

# Recent Image Search Techniques

CVPR 2016 Tutorial

Sung-Eui Yoon and **Zhe Lin**

# Outline

- Indexing and Encoding Schemes for Large-Scale Image Search (45 min)
  - Product quantization and its variants
  - Inverted index, inverted multi-index, residual-shortlist
- Applications of Image Search (45 min)
  - Object retrieval and localization
  - Facial attribute recognition
  - Discriminative feature learning with CNN
  - Large-scale semantic search, recommendation
  - Large-scale image tagging

# Indexing/Encoding Schemes

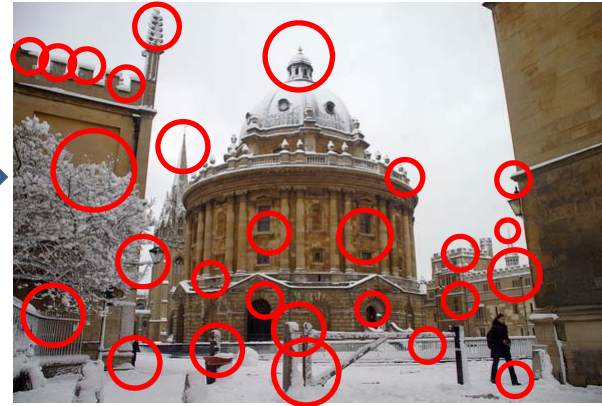
- Local descriptor-based method
  - Keypoints + Local invariant descriptors [Lowe99, Mikolajczyk04]
  - Bag of features model [Sivic and Zisserman03] [Philbin07]
  - Inverted index [Sivic and Zisserman03] [Nister06]
  - Geometric verification [Philbin07] [Jegou08]
- Global descriptor-based method
  - Product quantization [Jegou11]
  - Optimized product quantization [Ge13]
  - Distance-encoded product quantization [Heo14]
  - Inverted Multi-Index [Lempitsky13]
  - Shortlist computation [Heo16]

# Local Feature-based Method

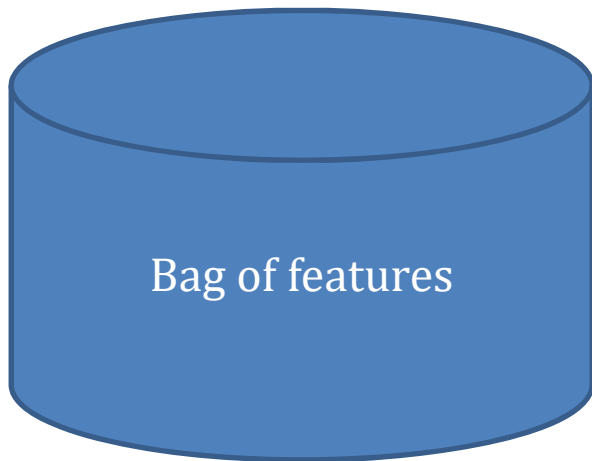
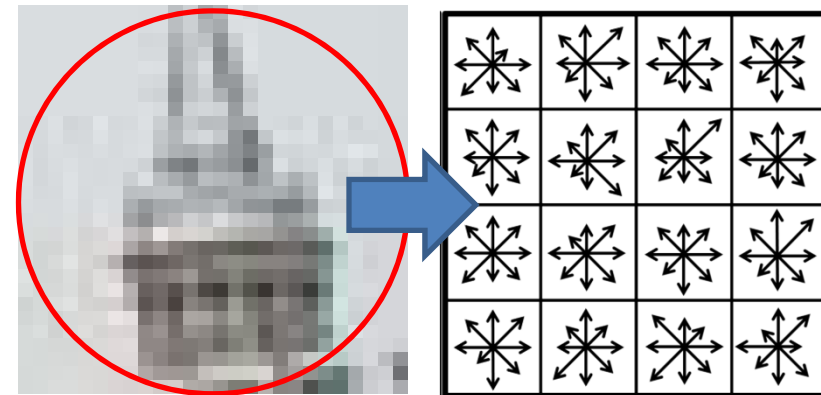


Feat. Extr.

*Interest points*



*Local descriptors*



Quantize



# Local Feature-based Method

- Mainly used for identical object/scene instance retrieval

Images from H. Jegou's SSMS'12 Talk Slide



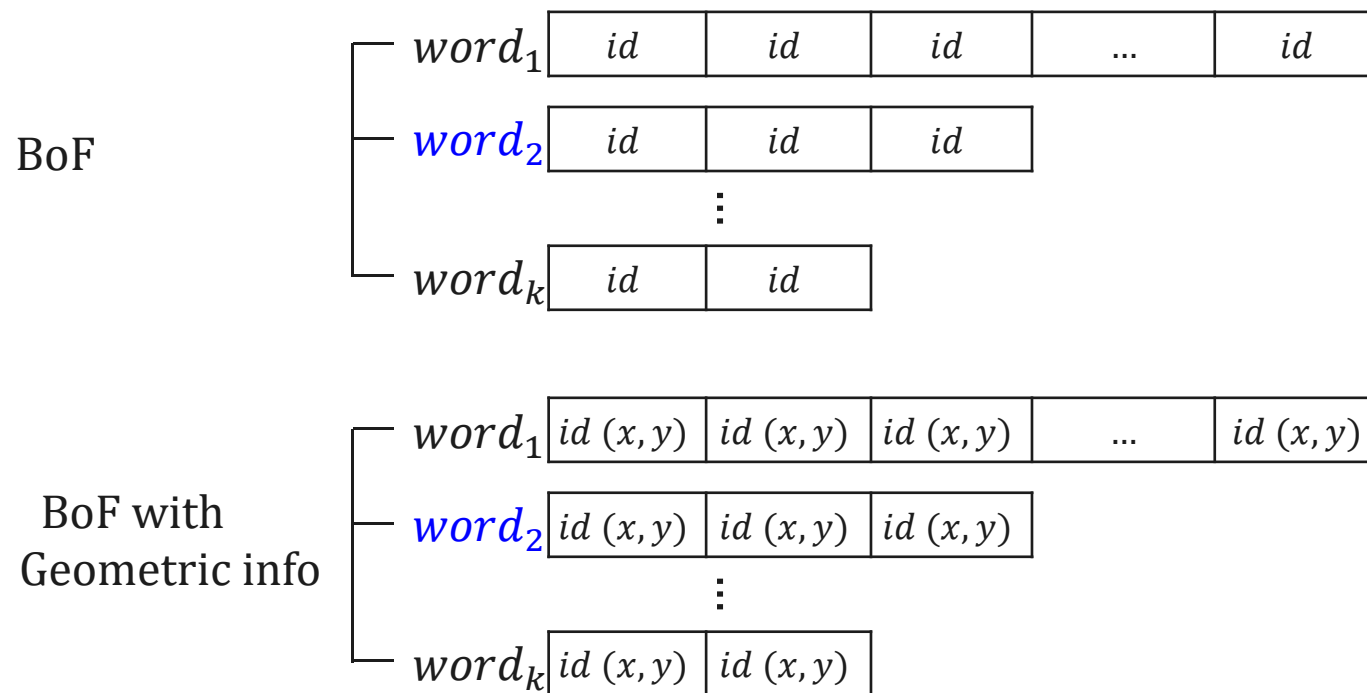
[X. Shen et al. CVPR 2012]

# Local Descriptor-based Method

- How to index bag-of-features ?
  - Build a codebook by k-means
  - Encode each local descriptor into a visual word
  - Store visual words into an **inverted file**

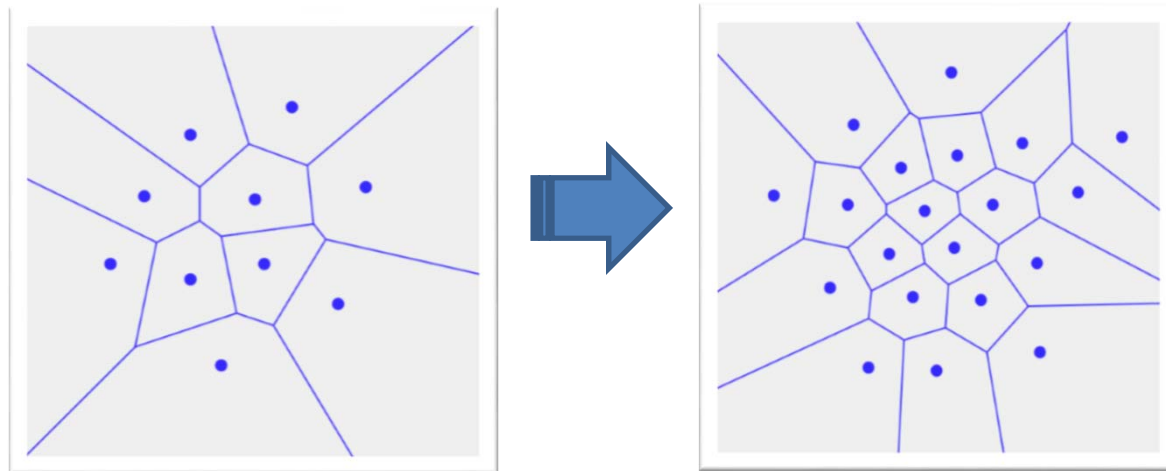
# Inverted Index

- Organize bag-of-features w.r.t. visual words



# Vocabulary Size

- Larger codebooks for efficiency ?
  - Lower quantization errors with increasing the voc. size
  - Increased assignment complexity and memory requirement
  - Tradeoff between assignment accuracy and efficiency

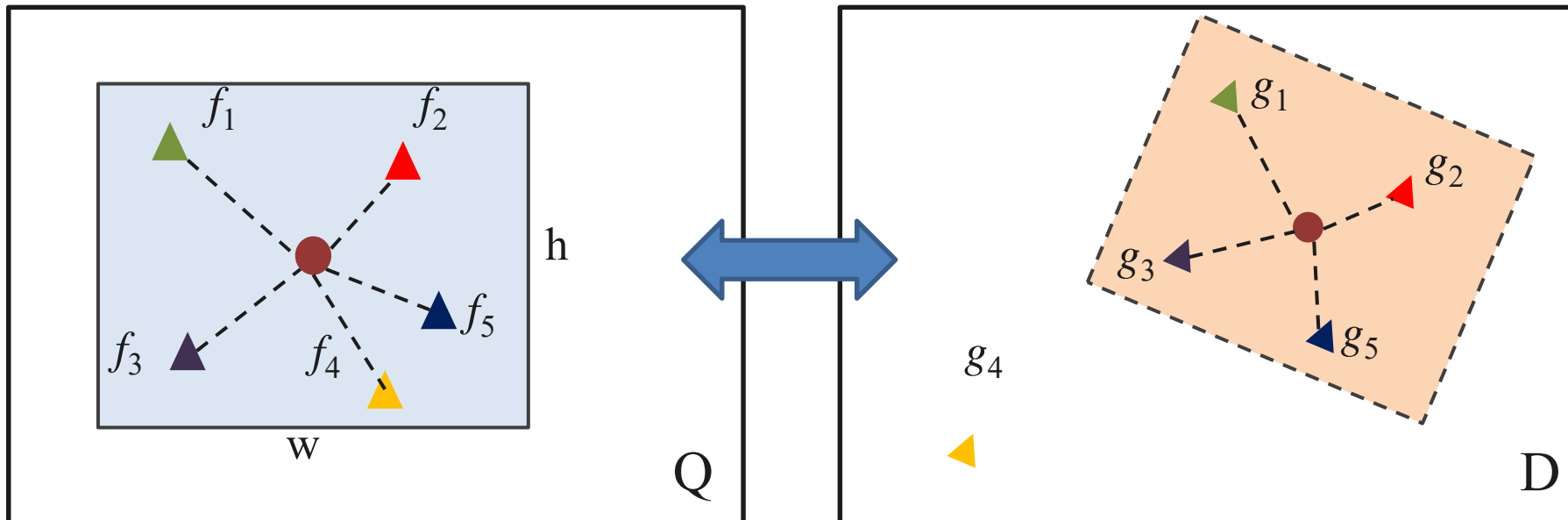


# Learning Large Vocabularies

- Hierarchical k-means [Nister06]
  - Quantize recursively
- Approximate k-means [Philbin07]
  - Flat k-means with fast approximate assignment step with randomized tree search

# Geometric Verification

- RANSAC-based method [Philbin07]
- Weak geometric consistency [Jegou08]
- Geometrical min-hash [Chum 09]
- Bundling features [Wu 09]
- Spatial inverted file / Local BoW [Lin 10]
- Geometry preserving visual phrases [Zhang 11]
- Generalized Hough-voting-based [Shen 12]



# Scalability

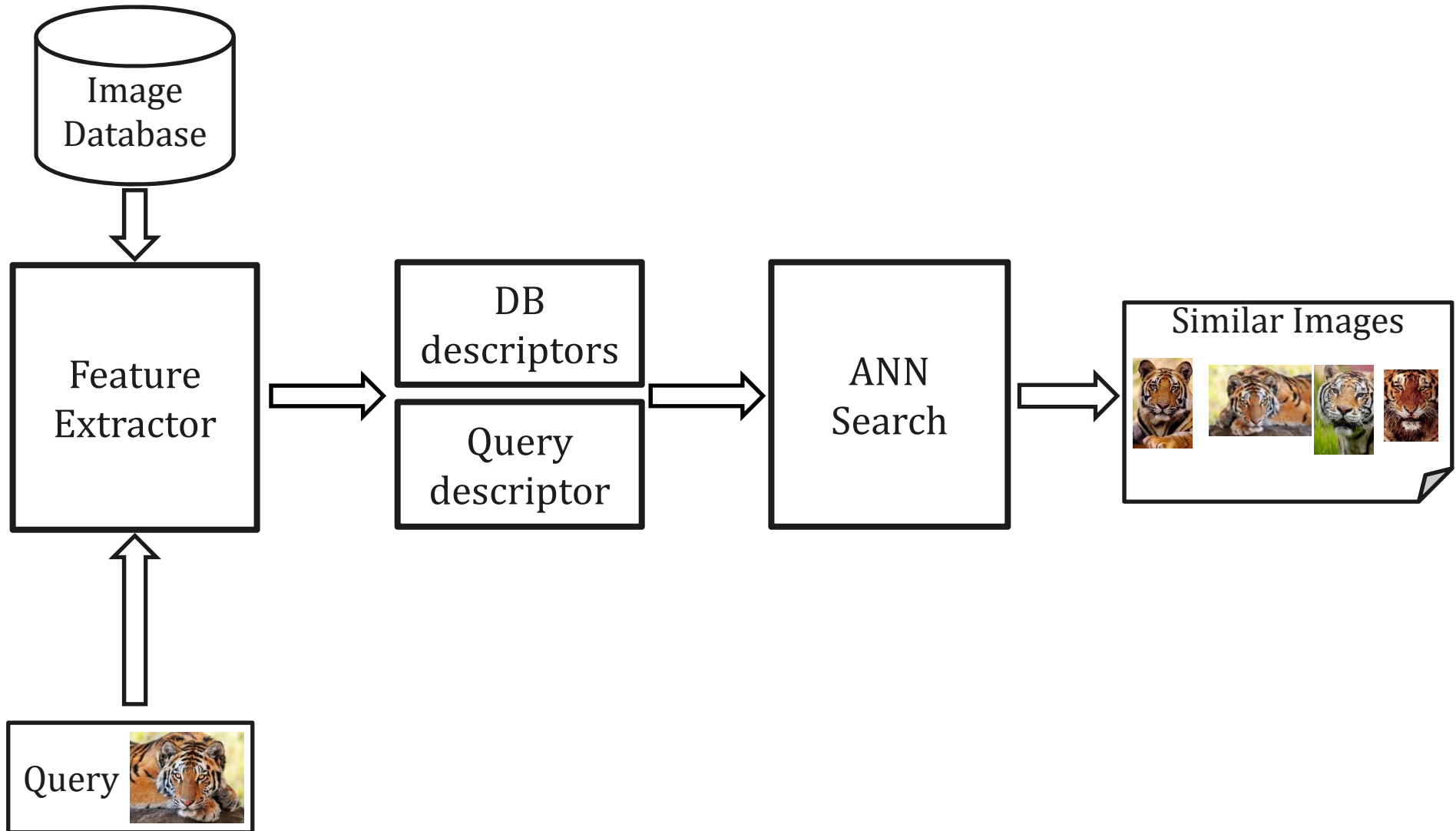
- Limited to a few million images due to memory cost
- How about larger scale search ?
  - Search on a database of 10M to 1B
    - Global descriptor
    - Indexing (coarse quantizer) -- speed
    - Encoding (compact representation) -- memory

# What is important for very large-scale search ?

- Performance criteria
  - Search accuracy
  - Search speed
  - Memory/storage usage



# Global Feature-based Method



# Nearest Neighbor Search

- Exhaustive NN Search
  - Euclidean distance metric

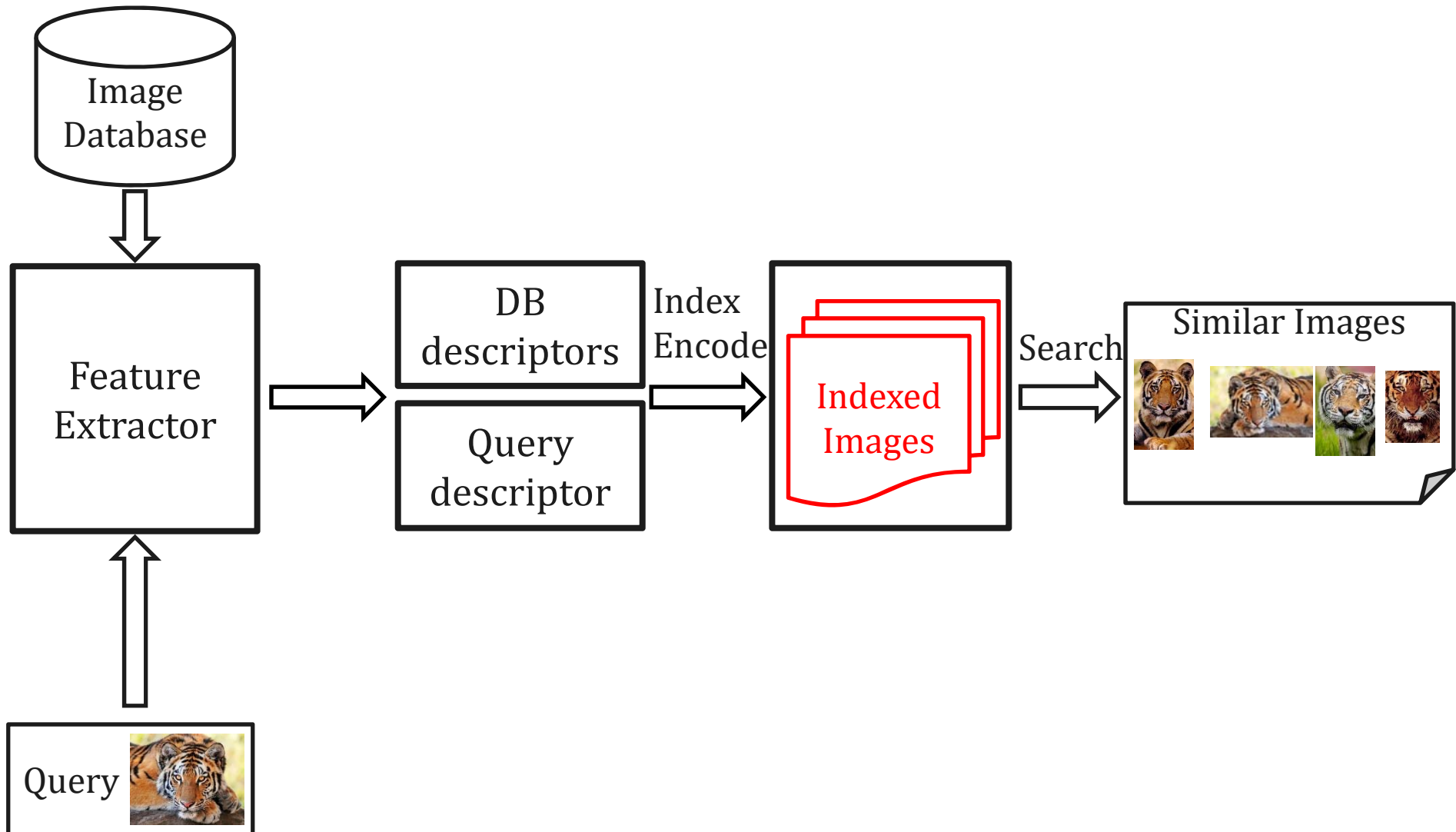
$$\text{NN}(x) = \arg \min_{y \in \mathcal{Y}} \|x - y\|^2$$

