Web Image Gathering with Region-based Bag-of-features and Multiple Instance Learning

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1. Objective & Background

Background

Web is the largest image DB.
It is also a very noisy DB.

- To remove noise, image analysis is needed.
- Since 2001, we have been working on Web Image Gathering with **image analysis**
  - Keiji Yanai: Image Collector: An Image-Gathering System from the World-Wide Web Employing Keyword-based Search Engines, ICME 2001, Tokyo, Japan, pp.704-707 (2001/08). (ACMMM 2003,..)
  - Non-interactive. No feedback. Fully-automatic.
  - To gather **visual knowledge of many concepts** ***for object recognition from the Web***

Objective of this paper

- Import region-based bag-of-features to our Web image "gathering" system [Yanai et al. ICME01, ACM MM03, ACM MIR 05, ICME08]

new combination !

【Image representation】

region-based bag-of-features

[Ravinovich et al. ICCV 07]

【Classifier】

mi-SVM (multiple instance learning)

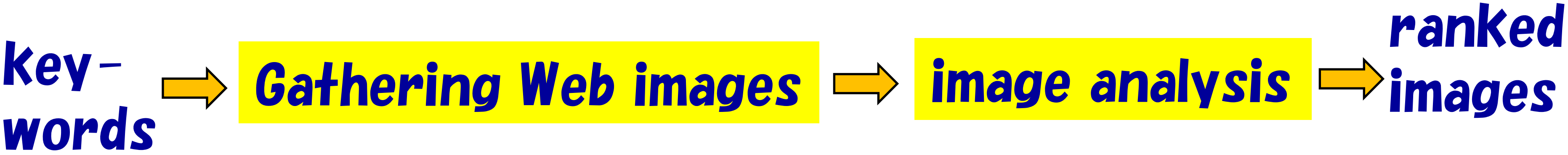
[Andrew et al. NIPS 03]

2. Related Work

General Framework: Web image search + Object Recognition Technique

- Firstly, gather images from the Web using Web (image) search engines such as Google, Ask.com and MSN search by providing given keywords.

- Secondly, re-rank the results from the Web search engines with object/scene recognition methods



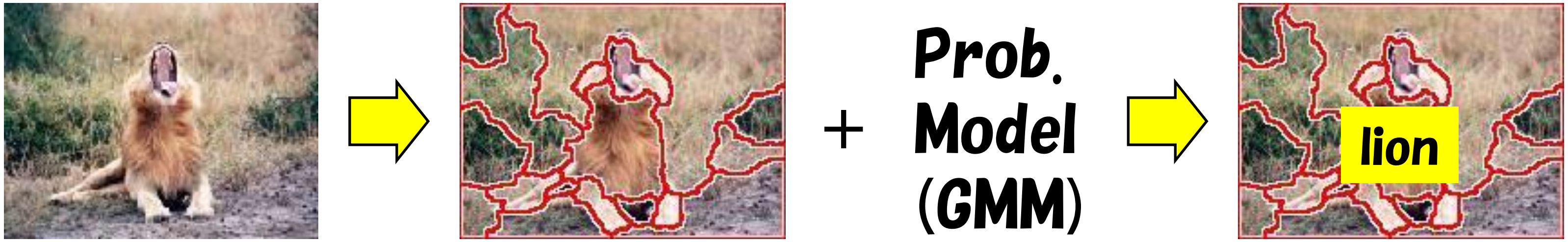
key-words → Gathering Web images → image analysis → ranked images

Literature: Web image search + Object Recognition Technique

- Color histogram + k-means [Yanai ICME01]
- Color signature + EMD + k-NN [Yanai ACM MM03]
- Constellation model + RANSAC [Fergus ICCV04]
- JSEG + GMM (image-word translation model) [Yanai & Barnard ACM MIR 05]
- Bag-of-features (BoF)+ pLSA [Fergus ECCV05]
- Bag-of-features + HDP(Hierarchical Dirichlet Process) (OPTIMOL) [Li CVPR07]
- Bag-of-features + SVM [ICCV Schroff 07] [Yanai 07]
- (This paper)
  JSEG + region-based bag-of-features
  + mi-SVM (multiple instance learning)

Literature: Web image search + Object Recognition Technique

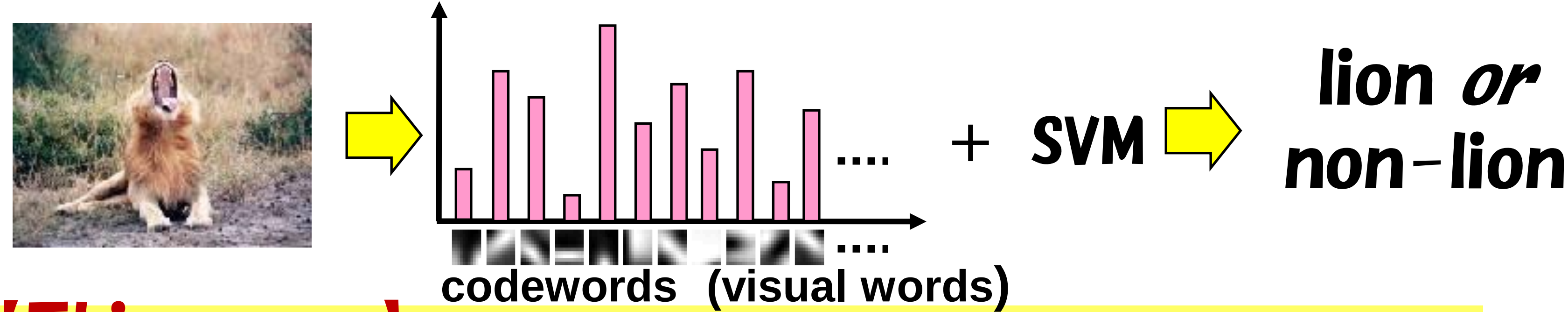
- JSEG + GMM (image-word translation model) *[Yanai & Barnard ACM MIR 05]*



