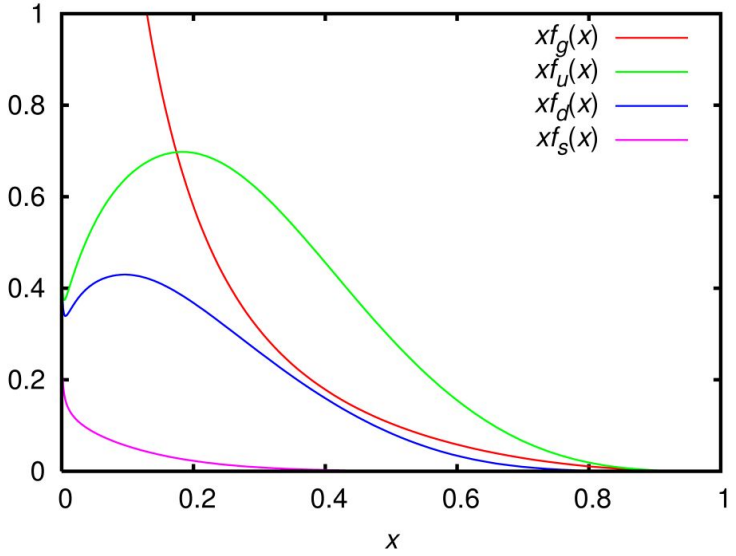
家庭相談員は，福祉事務所に設置されている家庭児童相談室に配置され，専門的な立場から児童の家庭養育に関する問題等について相談に応じ，それぞれのケースに応じた指導を行っている。家庭児童相談室は，平成6年12月現在1,044カ所あり，約1,700人の家庭相談員が配置されており，各年度中に相談指導を行った件数は，約64万5,000件となっている。

Samples, random variables, probability distribution









CV techniques: noise

Noise is a probabilistic function (aberration) over pixels.

Some part of noise is due to air/lens/dirt/...

Big part of the noise produced by **camera sensor**.

Additive Gaussian noise is one of the best models to describe this sensor noise.

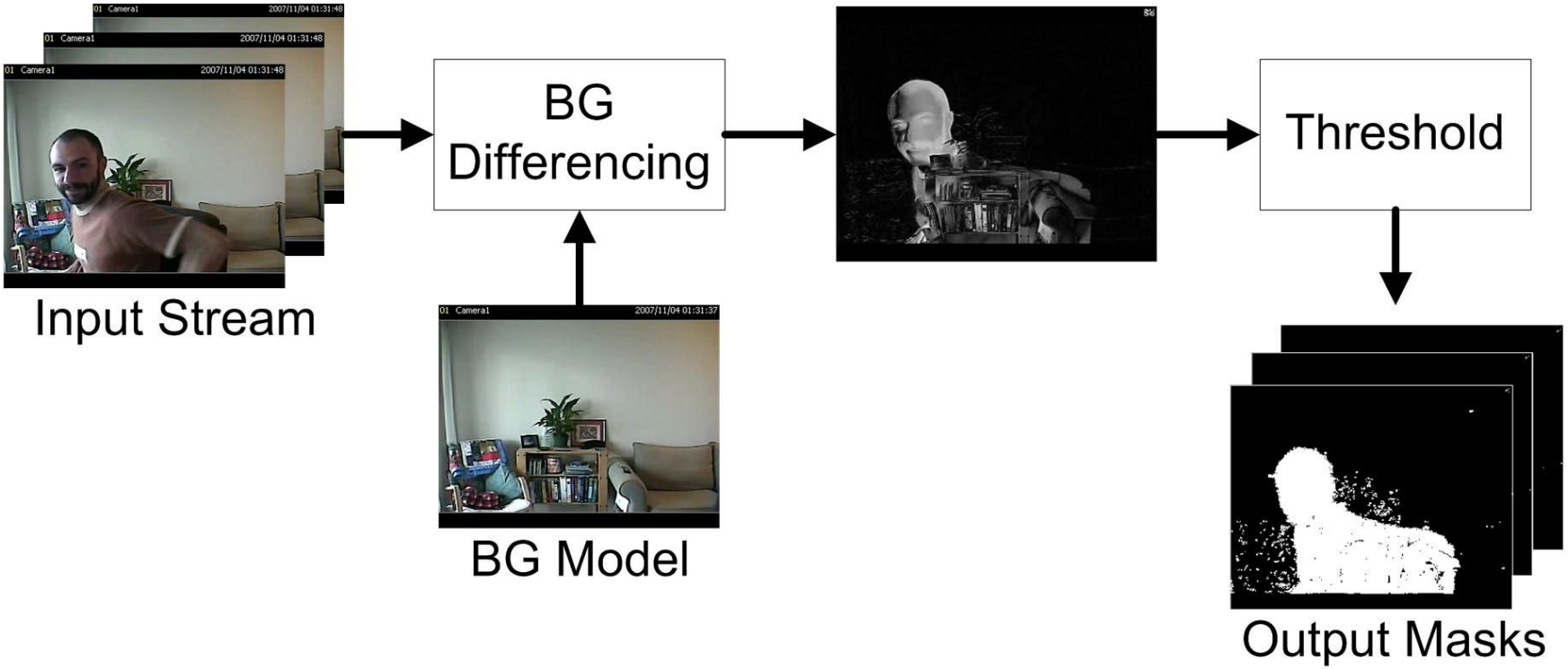
$$f(x \mid \mu, \sigma^2) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

NB: Noise is not necessarily white!


0
50
100
150
200
250
300
0
100
200
300
400


0
100
200
300
400
500
600
0
200
400
600
800

**Median filtering for video



Lab #1. Improve an image to be segmented better

Open tutorial

https://github.com/hsu-ai-course/hsu.ai/blob/master/code/07.%20Segmentation%20lab.ipynb

Apply different techniques to detach animals from background

What will work for you? Why?

Hometask

Detach fishes from background. See https://github.com/hsu-ai-course/hsu.ai/tree/master/homeworks/08