

Feature Sets

- Haar wavelets + SVM:
 - Papageorgiou & Poggio (2000)
 - Mohan et al (2001)
 - DePoortere et al (2002)
- Rectangular differential features + adaBoost:
 - Viola & Jones(2001)
- Parts based binary orientation position histogram + adaBoost:
 - Mikolajczk et al (2004)
- Edge templates + nearest neighbor:
 - Gavrilu & Philomen (1999)
- Dynamic programming:
 - Felzenszwalb & Huttenlocher (2000).
 - Loffe & Forsyth (1999)
- Orientation histograms:
 - C.F. Freeman et al (1996)
 - Lowe(1999)
- Shape contexts:
 - Belongie et al (2002)
- PCA-SIFT:
 - Ke and Sukthankar (2004)

Feature Descriptors

Local/Patch

- SIFT
- SURF
- FAST
- BRIEF
- ORB (\approx FAST+BRIEF)
- GLOH

Global/Object

- HOG
- GIST
- Shape Context

Speeded Up Robust Features (SURF)

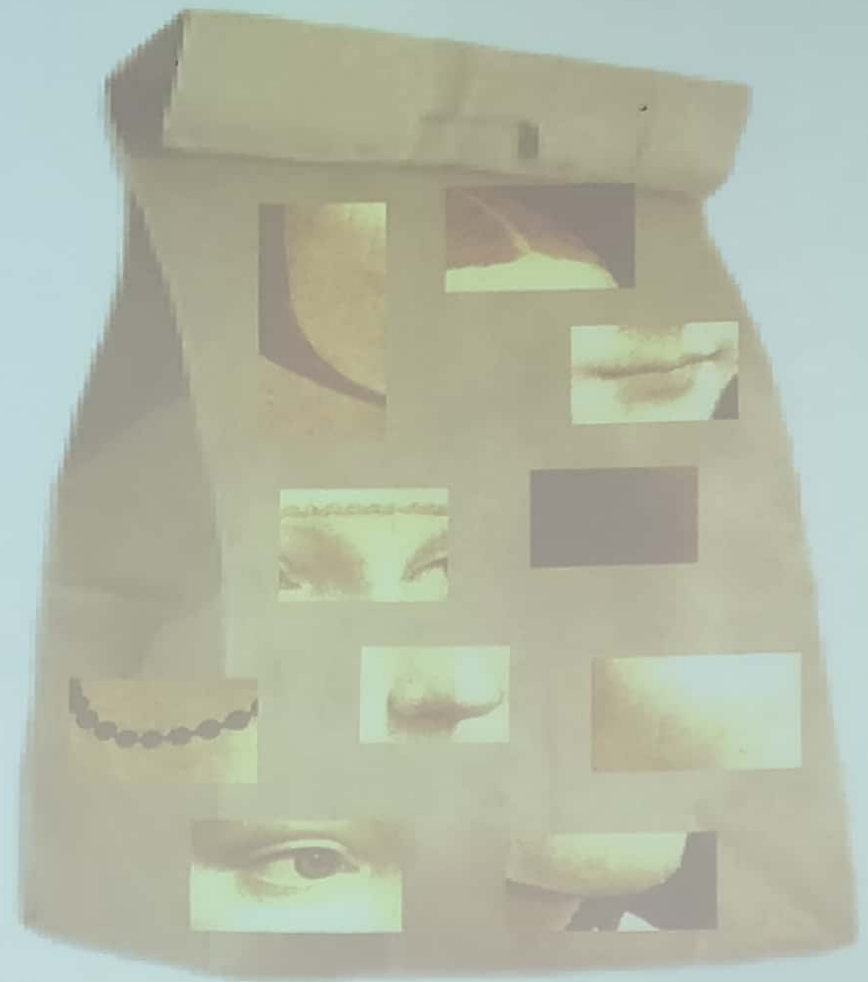
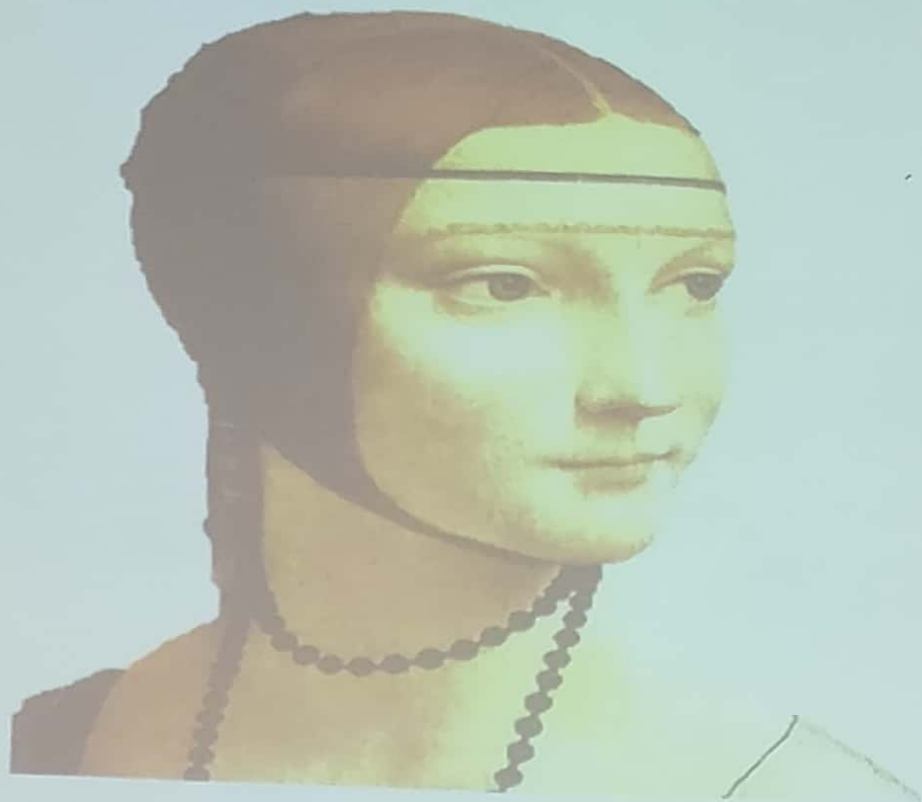
Oriented FAST and rotated BRIEF (ORB)