+ Prob. Model (GMM)

lion

- Bag-of-features + SVM *[ICCV Schroff 07]* *[Yanai 07]*



....

....

codewords (visual words)

+ SVM

lion *or* non-lion

- (This paper)
  JSEG + region-based bag-of-features
  + mi-SVM (multiple instance learning)

Contribution of this paper

- Import region-based bag-of-features to our Web image "gathering" system

【Image representation】

region-based bag-of-features

[Ravinovich et al. ICCV 07]

【Classifier】

mi-SVM (multiple instance learning)

[Andrew et al. NIPS 03]

3. Methods

Basic framework of our system [Yanai ICME01]～

Collection stage

Unchanged since [ICME01]

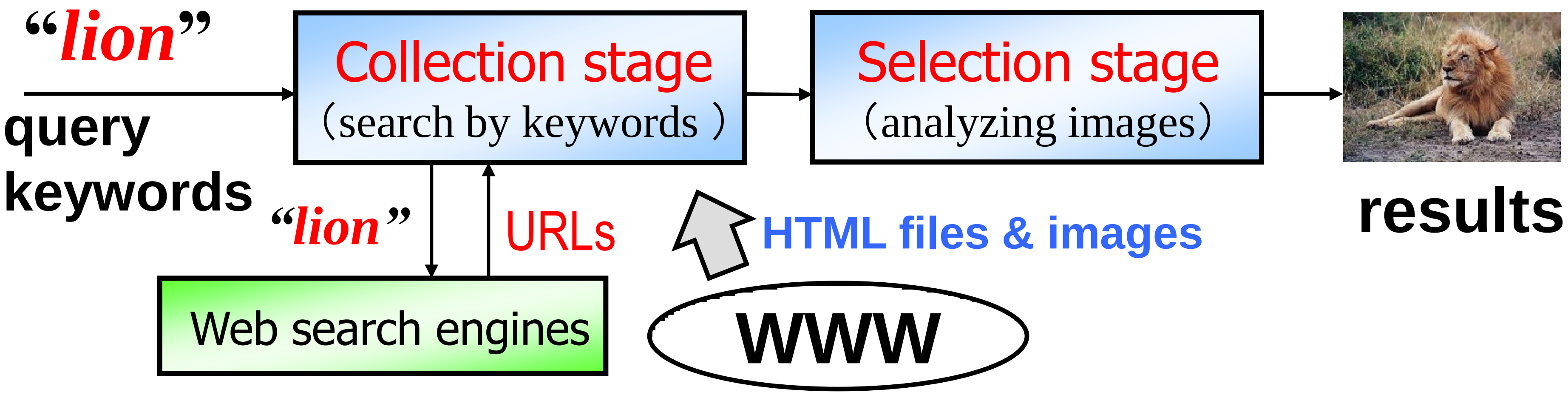
Gather image and HTML files using Web search engines.

Select ***pseudo-training images*** by ***HTML analysis***

Selection Stage

Use supervised object rec. methods with pseudo-training images

Train a classifier and rank images based on estimated relevancy



“*lion*”

query keywords

Collection stage
（search by keywords ）

“*lion*”