- Very costly when the DB is very large, and the d descriptor is very high dimensional:  $O(n*d)$
- Can be used as "verification" method on a small candidate set

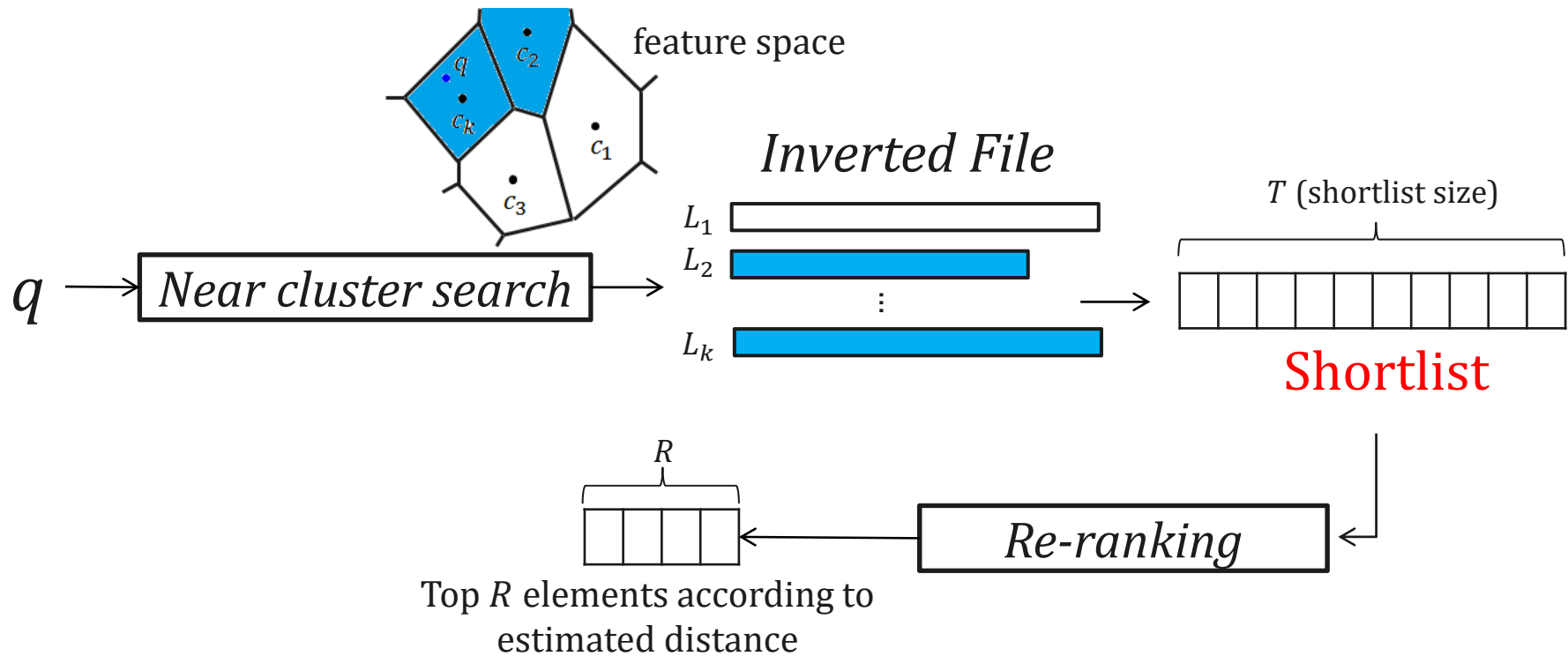
# Efficient Solutions

- Dimensionality reduction
  - e.g. PCA
- Hierarchical methods (ex: kd-tree, HKM)
  - Efficient and accurate for a mid-range dataset
  - Suffer from ‘curse of dimensionality’
  - Do not provide a compact data representation
  - e.g. FLANN library [Muja & Lowe 09]
- Binary code embedding
  - LSH, spectral hashing, min-hash, hamming embedding, etc.
  - Very fast during search time
  - But, may not handle well very high-dim data
  - Requires raw features in verification, e.g. 128GB for 1B SIFT
- **Quantization-based methods (\*)**
  - **Indexing:** inverted indexing, inverted multi-indexing, etc.
  - **Encoding:** vector quantization, product quantization, optimized product quantization, distance-encoded product quantization, etc.

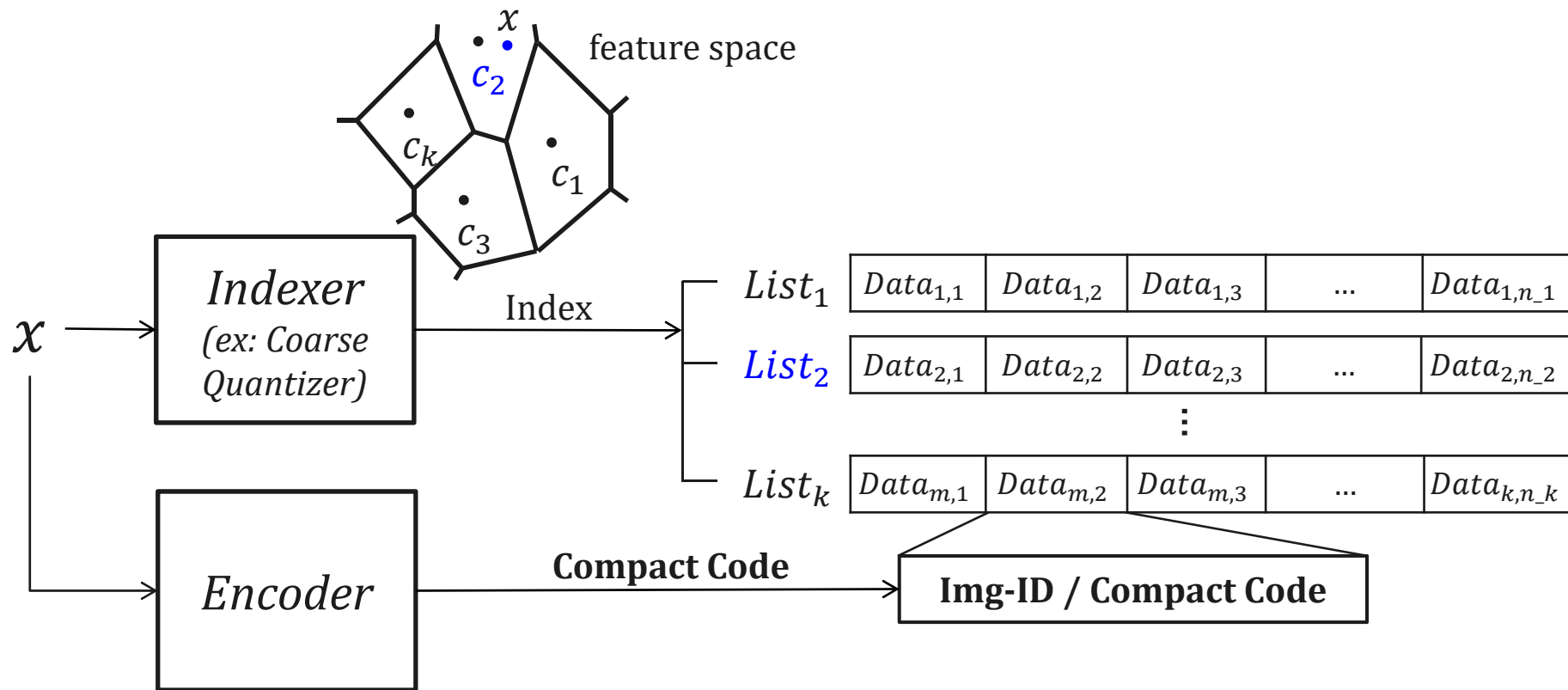
# Global Descriptor-based Method



# Search Framework (Global desc.)



# Indexing and Encoding



# Indexing and Encoding

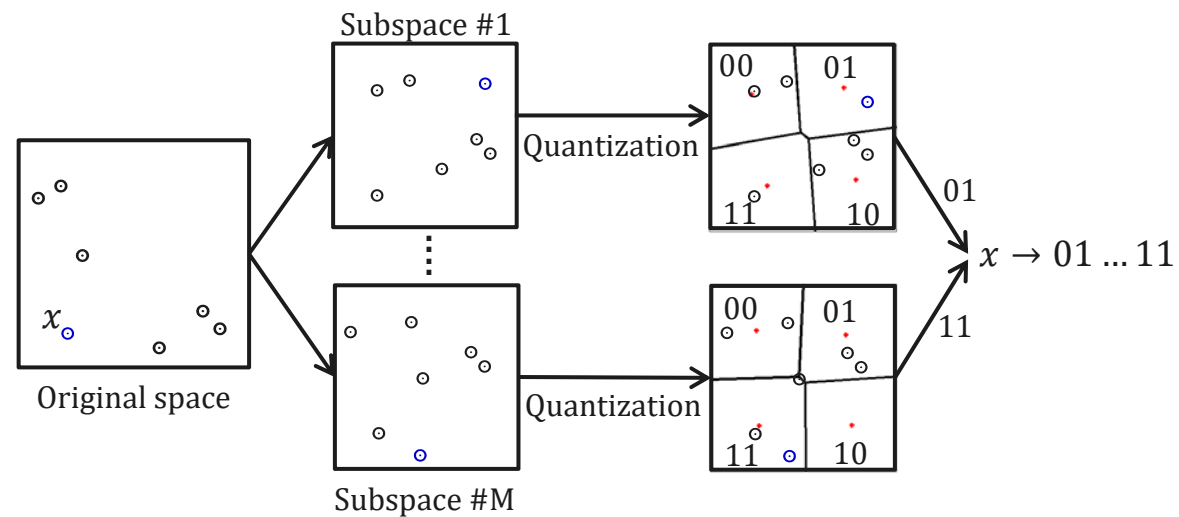
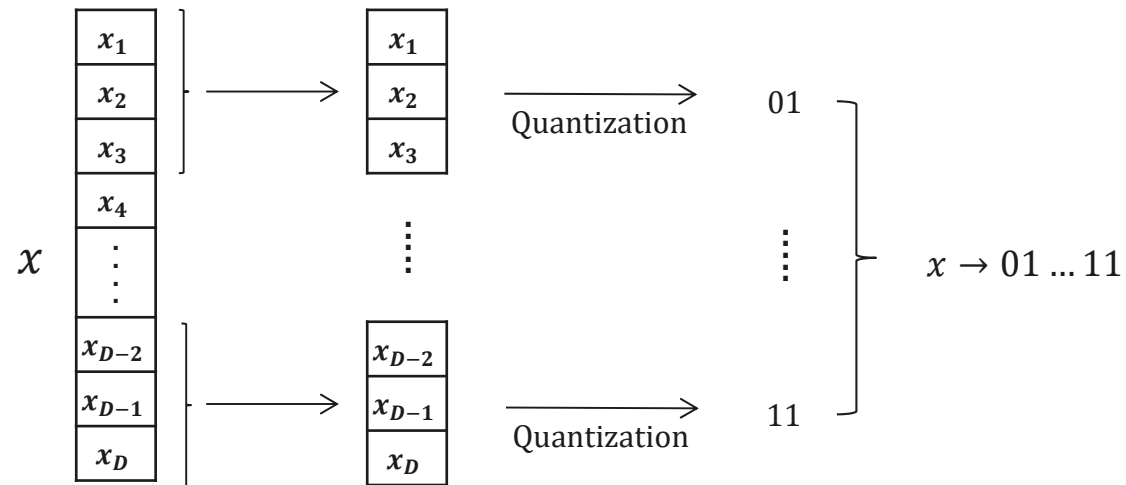
- **Encoding**
  - Residual vector as input to encoder
  - Product quantization and its variants
- **Indexing**
  - Inverted (multi-)index
  - Residual-aware shortlist selection

# Product Quantization [Jegou et al., TPAMI 2011]

- Vector quantization
  - For a very large codebook, e.g.  $K = 4^{64}$ 
    - intractable as an encoder (speed and memory)
- Product quantization
  - Cartesian product of subspace quantization
  - Can generate an exponentially large codebook at very low memory/time cost

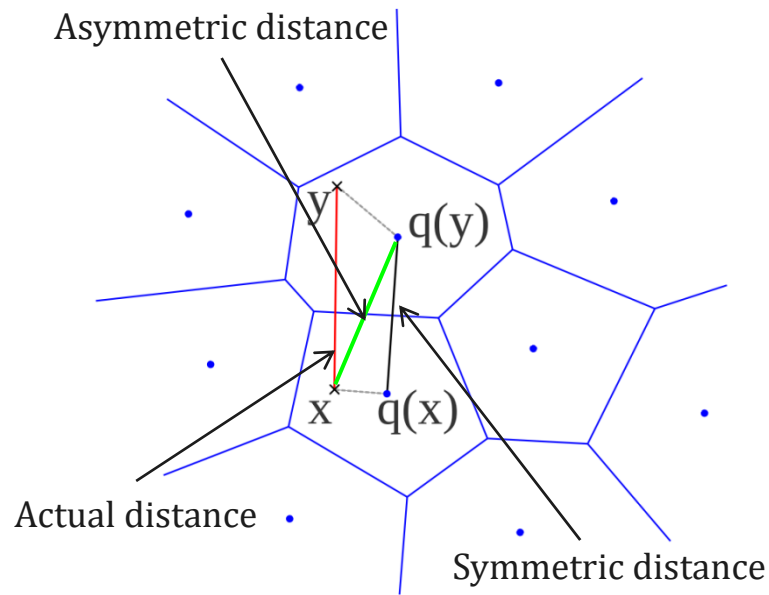


# Product Quantization [Jegou et al., TPAMI 2011]

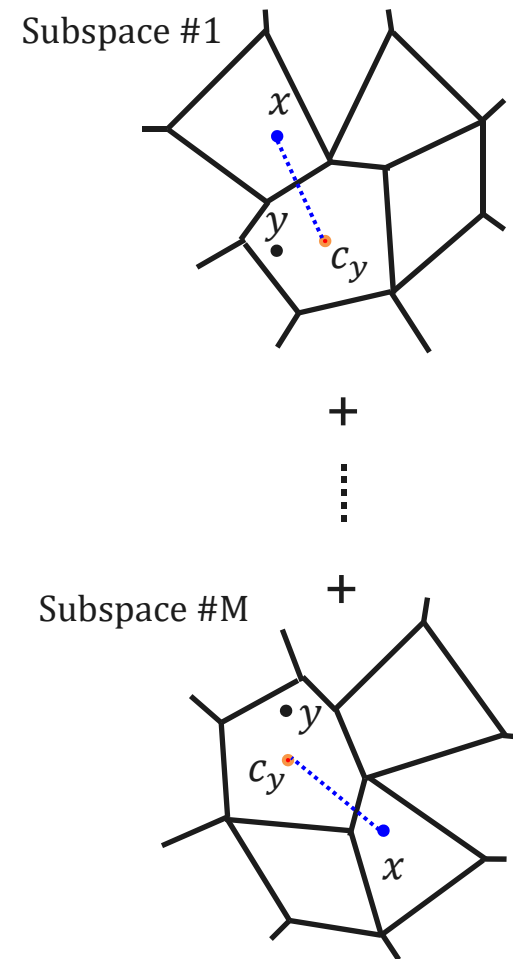


# Product Quantization [Jegou et al., TPAMI 2011]

Distance estimation  
(between encoded  $y$  and query  $x$ )



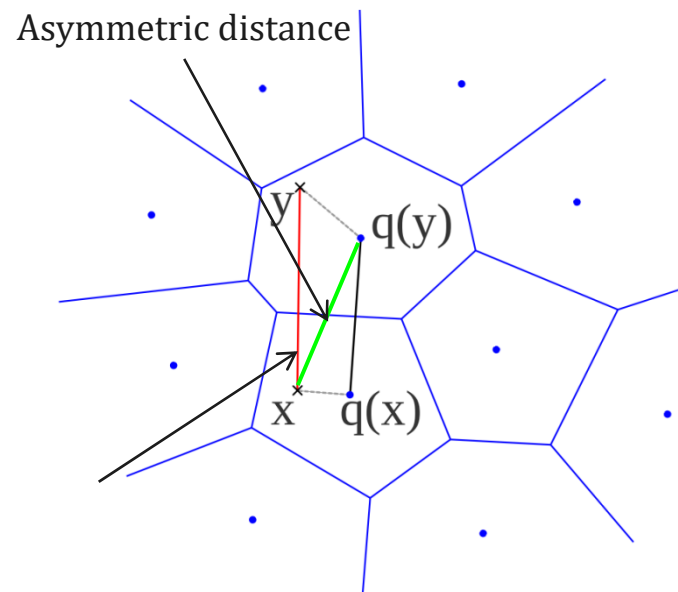
$x$ : query,  $y$ : data  
 $q(x) = c_x$   
 $q(y) = c_y$



# Distance Estimation Error

- Distance estimation error is statistically bounded by quantization error [Jegou PAMI 2011]
  - $\text{MSDE}(q) \leq \text{MSE}(q)$

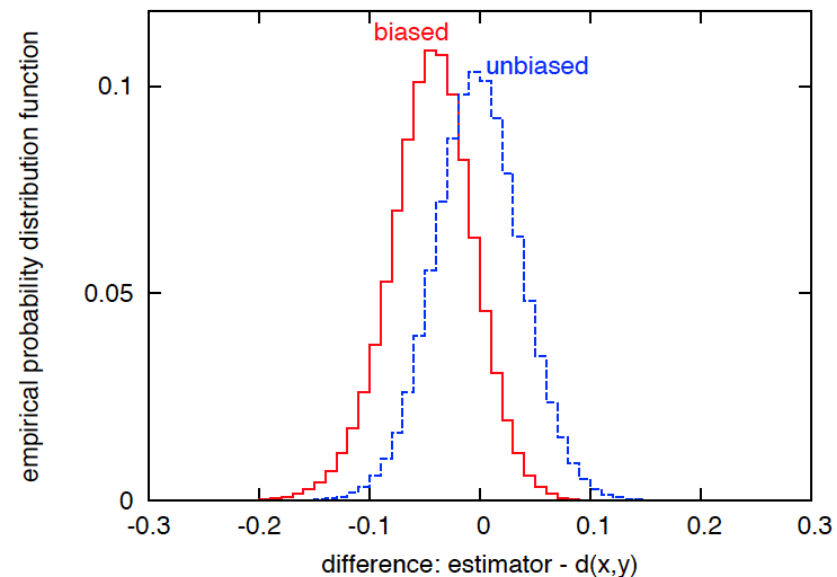
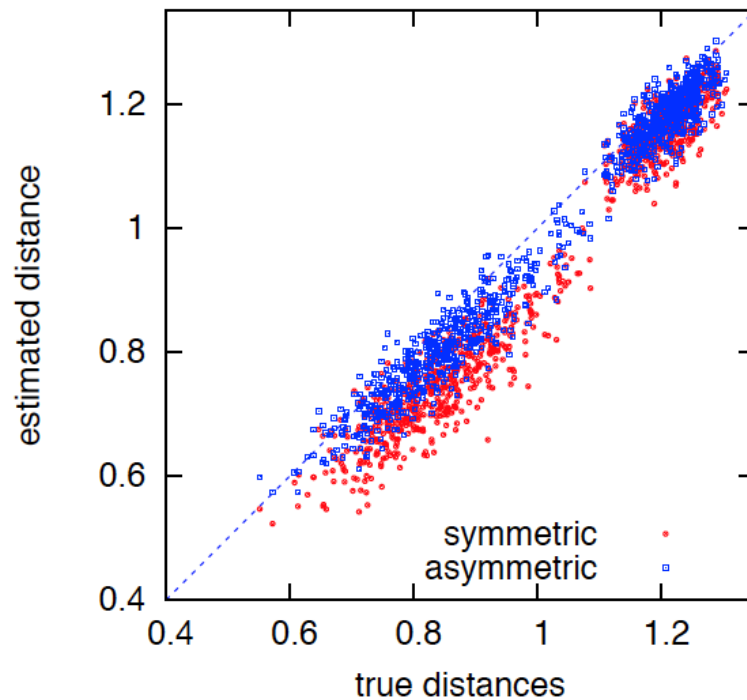
$$\left( d(x, y) - d(x, q(y)) \right)^2 \leq d(y, q(y))^2$$