Gradient Location and Orientation Histogram (GLOH)

Binary Robust Independent Elementary Features (BRIEF)

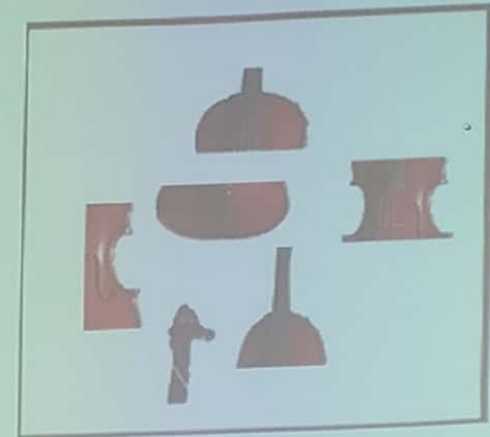
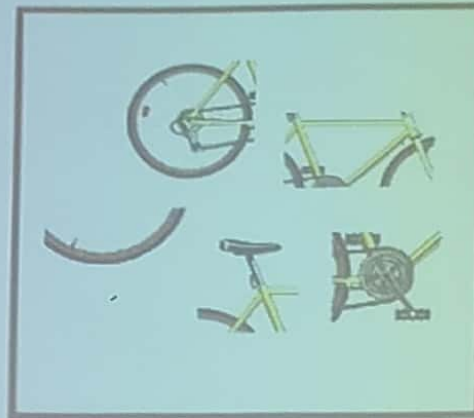
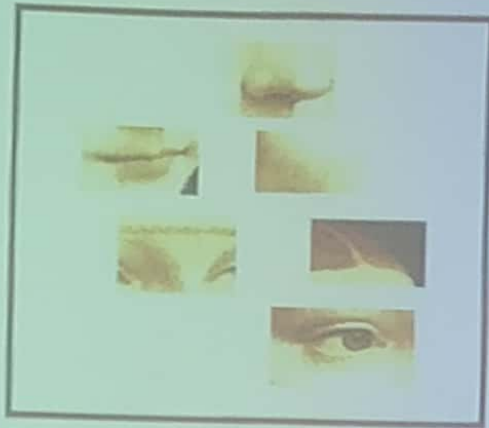
Features from Accelerated Segment Test (FAST)

Bag-of-Features Models

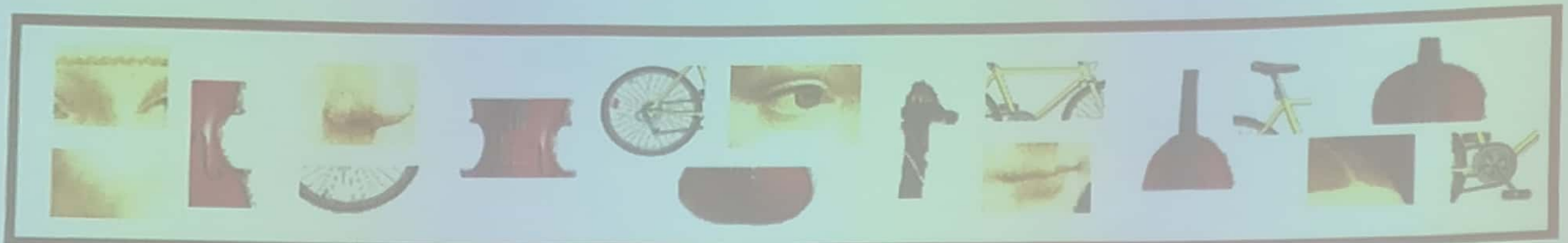


Bag of Features for Image Classification

- Extract Features



- Learn “visual vocabulary”



