Images search

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Agenda

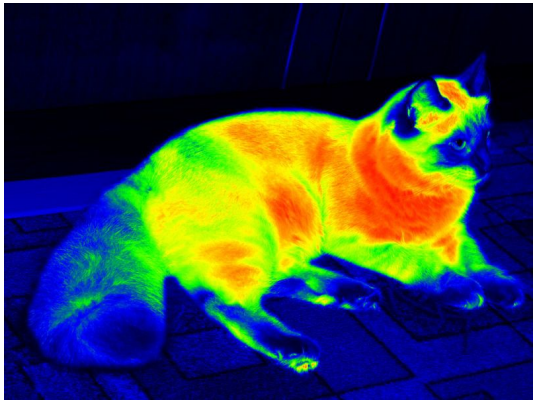
- How our eyes work
- Historical approach
- Duplicate search and CBIR
- Image and video understanding

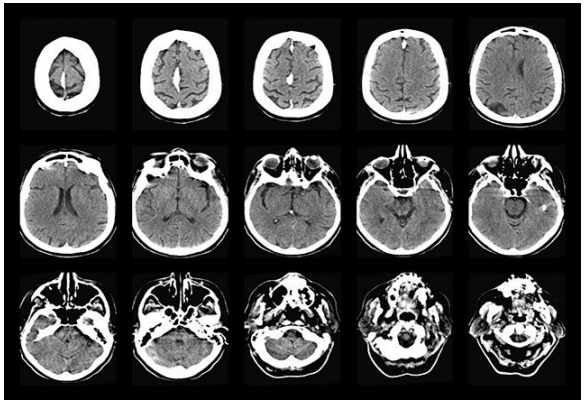
How our vision works

Vision

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

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

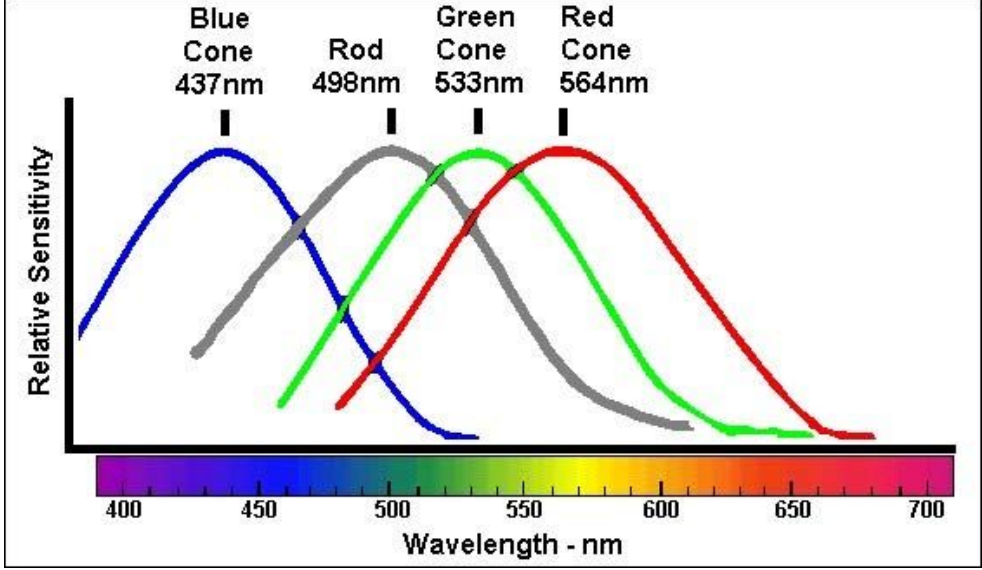


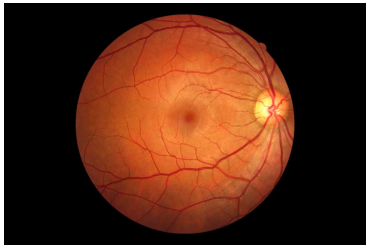


Human vision

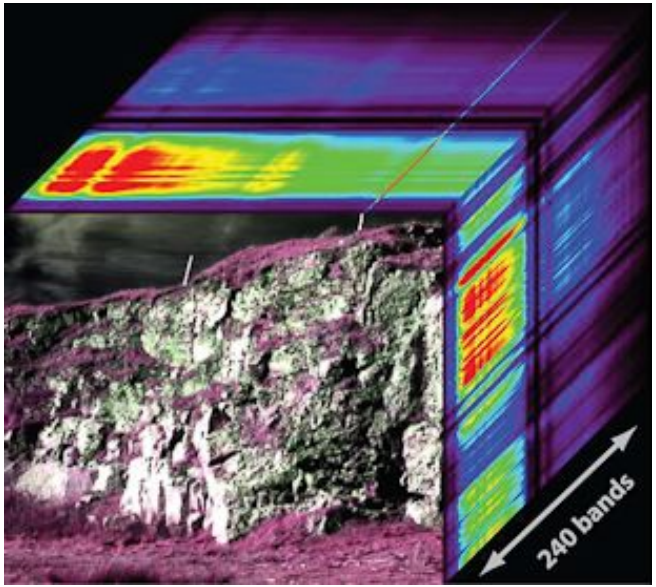
Major facts about vision:

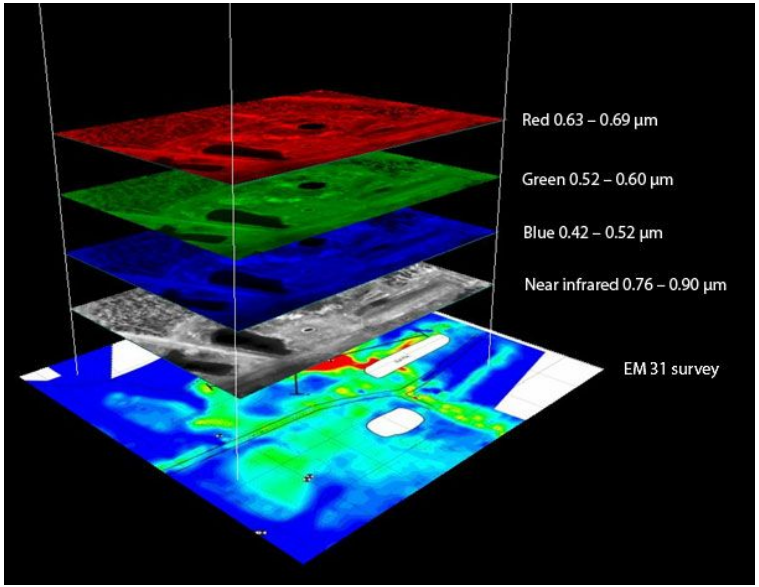
- **Binocular** — allows restore 3D
- **Retina** — discrete
- **Color** — quantized
  - 4 types of sensor cells:
    - S,M,L-*cone* cells
    - *Rod* cells
- Polarization and phase insensitive
- Supports **focus**
- **Opponent**-process theory and
- **Color constancy**
  - Brain process differences of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

OR

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

How images are (were) retrieved

Neighbouring text and subtitles

U. e. epops in Galicia, Spain.

The muscles of the head allow the hoopoe's bill to be opened when it is inserted into the ground