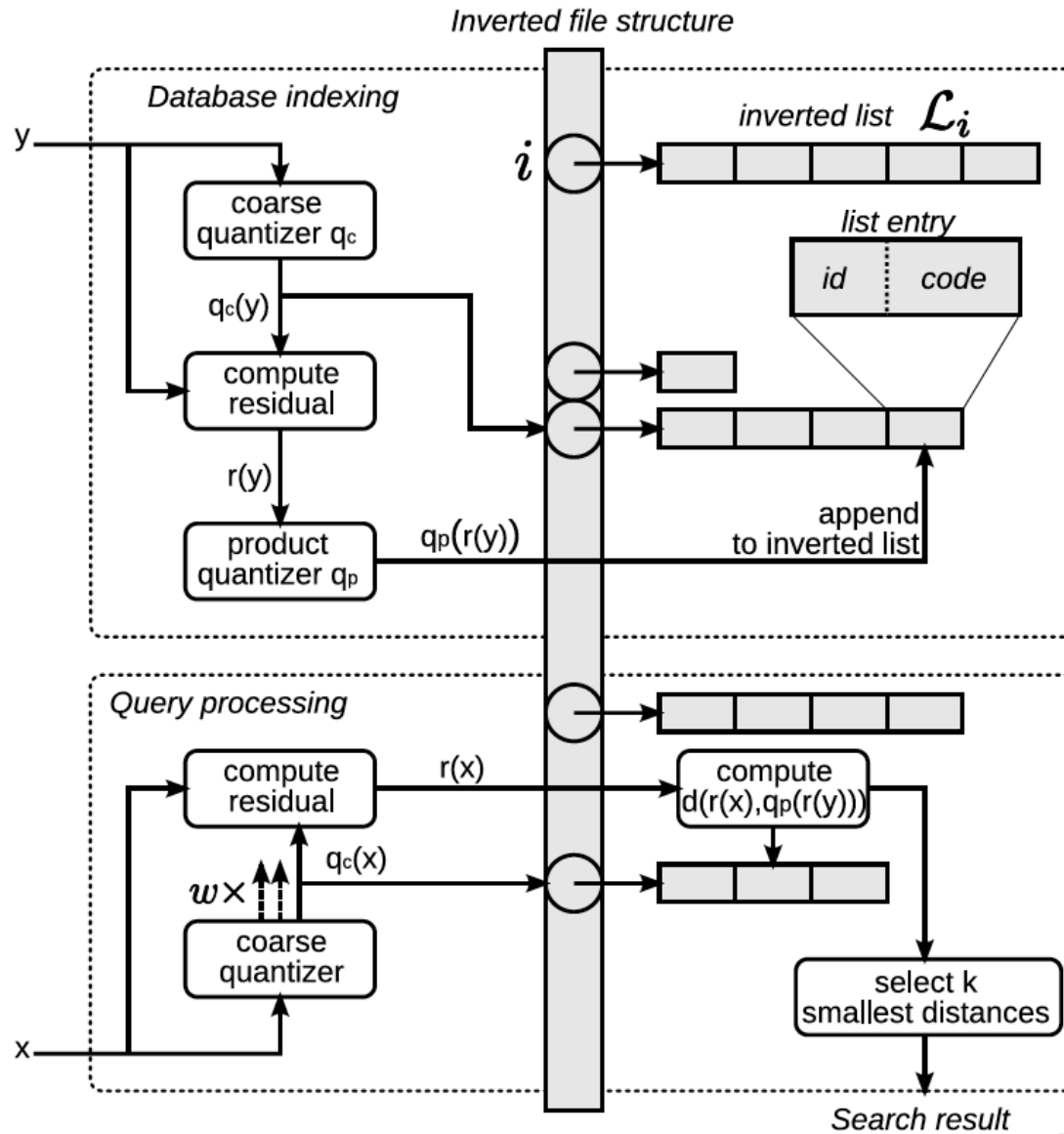
# Distance Estimation Bias

- Unbiased asymmetric estimator

$$\tilde{e}(x, y) = \tilde{d}(x, y)^2 + \sum_j \xi_j(y)$$



# Non-Exhaustive Search (IVFADC)

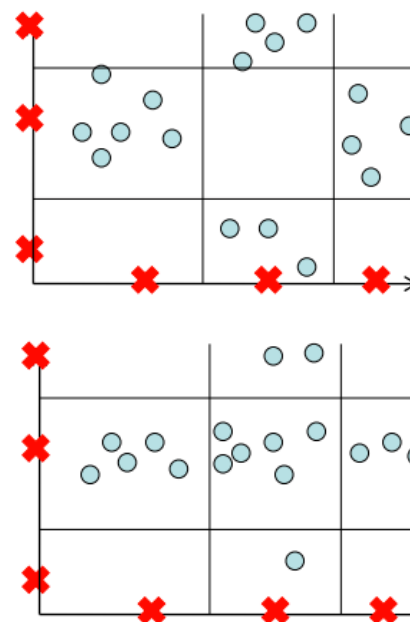


# Optimized Product Quantization

[Ge et al., CVPR 2013]

[Norozi and Fleet, CVPR 2013]

- Problem of product quantization
  - Subspaces are assumed to be independent
  - Subspaces have unbalanced variances
- Subspace decomposition



Figures from Arandjelovic's slides

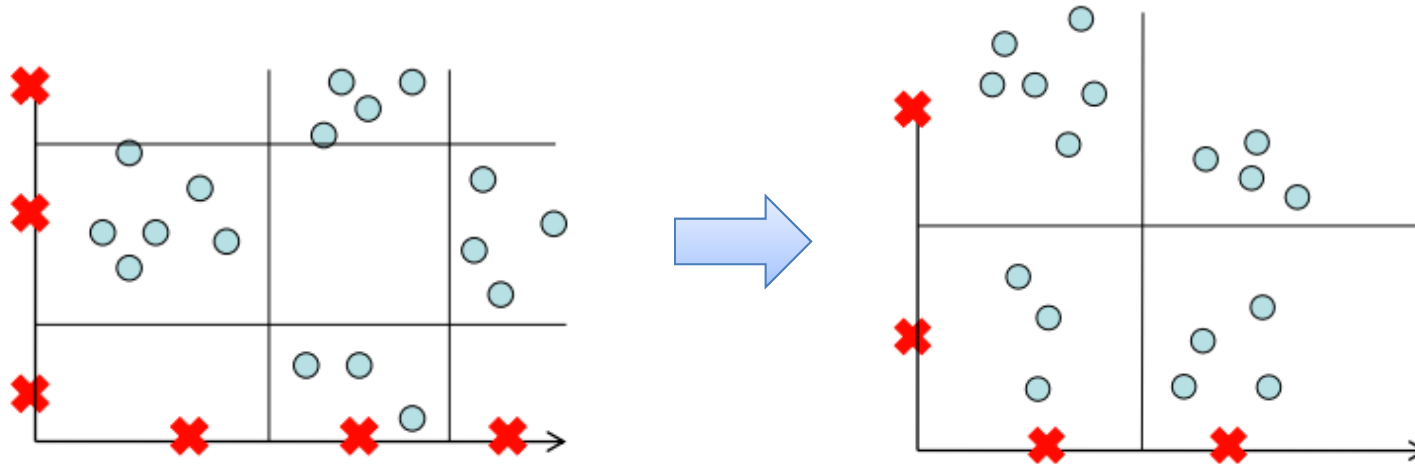
$m$	SIFT		GIST
	4	8	8
natural	0.593	0.921	0.338
random	0.501	0.859	0.286
structured	0.640	0.905	0.652

# Optimized Product Quantization

[Ge et al., CVPR 2013]

[Norozi and Fleet, CVPR 2013]

- Optimal subspace decomposition
  - Estimate a rotation projection matrix  $R$  to minimize quantization distortion
  - Rotation can de-correlate data and balance subspace variances well



# Optimized Product Quantization

[Ge et al., CVPR 2013]

[Norozi and Fleet, CVPR 2013]

- Formulation

$$\min_{R, \mathcal{C}^1, \dots, \mathcal{C}^M} \sum_{\mathbf{x}} \|\mathbf{x} - \mathbf{c}(i(\mathbf{x}))\|^2,$$

$$s.t. \quad \mathbf{c} \in \mathcal{C} = \{\mathbf{c} \mid R\mathbf{c} \in \mathcal{C}^1 \times \dots \times \mathcal{C}^M, R^T R = I\}$$

- Solutions

- Nonparametric solution

- (step1) Fix  $R$ , estimate clusters  $\mathbf{c}$  and assignment  $i(\mathbf{x})$  – k-means
- (step2) Fix  $\mathcal{C}$ 's and optimize  $R$  – *orthogonal procrustes problem*
- Alternate step1 and step2 until max iteration

- Parametric solution

- Assumes Gaussian distribution
- Eigenvalue allocation algorithm
  - Align the data by PCA (make subspaces independent)
  - Allocate eigenvalues to buckets with balance

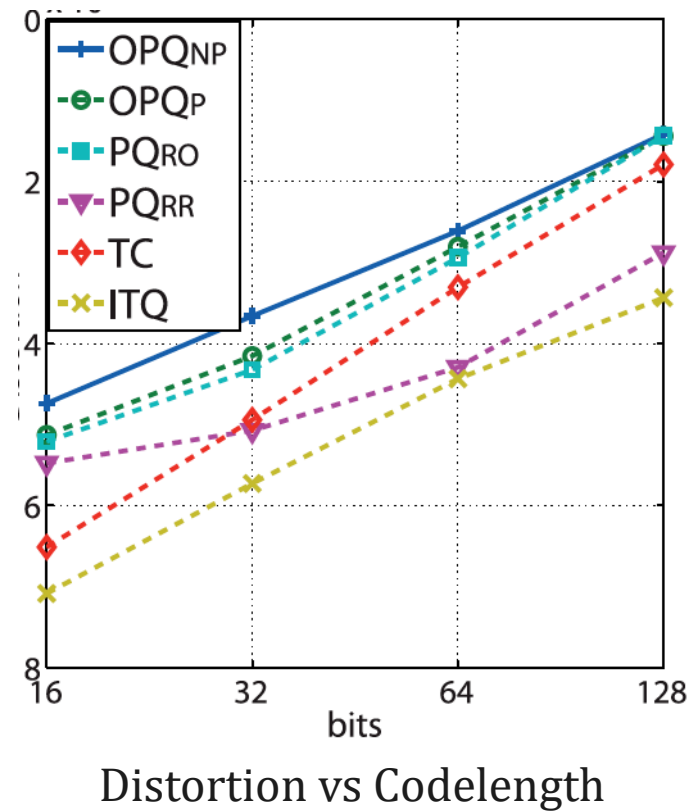
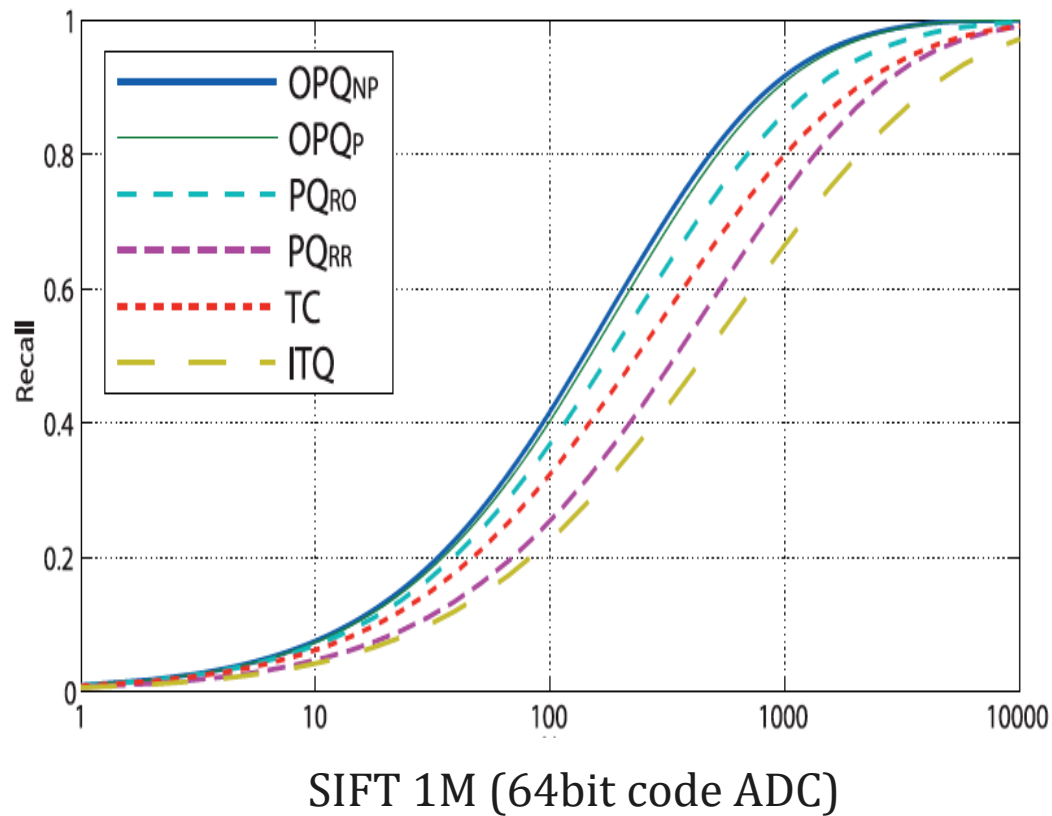


# Optimized Product Quantization

- Results

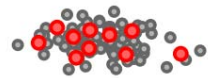
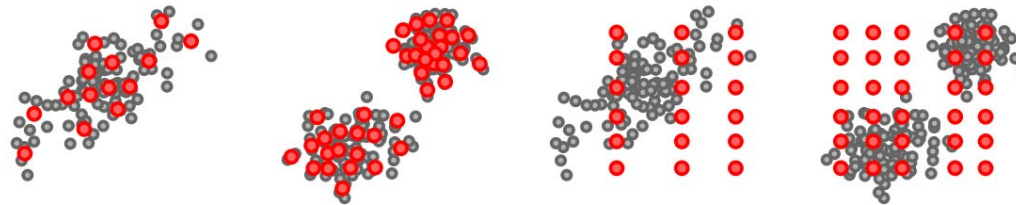
[Ge et al., CVPR 2013]

[Norozi and Fleet, CVPR 2013]



# Locally Optimized PQ

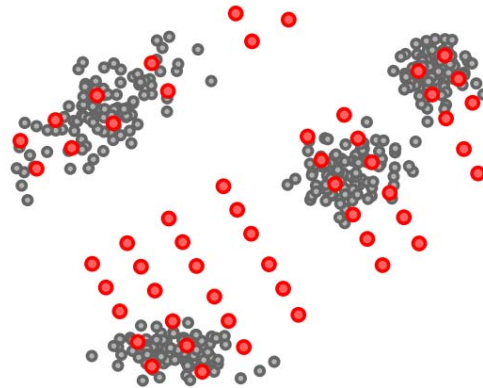
[Kalantidis et al., CVPR 2014]



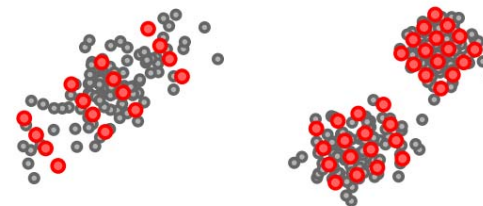
(a)  $k$ -means



(b) PQ



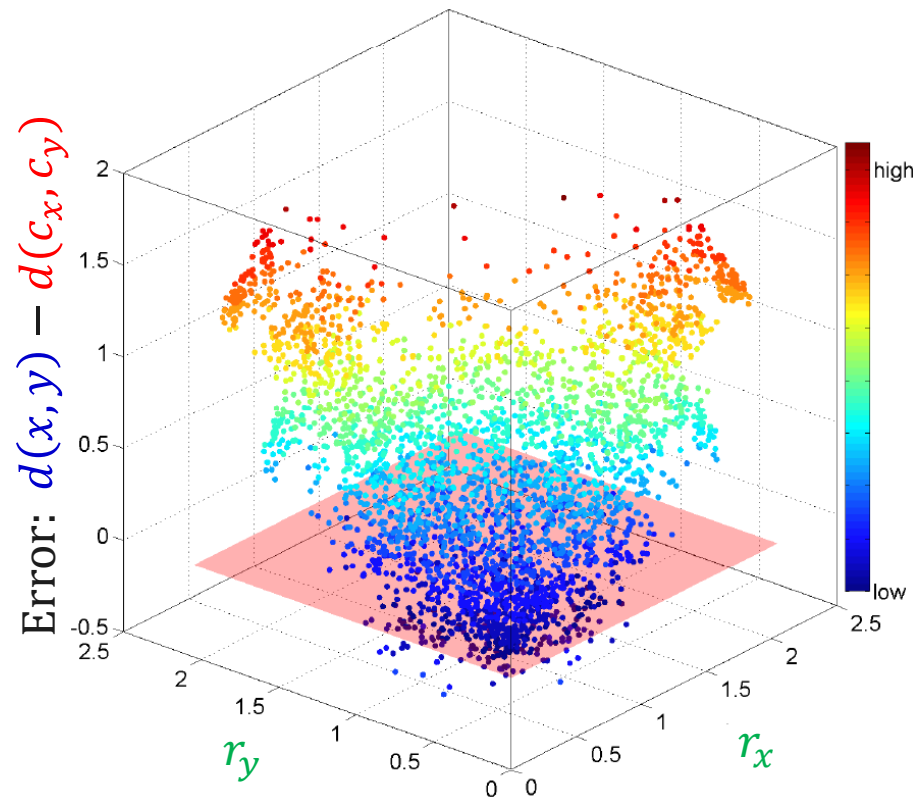
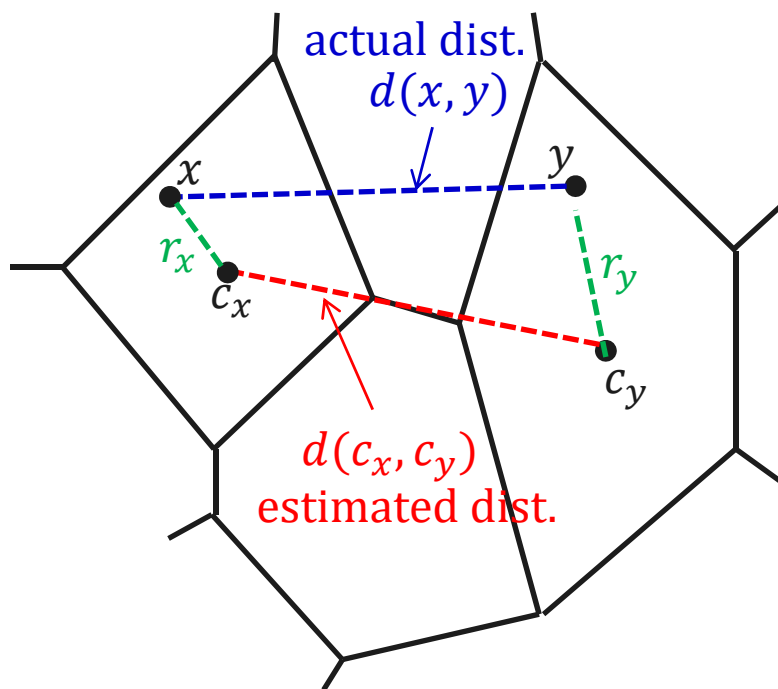
(c) OPQ



(d) LOPQ

# Distance Encoded PQ

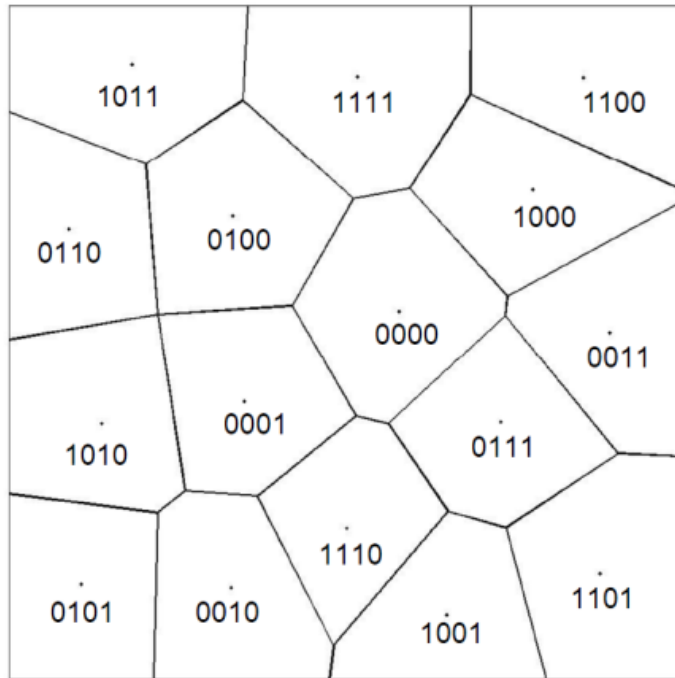
[J. Heo et al., CVPR 2014]



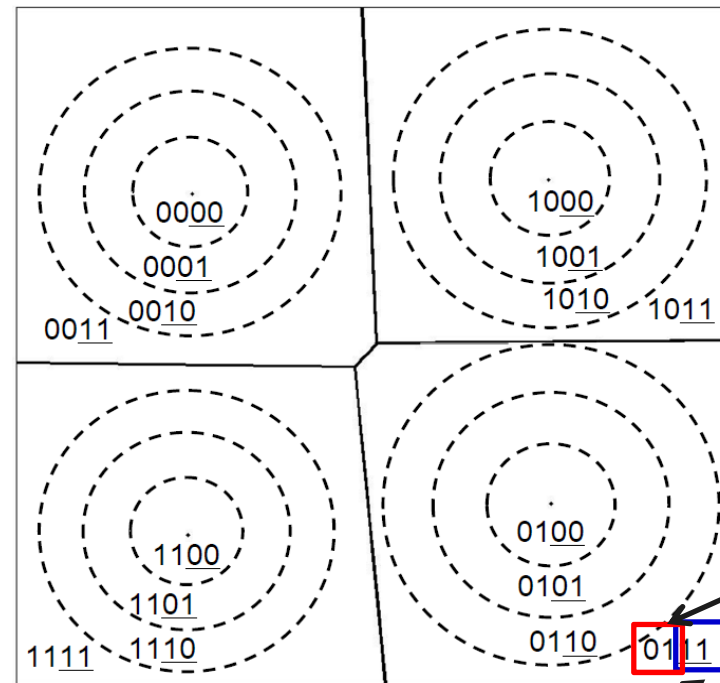
In PQ, errors of estimated distances  $d(x, y) - d(c_x, c_y)$  tends to be higher as  $r_x$  and  $r_y$  becomes larger.

