Tutorial on Image Clustering

by Joris Guérin

Problem definition

Inputs: Dataset of unlabelled images

Objective: make groups within these images







➢ Difference with Image classification?

Motivations

Search web image databases

Web-scale image clustering revisited

Yannis Avrithis[†], Yannis Kalantidis[‡], Evangelos Anagnostopoulos[†], Ioannis Z. Emiris[†]
[†]University of Athens, [‡]Yahoo! Labs

Storyline reconstruction

Joint Summarization of Large-scale Collections of Web Images and Videos for Storyline Reconstruction

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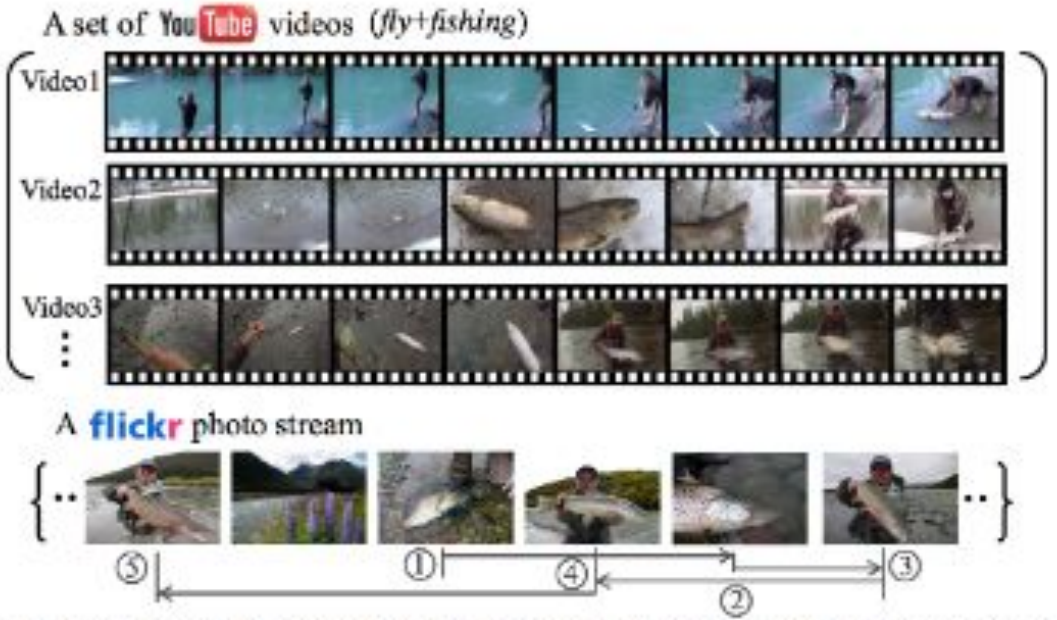
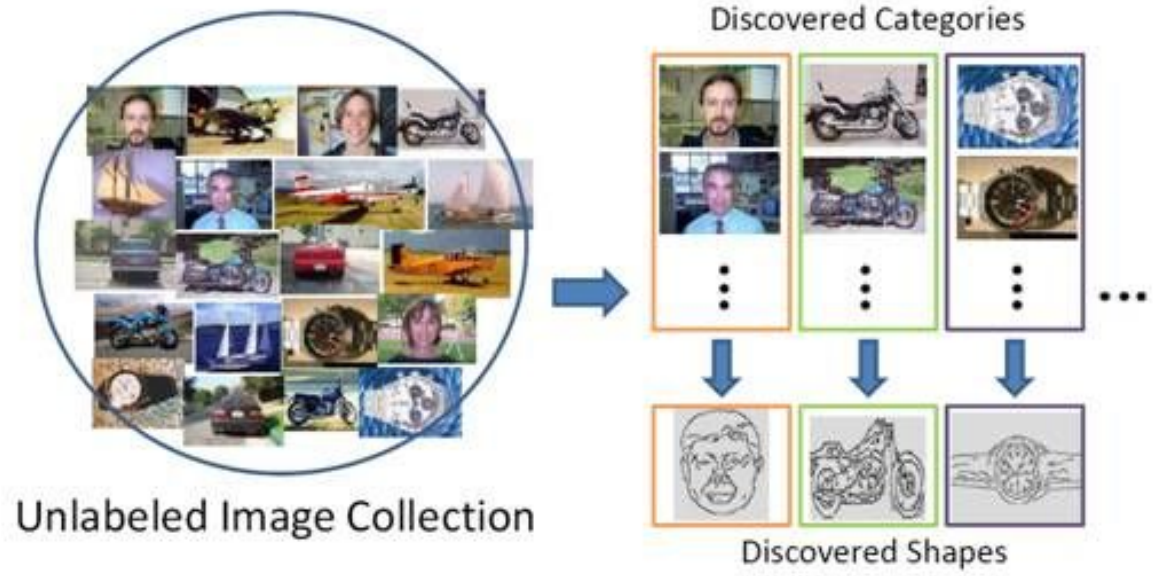