Difference Between Features & Words

Words

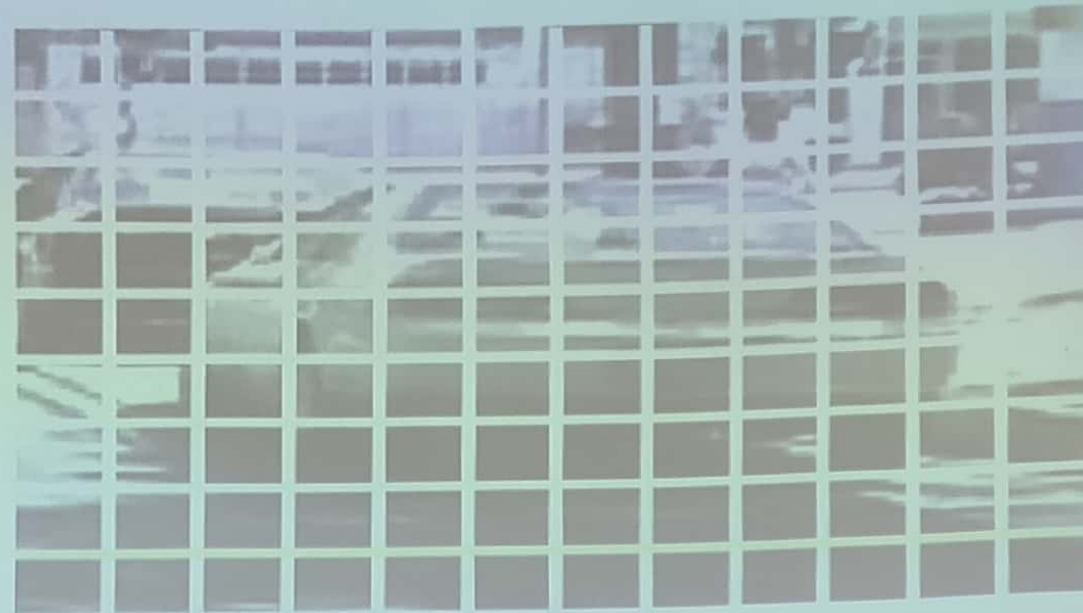
- Dictionary/Vocab.
- Meaning.
- Finite/Precise.
- Language known.

Features

- Dictionary/Vocab ?
- Meaning ?
- Finite/Precise ?
- What Language ?

1. Feature extraction

- Regular grid
 - Vogel & Schiele, 2003
 - Fei-Fei & Perona, 2005



K-means clustering

- Want to minimize sum of squared Euclidean distances between points x_i and their nearest cluster centers m_k

$$D(X, M) = \sum_{\text{cluster } k} \sum_{\text{point } i \text{ in cluster } k} (x_i - m_k)^2$$

- Algorithm:
- Randomly initialize K cluster centers
- Iterate until convergence:
 - Assign each data point to the nearest center
 - Recompute each cluster center as the mean of all points assigned to it

From clustering to vector quantization

- Clustering is a common method for learning a visual vocabulary or codebook
 - Unsupervised learning process
 - Each cluster center produced by k-means becomes a codevector
 - Codebook can be learned on separate training set
 - Provided the training set is sufficiently representative, the codebook will be “universal”
- The codebook is used for quantizing features
 - A *vector quantizer* takes a feature vector and maps it to the index of the nearest codevector in a codebook
 - Codebook = visual vocabulary
 - Codevector = visual word