# Distance Encoded PQ (DPQ)

- Encode quantized distance from cluster center as well as the cluster index



PQ



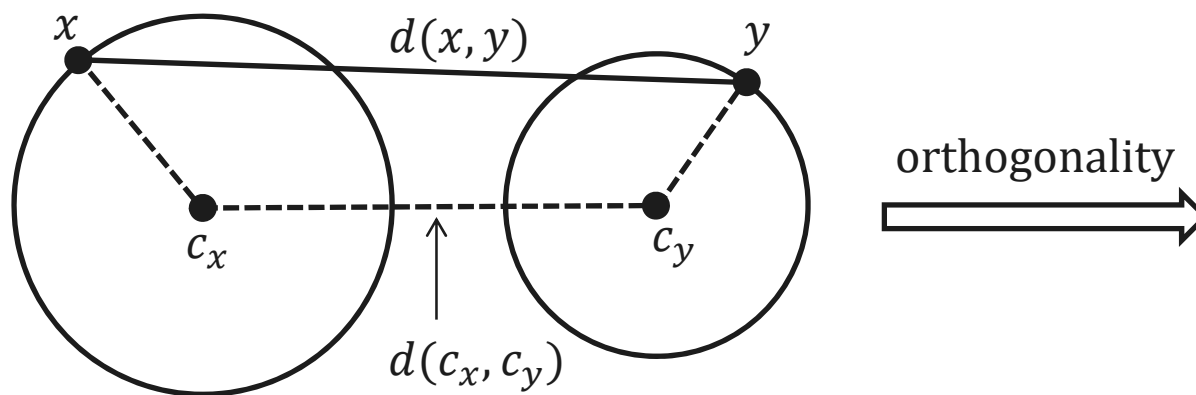
DPQ

cluster index

quantized distance from cluster center

# Orthogonality in High Dim. Space

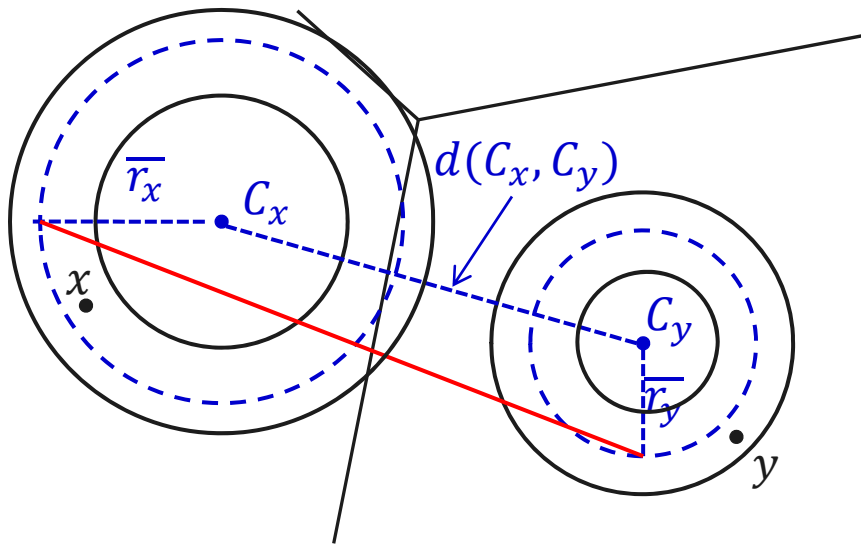
In high dimensional space, two randomly chosen vectors are highly likely to be orthogonal\*.



$$\begin{aligned}d(x, y)^2 &= \|x - y\|^2 = \|(c_x - c_y) + (x - c_x) + (y - c_y)\|^2 \\ &\approx \|c_x - c_y\|^2 + \|x - c_x\|^2 + \|y - c_y\|^2\end{aligned}$$

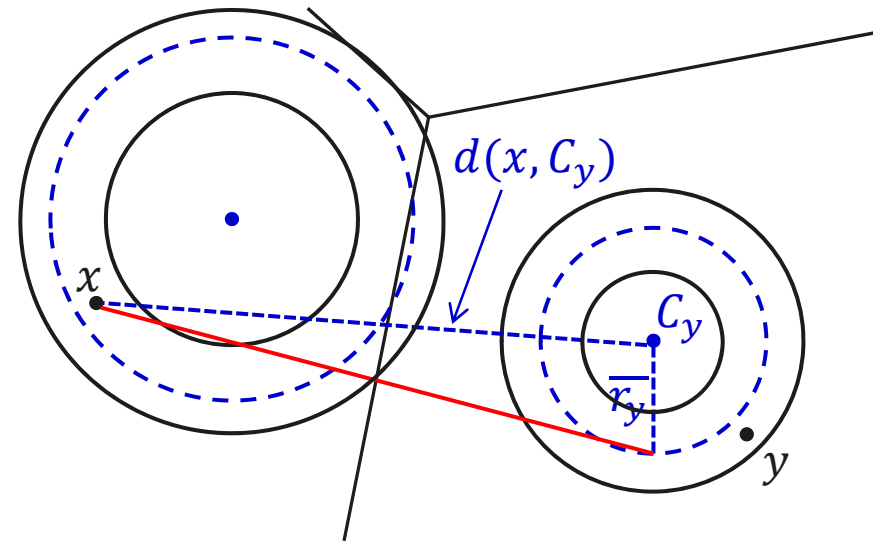
( $\because c_x - c_y, x - c_x$ , and  $y - c_y$  are mutually orthogonal.)

# Distance Estimation



Symmetric Distance

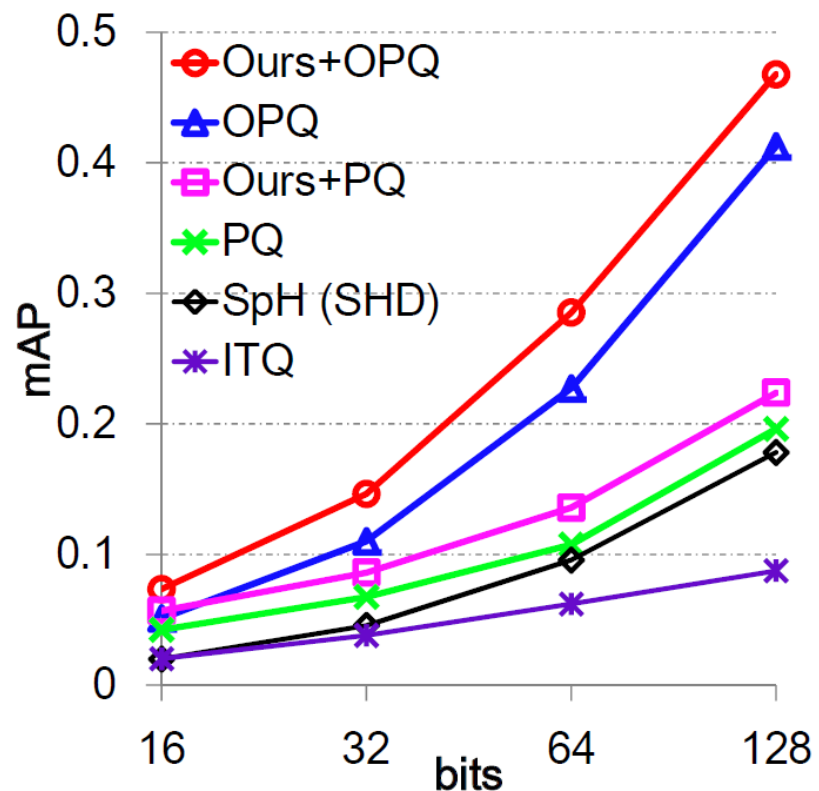
$$d_{SD}^{DPQ}(x, y)^2 = d(C_x, C_y)^2 + \bar{r}_x^2 + \bar{r}_y^2$$



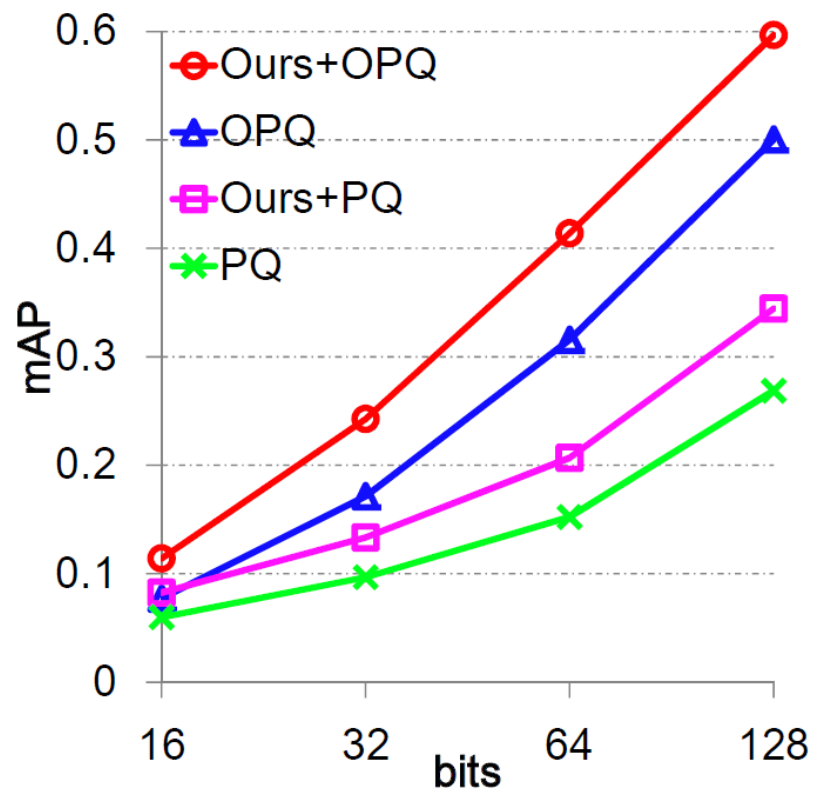
Asymmetric Distance

$$d_{AD}^{DPQ}(x, y)^2 = d(x, C_y)^2 + \bar{r}_y^2$$

# Result (1M, 960-Dim GIST)



Symmetric distance



Asymmetric distance

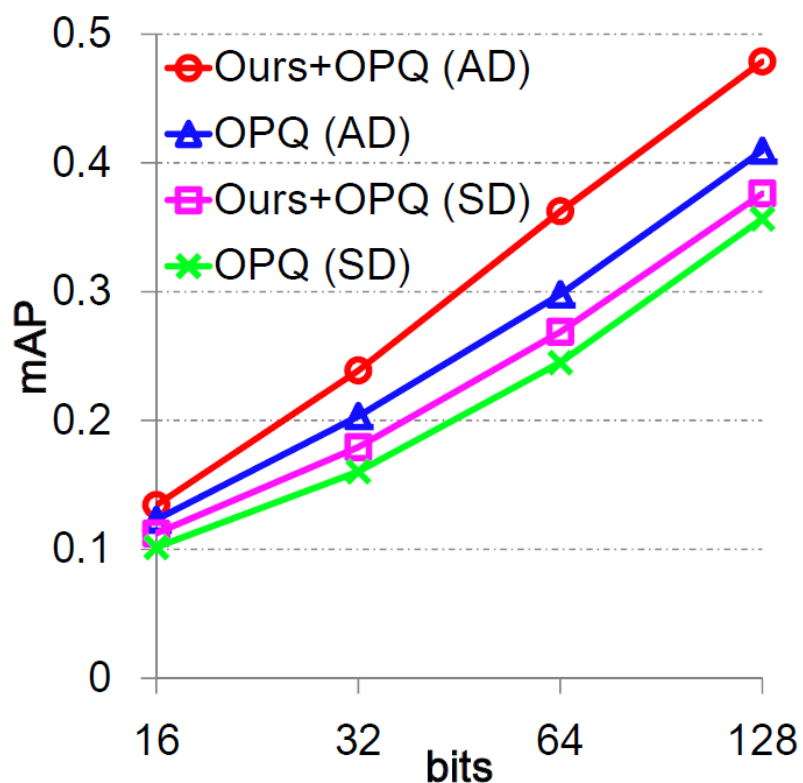
1000-nearest neighbor search mAP

OPQ: Optimized PQ [Ge et al., CVPR 2013]

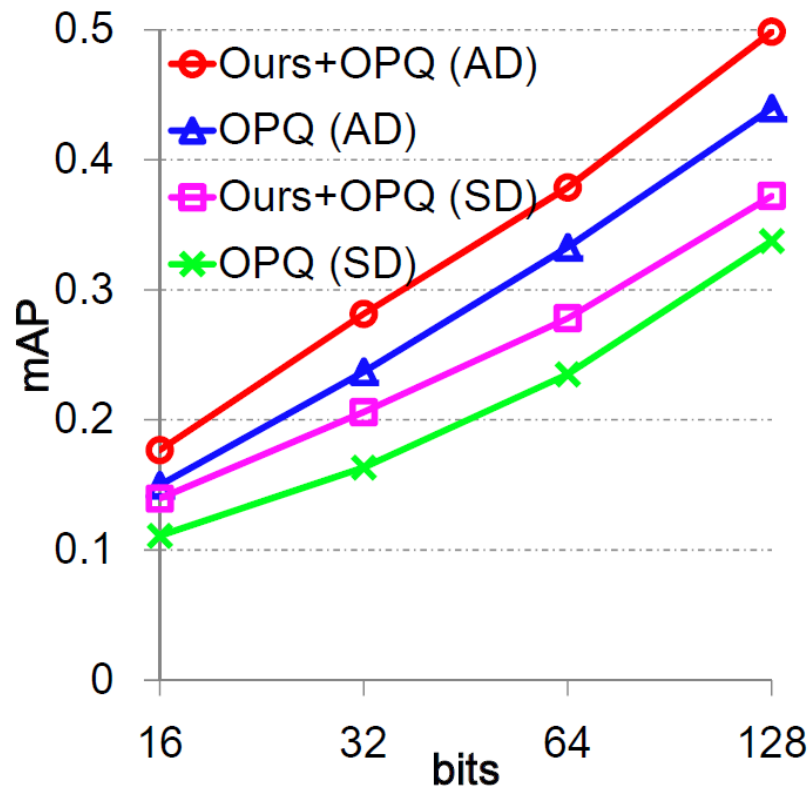
SpH: Spherical Hashing [Heo et al., CVPR 2012]

ITQ: Iterative Quantization [Gong and Lazebnik, CVPR

# Result (1M, 1024-Dim BoW)



Original Data



$L_2$  Normalized data

1000-nearest neighbor search mAP

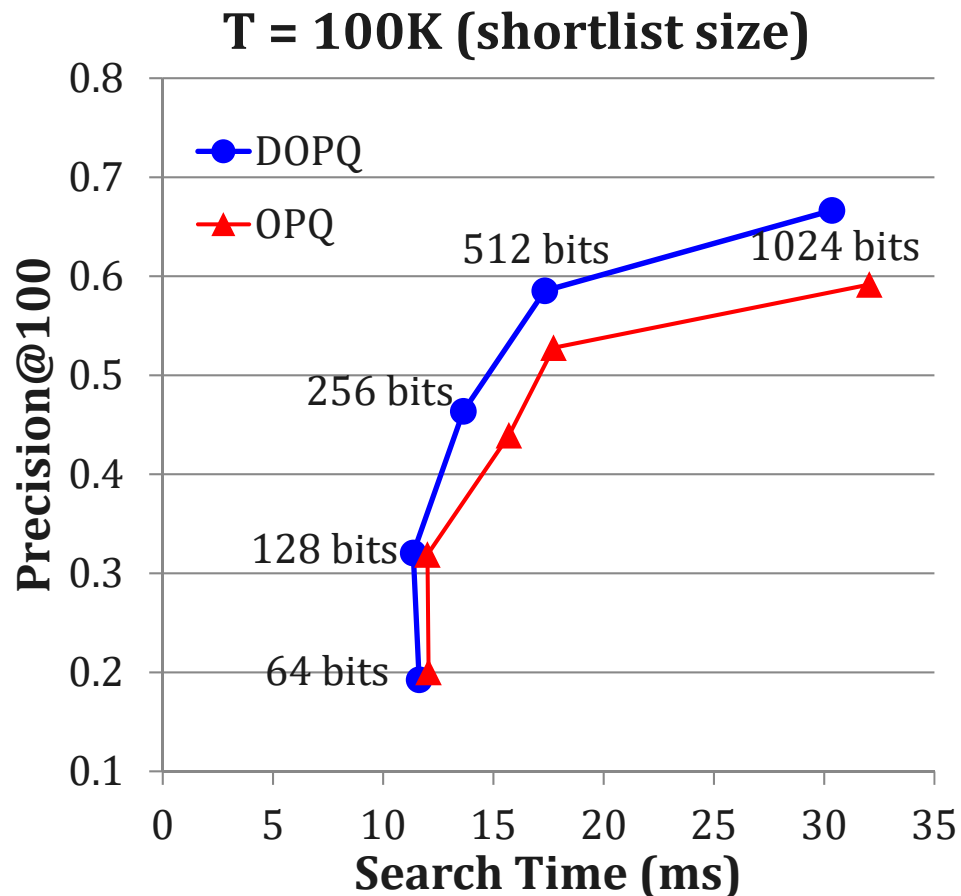
SD: Symmetric distance

AD: Asymmetric distance



# Result (Accuracy/Time/Memory)

- Tested on 4096-dimensional 11M CNN features
- Indexer: Vector Quantization with 4K centroids (4K lists)



# Indexing and Encoding

- **Encoding**
  - Residual vector as input to encoder
  - Product quantization or its variant
- **Indexing**
  - Inverted (multi-)index
  - Residual-aware shortlist selection

