Recognition of Objects

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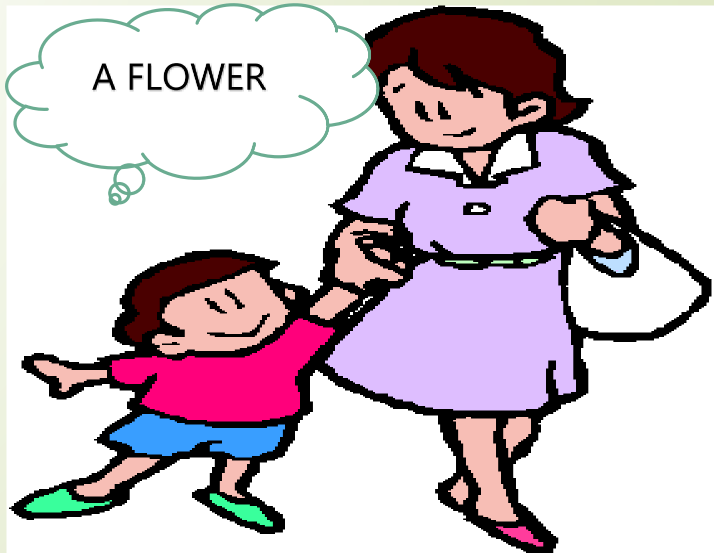
Recognition problem hard with computer

- For **human** being it is easy to recognize the objects by color, texture and appearance.
- A spontaneous, natural activity for humans and other biological systems. People know about millions of different objects, yet they can easily distinguish among them.
- But in the case of **computers** they are not able to recognize just with appearance. There must be detailed screening to be done to identify a object.



Main **problems** faced by computer while detecting **objects**

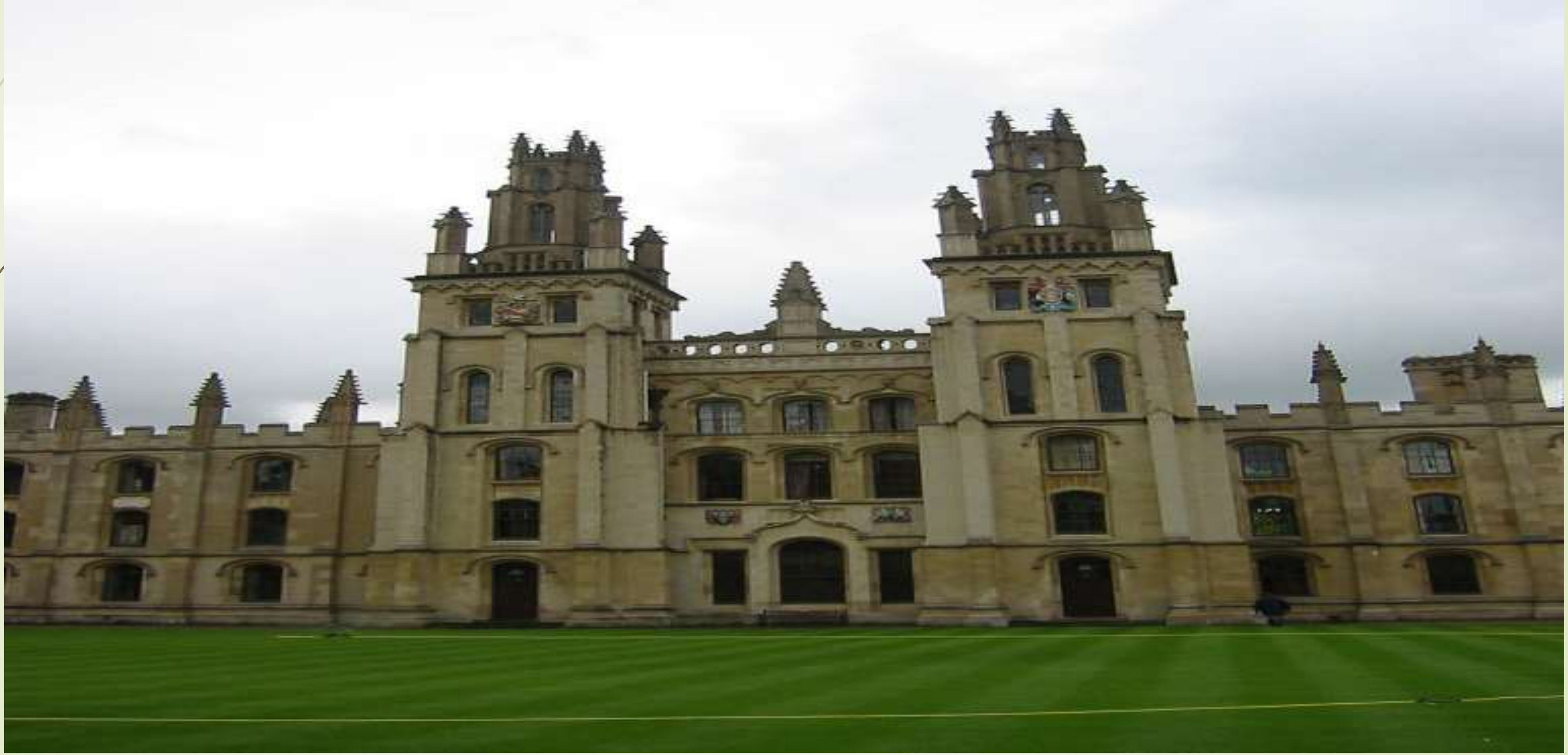
- Scale and shape of the imaged object varies with viewpoint
- Occlusion (self- or by a foreground object)
- Lighting changes
- Background “clutter”

Occlusion

Rotation

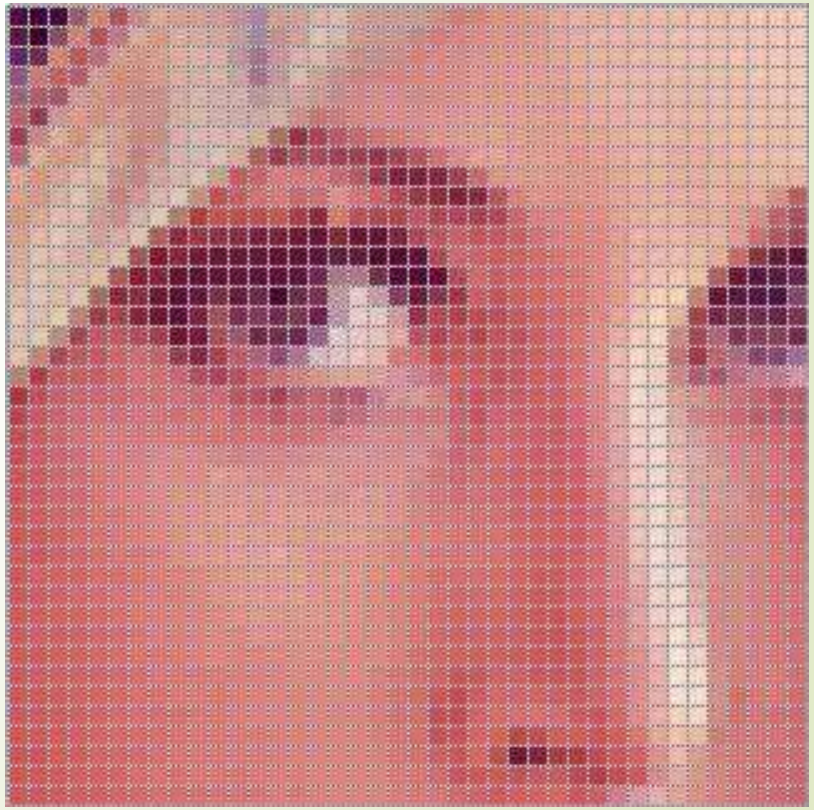
Lighting Changes

Scaled Image



Pixel Representation

- Just pixels is a bad representation
- Pixel intensities are affected by a lot of different things like

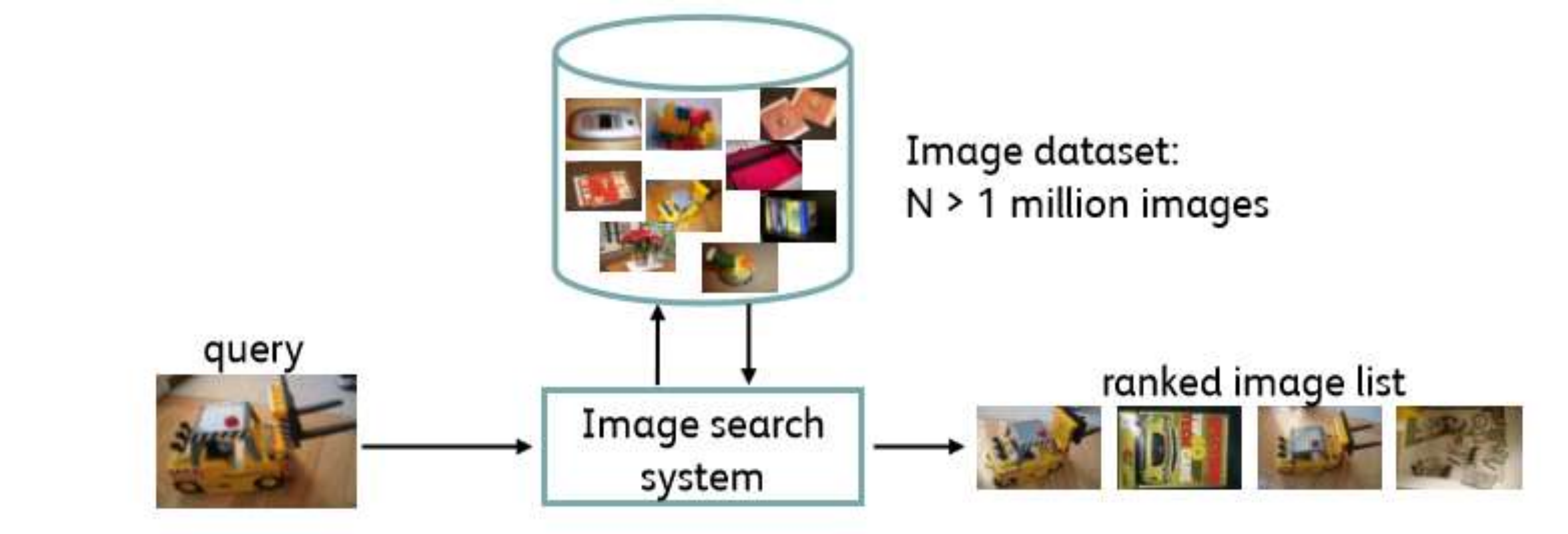


Why pixel matching is not a good method??

- **Rotation**
- **scaling**
- **perspective**
- **Illumination changes**
- **Reordering of scenes**

OBJECT RECOGNITION

– starting from an image of an object of interest (the query), search through an image dataset to obtain (or retrieve) those images that contain the target object.