(a) A set of videos help discover the sequential structure of a photo stream

Concept discovery

Shape Discovery from Unlabeled Image Collections

Yong Jae Lee and Kristen Grauman
University of Texas at Austin



Medical diagnoses

Unsupervised Joint Mining of Deep Features and Image Labels for Large-scale Radiology Image Categorization and Scene Recognition

Xiaosong Wang, Le Lu, *IEEE Senior Member*, Hoo-chang Shin, Lauren Kim,
Mohammadhadi Bagheri, Isabella Nogues, Jianhua Yao, Ronald M. Summers
Department of Radiology and Imaging Sciences, National Institutes of Health Clinical Center,
10 Center Drive, Bethesda, MD 20892

Cluster #23

Word	Frequency
liver	524
abdomen	337
enhancement	217
mass	198
lesion	168
lobe	161
adenopathy	119
lesions	103
segment	58
bulky	45

Cluster #64

Word	Frequency
enhancement	277
cerebellar	193
lesion	192
lobe	186
flair	173
hemisphere	155
mass	134
abnormal	119
frontal	115
cerebellum	113

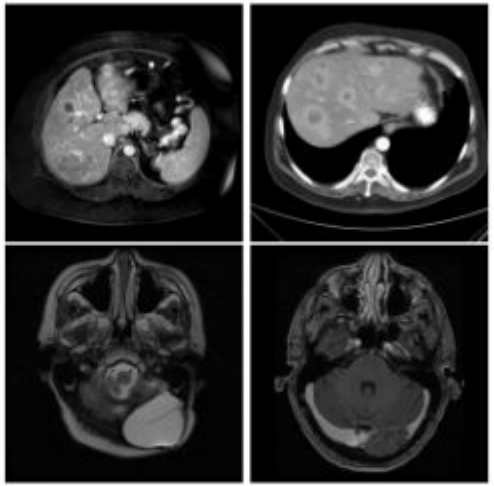
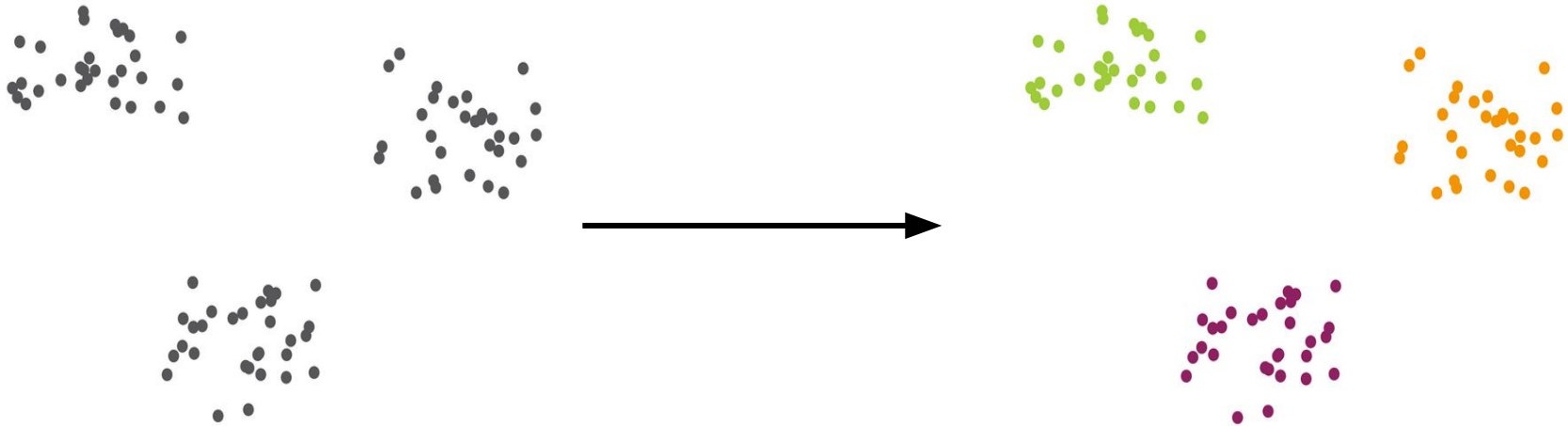