Difference between Features & Words

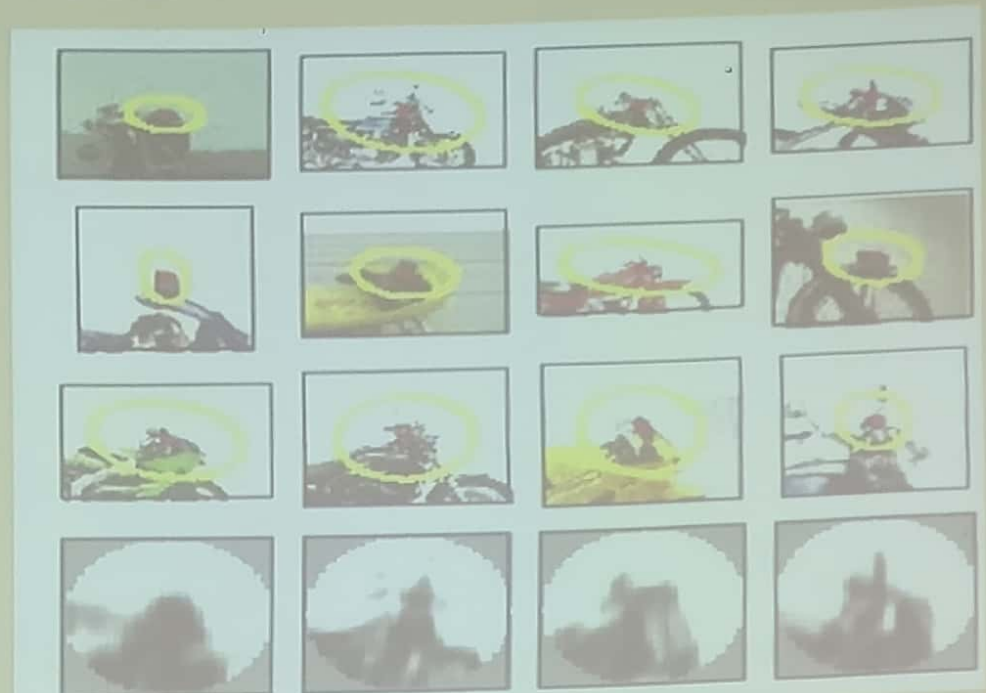
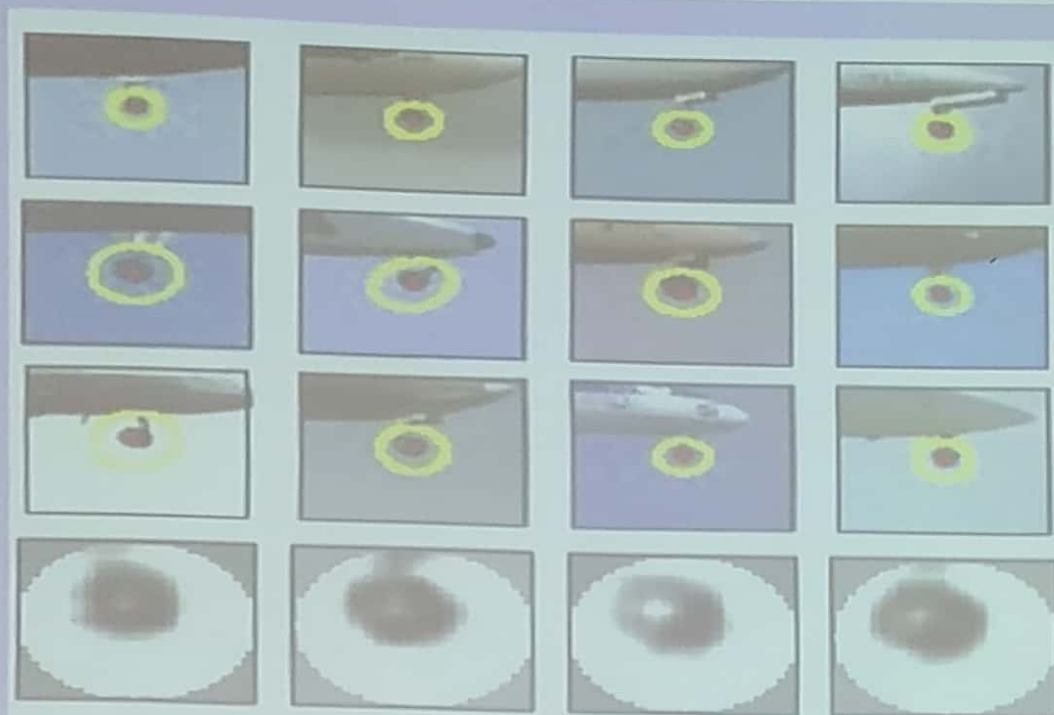
Features

- Dictionary/Vocab ?
- Meaning ?
- Finite/Precise ?
- What language ?
- Complicated!
- Training subjective!

Words

- Dictionary/Vocab.
- Meaning.
- Finite/Precise.
- Language known.
- Simple.
- Language-objective