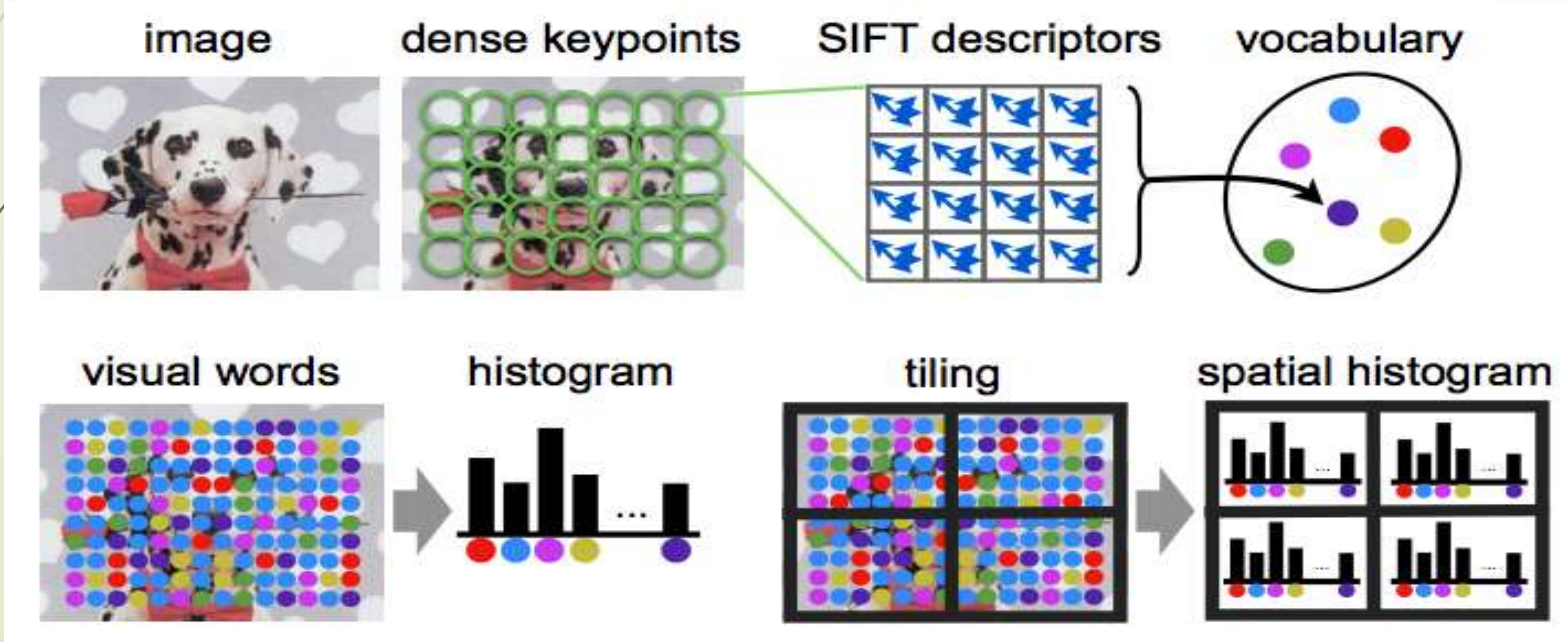


Definition

- **Object recognition** is a task of finding and identifying object in an image or video sequence.

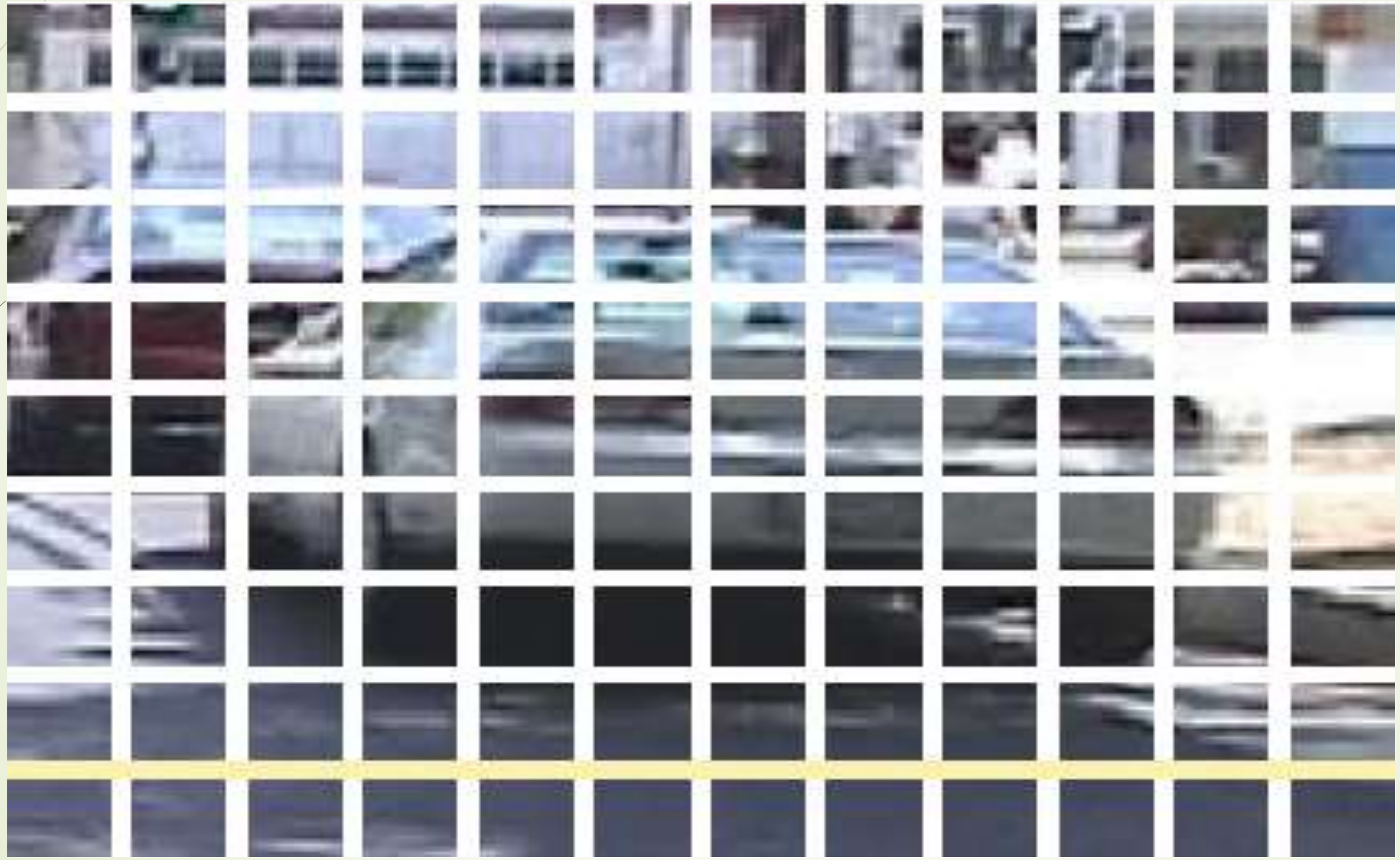
- The goal of instance-level recognition is to match (recognize) a specific object or scene.

Object Recognition Process

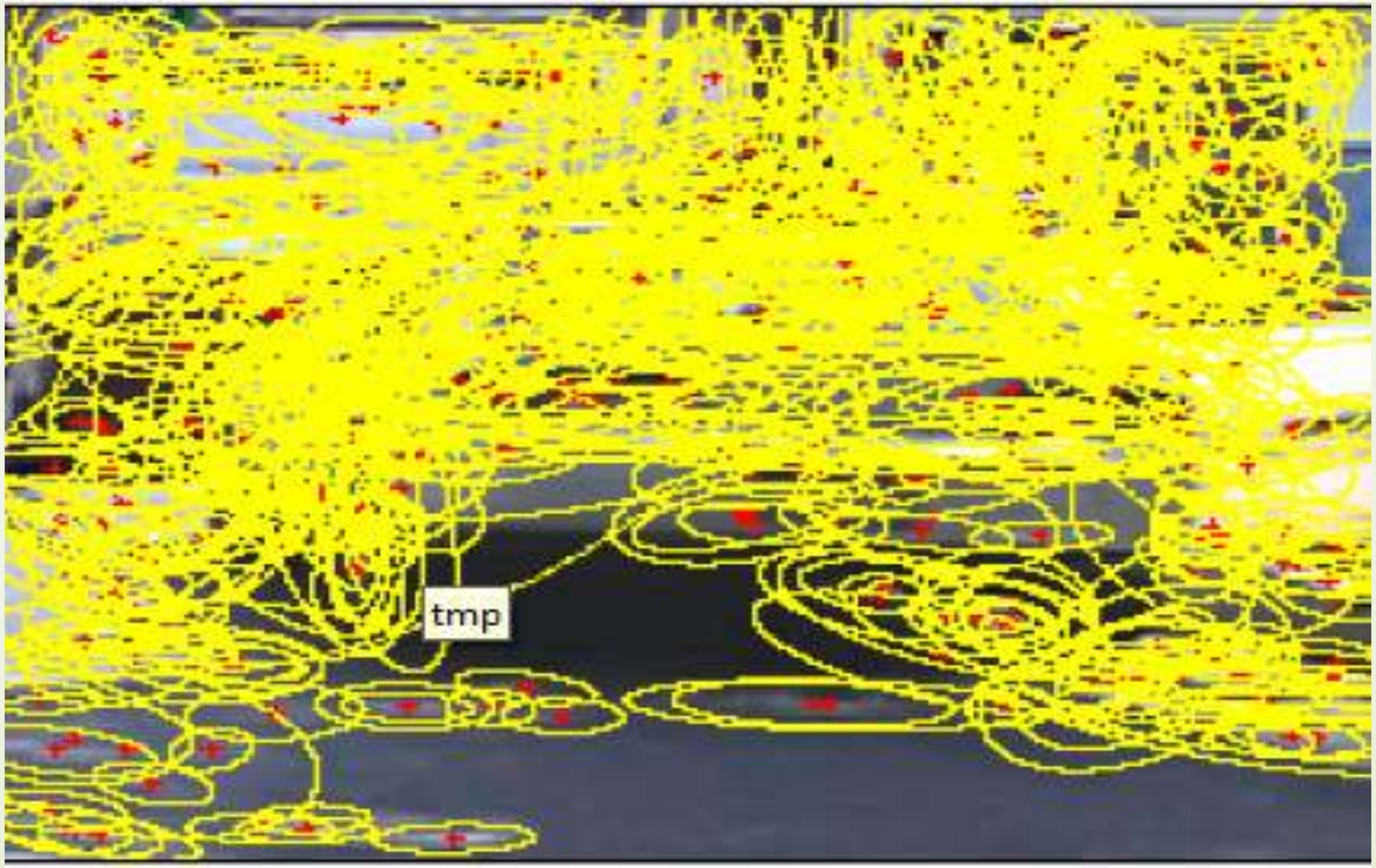


Query Image

Divide it into grids



Find key points



How to Detect Key points

- Key points are the features or points in an image that doesn’t change their positions in the original image even if the image is scaled, rotated or translated.
- These points remains fixed in all these cases.

Descriptors

- Each key point has many descriptions.
- Lowe's method for image feature generation transforms an image into a large collection of feature vectors, each of which is
  - invariant to image translation,
  - invariant to scaling,
  - invariant to rotation.

How can we find descriptors??

Commonly used methods

- SIFT
- SURF

SIFT Descriptors

- Scale Invariant Feature Transform
- Compute regions in each image independently
- "Label" each region by a vector of descriptors
- Find corresponding regions by matching to closest descriptor vector
- Score each frame in the database by the number of matches
- Difference of Gaussians function is applied in scale space to a series of smoothed and re-sampled images.