URLs

Web search engines

HTML files & images

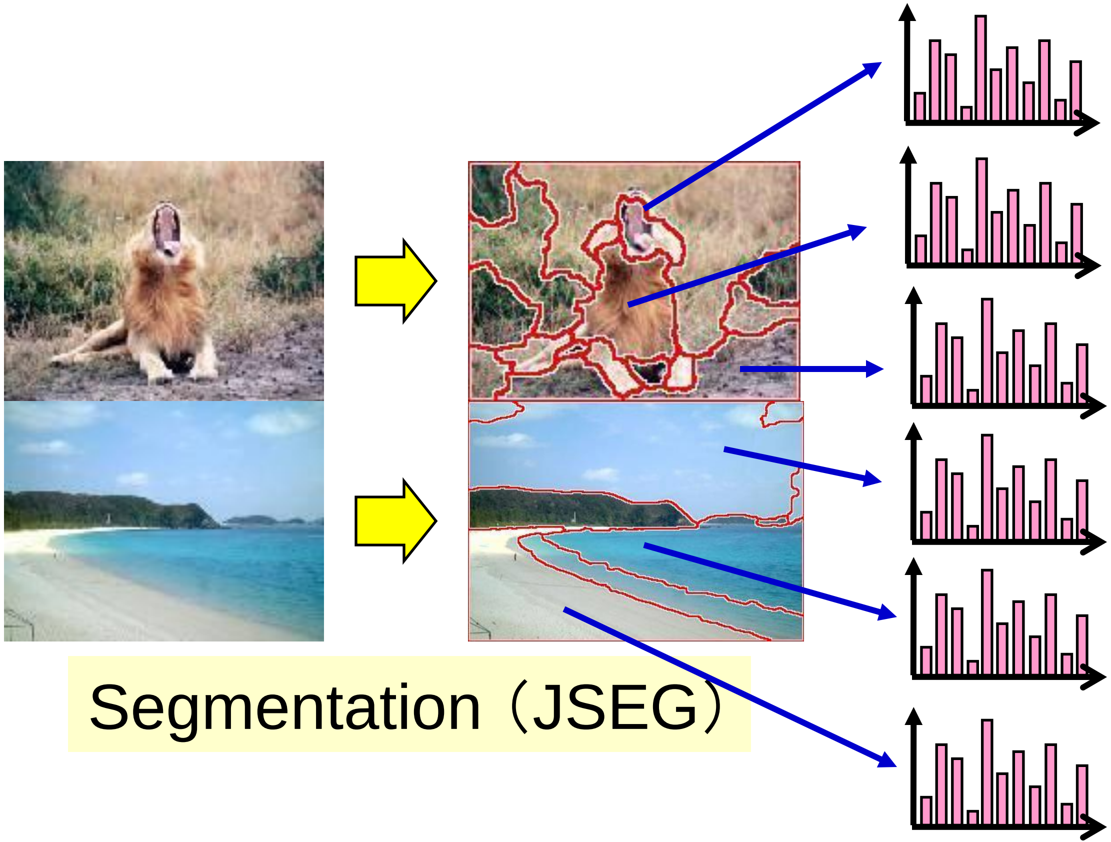
WWW

Selection stage
（analyzing images）

results

Image features

- Divide each image into regions by JSEG (8 regions on the average)

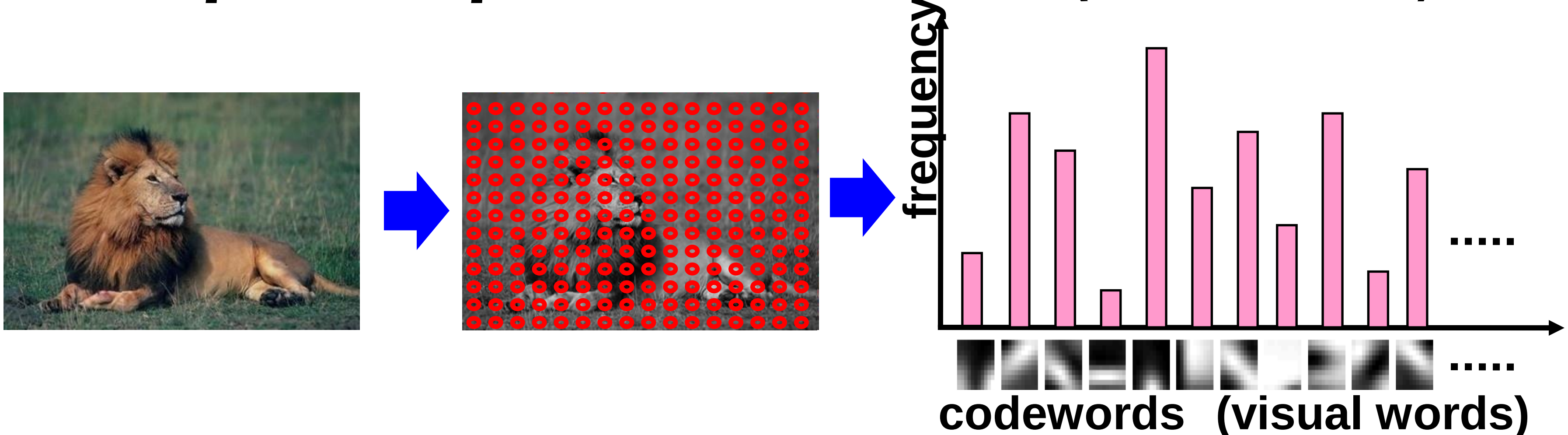


Segmentation（JSEG）

Bag-of-features (BoF) histograms (1000-dim)

[image representation]
Bag-of-features

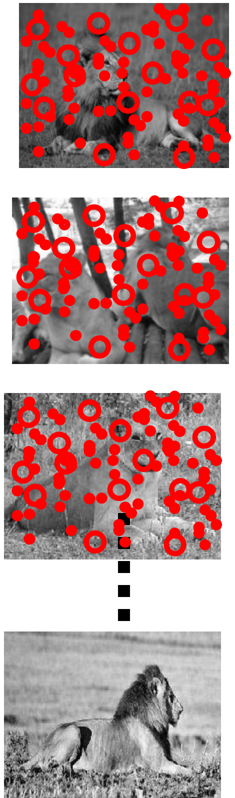
- Represent an image as sets of features
  1. Densely-sample points along regular grids
  2. Represent local patterns around sampled points with SIFT descriptor
  3. Vector-quantize SIFT vectors based on pre-computed visual words (codewords)