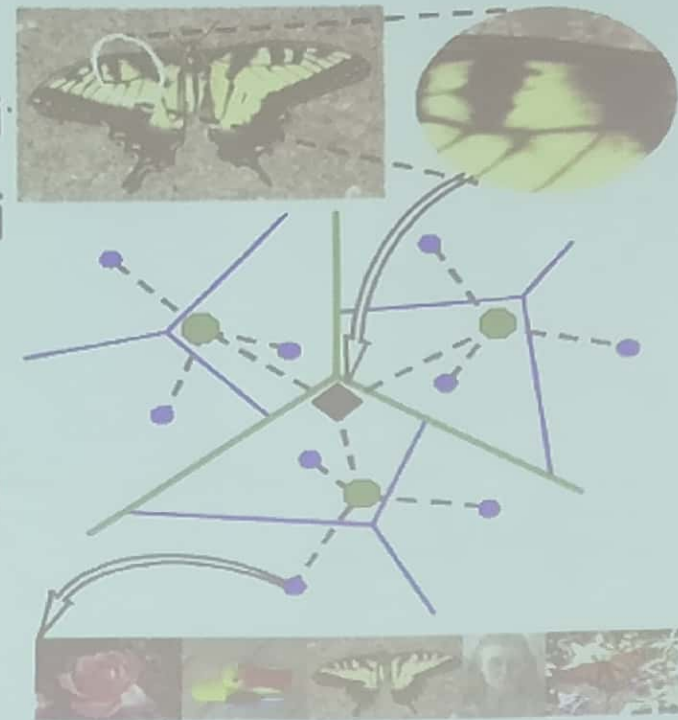
Image patch examples of visual words



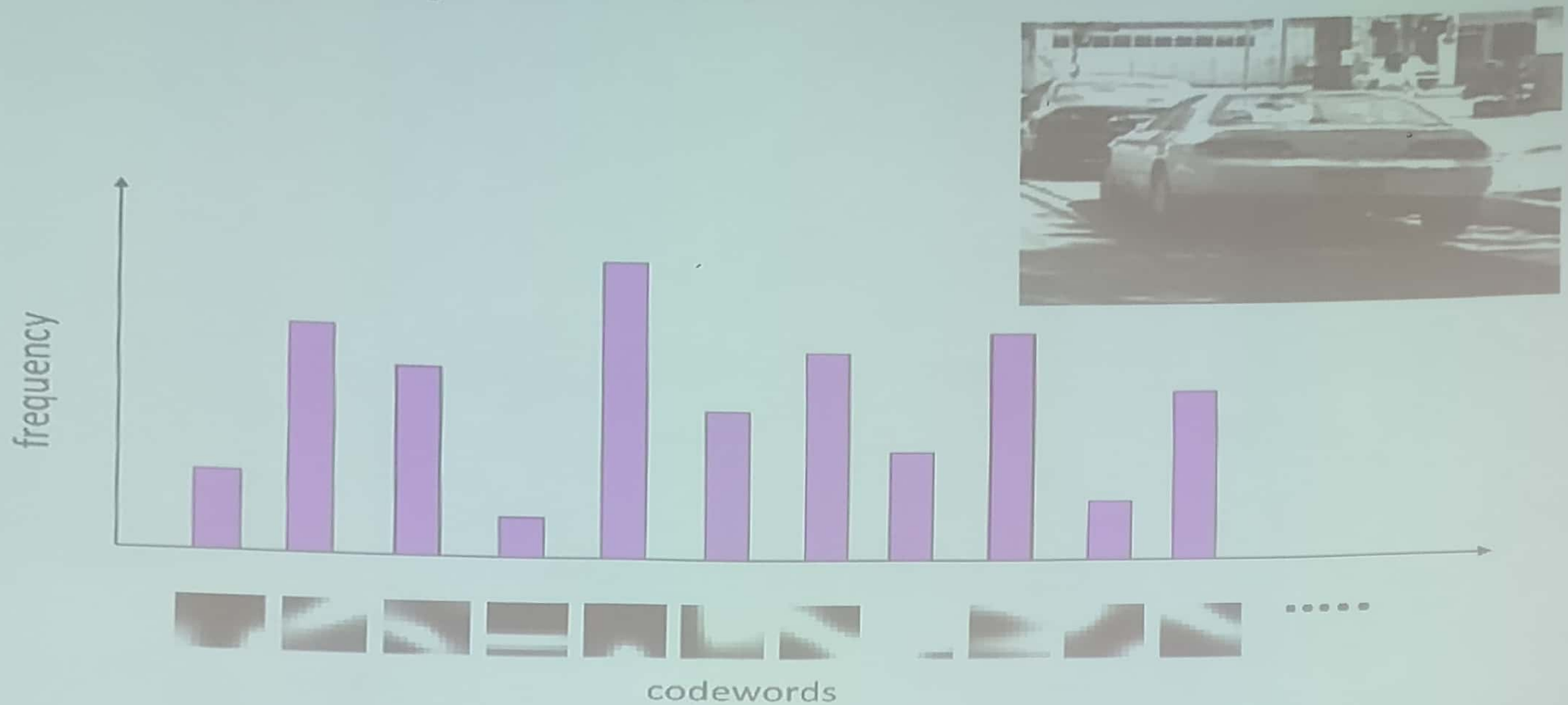
Sivic et al. 2005

Visual vocabularies: Issues

- How to choose vocabulary size?
 - Too small: visual words not representative of all patches
 - Too large: quantization artifacts
- Generative or discriminative
- Computational efficiency
 - Vocabulary trees (Nister & Stewenius, 2006)



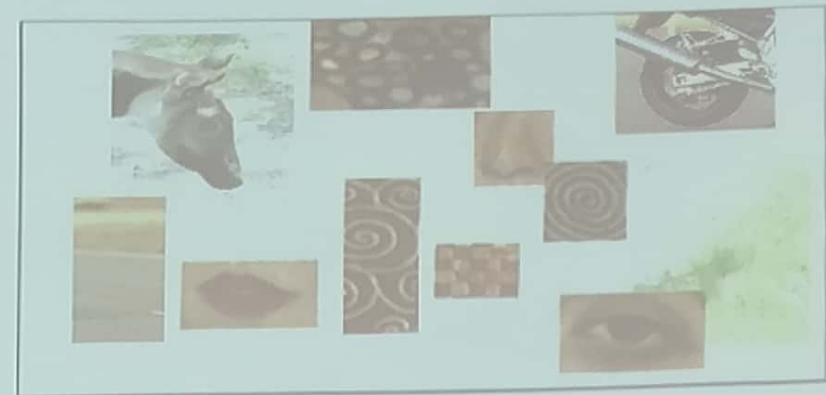
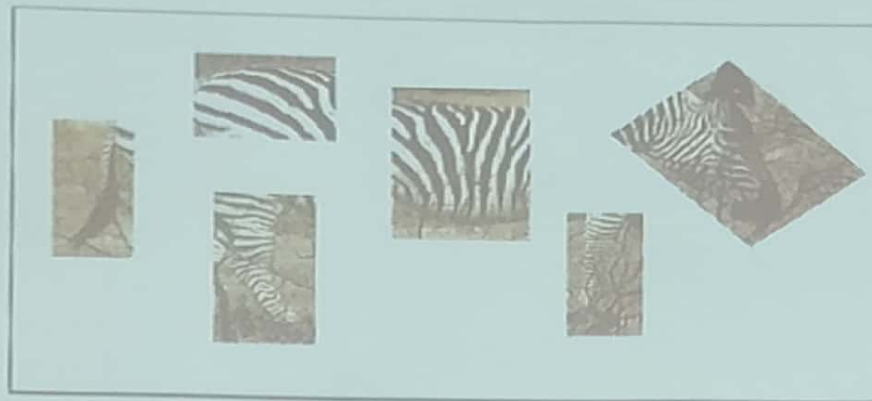
3. Image representation