(a)233x189 image
(b) 832 DOG extrema

- Consider a certain threshold value.
  Discard points that are not within the range of this threshold.
  729 left after peak value threshold

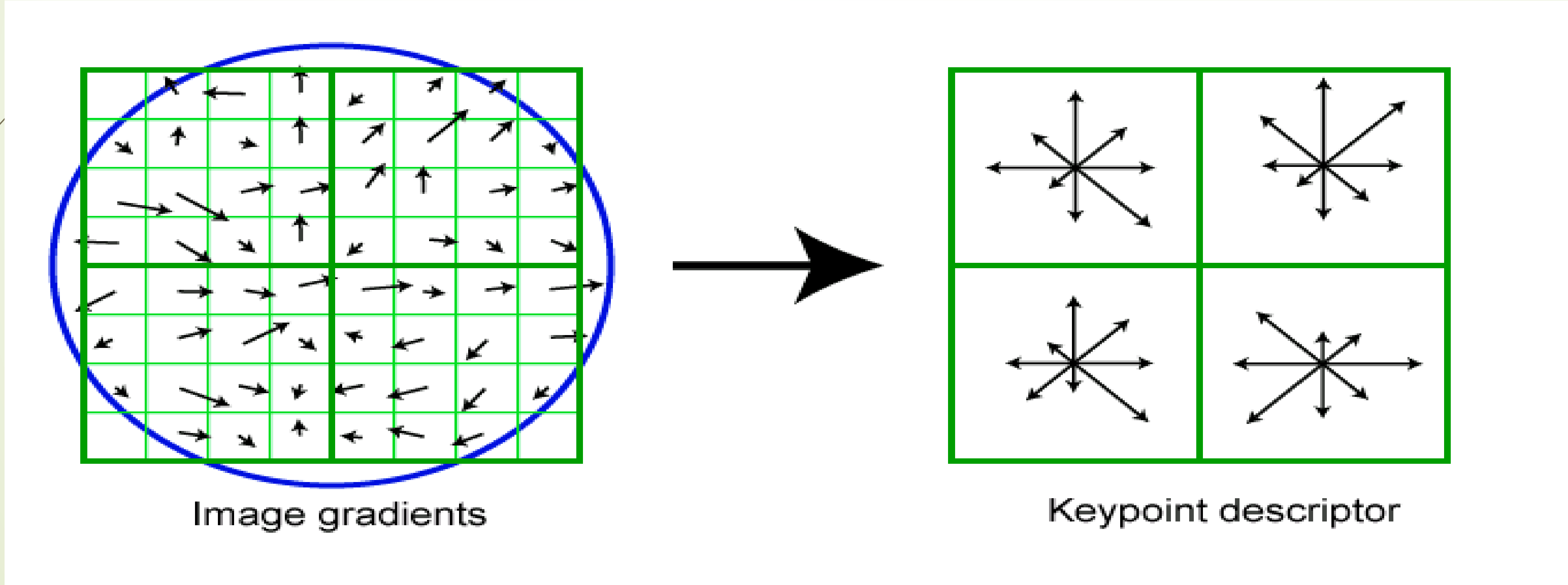
Dominant orientations are assigned.

These steps ensure that the key points are more stable for matching and recognition.

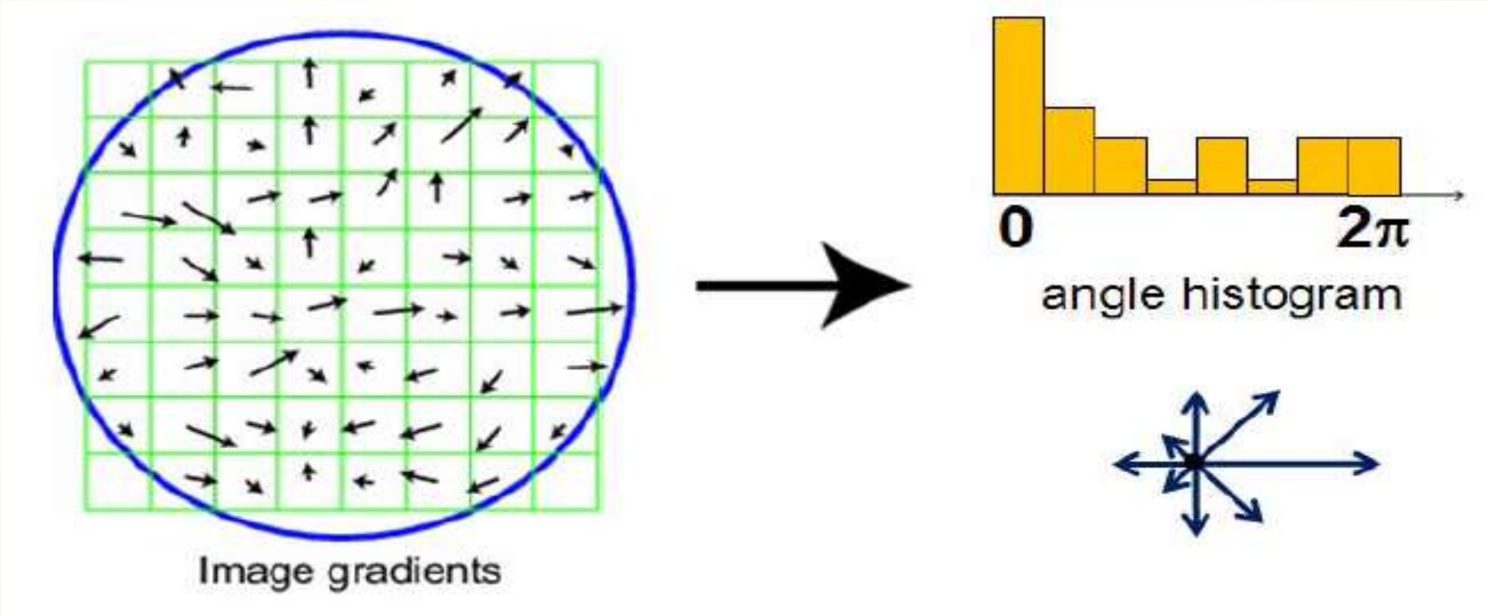
536 left after testing ratio of principle curvatures

SIFT vector formation

- SIFT descriptors are then obtained by considering pixels around the radius of a key location



- Create array of orientation histograms



SURF

- Speeded Up Robust Features
- It is a high-performance scale and rotation-invariant detector / descriptor
- The standard version of SURF is several times faster than SIFT and claimed by its authors to be more robust against different image transformations than SIFT.


IS ANYONE LISTENING ?

Feature matching using Nearest Neighbor

- Next we will use the descriptor computed over each detection to match the detections between images.
- We will use the simplest matching scheme- the nearest neighbor of descriptors
- The nearest neighbors are defined as the keypoints with minimum *Euclidean distance* from the given descriptor vector.

Nearest Neighbor Ratio

- The probability that a match is correct can be determined by taking the ratio of distance from the closest neighbor to the distance of the second closest.

$$\mathrm{NNDR} = \frac{d_1}{d_2}$$

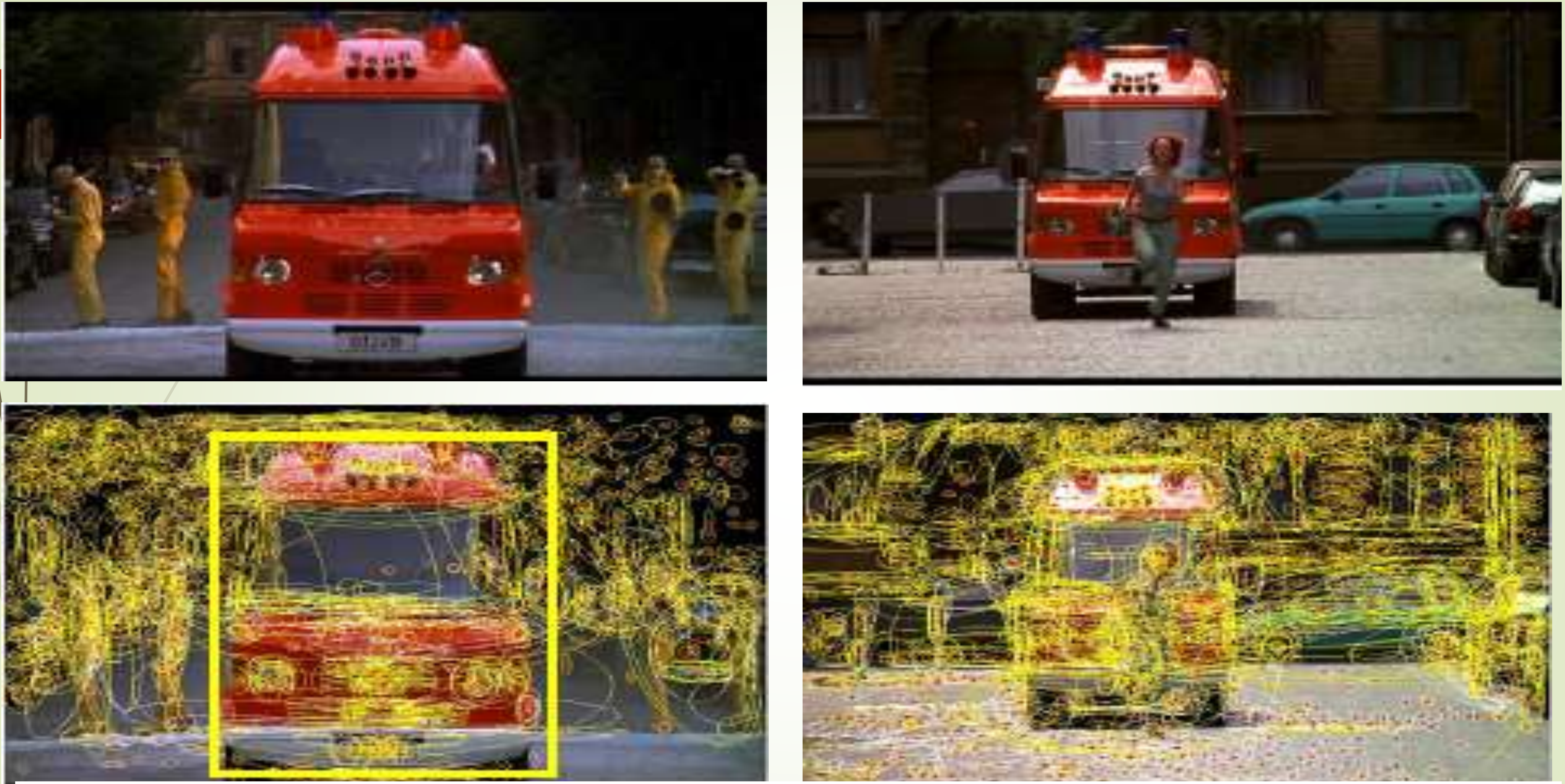
- where d1 and d2 are the nearest and second nearest neighbor distances
- The value of the resultant ratio varies from 0.1 to 0.9. best value is 0.8.