How to obtain visual words

- Extract many SIFT vectors from positive and negative training samples
- Perform k-means clustering

center of clusters are “visual words”.



v_i v_i

v_i v_i

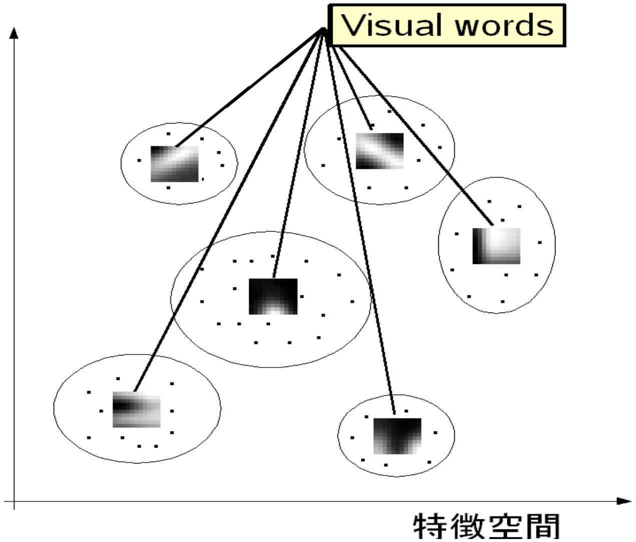
v_i

v_i v_i

v_i

v_i v_i

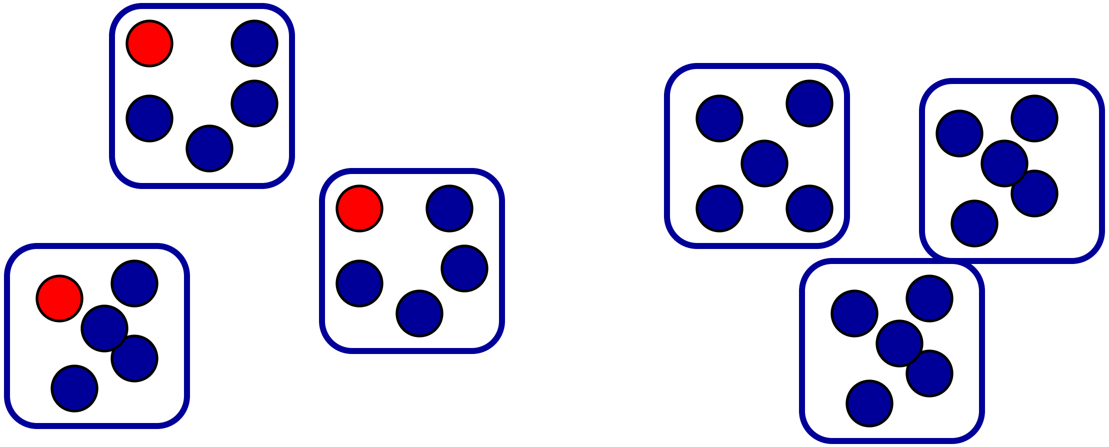
SIFT vectors



“Visual words” are representative local patterns.

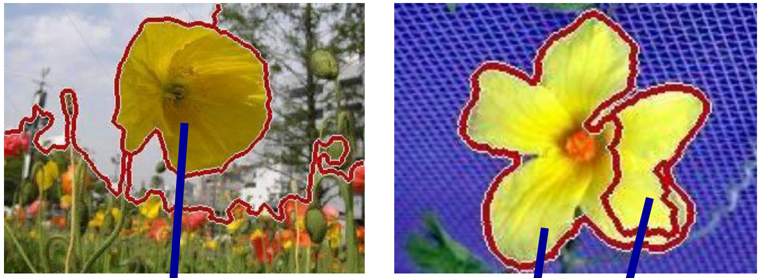
Multiple Instance Setting

- Positive bags / Negative bags



● positive ins. (foreground)

● negative ins. (background)



Positive instances of "flower"

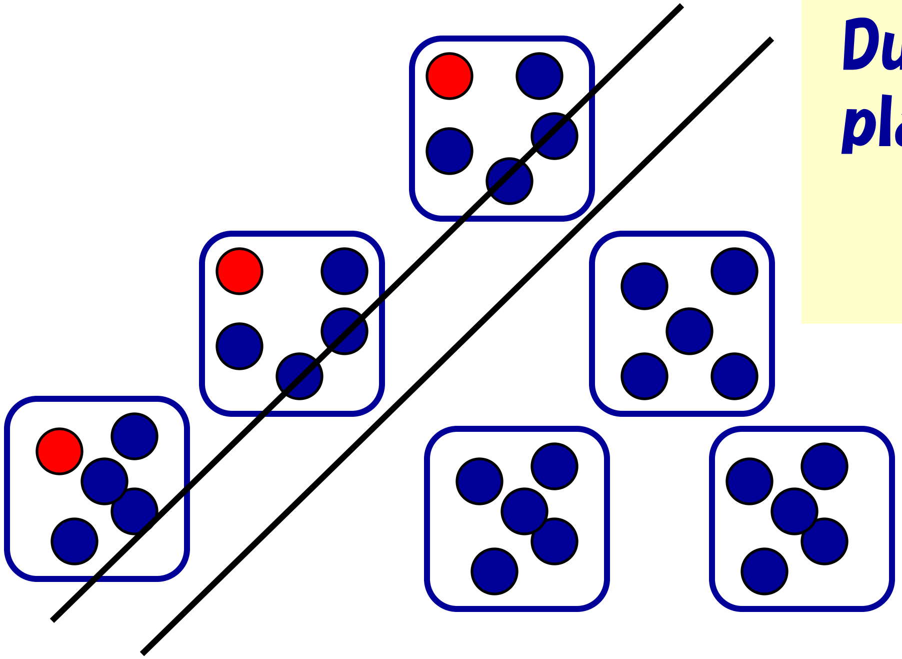
The rest of regions are negative regions.