# Inverted Index

## Construction time:

- Generate a codebook by quantization
  - e.g. k-means clustering

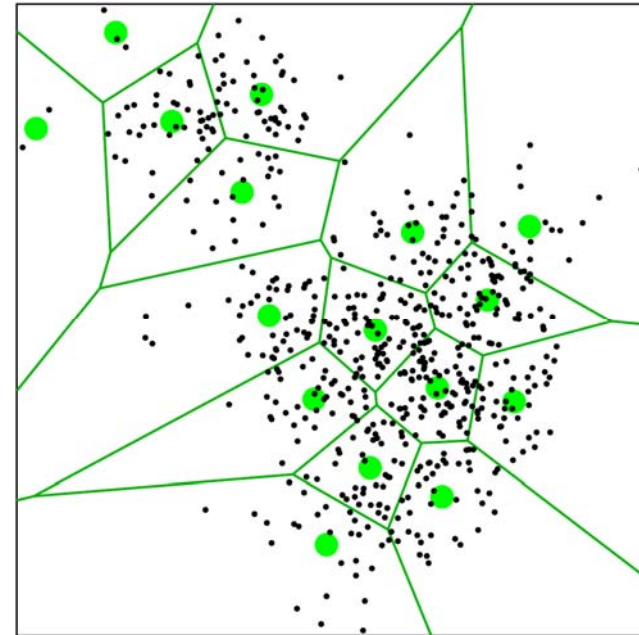
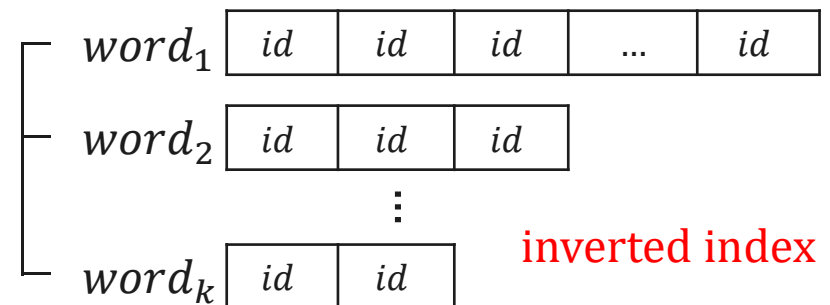


Figure from Lempitsky's slides

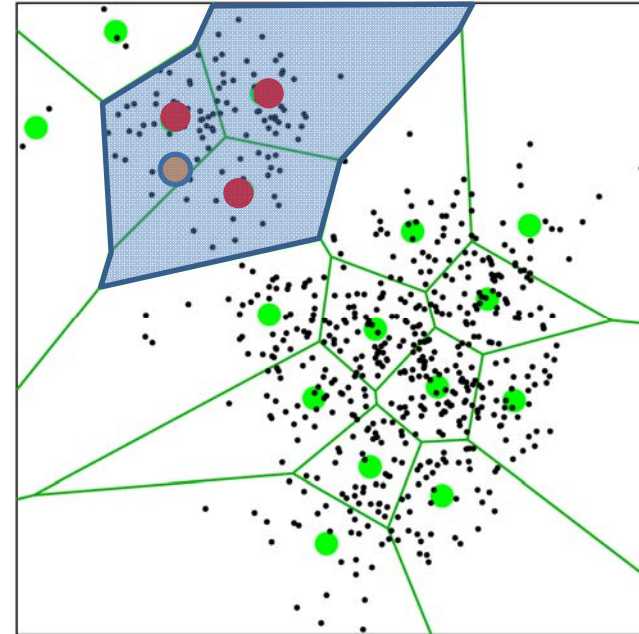
- Build an inverted index
  - Quantize each descriptor into the closest word
  - Organize desc. IDs in terms of words



# Inverted Index

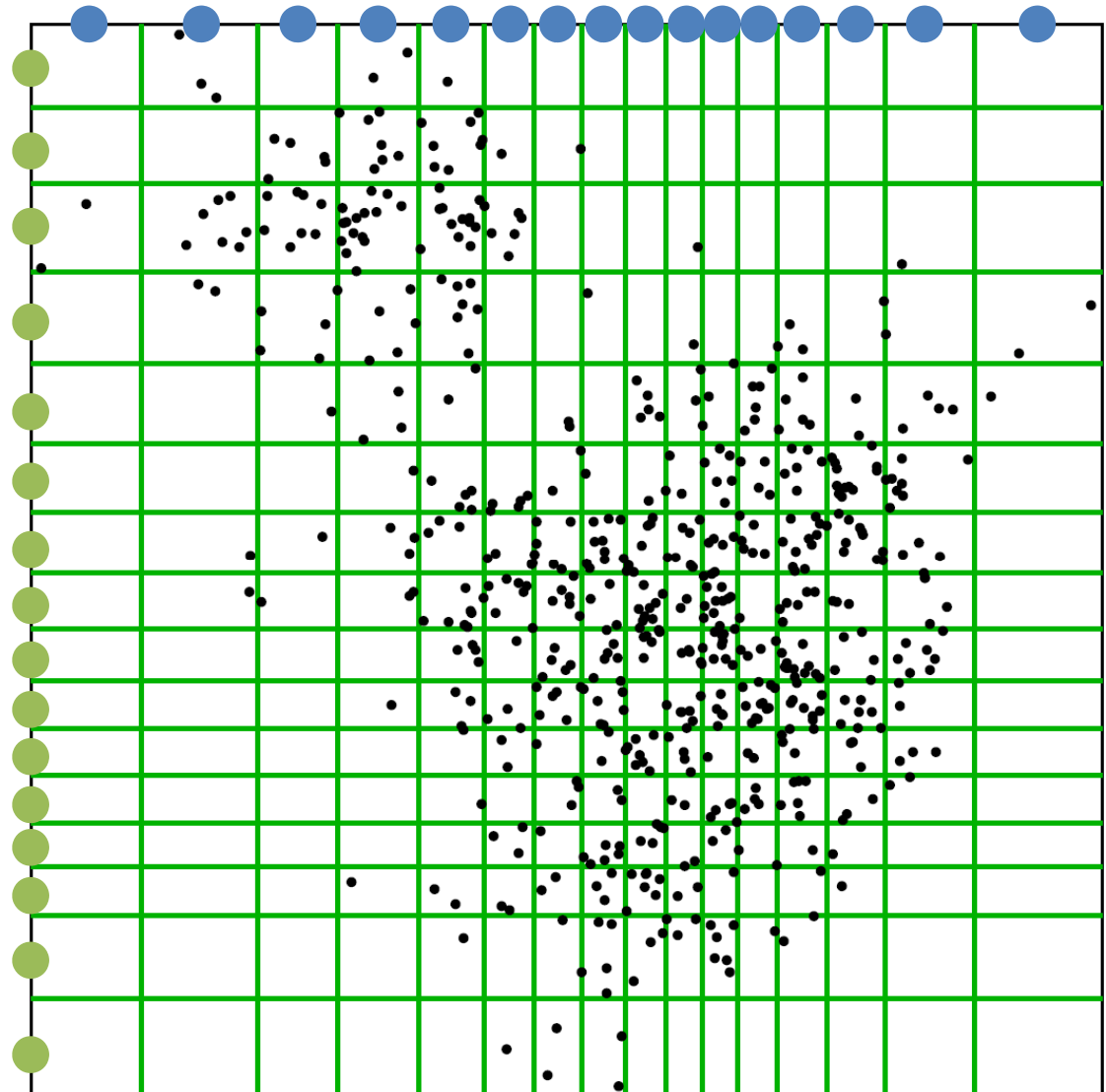
## Query time:

- Given a query,
  - Find its K closest **words**
  - Retrieve all the data in the K lists corresponding to the words
- Large K
  - Low quantization distortion
  - Expensive to find kNN words

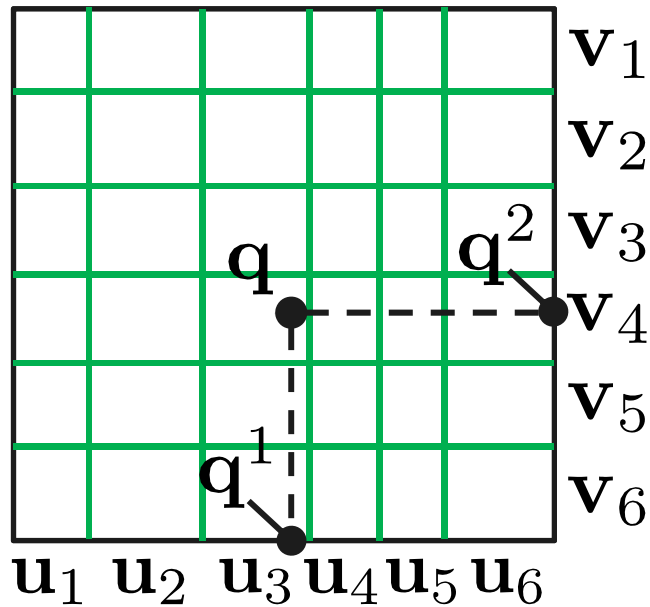


# Inverted Multi-Index [Babenko and Lempitsky, CVPR 2012]

- **Product quantization for indexing**
- **Main advantage:**
  - For the same  $K$ , much finer subdivision
  - Very efficient in finding  $k$ NN codewords



# Inverted Multi-Index [Babenko and Lempitsky, CVPR 2012]



$q^2$  vs.  $\mathcal{V}$

$j$	$v_{\beta(j)}$	$s$
1	$v_4$	0.1
2	$v_3$	2
3	$v_5$	3
4	$v_2$	6
5	$v_6$	7
6	$v_1$	11



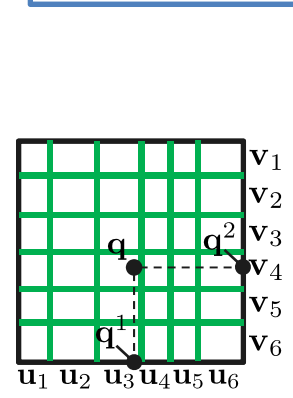
$q^1$  vs.  $\mathcal{U}$

$i$	$u_{\alpha(i)}$	$r$
1	$u_3$	0.5
2	$u_4$	0.7
3	$u_5$	4
4	$u_2$	6
5	$u_1$	8
6	$u_6$	9

	<b>inverted index</b>	<b>inverted multi-index</b>
number of entries	K	$K^2$
operations to match to codebooks	$2K+O(1)$	$2K+O(1)$

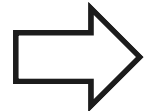
# Inverted Multi-Index [Babenko and Lempitsky, CVPR 2012]

multi-sequence algorithm



$i$	$u_{\alpha(i)}$	$r$
1	$u_3$	0.5
2	$u_4$	0.7
3	$u_5$	4
4	$u_2$	6
5	$u_1$	8
6	$u_6$	9

$j$	$v_{\beta(j)}$	$s$
1	$v_4$	0.1
2	$v_3$	2
3	$v_5$	3
4	$v_2$	6
5	$v_6$	7
6	$v_1$	11

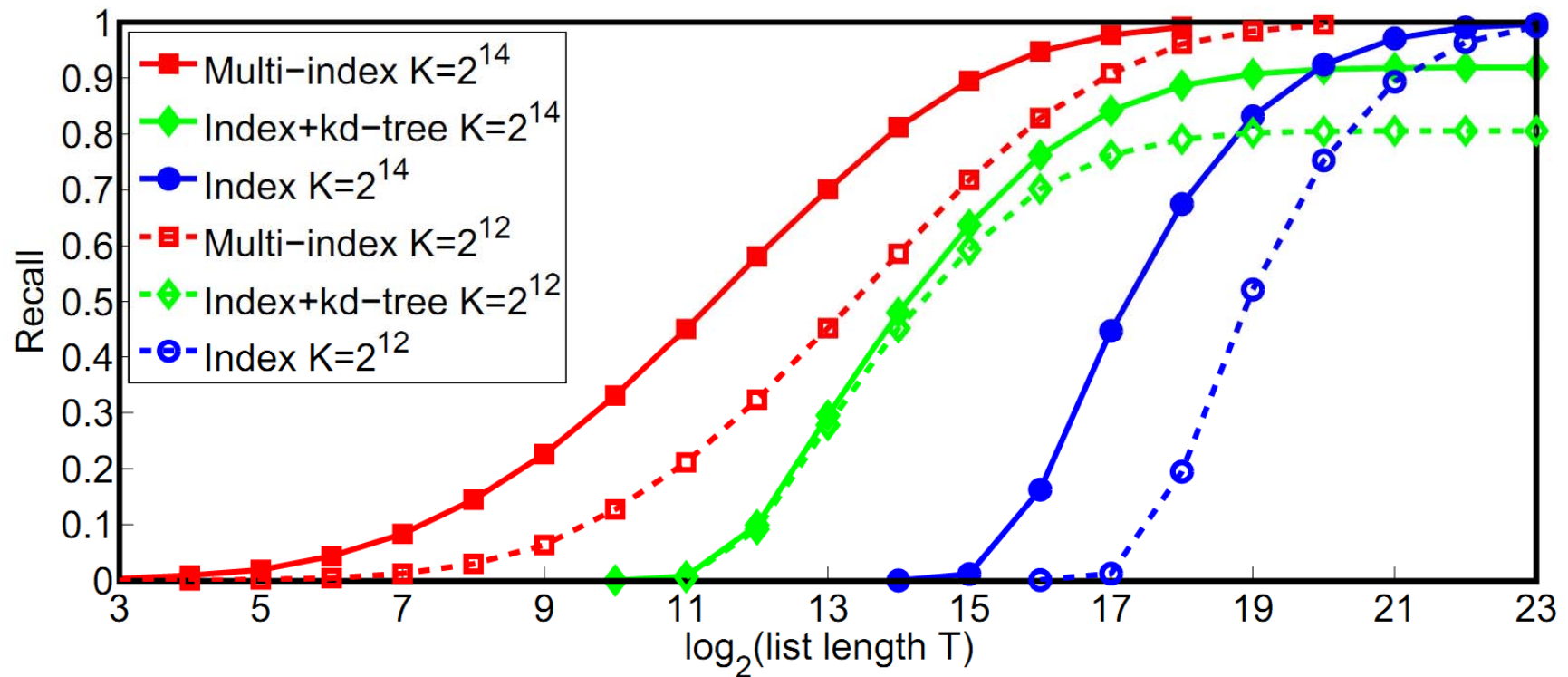


$[u_{\alpha(i)} \ v_{\beta(j)}]$	$(i, j)$	$r(i) + s(j)$
$[u_3 \ v_4]$	(1,1)	0.6 (0.5+0.1)
$[u_4 \ v_4]$	(2,1)	0.8 (0.7+0.1)
$[u_3 \ v_3]$	(1,2)	2.5 (0.5+2)
$[u_4 \ v_3]$	(2,2)	2.7 (0.7+2)
$[u_3 \ v_5]$	(1,3)	3.5 (0.5+3)
$[u_4 \ v_5]$	(2,3)	3.7 (0.7+3)
$[u_5 \ v_4]$	(3,1)	4.1 (4+0.1)
$[u_5 \ v_3]$	(3,2)	6 (4+2)
$[u_3 \ v_2]$	(1,4)	6.5 (0.5+6)
...		

$(1, 1) \rightarrow W_{3,4}$    
  $(2, 1) \rightarrow W_{4,4}$    
  $(1, 2) \rightarrow W_{3,3}$    
  $(2, 2) \rightarrow W_{4,3}$    
  $(1, 3) \rightarrow W_{3,5}$

# Inverted Multi-Index

[Babenko and Lempitsky, CVPR 2012]



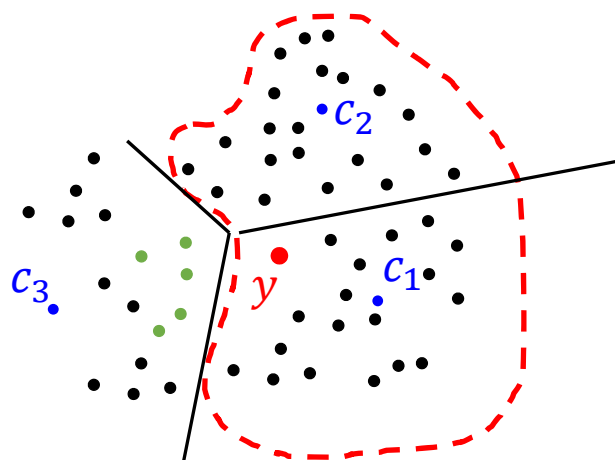
1B SIFT Dataset



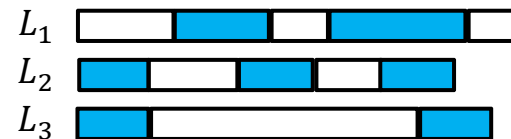
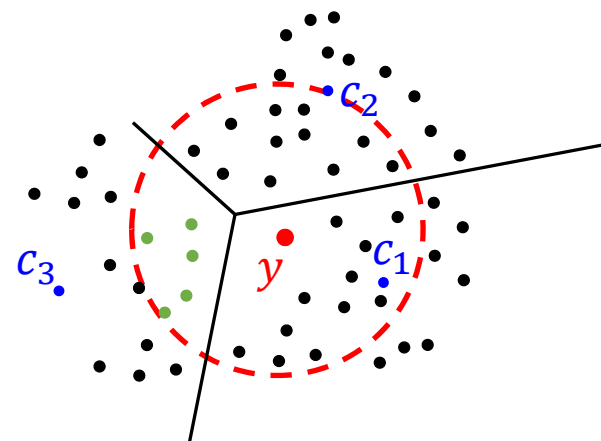
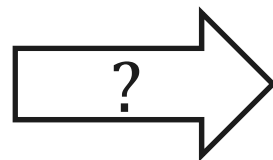
# Residual-Aware Shortlist Retrieval

[Jaepil et al., CVPR 2016]

Limitation of prev. methods



Neighbors could be missed due to the quantization error

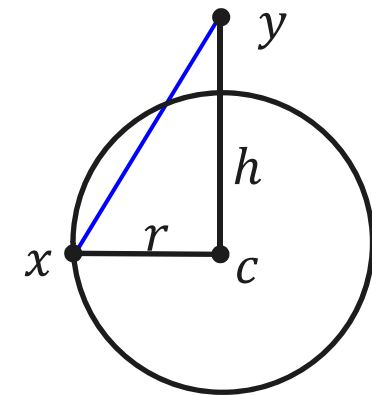


Select promising subset in parallel from all the lists

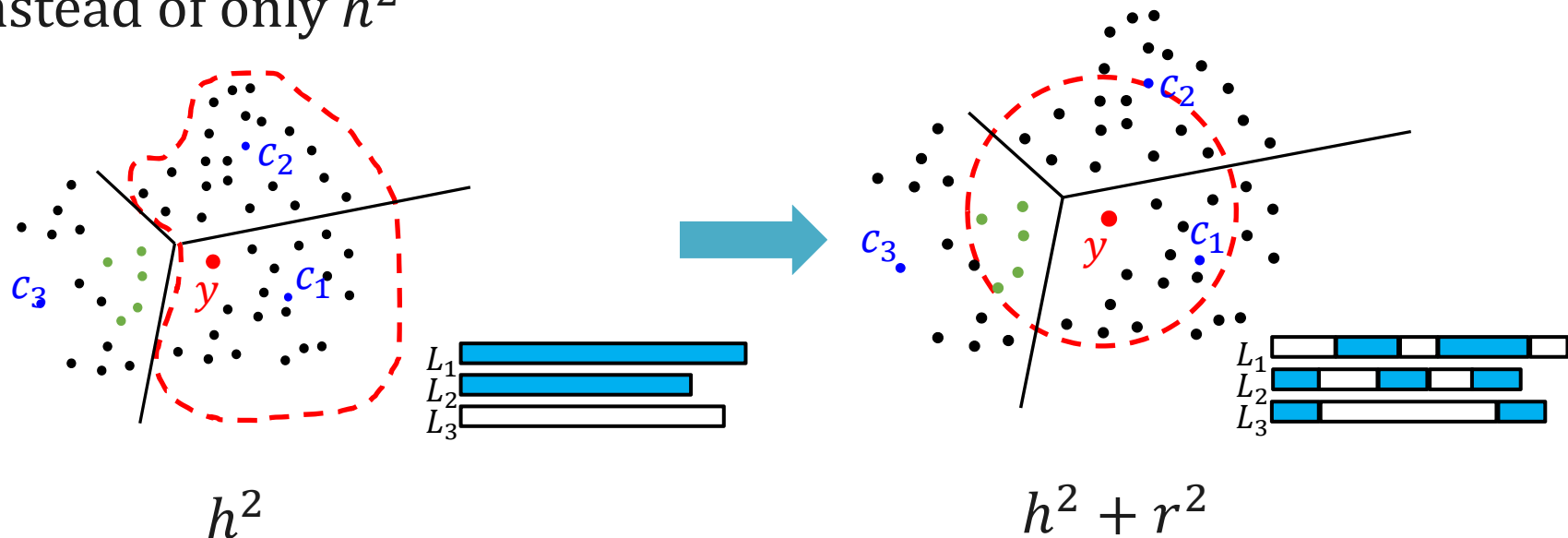
# Motivation: Better Distance Estimator ?