Problems we can solve (attempt) ?

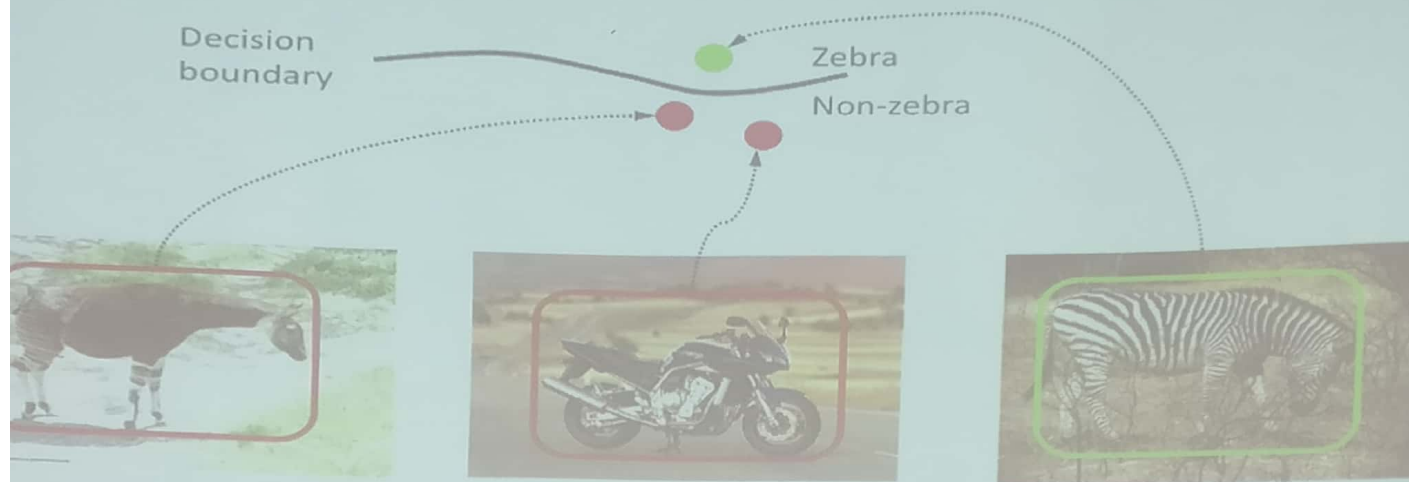
- Classification: Do these two images (visual documents) belong to the same subject ?
- Recognition: Which images contain chairs ?
- If images are documents, what are videos ?
- Actions are sequence of visual words organized in time.
- How to get better (spatial) representation (to enforce "structure" in documents/images) ?
- Search!

Discriminative and generative methods for bags of features

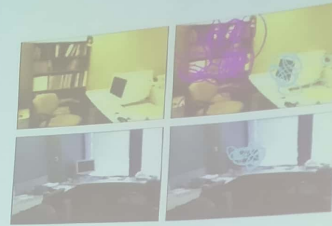
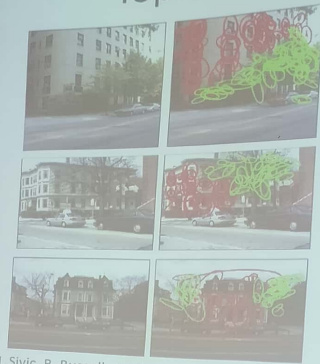


Discriminative methods

- Learn a decision rule (classifier) assigning bag-of-features representations of images to different classes



Topic discovery in images



J. Sivic, B. Russell, A. Efros, A. Zisserman, B. Freeman, [Discovering Objects and their Location in Images](#), ICCV 2005

Topic discovery in images



J. Sivic, B. Russell, A. Efros, A. Zisserman, B. Freeman, [Discovering Objects and their Location in Images](#), ICCV 2005