pseudo-training images

random images

mi-SVM [Andrew et al. NIPS 03]

- Apply soft-margin SVM iteratively
  - Training → classifying → training → classifying → ……



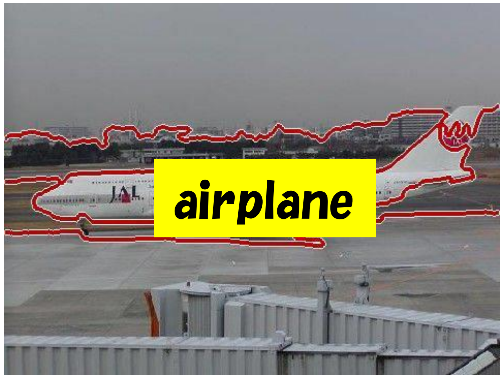
During the iteration, the hyper-plane is approaching the optimal plane to discriminate positive instances from negative ones.

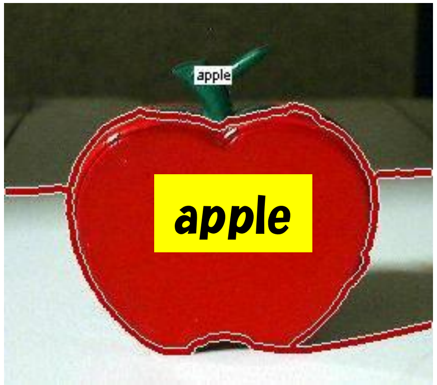
🔴 positive ins. (foreground)

🔵 negative ins. (background)

Final Image Re-ranking

- Regard the best SVM output score of the regions within an image as the score of the image
  - An image having one positive region at least is a positive image !
- Rank images based on the scores