- Distance estimator between  $y$  and  $x$  based on orthogonality in high-dimensional space:

$$d(y, x)^2 \approx d(y, c)^2 + d(c, x)^2 = h^2 + r^2$$



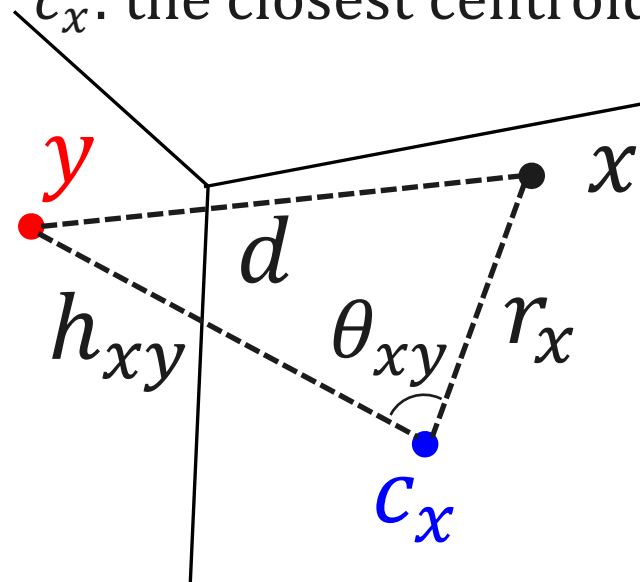
- Compute shortlist according to  $h^2 + r^2$ , instead of only  $h^2$



# Distance Estimator

$$\begin{aligned}
 d^2 &= h_{xy}^2 + r_x^2 - 2h_{xy}r_x \cos \theta_{xy} \\
 &= h_{xy}^2 + \left(1 - \frac{2h_{xy}}{r_x} \cos \theta_{xy}\right)r_x^2 \\
 &\approx h_{xy}^2 + \alpha_K r_x^2
 \end{aligned}$$

$y$ : query /  $x$ : data  
 $c_x$ : the closest centroid of  $x$

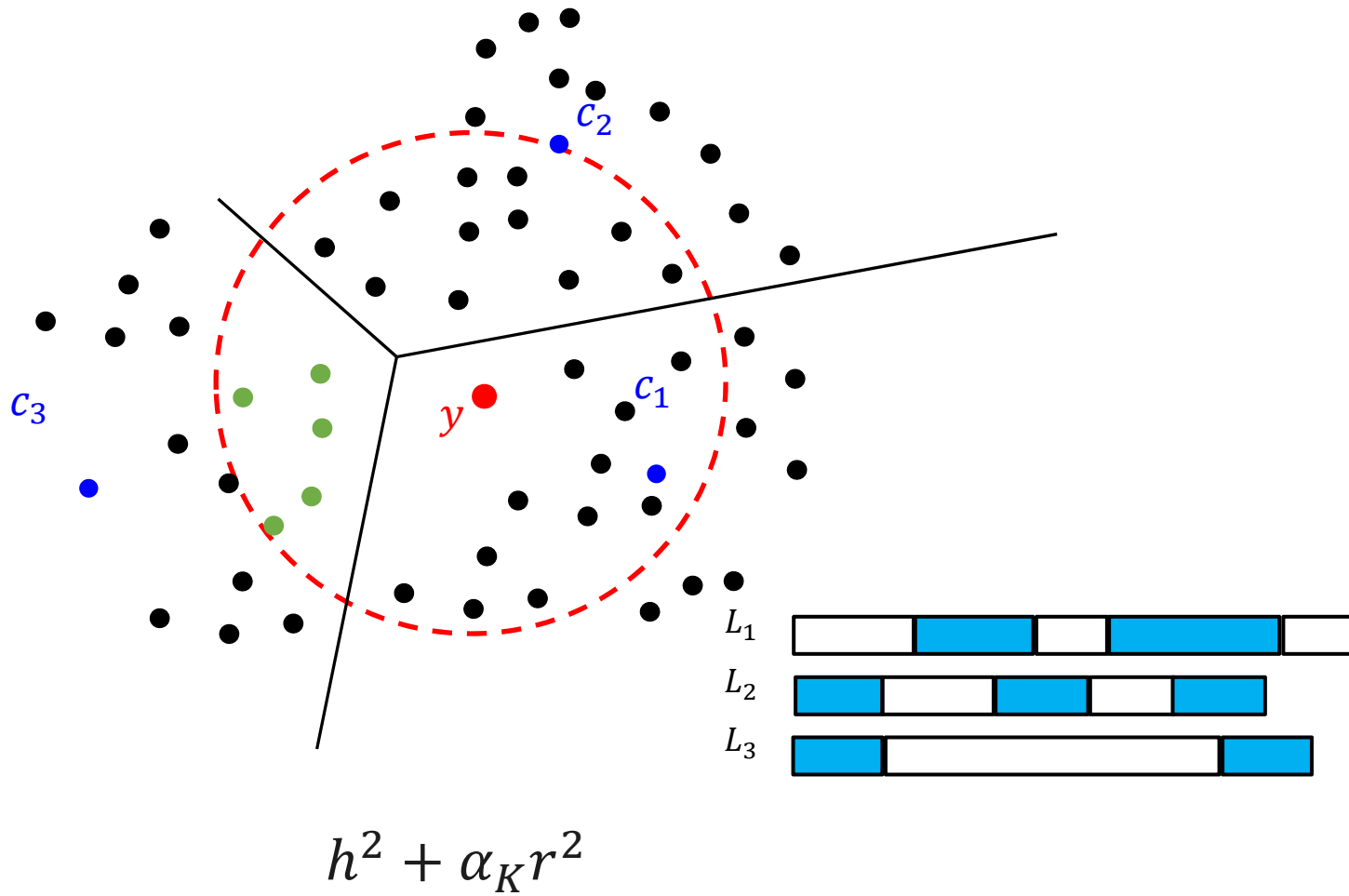


$\alpha_K$  is a constant depending on  $K$  (= number of desired neighbors)

= avg( [ ] with  $K$ -NN pairs and [ ] with random pairs)

e.g)  $\alpha_1 = 0.5$  /  $\alpha_{10} = 0.55$  /  $\alpha_{100} = 0.62$  /  $\alpha_{1000} = 0.70$

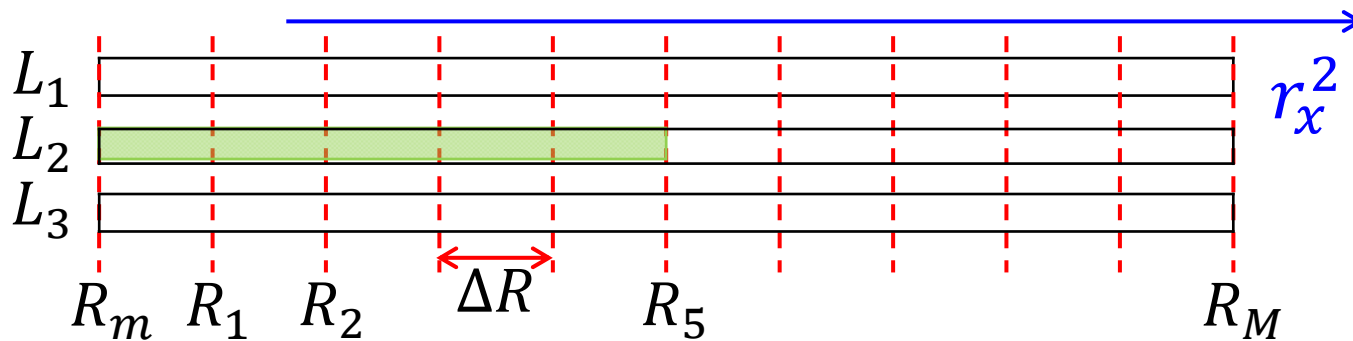
# Distance Estimator



# Shortlist with Inverted Index

- **Lookup Table Precomputation**

- Sort and partition each inverted list according to  $r_x^2$



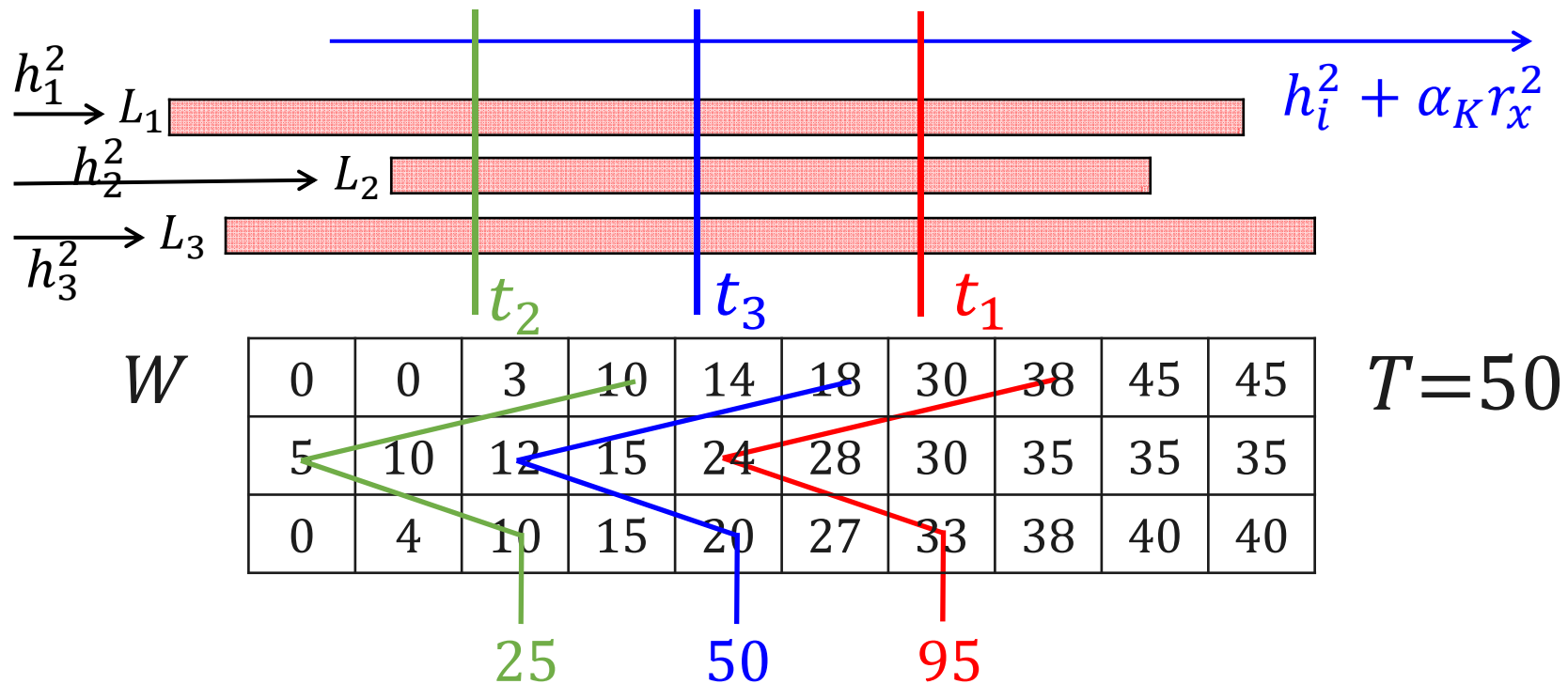
- Compute a lookup table  $W(i, j)$  – the number of data in  $L_i$  whose  $r_x^2$  are smaller than  $R_j$

$W$	0	0	3	10	14	18	30	38	45	45
	5	10	12	15	24	28	30	35	35	35
	0	4	10	15	20	27	33	38	40	40

# Shortlist with Inverted Index

- **Runtime Shortlist Selection**

- Given a query  $y$ , shortlist size  $T$ , and the target number of neighbors  $K$
- Compute squared distances to centroids  $h_i^2$
- Do **binary search** to find a distance threshold that corresponds to  $T$

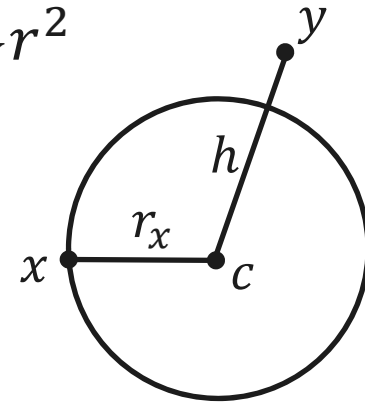


# Shortlist with Inverted Multi-Index

- **Residual-Aware Indexing**

- Partition each cluster by  $r_x$  to define index (subspace ID, cluster ID, distance ID)
- Compute a representative residual distance  $\bar{r}_{s,i,j}^2$  for each index  $(s, i, j)$

$$h^2 + \alpha_K r^2$$



		Subspace #1					
Subspace ID		(1,1,1)	(1,1,2)	(1,2,1)	(1,2,2)	Subspace #1	Subspace #2
Subspace #2	(2,1,1)					$\bar{r}_{1,1,1}^2 = 0.3$	$\bar{r}_{2,1,1}^2 = 0.7$
	(2,1,2)					$\bar{r}_{1,1,2}^2 = 1.3$	$\bar{r}_{2,1,2}^2 = 0.9$
	(2,2,1)					$\bar{r}_{1,2,1}^2 = 0.4$	$\bar{r}_{2,2,1}^2 = 0.6$
	(2,2,2)					$\bar{r}_{1,2,2}^2 = 0.8$	$\bar{r}_{2,2,2}^2 = 1.0$
		Distance ID					
		Cluster ID					

# Shortlist with Inverted Multi-Index

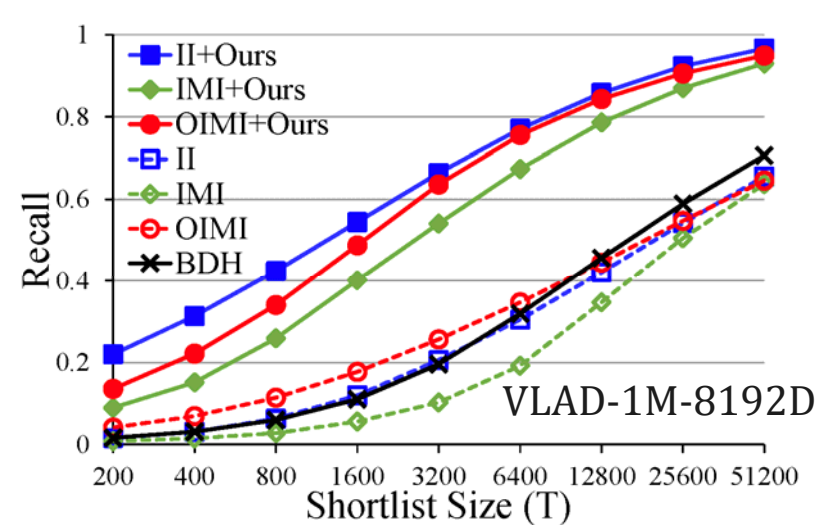
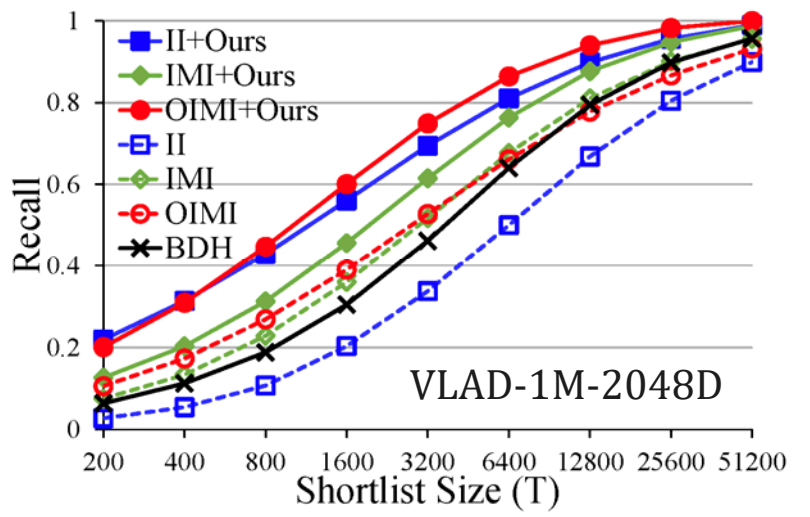
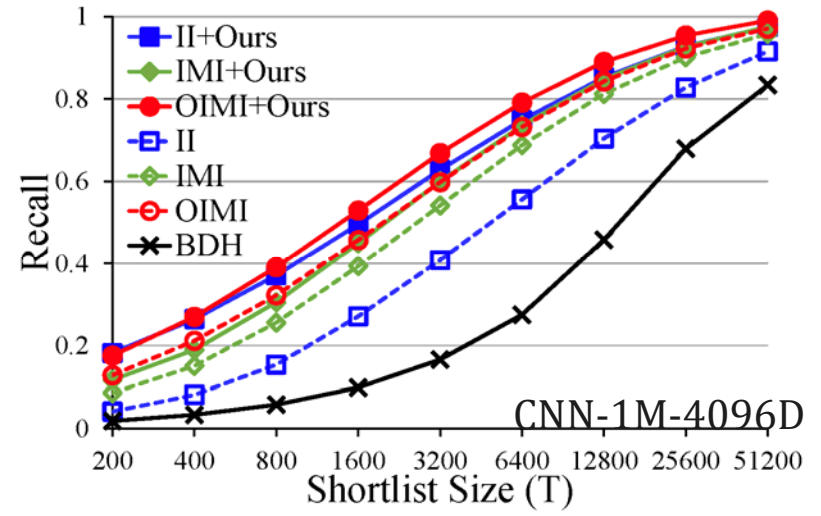
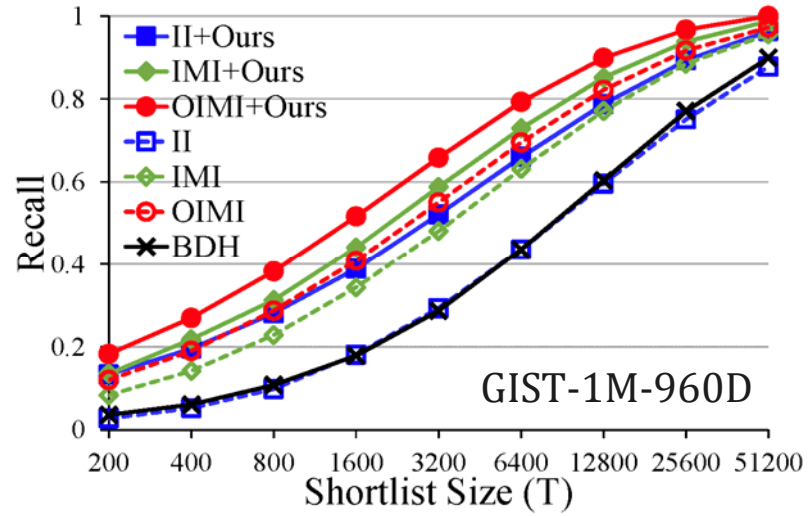
- **Runtime Shortlist Selection**
  - Compute  $h_{s,i}^2$  (the distance to  $i$ -th centroid of  $s$ -th subspace), and sort the indices in each subspace according to  $h_{s,i}^2$
  - Traverse the table by using the multi-sequence algorithm