Multiple Actions

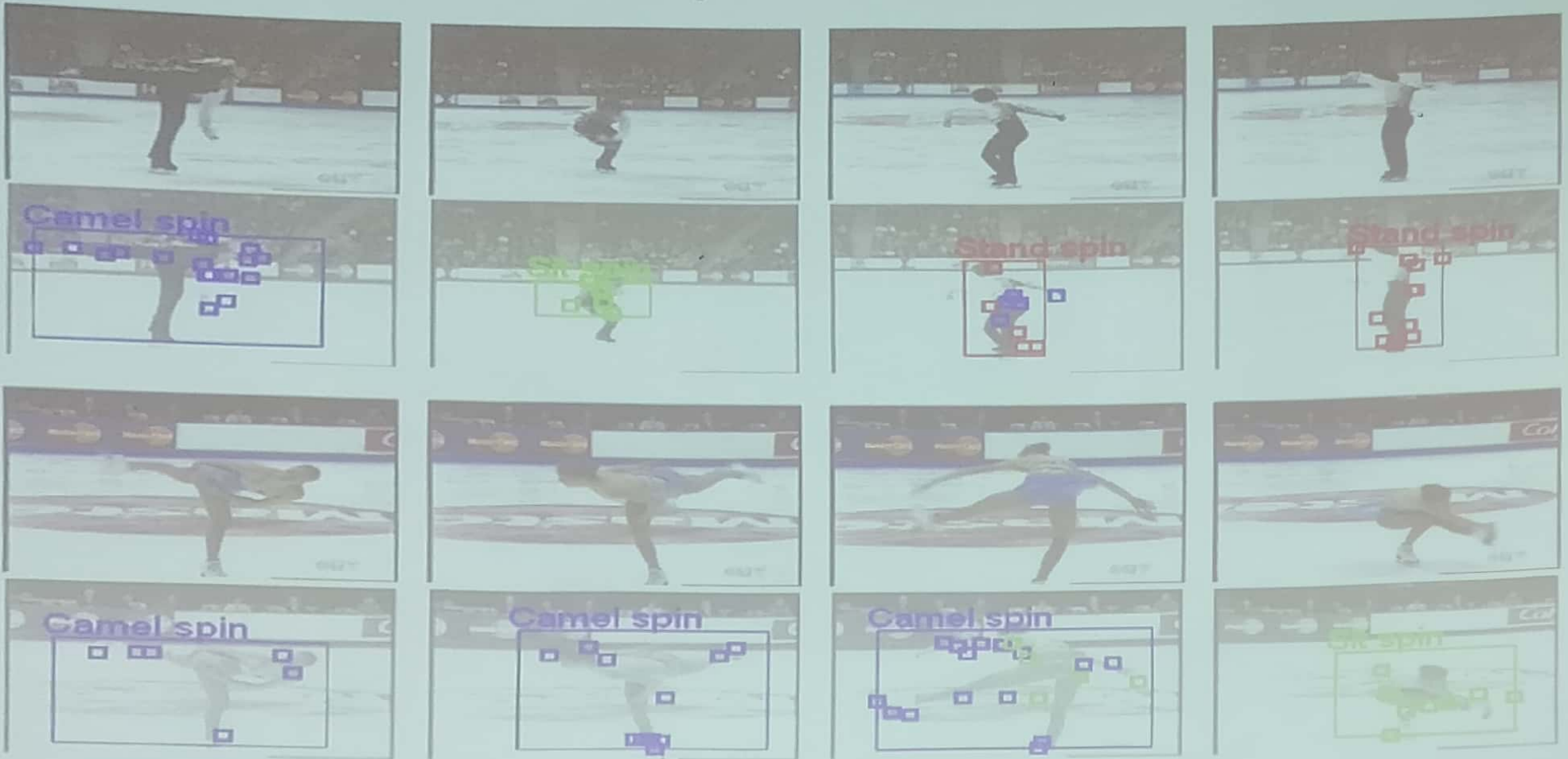


Image Search!

- What kind of searches possible ?
 - We will see at least 2 types.
- Why is image search important ?
 - Copyright problems / attribution !
 - Words might not be enough. (Find me images of dresses / goggles worn by in movie)
 - What is the name of the monument in this image ?



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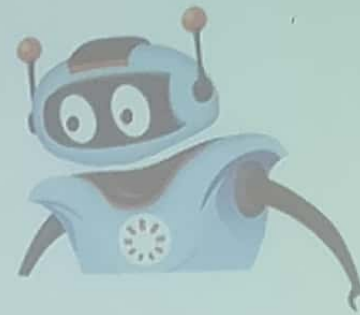
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Reverse Image Search



UPLOAD Your Image

Browse... No file selected.

or

ENTER Image Address

paste URL here (page or image)

Search

Interesting searches: [Dollar bill](#), [Man on the moon](#), [V-J day](#)



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Available for Firefox, Chrome, Safari, Internet Explorer & Opera.