Figure 2. *Sample images of two unsupervisedly discovered image clusters with associated clinically semantic key words, containing (likely appeared) anatomies, pathologies , their attributes and imaging protocols or properties.*

Intro to clustering

Data clustering



K-Means clustering

$$\underset{A,\, c}{\text{Minimize}} \quad \sum_{i=1}^{M} \sum_{k=1}^{K} a_{ik} \times d(x_i, c_k),$$

$$\text{subject to} \quad \sum_{k=1}^{K} a_{ik} = 1, \ \forall i \in \{1, \ldots, M\},$$

$$a_{ik} \in \{0, 1\}, \ \forall i, \forall k.$$

With

- c_k cluster centers,
- a_{ik} membership binary variables,
- $d(.,.)$ distance metric used.

→ Alternating optimization : EM algorithm

External metrics

Purity

$$\text{purity}(\Omega, \mathbb{C}) = \frac{1}{N} \sum_k \max_j |\omega_k \cap c_j|$$

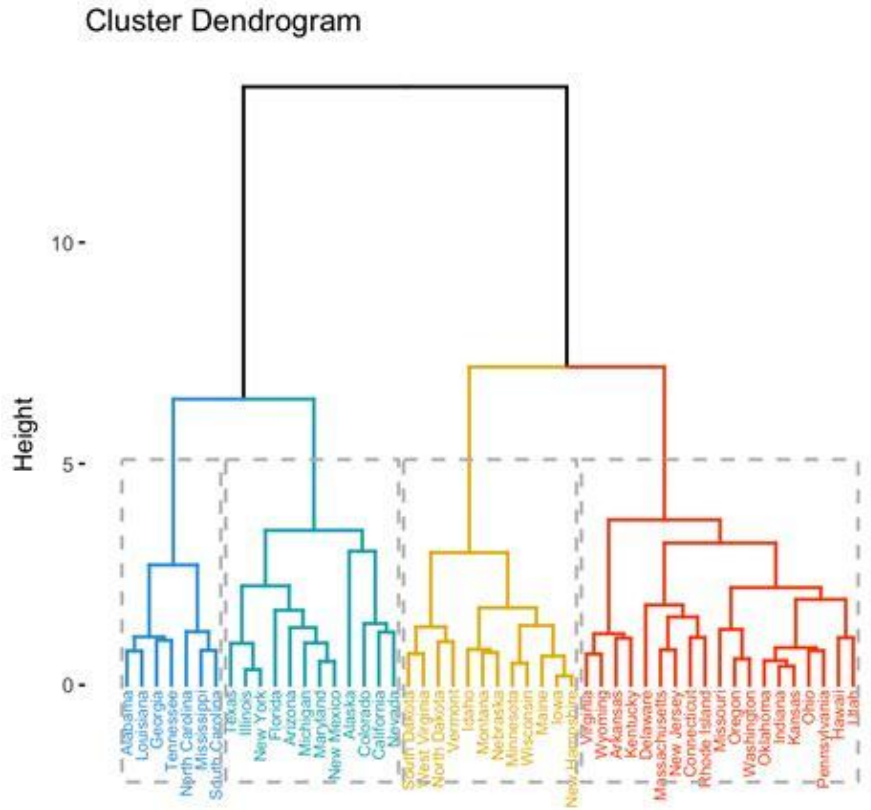
Normalized Mutual Information

$$\text{NMI}(\Omega, \mathbb{C}) = \frac{I(\Omega; \mathbb{C})}{[H(\Omega) + H(\mathbb{C})]/2}$$