		$h_{1,i}^2 + \alpha_{K,1} r_{1,i,j}^2 \rightarrow$			
Subspace #1		(1,1,1)	(1,2,1)	(1,2,2)	(1,1,2)
$\bar{h}_{1,1}^2 = 0.8$ $\bar{h}_{1,2}^2 = 1.0$		1.1	1.4	1.8	2.1
	(2,2,1) 1.2	2.3	2.6	3.0	3.3
Subspace #2 $\bar{h}_{2,1}^2 = 1.1$ $\bar{h}_{2,2}^2 = 0.6$	(2,2,2) 1.6	2.7	3.0	3.4	3.7
	(2,1,1) 1.8	2.9	3.2	3.6	3.9
	(2,1,2) 2.0	3.1	3.4	3.8	4.1



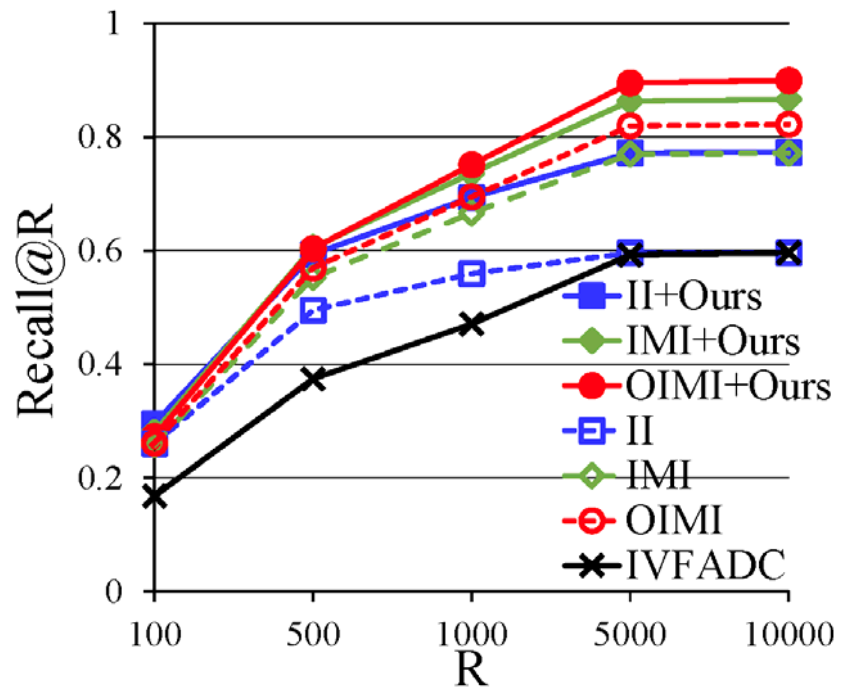
# Shortlist Evaluation

Accuracy of Shortlist retrieving top 100 GT

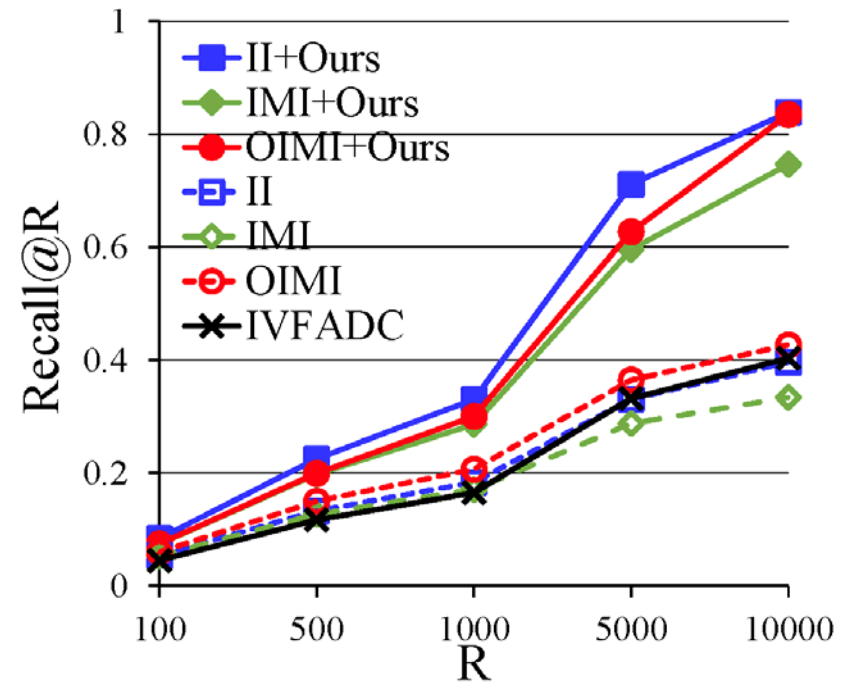


# Shortlist Evaluation

## End-to-End Accuracy



GIST-1M-960D, Re-ranked



VLAD-1M-8192D, Re-ranked

# Applications

- Object retrieval and localization
- Product image recognition
- Face detection and attribute recognition
- Large-scale semantic image search
- Large-scale image tagging
- Free-text image search

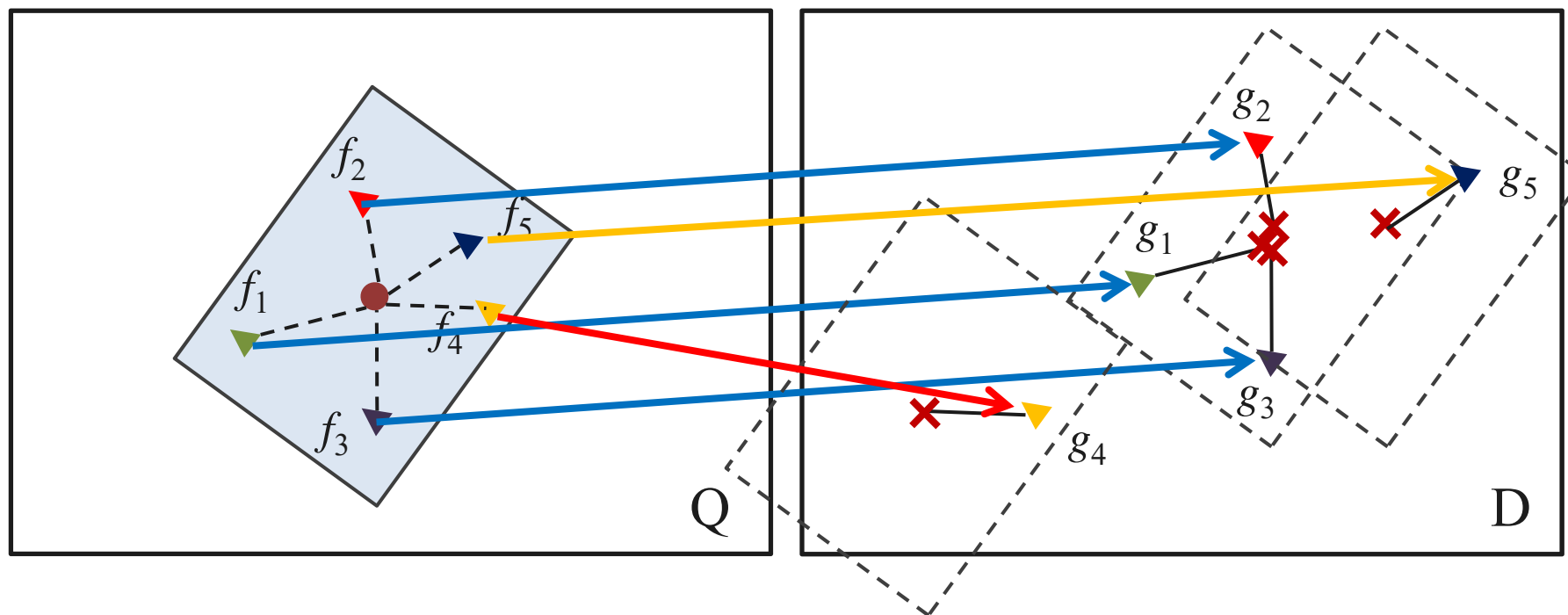
# Object Retrieval and Localization



[X. Shen et al., CVPR 2012]

# Object Retrieval and Localization

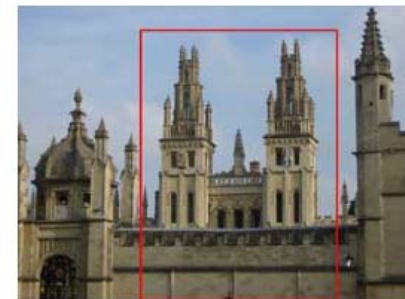
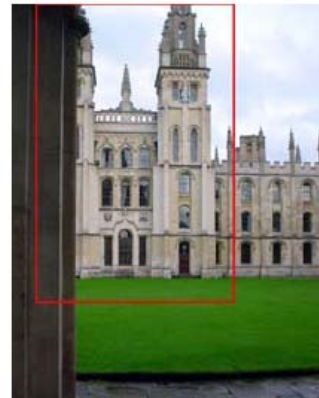
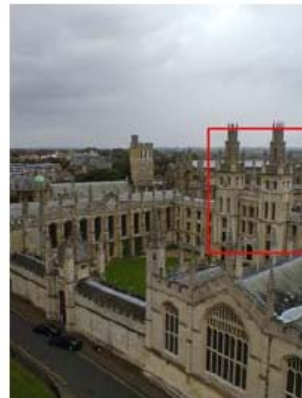
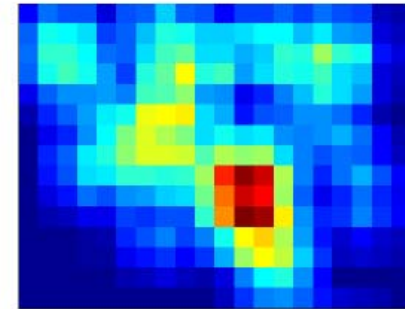
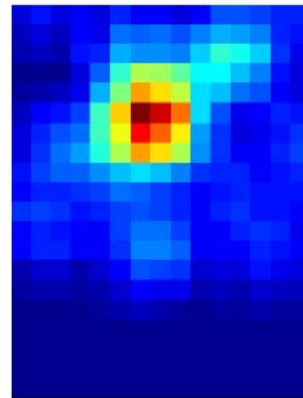
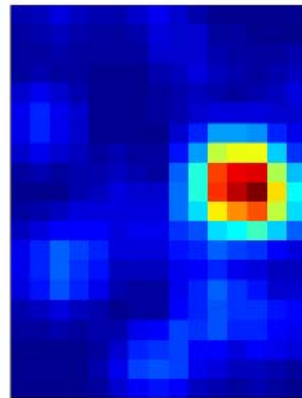
- Local correspondence voting for non-rigid object matching



tf-idf pair voting score: 
$$\frac{idf(k) \cdot idf(k)}{tf(Q, k) \cdot tf(D, k)}$$

Choose the transformation with the highest score!

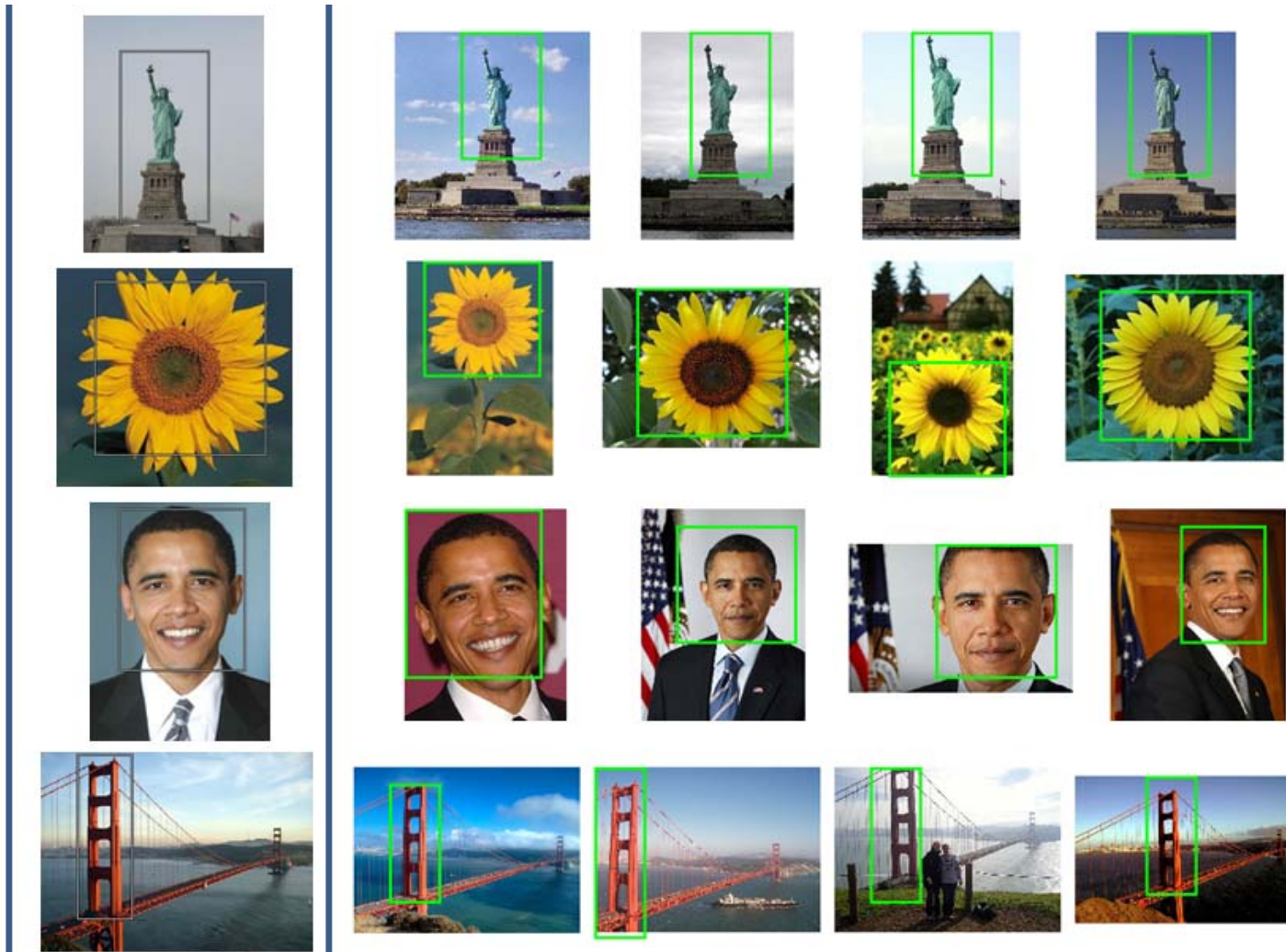
# Object Retrieval and Localization



Examples of Voting Maps



# Object Retrieval and Localization



Non-rigid cases

# Product Image Recognition

[X. Shen et al., ECCV 2012]



Examples of product images in the database



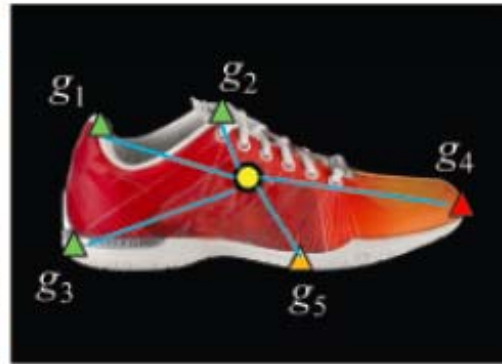
Examples of query images taken by mobile phones



# Product Image Recognition



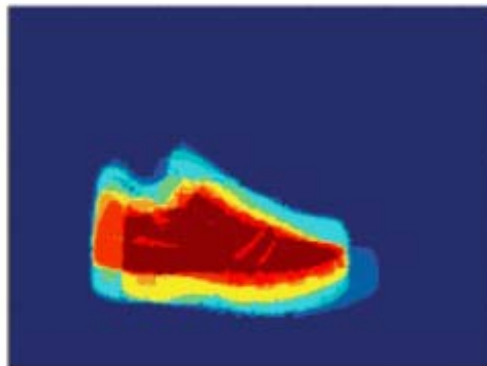
(a)



(b)



(c)



(d)



(e)



(f)

# Product Image Recognition



Images

Support map

Extraction

GrabCut

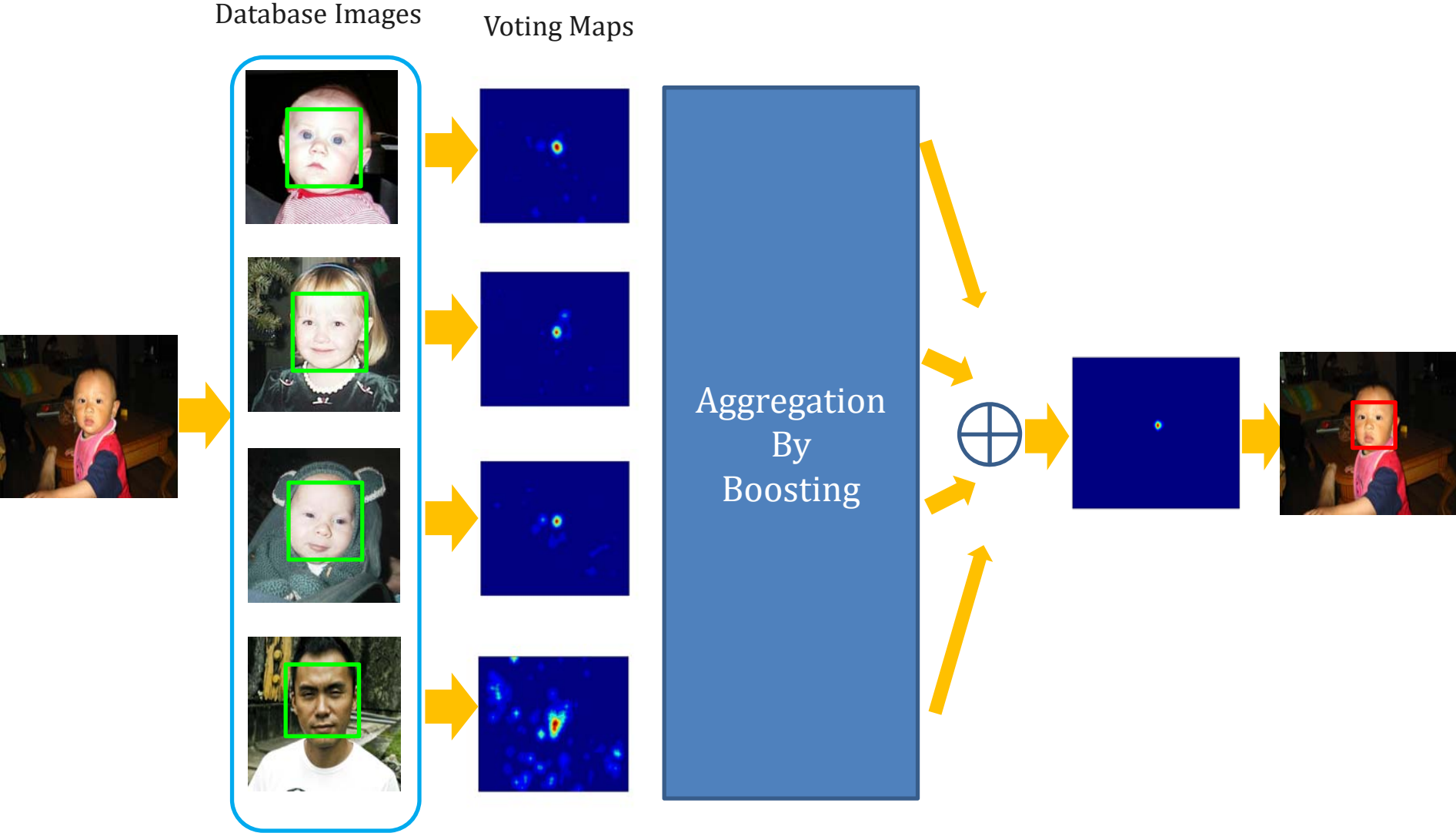
# Face Detection by Image Retrieval



[X. Shen et al., CVPR 2013]

[H. Li et al., CVPR 2014]