the male.[4]

```
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  <a href="/wiki/File:Common_Hoopoe_(Upapa_epops)_at_Hodal_I_IMG_9225.jpg" class="image">
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  </a>
  <div class="thumbcaption">
    <div class="magnify">…</div>
    "The muscles of the head allow the hoopoe's bill to be opened when it is inserted into the ground"
  </div>
</div>
```
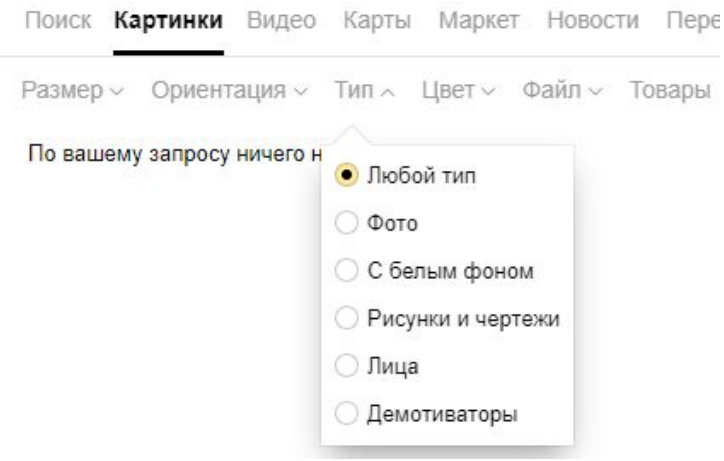
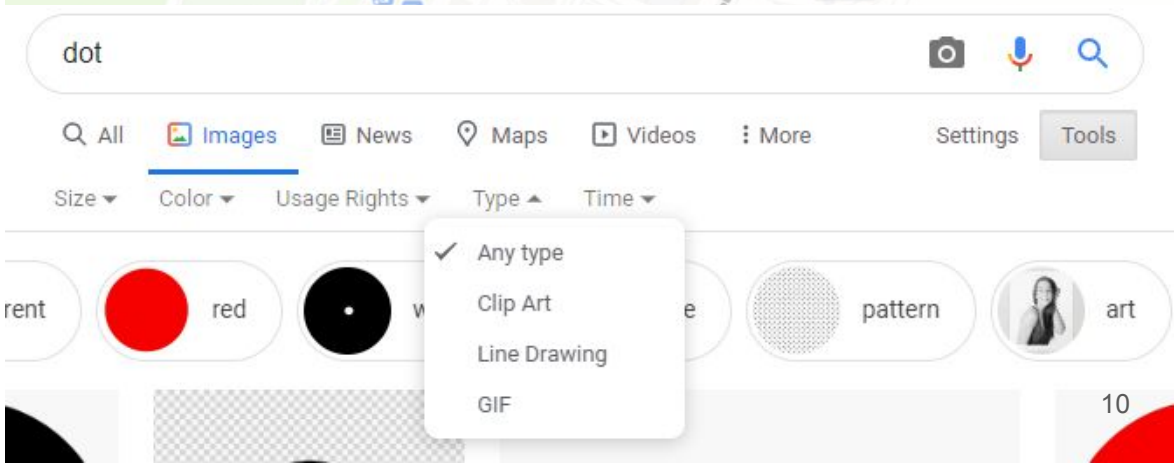

High-level features for filtering

- Color (using k-Means clustering)
- Textures (Haralick/GLCM features, wavelets), shapes and easily computable features (drawing vs photo, ...)
- Metadata (size, EXIF metadata)





CBIR = Content Based Image Retrieval

CBIR

Problems (sensitivity increases)

- Similarity search
- Duplicate search
- Identification (exactly the same, but with respect to e.g. compression)

Similarity and duplicate search: image as a bag of words

In CV ... a **feature [point]** is defined as an "interesting" part of an image.

Usually for **interesting points** consider:

- Edges
- Corners
- Regions

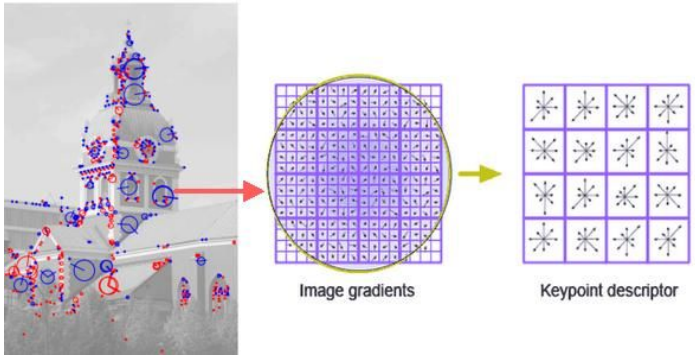
After detector *feature vector* (**descriptor**) is computed.

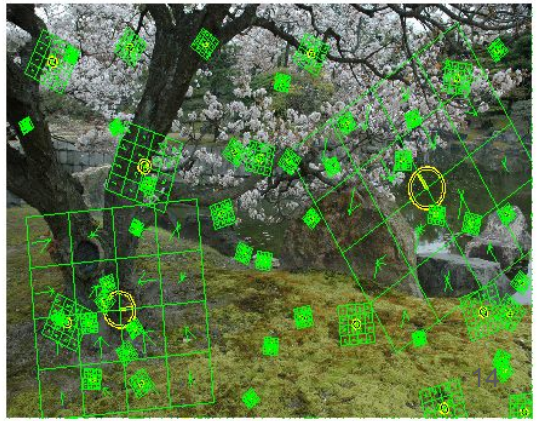
Use feature vector sets to describe **objects**

$$\Delta[G_\sigma(x,y) * f(x,y)] = [\Delta G_\sigma(x,y)] * f(x,y) = LoG * f(x,y)$$