Represent each region by SIFT descriptor (128-vector)

1000+ regions per image

Harris-affine

Maximally stable regions



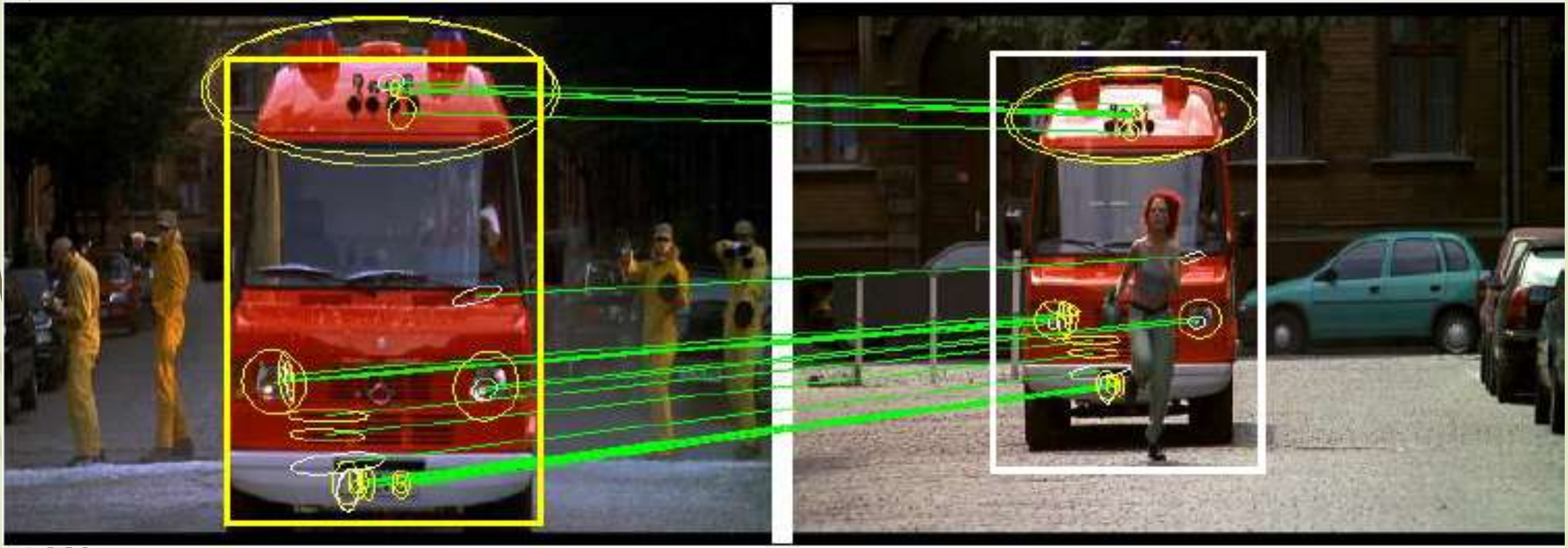
1000+ regions per image

Harris-affine

Maximally stable regions

Clustering

- There will be thousands of points. How to group them ?
- The answer is use clustering method.
- When clusters of features are found for an object, the probability of the interpretation being correct is much higher than for any single feature.



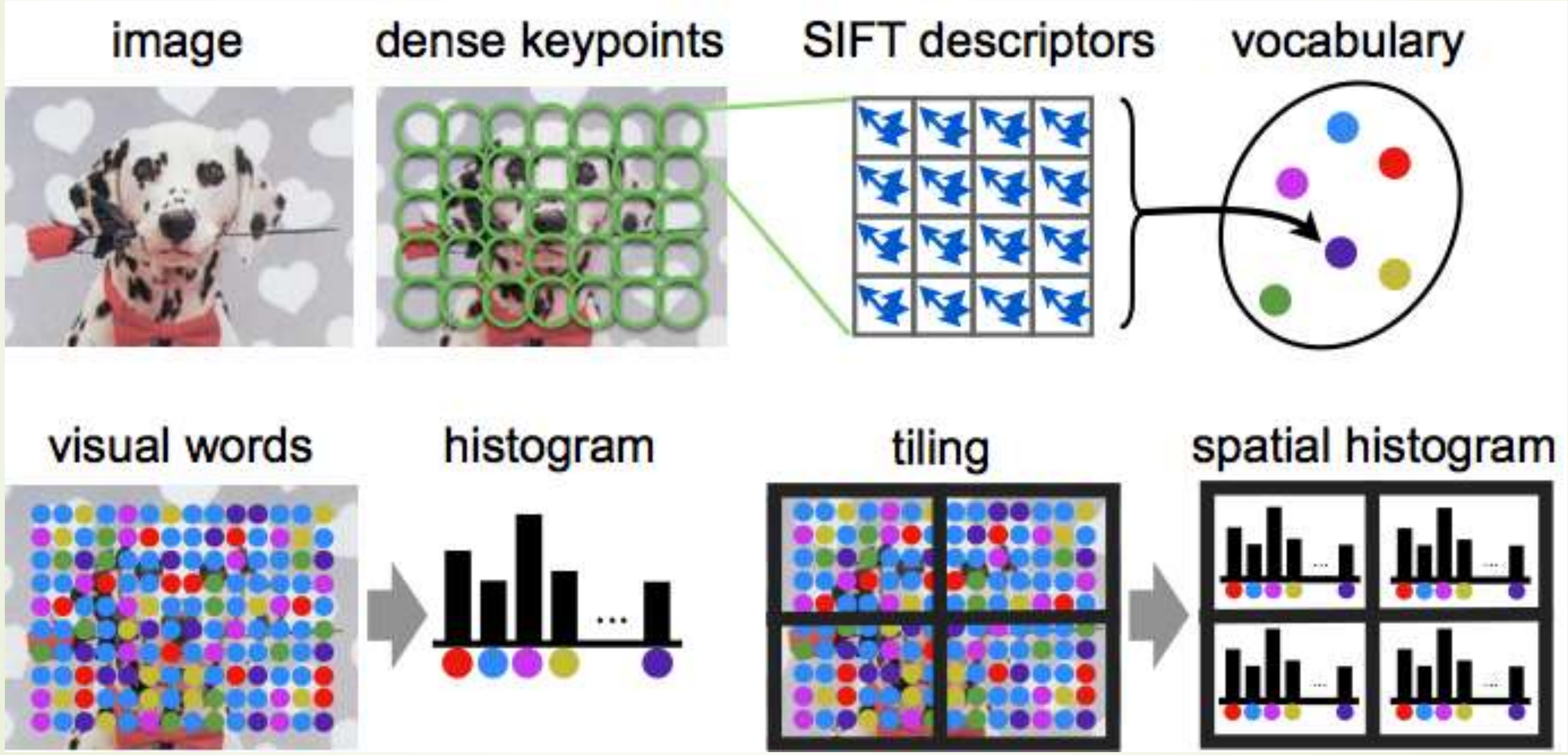
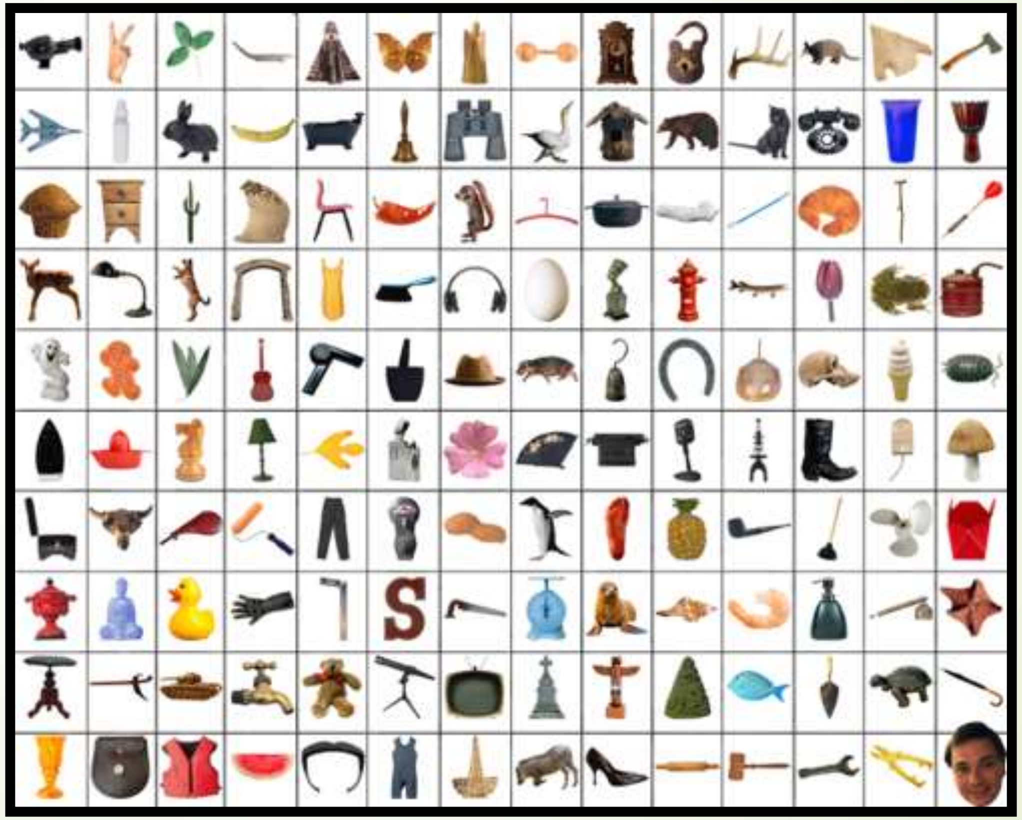


image
dense keypoints
SIFT descriptors
vocabulary
visual words
histogram
tiling
spatial histogram

Towards Large Scale Retrieval



Large Scale Retrieval

- In large scale retrieval the goal is to match a query image to a large database of images (for example the WWW or Wikipedia).
- The quality of a match is measured as the number of geometrically verified feature correspondences between the query and a database image.
- While the techniques discussed in Part I and II are sufficient to do this, in practice they require too much **memory** to store the SIFT descriptors for all the detections in all the database images
- We explore next two key ideas: one to reduce the memory; the other to speed up image retrieval.

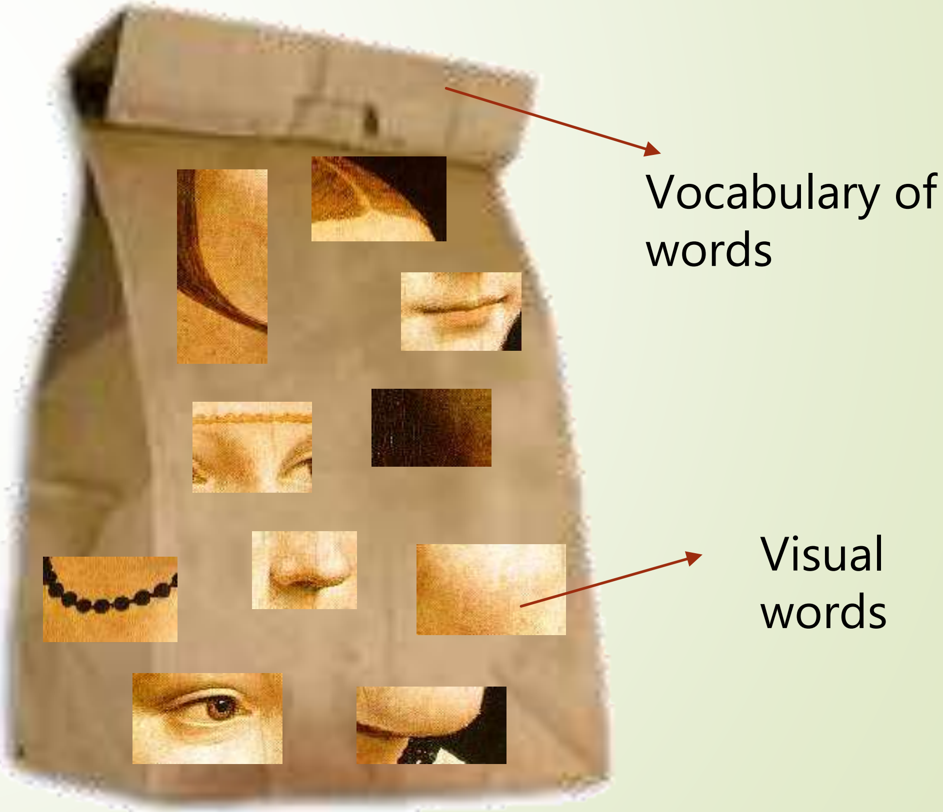
1. CREATING VISUAL WORDS

2. INVERTED INDEX

CREATE VOCABULARY

Object

Bag of 'words'