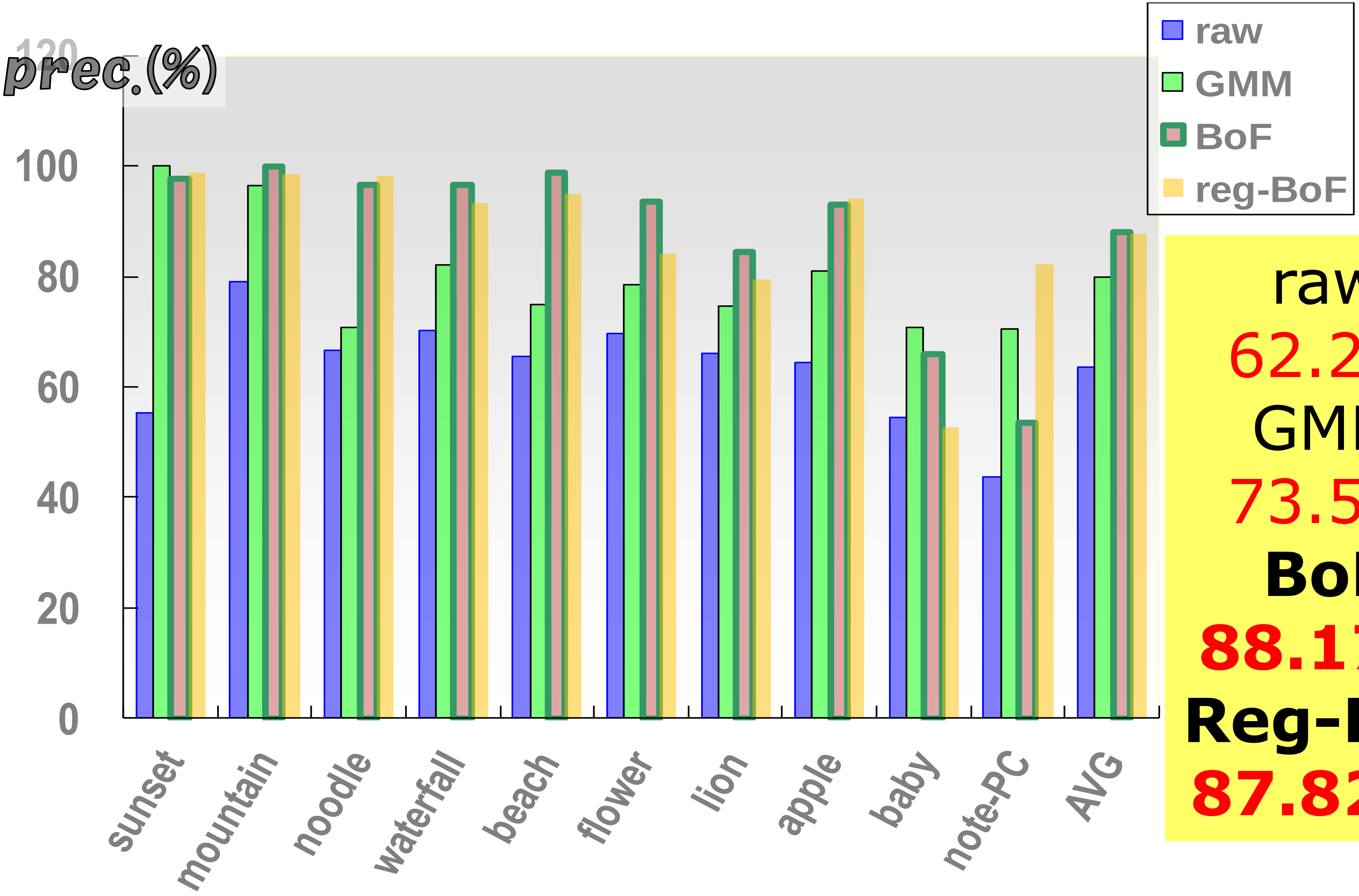
4. Experimental results

Experiments for 10+5 words

- **sunset, mountain, waterfall, beach,** (4scenes)
  noodle, flower, lion, apple, baby, laptop-PC, (6objects)
  airplane, guitar, leopard, motorbike, watch (5objects)

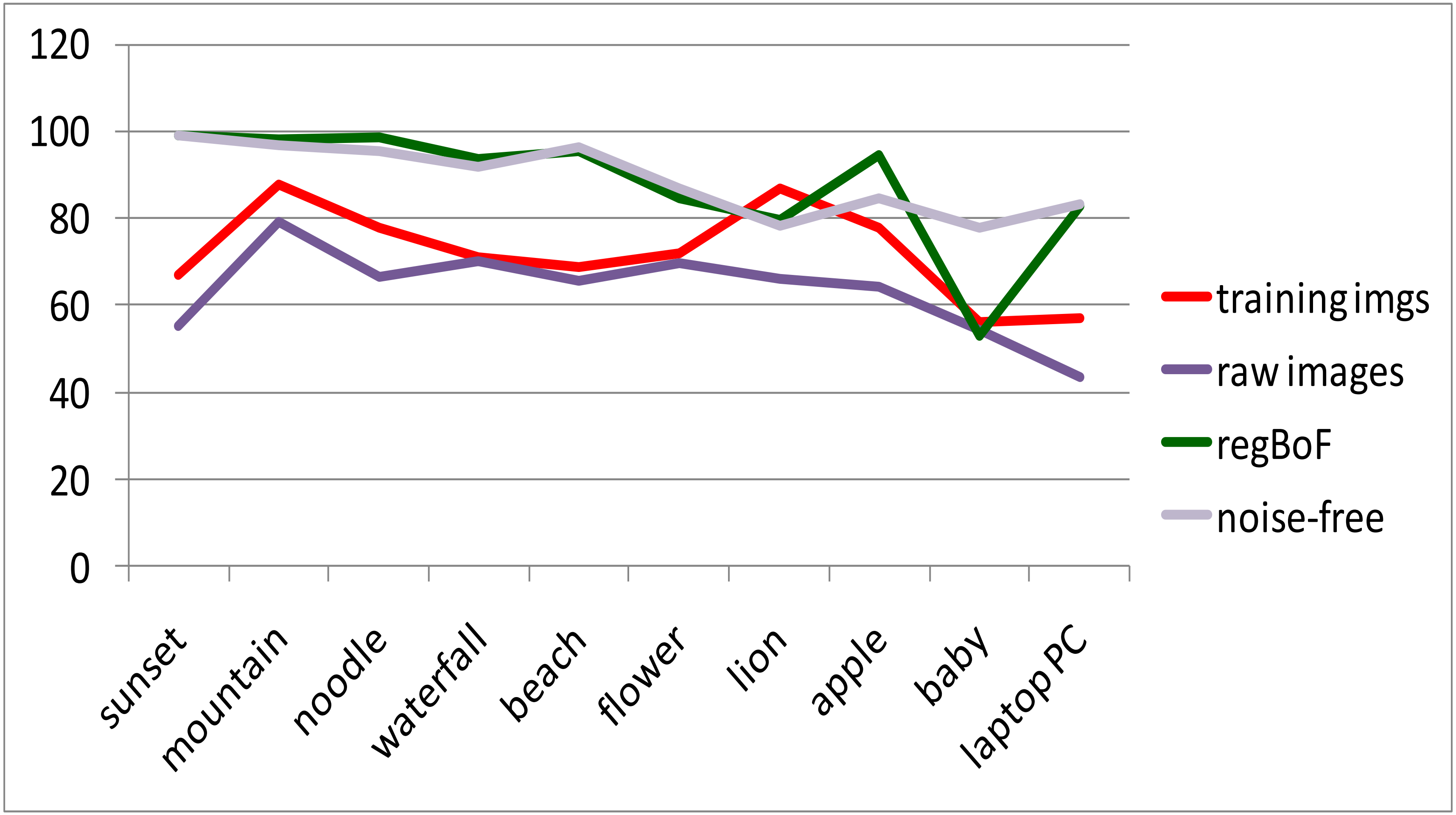
- **Method:**
  [raw data] **raw** (only HTML analysis) **39,143** images for **15** words
  [baseline1] **GMM-based region probabilistic model** [ACM MIR05]
  [baseline2] **BoF + SVM**
  [proposed] **region-based BoF + SVM**
- **Evaluation: precision at 15% recall**
  the same as [ICCV Schroff 07]