SIFT: Scale-invariant feature transform

1) Compute gradients for images in *image pyramid* using difference of Gaussians (DoG). (Image pyramid ~ Scale invariant)
2) Search for local extrema in scale and space (*keypoints*)
3) Compute *direction* (*rotation invariant*)
4) Create descriptor: in 16x16 neighbourhood make 16 blocks, compute gradients (8 bins for angles) and make a vector.
5) Normalize (*intensity invariant*)





SIFT overview

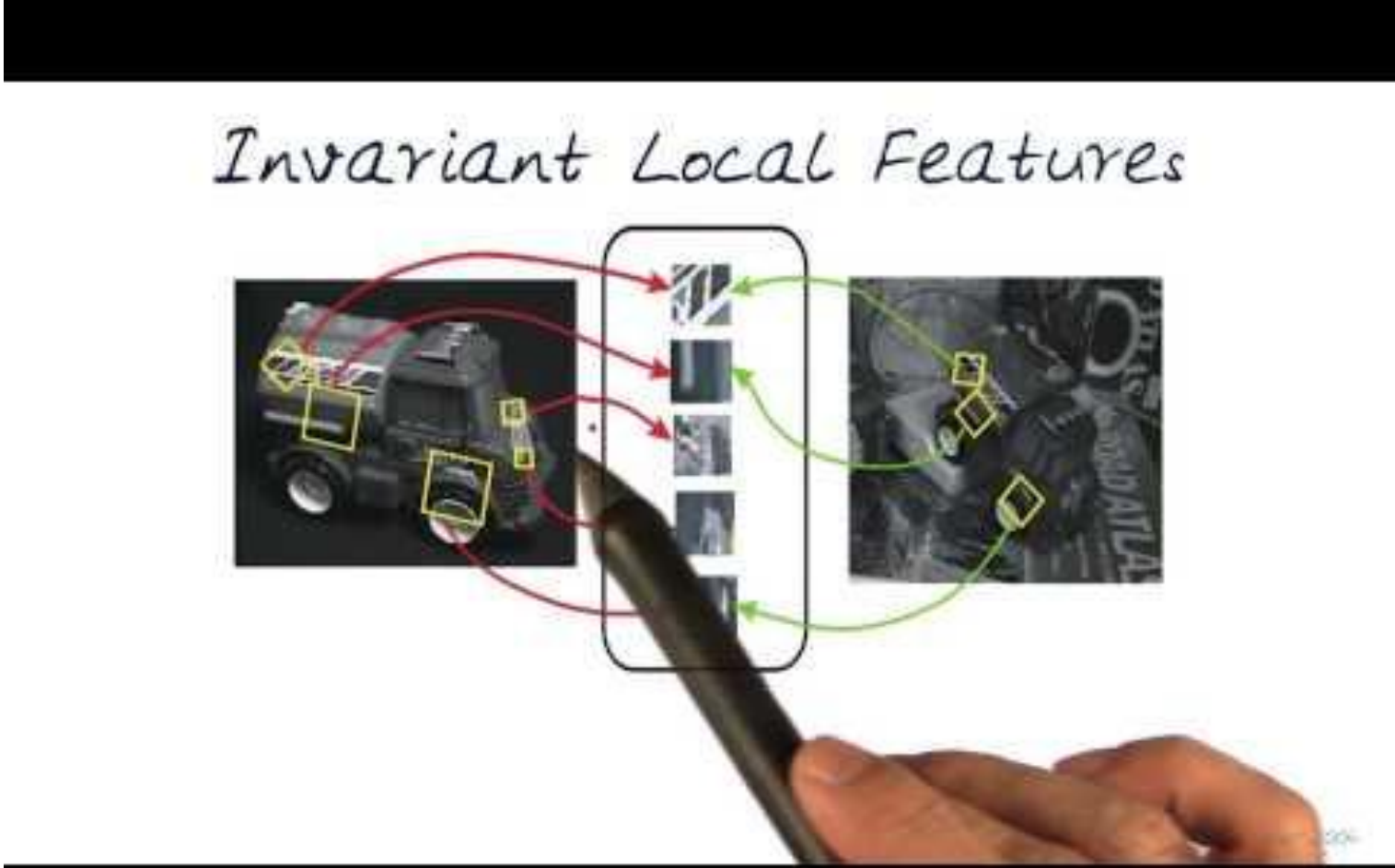
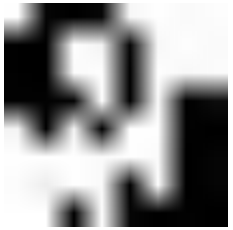