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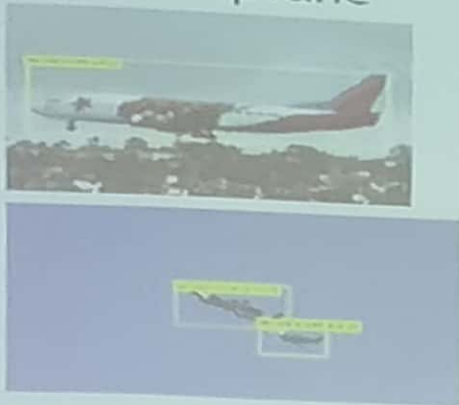
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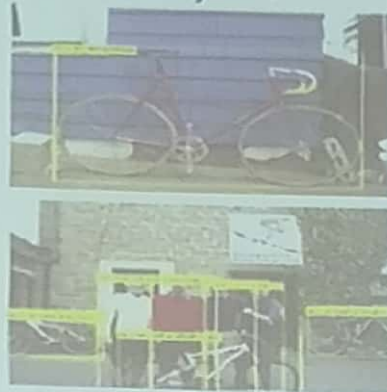
Pin It

Examples from PASCAL VOC Challenge 2010

Aeroplane



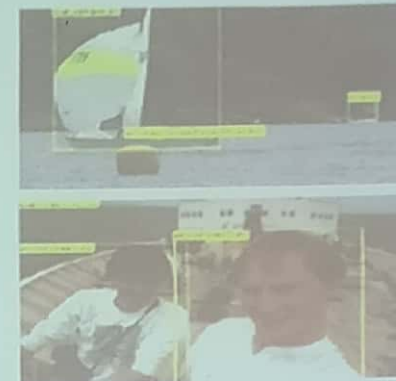
Bicycle



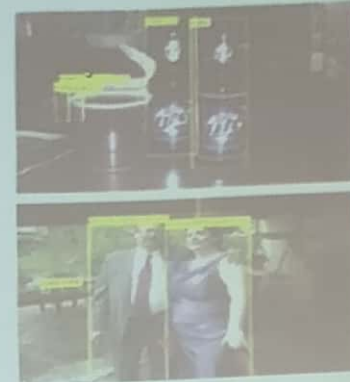
Bird



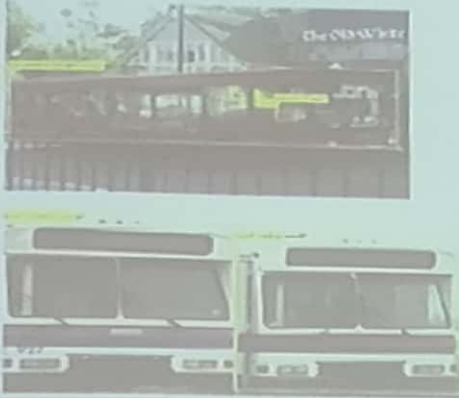
Boat



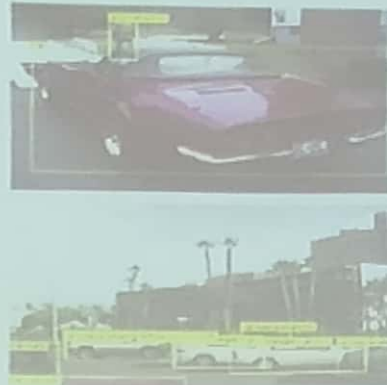
Bottle



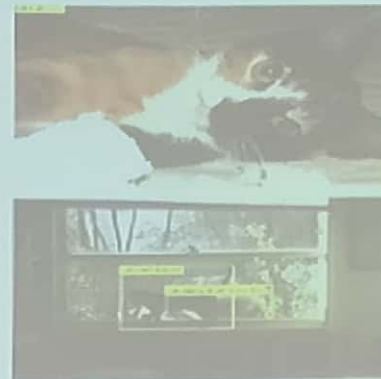
Bus



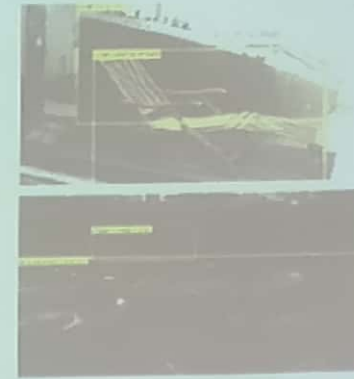
Car



Cat



Chair



Cow

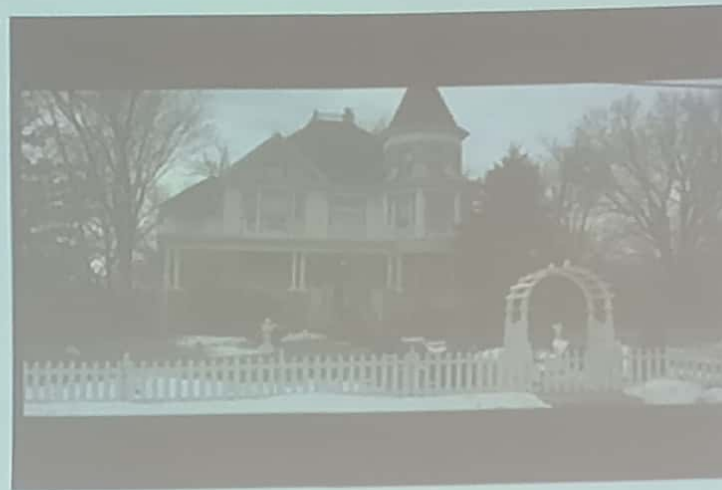


Video Google

Enable video, e.g. a feature length film, to be searched on its **visual content** with the same ease and success as a Google search of text documents.



"Run Lola Run" ('Lola Rennt')
[Tykwer, 1999]



"Groundhog Day" [Rammis, 1993]