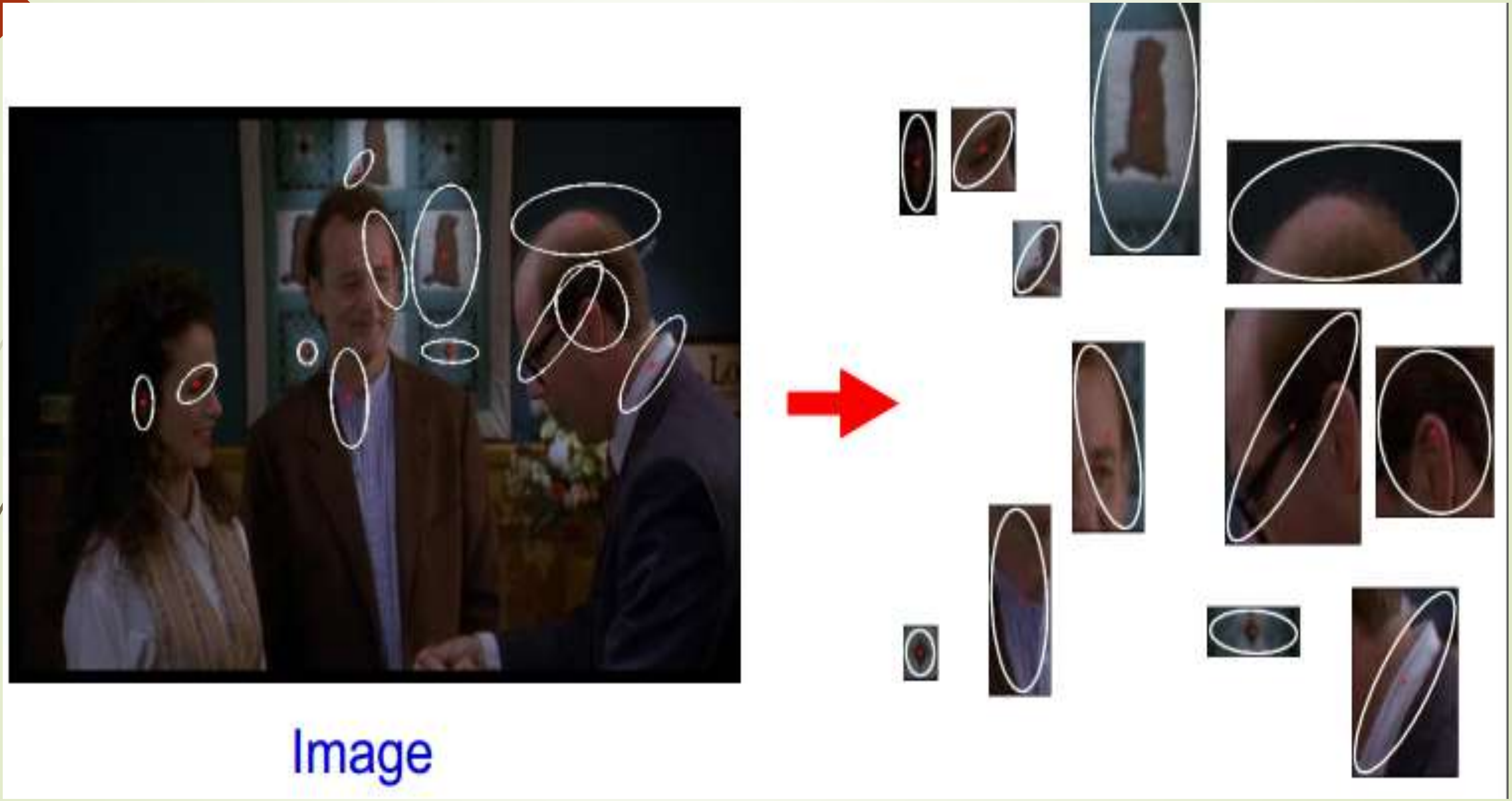
Bag of features

- First, take a bunch of images, extract features, and build up a “dictionary” or “**visual vocabulary**” – a list of common features

- **Visual words** are the representation of the whole features extracted

Bag of features: outline

1. Extract features

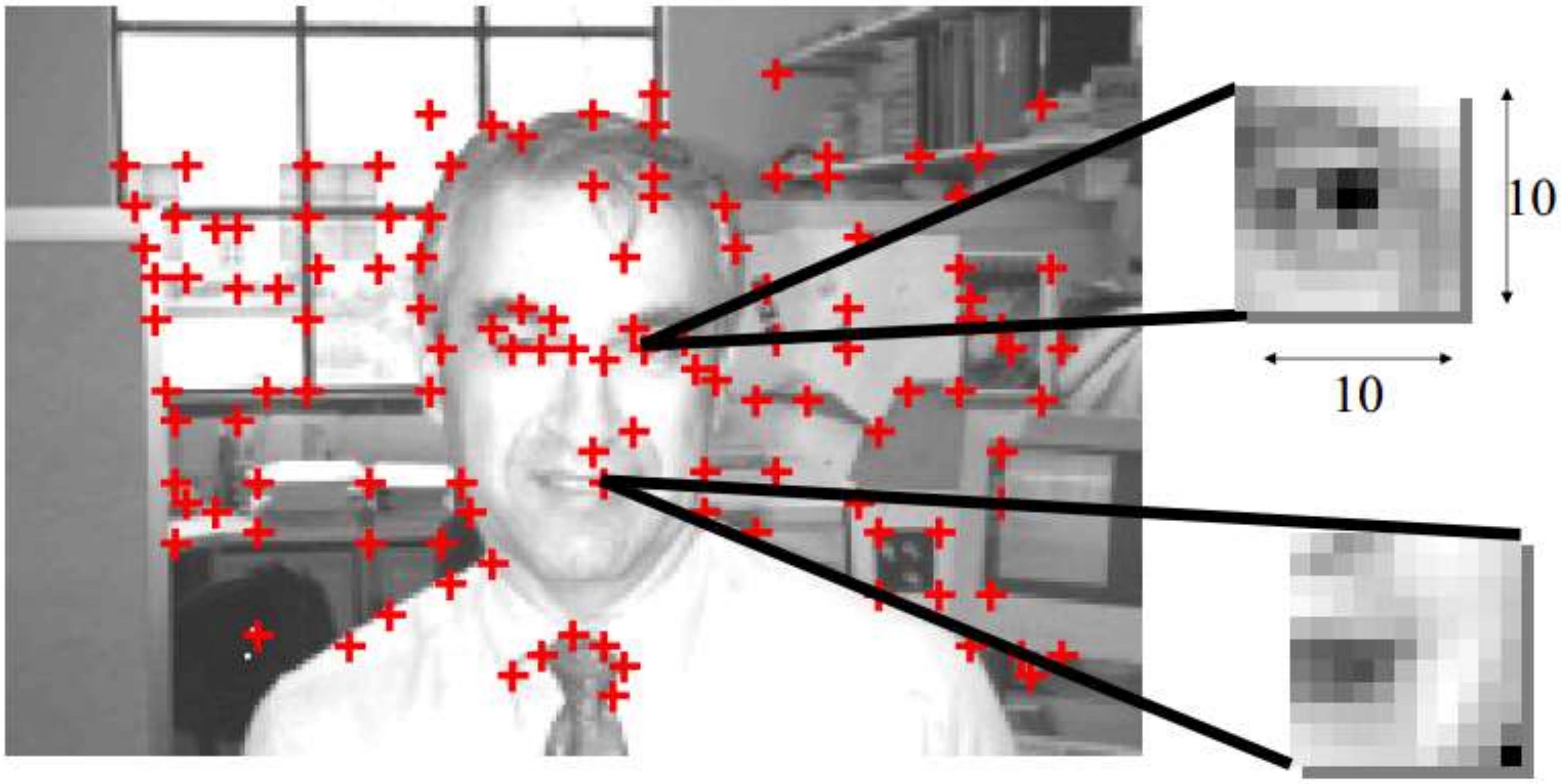


Image

Bag of features:

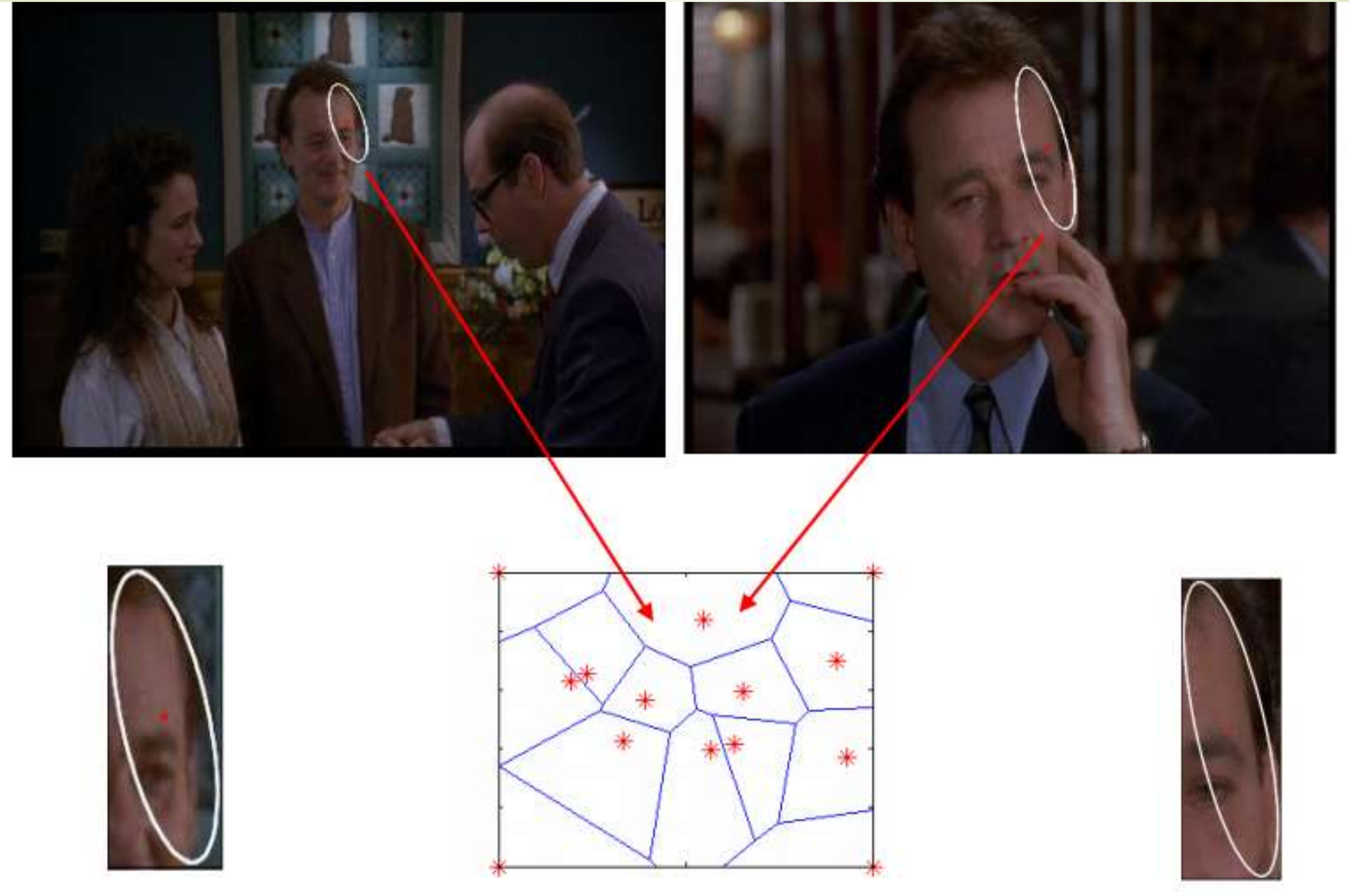
1. Extract features
2. Learn "visual vocabulary"