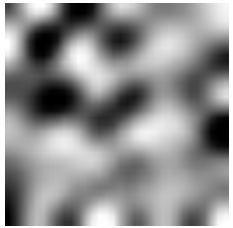
Image fingerprinting for **duplicate search**

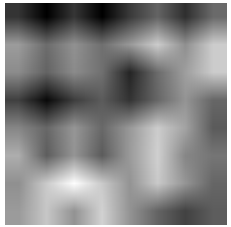
1. Use `PoI`. Allows cropping, need ~100 points, fails for texts
2. Use hash functions:
    a. Image.Match based on Xerox features
    - Grayscale color image
    - Place 9x9 uniform grid of pixels
    - Each point is described with 8-neighbourhood {darker = -2, mild darker , … , lighter = +2 }
    - Concatenate

Image fingerprinting for **duplicate search (2)**



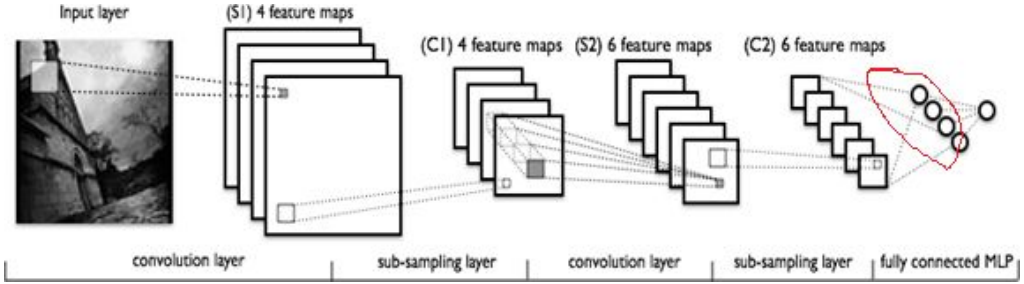
- Hash functions (pip install ImageHash):
- [average] aHash
  - Resize to 8x8
  - Grayscale
  - Binarize by average
  - Use Hamming dist
- [perception] pHash and [wavelet] wHash
  - pHash uses DCT
  - wHash - DWT, both coarse grained
  - Use Hamming dist
- [difference] dHash
  - Resize to 9x8
  - Grayscale
  - Compute `I[x+1, y] <> I[x, y]` and use this as a bit



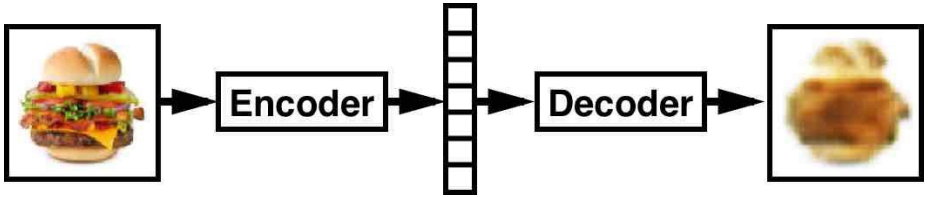


Deep networks for specific and general **similarity** search

1. Images are of **different types** (classes, e.g. ImageNet). Train classification network (AlexNet, VGG16, …) and use embeddings (from inner layer) as index.



2. Images are of the same type (faces). Train deep convolutional autoencoder which creates small-dimensional embeddings.



*Superresolution

Image understanding, video structure

Semantic retrieval

Deep classification and region-based networks allow adding semantic indices.

NB: how many $$ will single inference will cost for 20B of images?

Video structure mining

As text can be searched for a **paragraph**, Long videos should be also indexed with **scenes**. [demo]