Fowlkes-Mallows index

$$FM = \sqrt{\frac{TP}{TP + FP} \cdot \frac{TP}{TP + FN}}$$

Agglomerative clustering

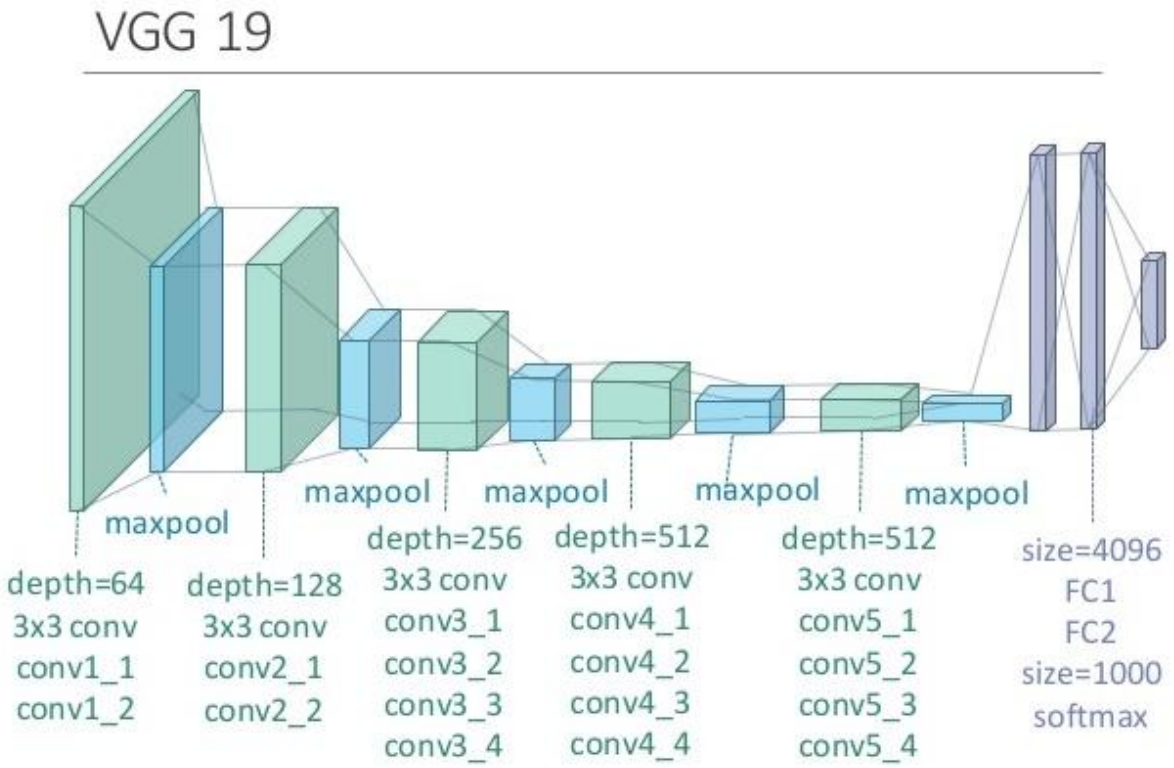


Clustering on raw images

Clustering on standard CV features

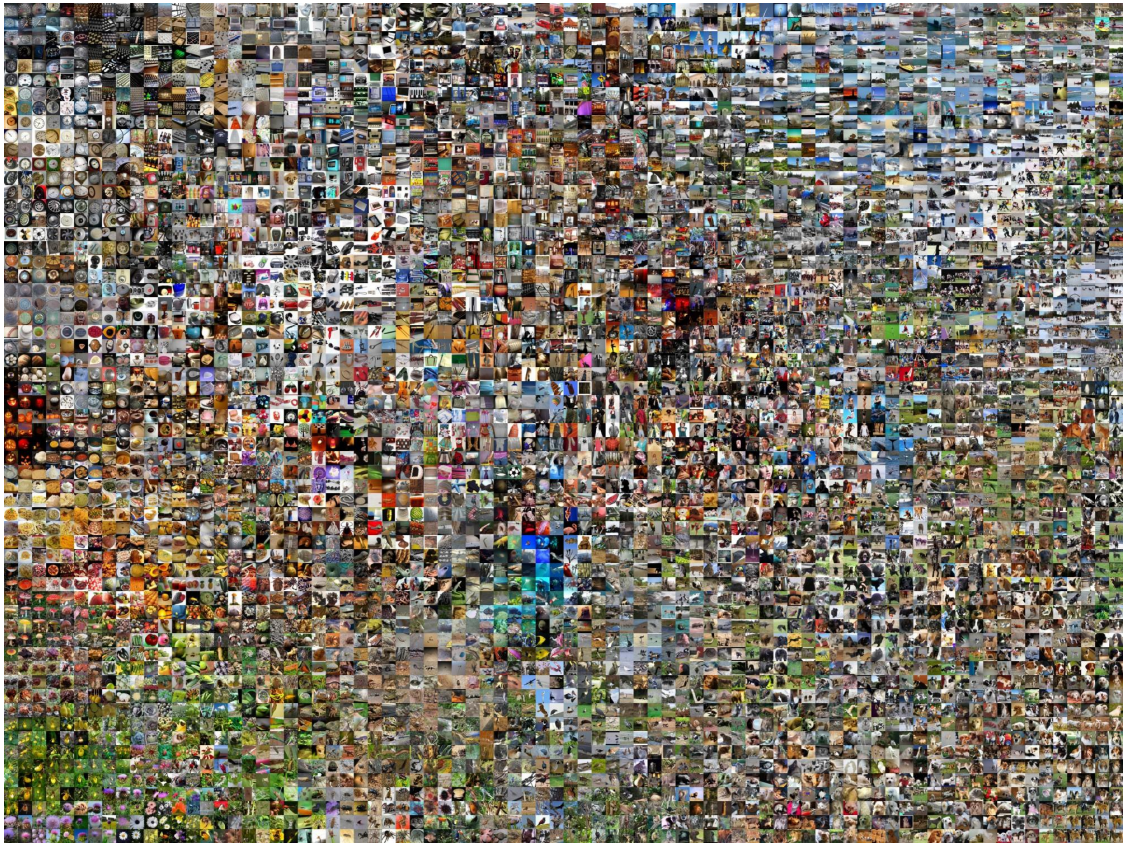
Clustering on deep CNN features

CNN feature extractor



- Complex model
- Solve many computer vision tasks recently
- Trained in a supervised way

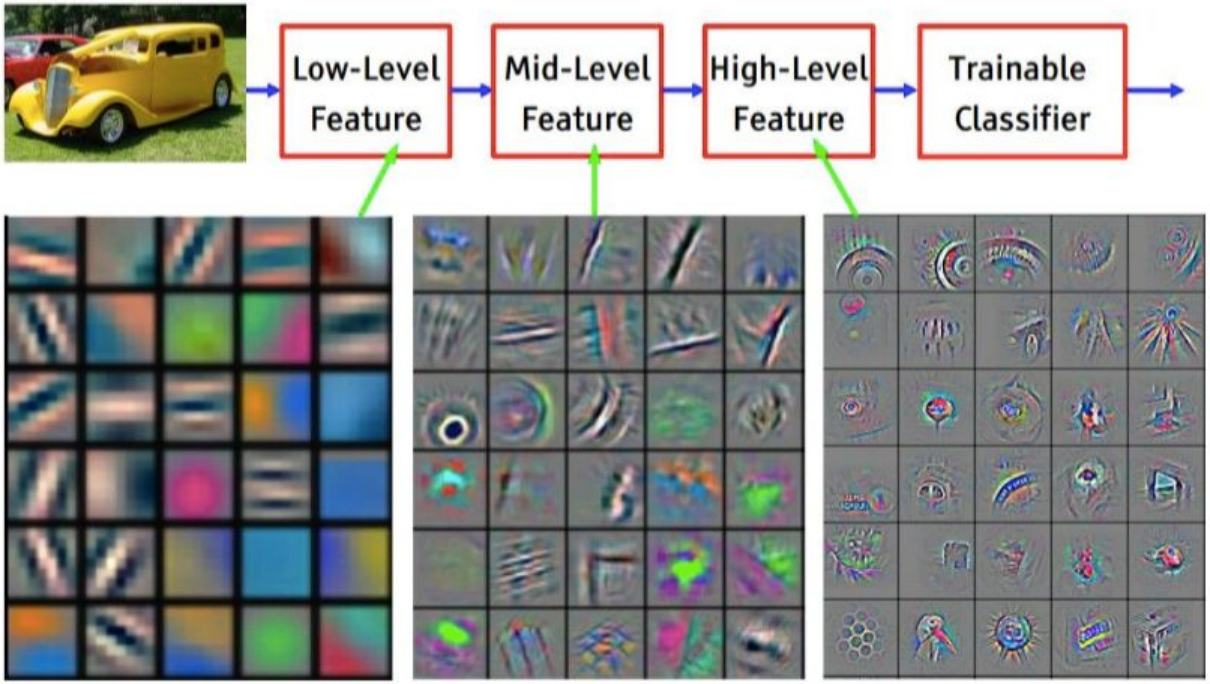
CNN feature extractor - pre-training



ImageNet

- Several million images
- 1000 categories

CNN feature extractor - image processing



Feature visualization of convolutional net trained on ImageNet from [Zeiler & Fergus 2013]

ImageNet

- Several million images
- 1000 categories

For next time (21/03/2019)

- Choose an image dataset.
- Repeat the experiments on you dataset with various feature extractors
  - 10 available in Keras: https://github.com/keras-team/keras-applications/tree/master/keras_applications
- You can try different architectures, different layers, different clustering algorithms ...
  - https://scikit-learn.org/stable/modules/clustering.html
- Record and send all your results and send them to me 24 hours before the class.

For next time (21/03/2019)

- Code available at :
  https://github.com/jorisguerin/tutorial_IC

- Send your results to:
  jorisguerin.research@gmail.com