Comparison of 4 methods (raw, GMM, BoK, reg-BoF)



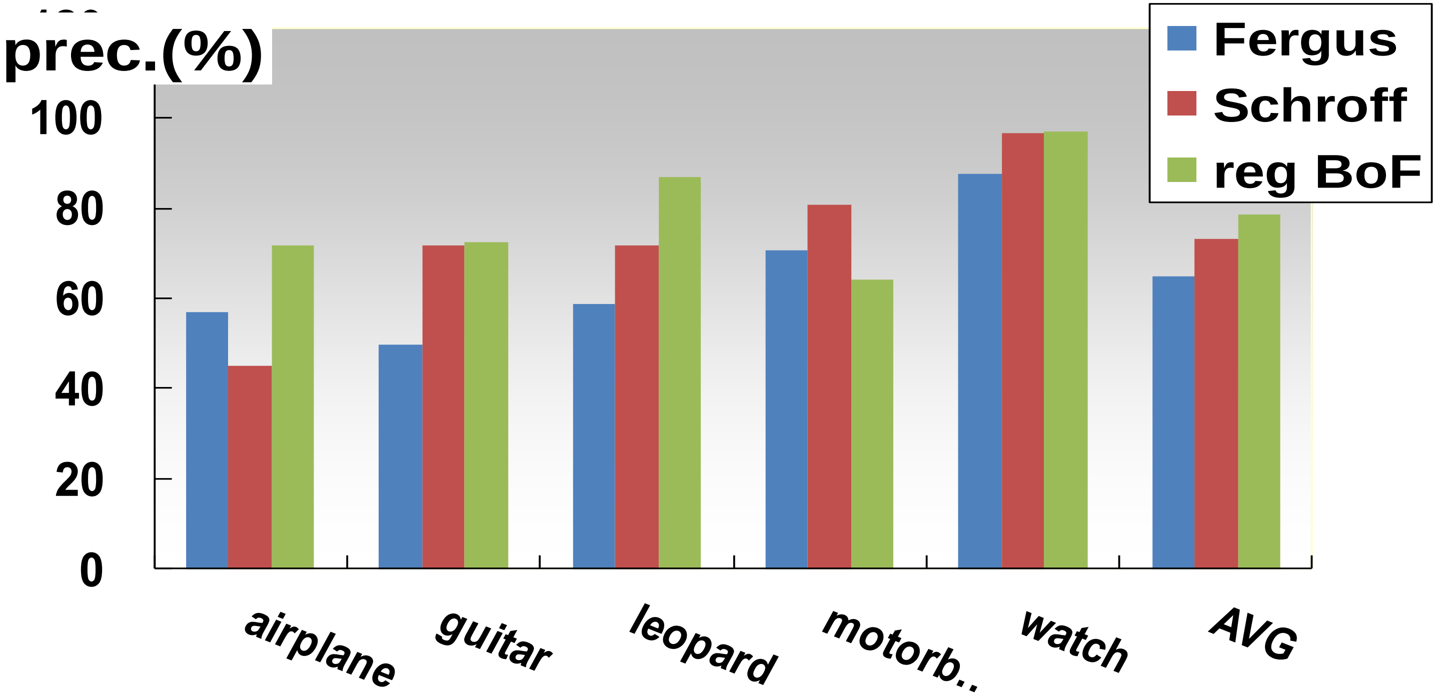
raw
62.2%
GMM
73.5%
BoF
88.17%
Reg-BoF
87.82%

Pseudo-training image sets and results by perfect training set (noise-free)



Comparison with related work

- [Fergus ICCV05] Bag-of-features + pLSA
- [Schroff ICCV07] Bag-of-features + SVM
- **[new] Region-based BoF + mi-SVM**



Many result images

- Laptop-PC (*positive and negative*)
- Mountain
- Waterfall
- Flower
- Airplane
- ???
- As by-products, we can estimate representative regions of images. *(different from standard BoF)*