Example: Learn visual words by clustering



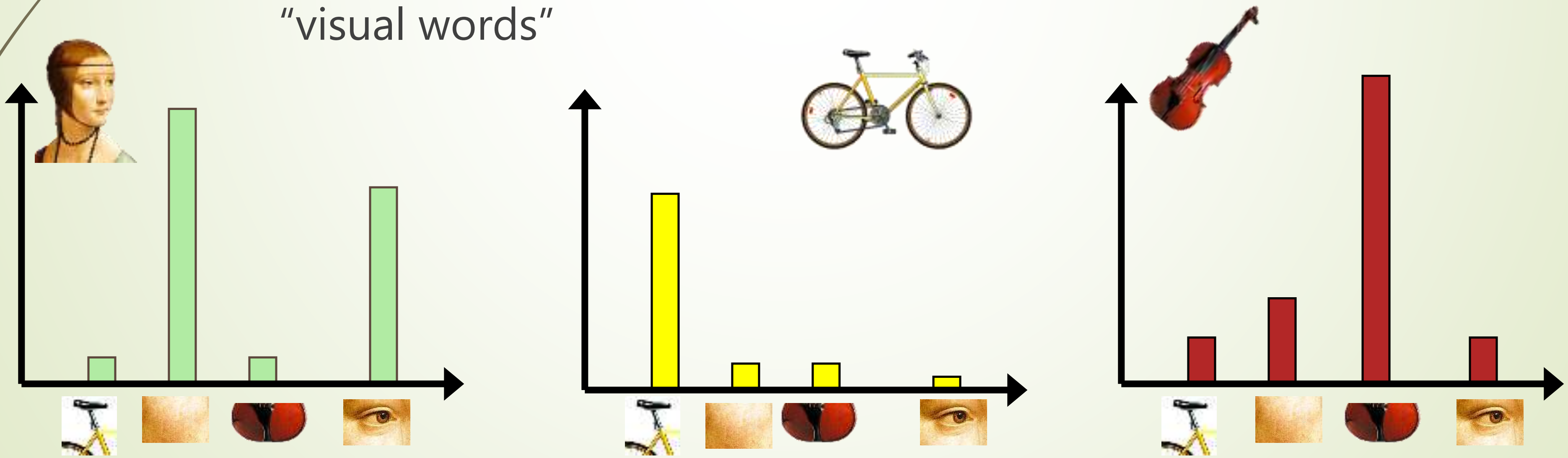
Bag of features:

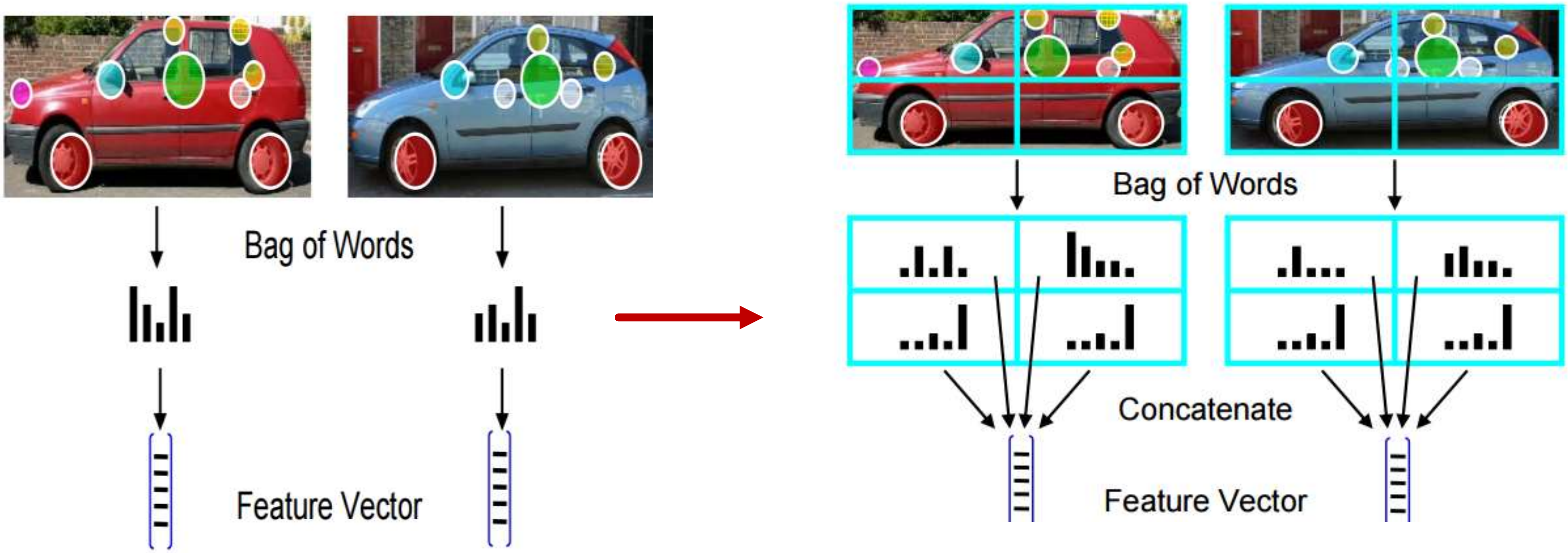
1. Extract features
2. Learn “visual vocabulary”
3. Quantize features using visual vocabulary



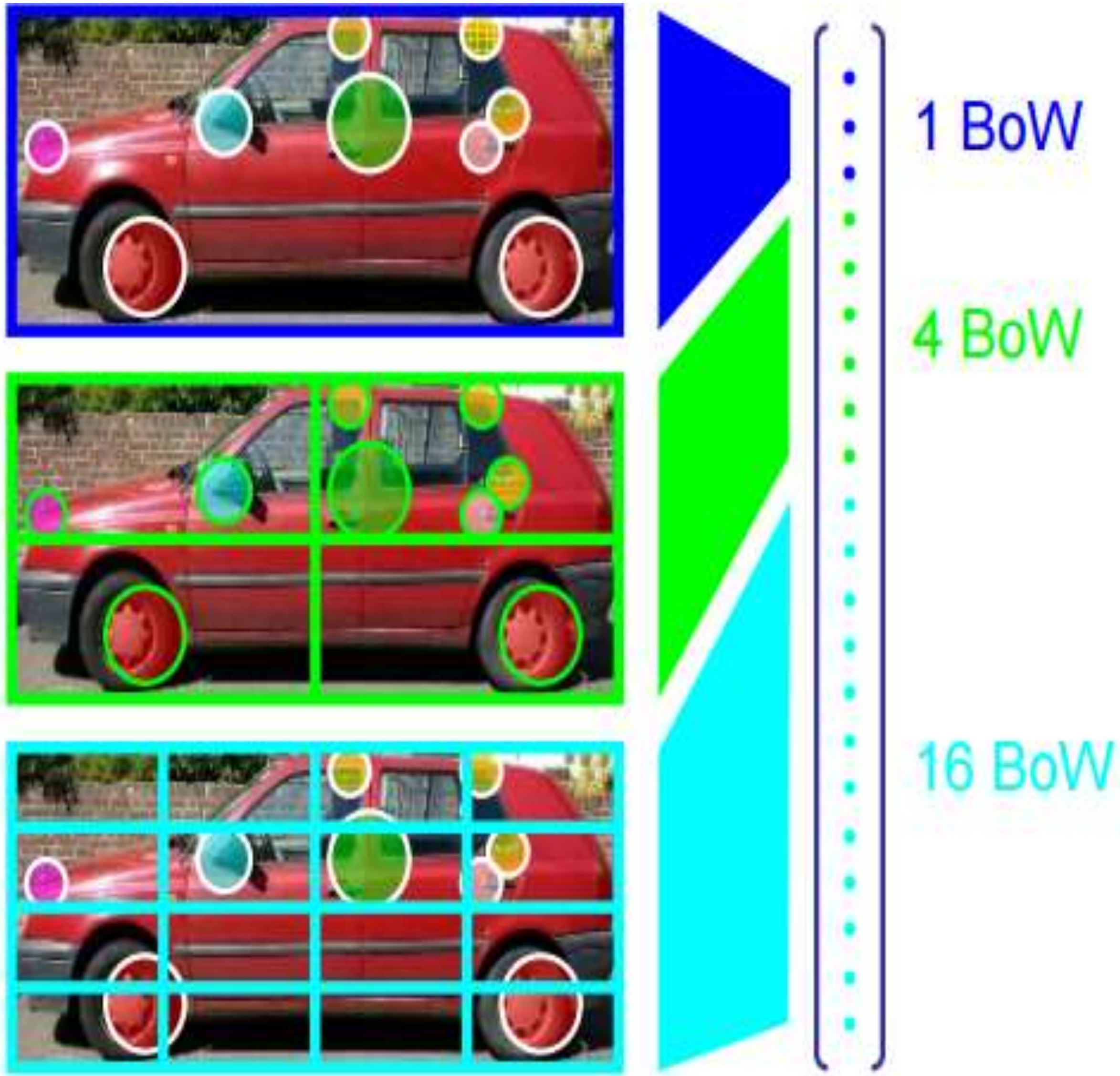
Bag of features:

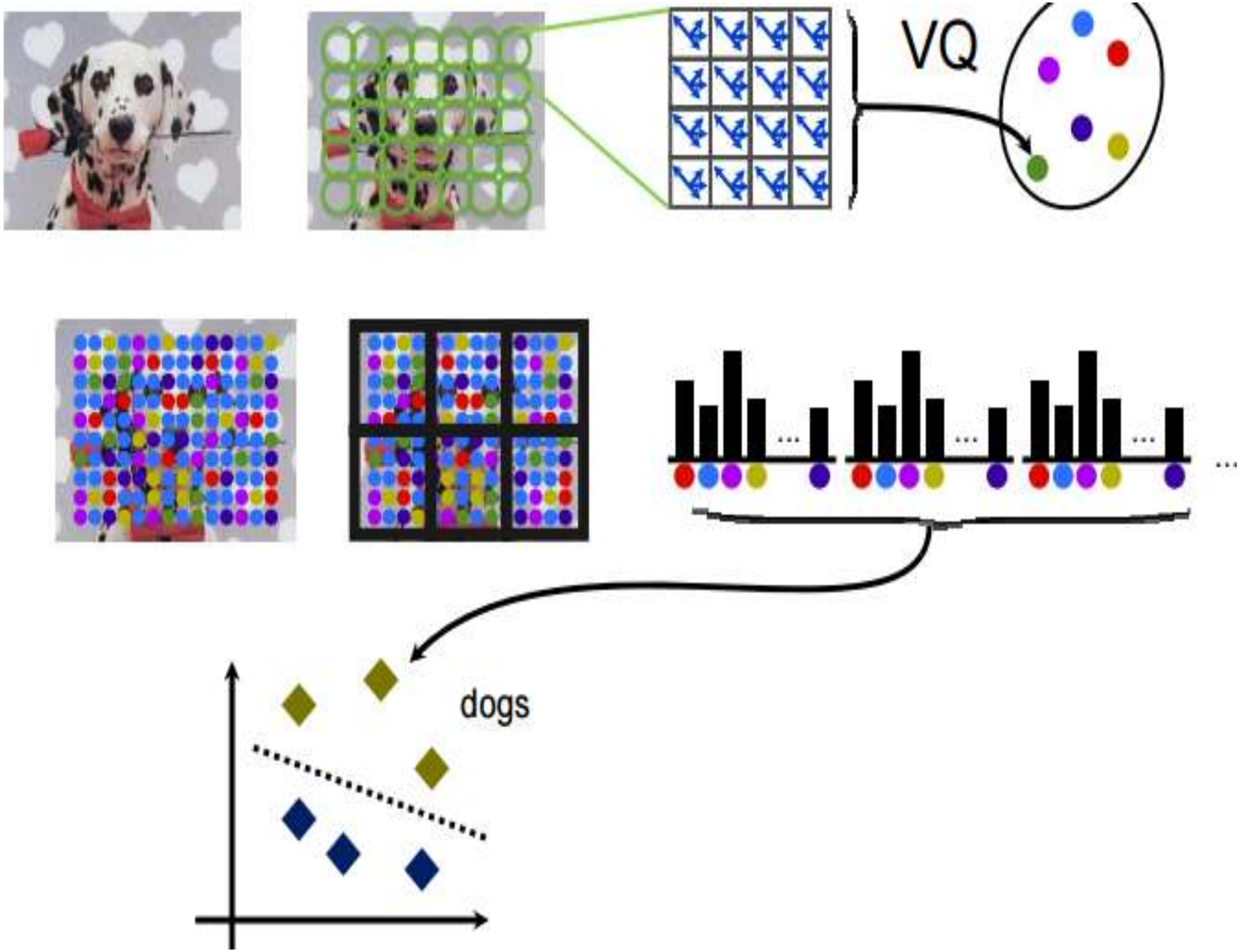
1. Extract features
2. Learn "visual vocabulary"
3. Quantize features using visual vocabulary
4. Represent images by frequencies of "visual words"





Bag of Words
Feature Vector
Bag of Words
Concatenate
Feature Vector


1 BoW
4 BoW
16 BoW

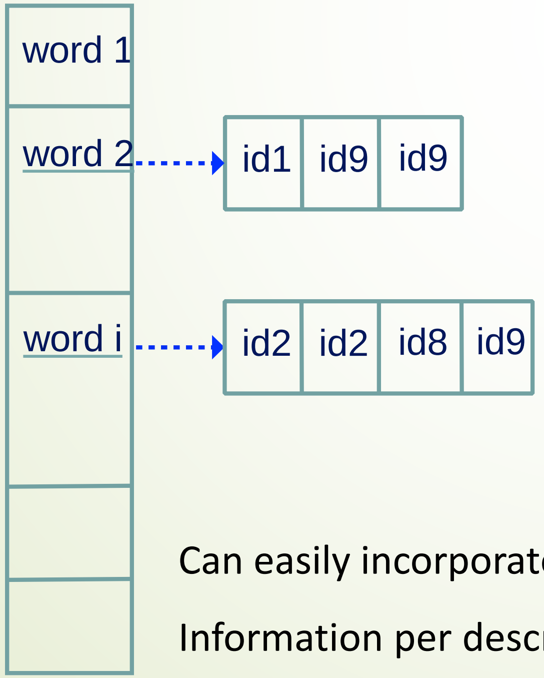

VQ
dogs

Inverted index

- Indexing all the feature vectors extracted from the database.
- In this work, each of the visual descriptors is hierarchically quantized by hierarchical K-means clustering.
- Here, K defines the branch factor of the tree rather than the final number of clusters
- we kept an inverted file associated with each leaf node—a representative descriptor (visual word)—in the vocabulary tree.
- However, we recorded not only the visual instances that contain the word, but also those word IDs.
- Can quickly use the inverted file to compute similarity between a new image and all the images in the database
  - Only consider database images whose bins overlap the query image

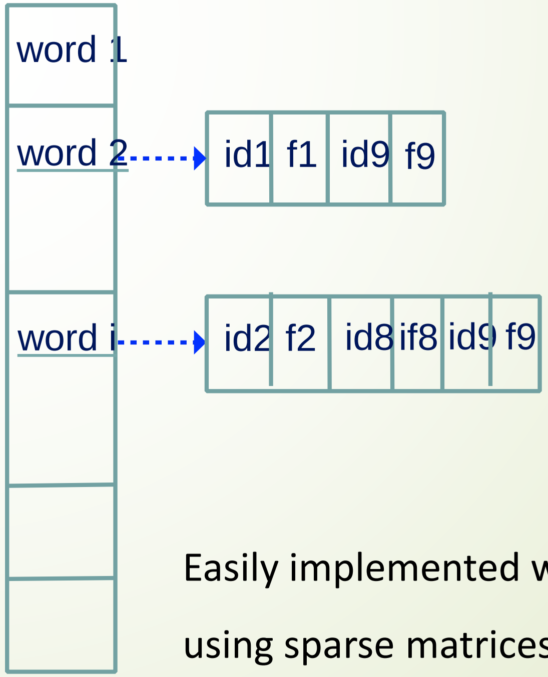
Advantage of Indexing

- One merit of the adaptive vocabulary tree is that the tree needs not to be re-built when the database slightly changes.
- Moreover, the tree grows based on a measure that encourages splitting those nodes that become too ambiguous and pruning nodes that are not active for the current set of tasks.



Can easily incorporate meta

Information per descriptor



Easily implemented with Matlab

using sparse matrices/vectors

APPLICATIONS

- Digital watermarking
- Face detection
- OCR
- Quality control and assembly in industrial plants.
- Robot localization and navigation.
- Monitoring and surveillance.
- Automatic exploration of image databases
- Appearance Recognition

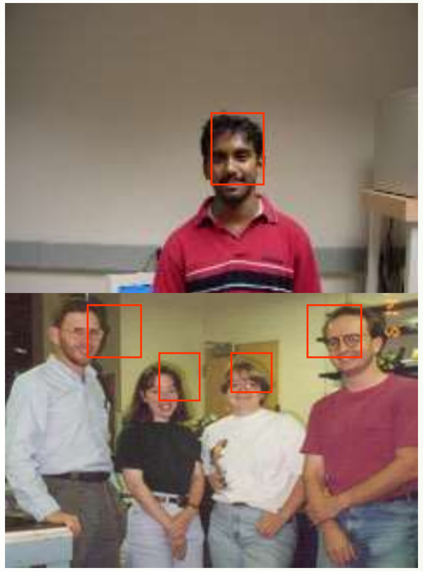
Digital watermarking

- A digital watermark is a kind of marker embedded in a noise-tolerant signal such as an audio, video or image data.
- It is typically used to identify ownership of the copyright of such signal.
- "Watermarking" is the process of hiding digital information in a carrier signal; the hidden information should, but does not need to, contain a relation to the carrier signal.

Face detection

Face detection is a computer technology being used in a variety of applications that identifies human faces in digital images. Face detection also refers to the psychological process by which humans locate and attend to faces in a visual scene.

Face Detection



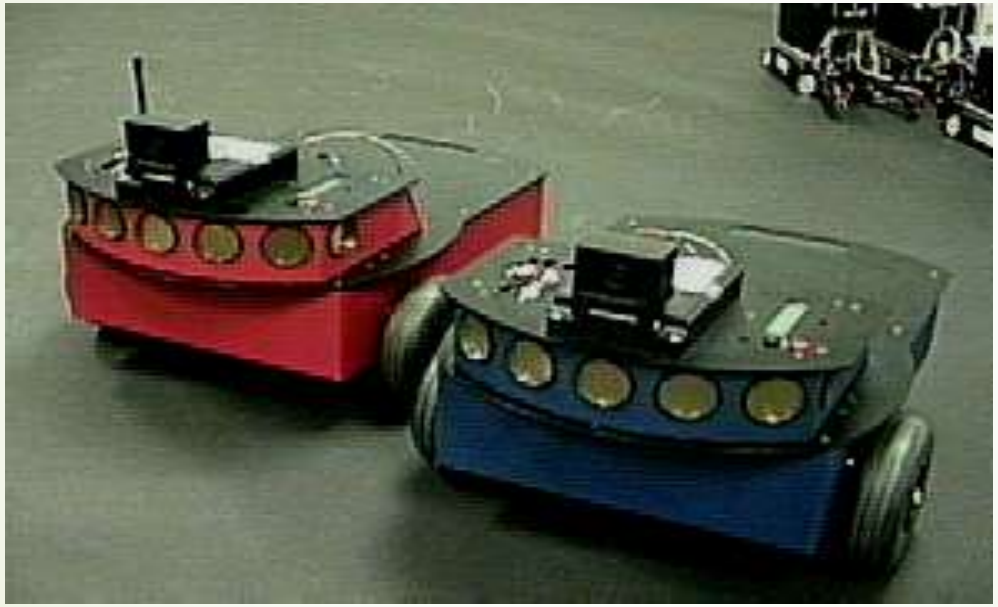
OCR

- Optical character recognition (optical character reader) (OCR) is the mechanical or electronic conversion of images of typed, handwritten or printed text into machine-encoded text.

- It is widely used as a form of data entry from printed paper data records, etc.

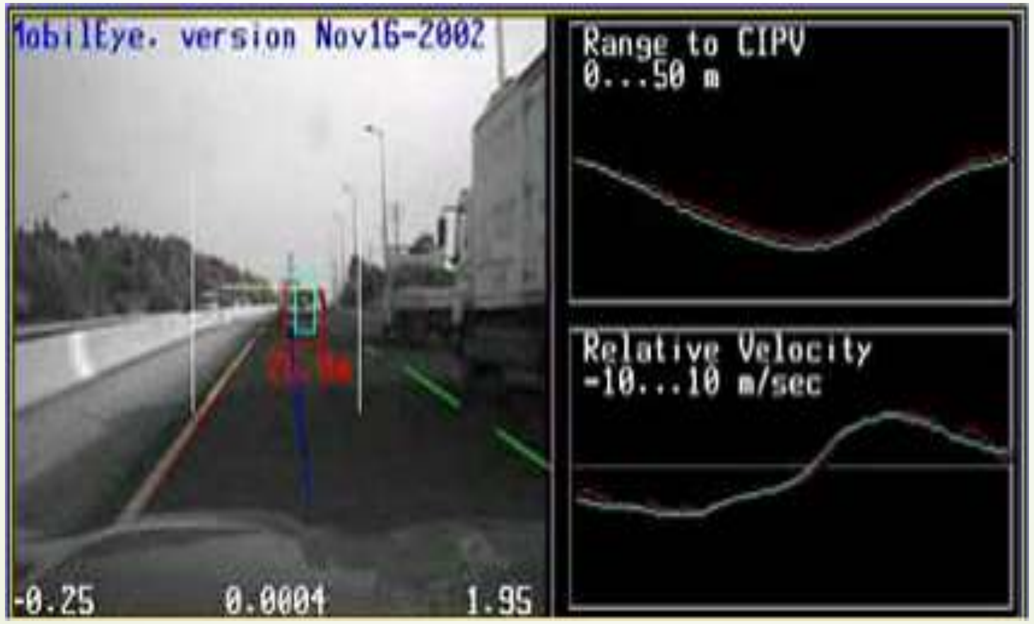
- It is a common method of digitizing printed texts so that it can be electronically edited, searched, stored more compactly, displayed on-line, and used in machine processes such as machine translation, text-to-speech, key data and text mining.