Conclusion

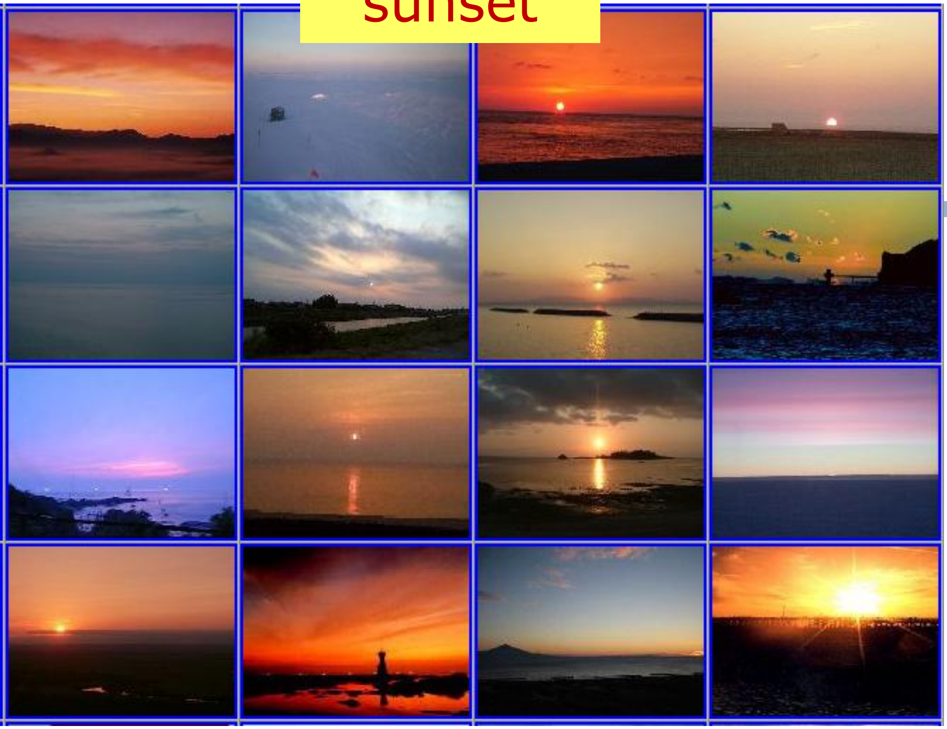
- Import region-based bag-of-features (BoF) and mi-SVM
  into the Web image gathering task.
  - In spite of noisy training data,
    the proposed method worked well.
  - It was especially effective for object concepts.

Future work

- Large-scale experiments
  - More than concept for 1000 concepts

- Improve the text analysis part to obtain more accurate psudo-training samples
  - Use co-occurrency of tags
  - Use taxonomy dic. (Wordnet, Wikipedia)

Thank you!



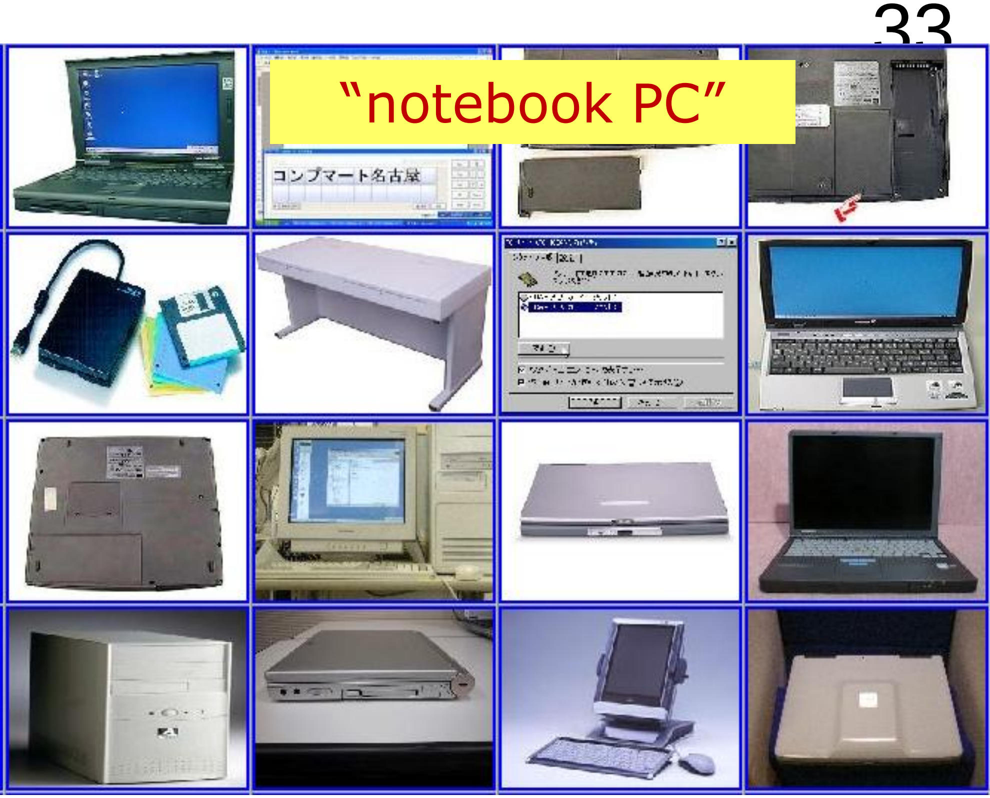
“sunset”

“waterfall”

Rejected “sunset”

Rejected “waterfall”

"Chinese noodle"



"notebook PC"

"lion"

"baby"