Robot localization and navigation.

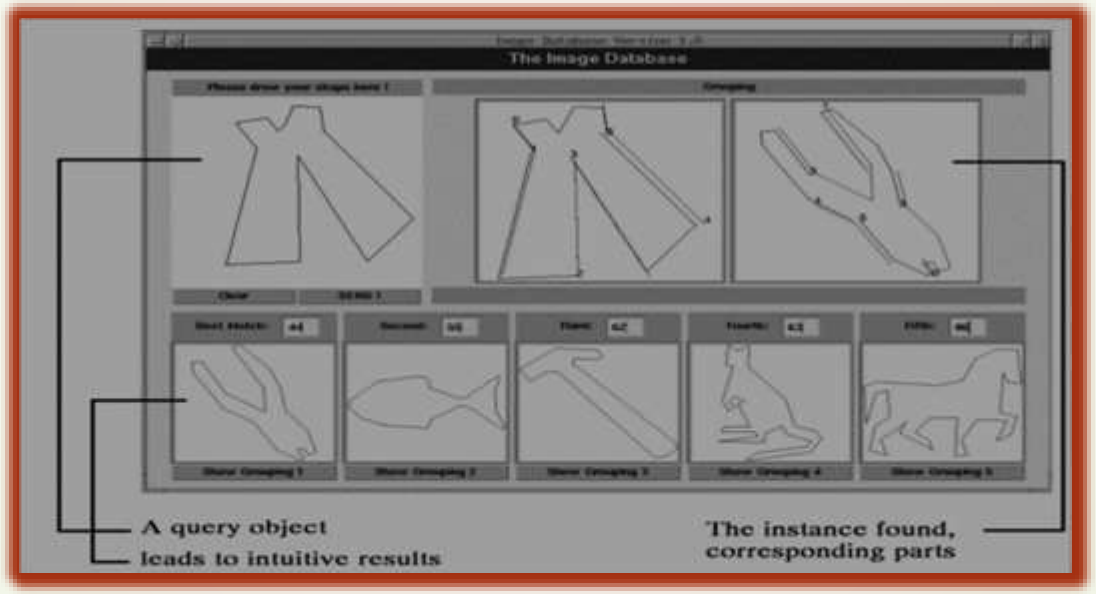


Vehicle Detection

- Intelligent vehicles aim at improving the driving safety by machine vision techniques



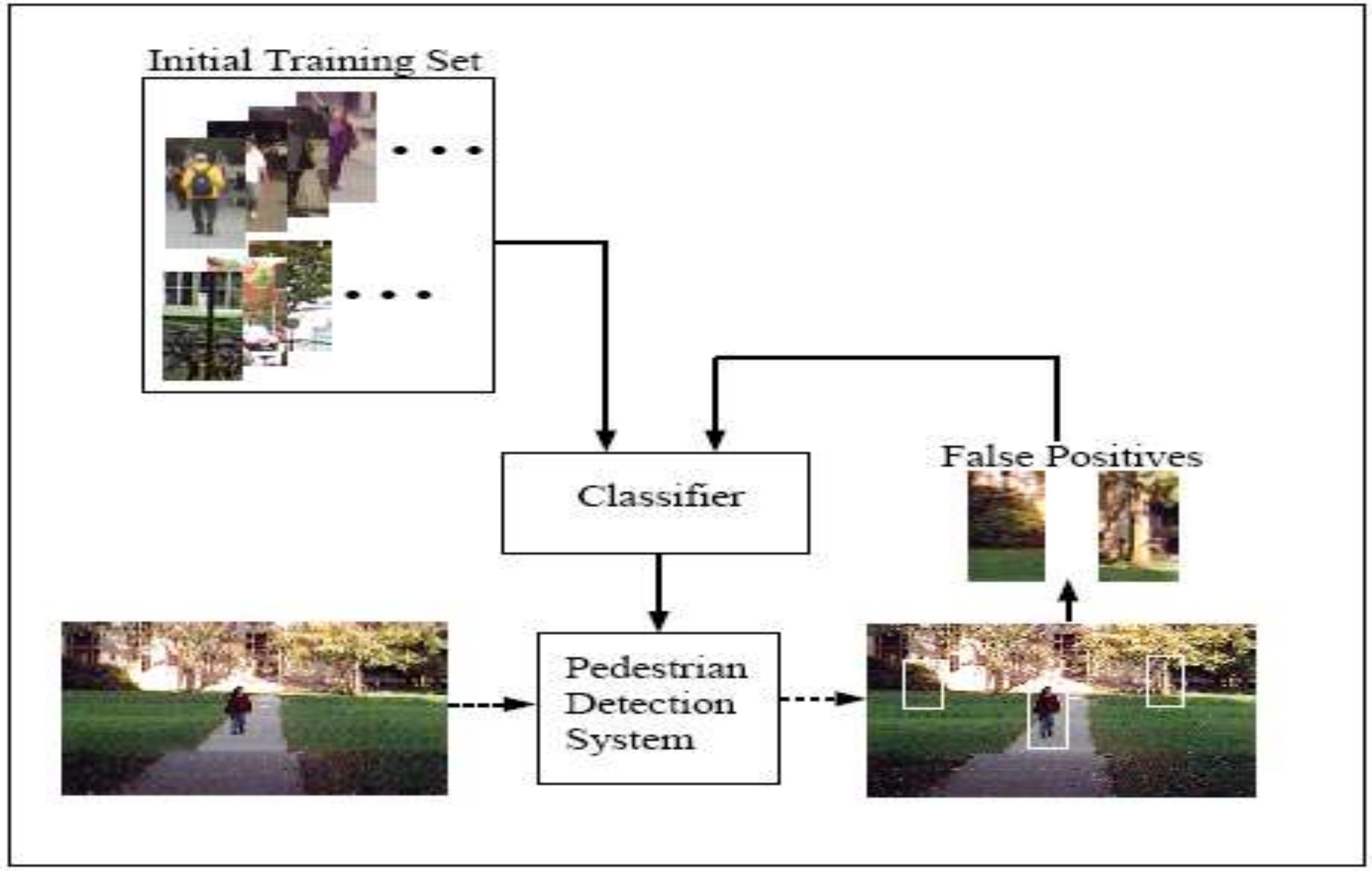
Quality control and assembly in industrial plants



Pedestrian Detection

- Why do we need to detect pedestrians?
  - Security monitoring
  - Intelligent vehicles
  - Video database search
- Challenges
  - Uncertainty with pedestrian profile, viewing distance and angle, deformation of human limb

Learning-based Pedestrian Detection

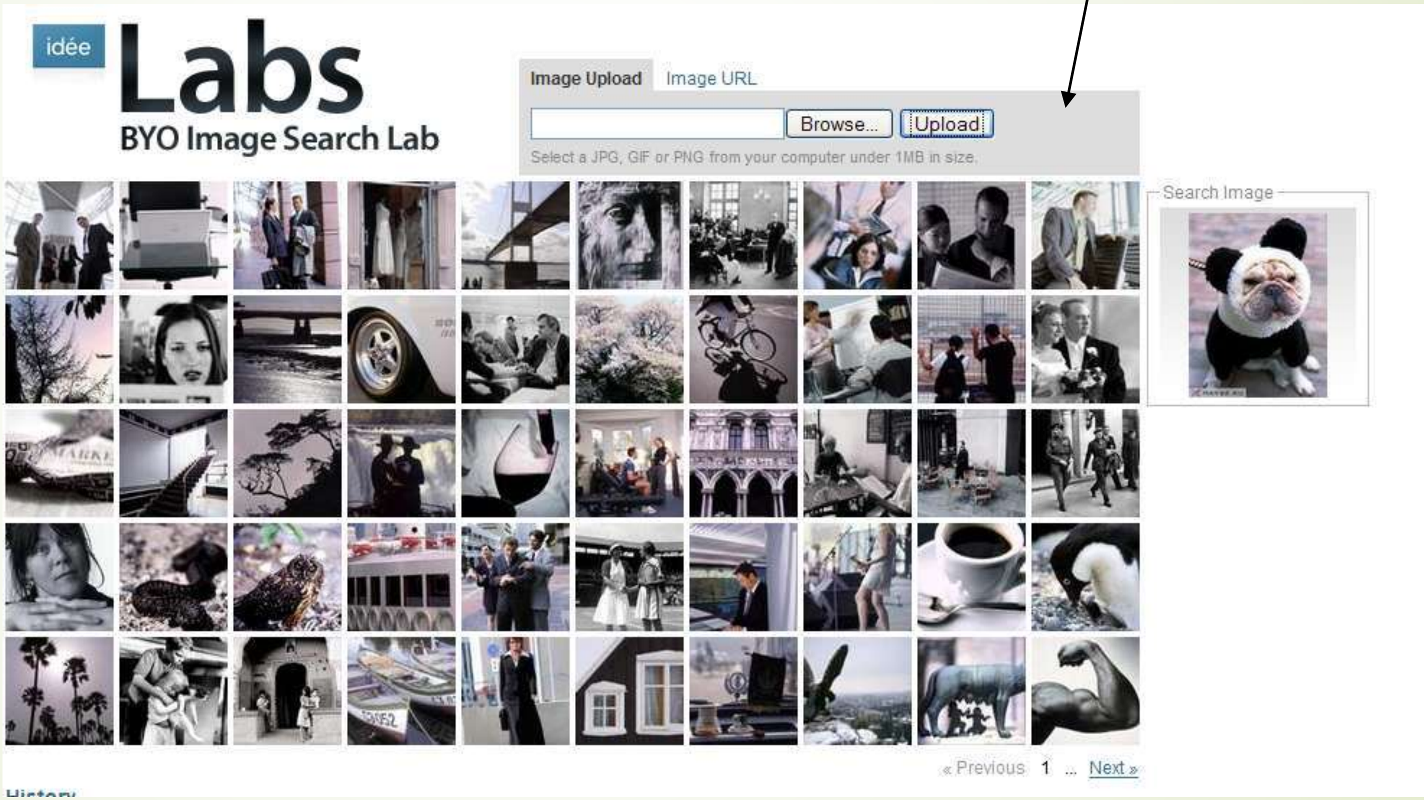


Represent an object by the set of its possible appearances (i.e., under all possible viewpoints and illumination conditions).

Identifying an object implies finding the closest stored image.

Upload or provide url for image, and find visually similar photos

Site :-http://www.stevesdigicams.com/BYO.jpg



Conclusion

- Any information can be retrieved from the system with accurate results.
- Many applications such as face detection, pattern recognition is based on the technique object recognition


Thank you so much everybody!

QUESTIONS??