# Face Detection by Image Retrieval



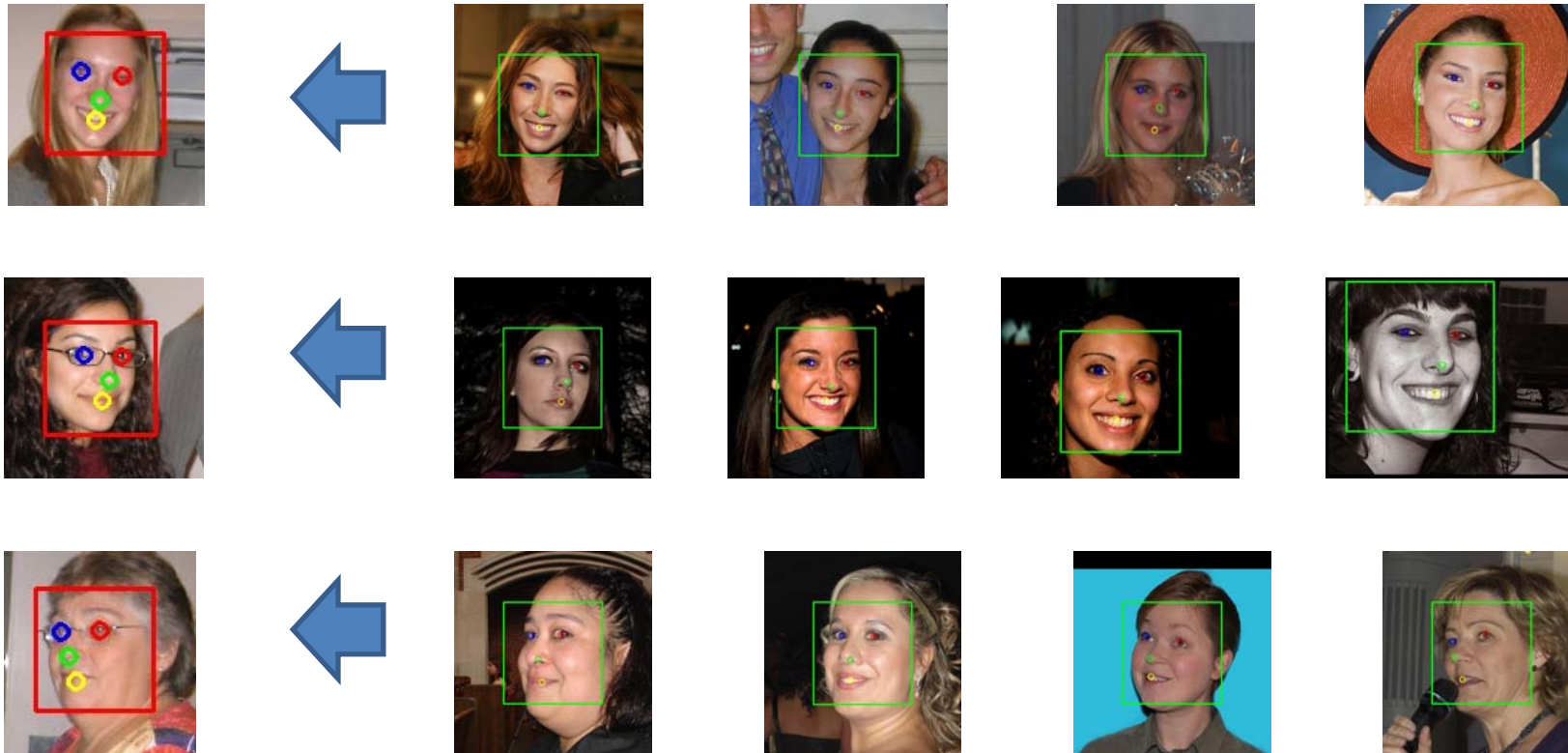


# Face Detection by Image Retrieval



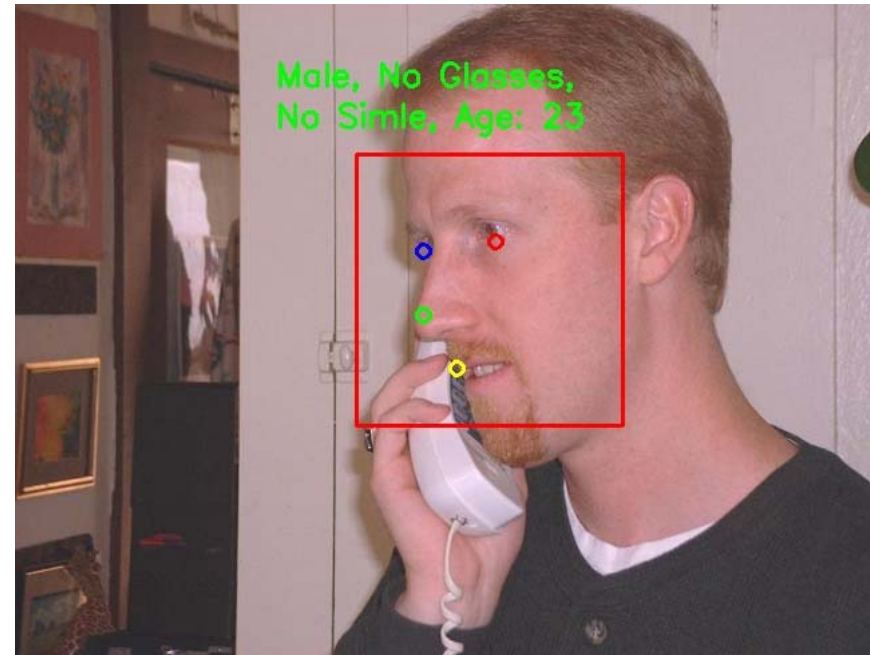
Example detection results

# Facial Attribute Recognition



transfer landmark, pose, age, gender, expression...

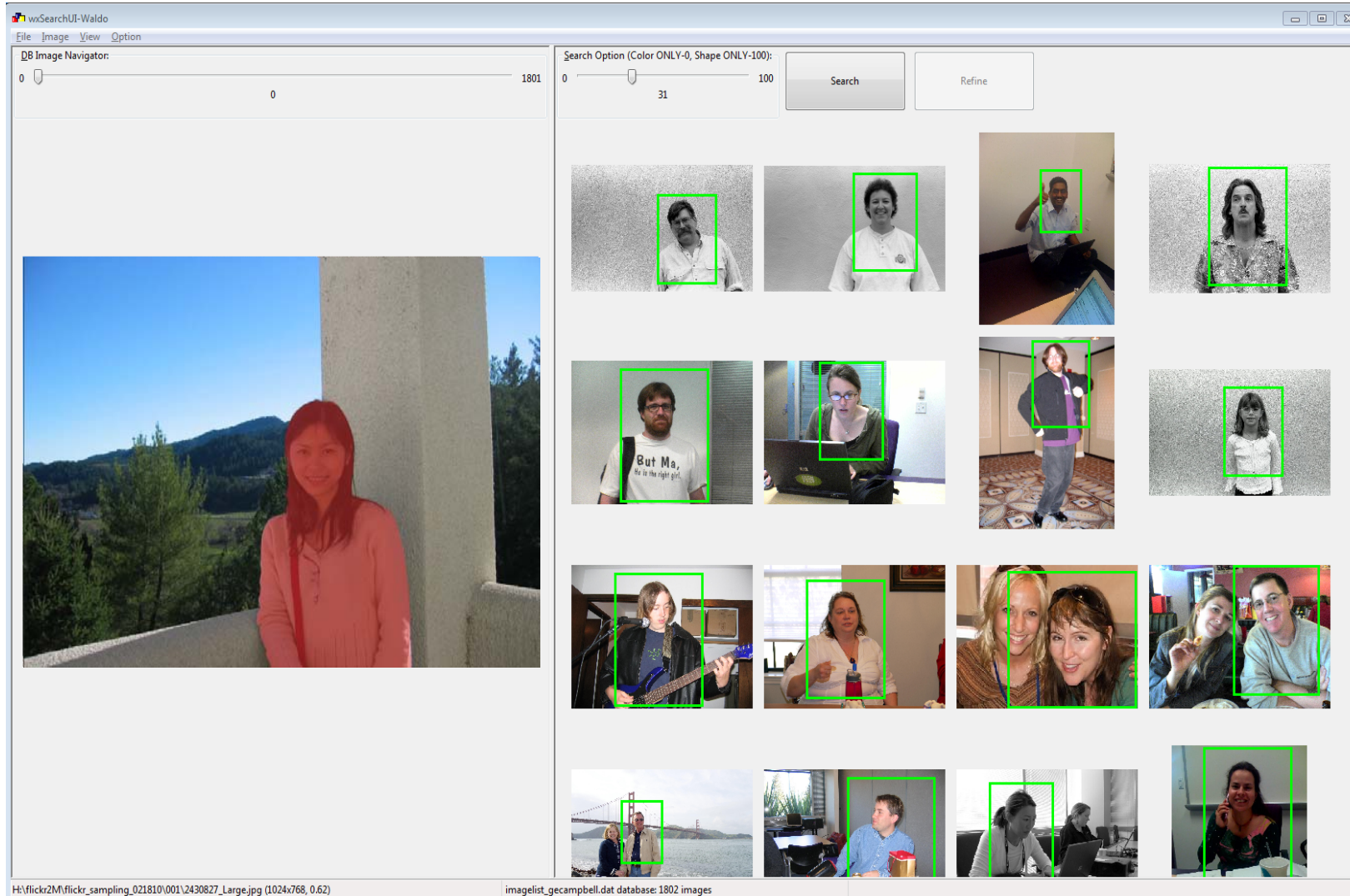
# Facial Attribute Recognition





# Data-Driven Object Segmentation

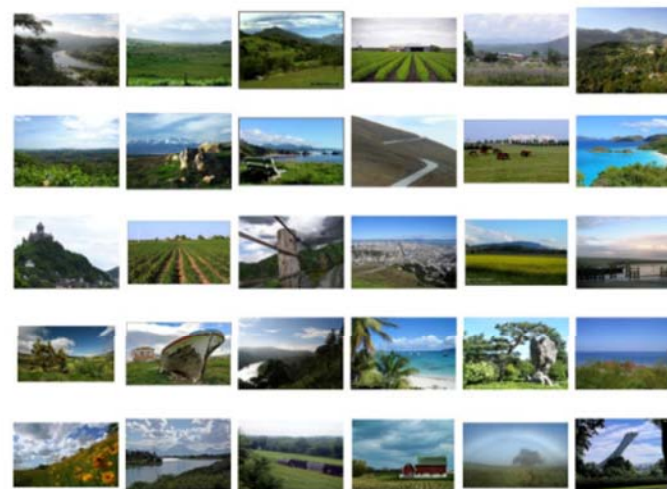
[J. Yang et al. CVPR 2014]



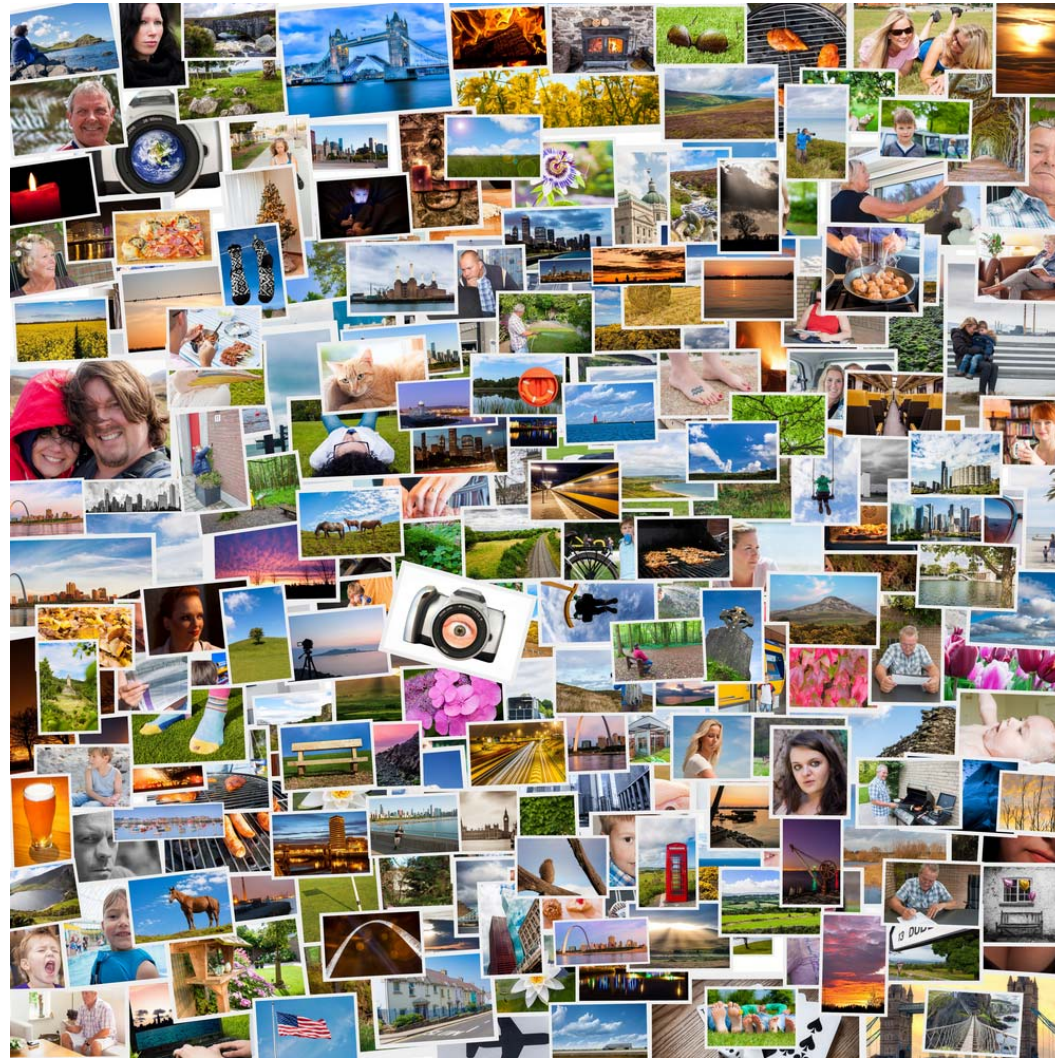


# Data-Driven Automatic Cropping

[A. Samii et al. CGF 2015]

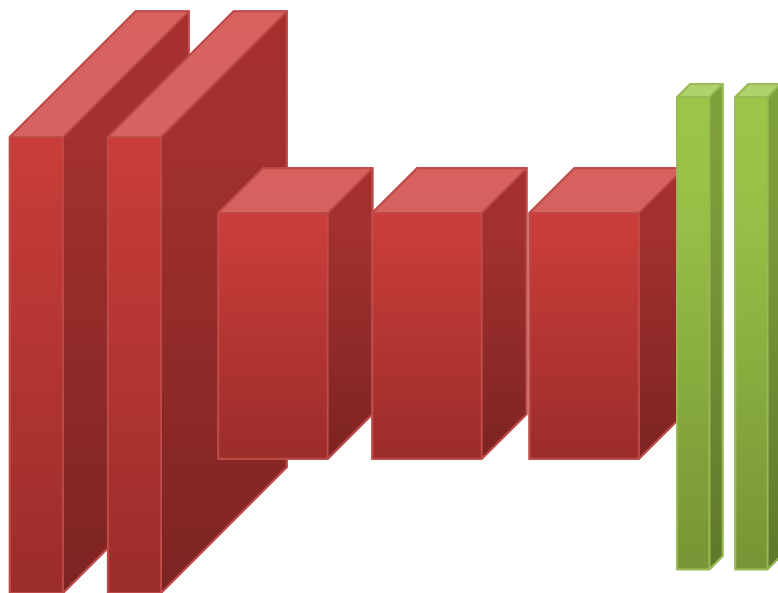


# Image Similarity Search

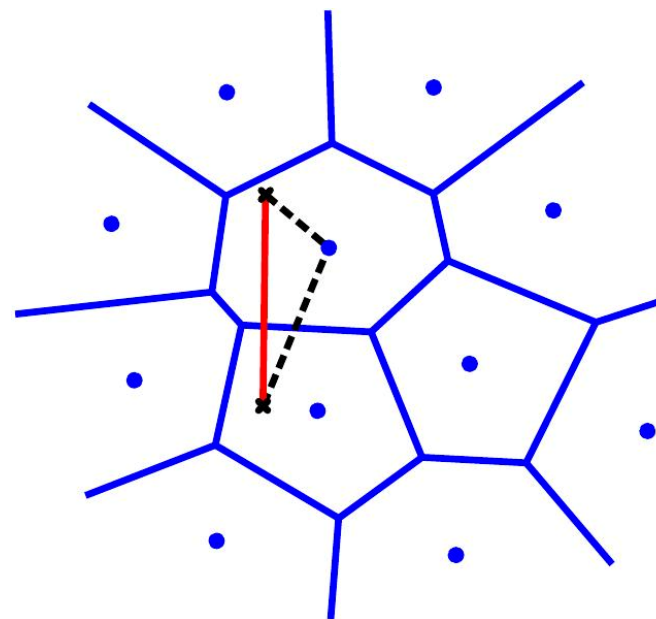


# Image Similarity Search

Deep Convolutional Neural Network



Distance Encoded OPQ





# Image Similarity Search

ImageSearch\_Demo
->> InvFile loading finished (15.85 sec): num images 3M 312K 600, invFile size: 225M 273K 304 bytes

Search Params

n.Visits:

n.Result:

InvFile Params





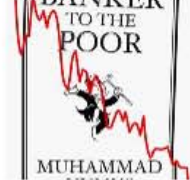























Indexer:

n.Index:

Encoder:

CodeLen:

EncData:

# 435275	# 313782	# 1719897	# 2899695	# 2925048	# 198403	# 2454766
						
# 1828318	# 2406921	# 2540400	# 239285	# 2511418	# 301155	# 1919316
						
# 1994702	# 2068644	# 1849015	# 343252	# 1466371	# 1652636	# 882975
						
# 542778	# 2098742	# 636669	# 480204	# 1132528	# 1100477	# 1018436
						

# Automatic Image Tagging

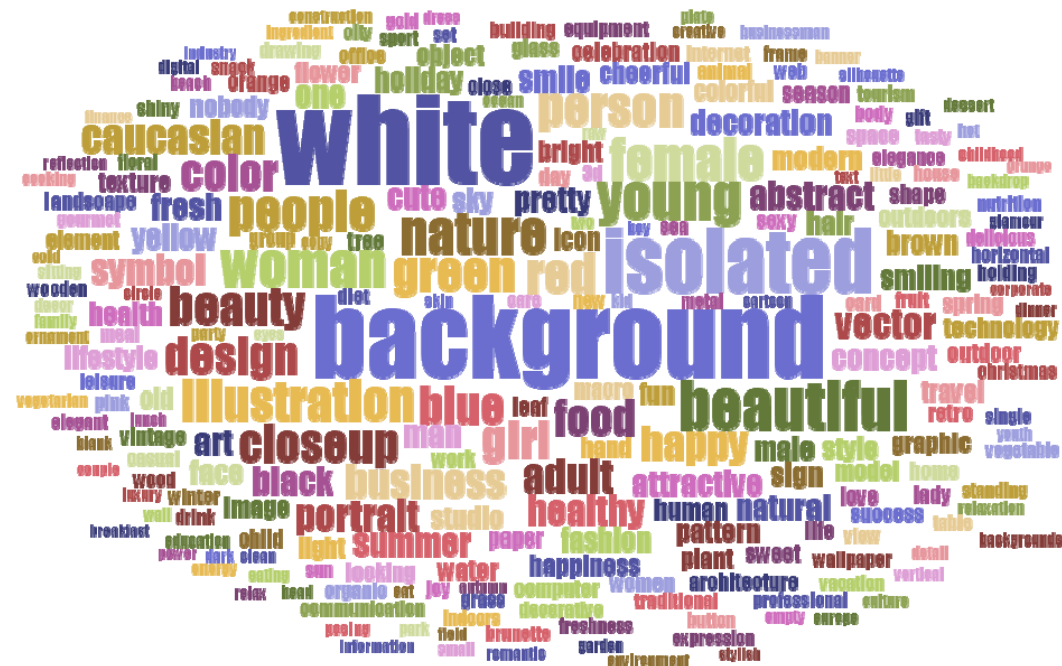


attractive white  
woman girl  
fashion women  
brunette glamour girls  
underwear dress  
erotic wedding mark red  
bride 20s beauty adult  
beautiful young sexy background  
sensual rest sleep lingerie  
happy bed wedding caucasian wellness  
married adorable relaxing outdoors lying body  
flower adorable wedding lying face

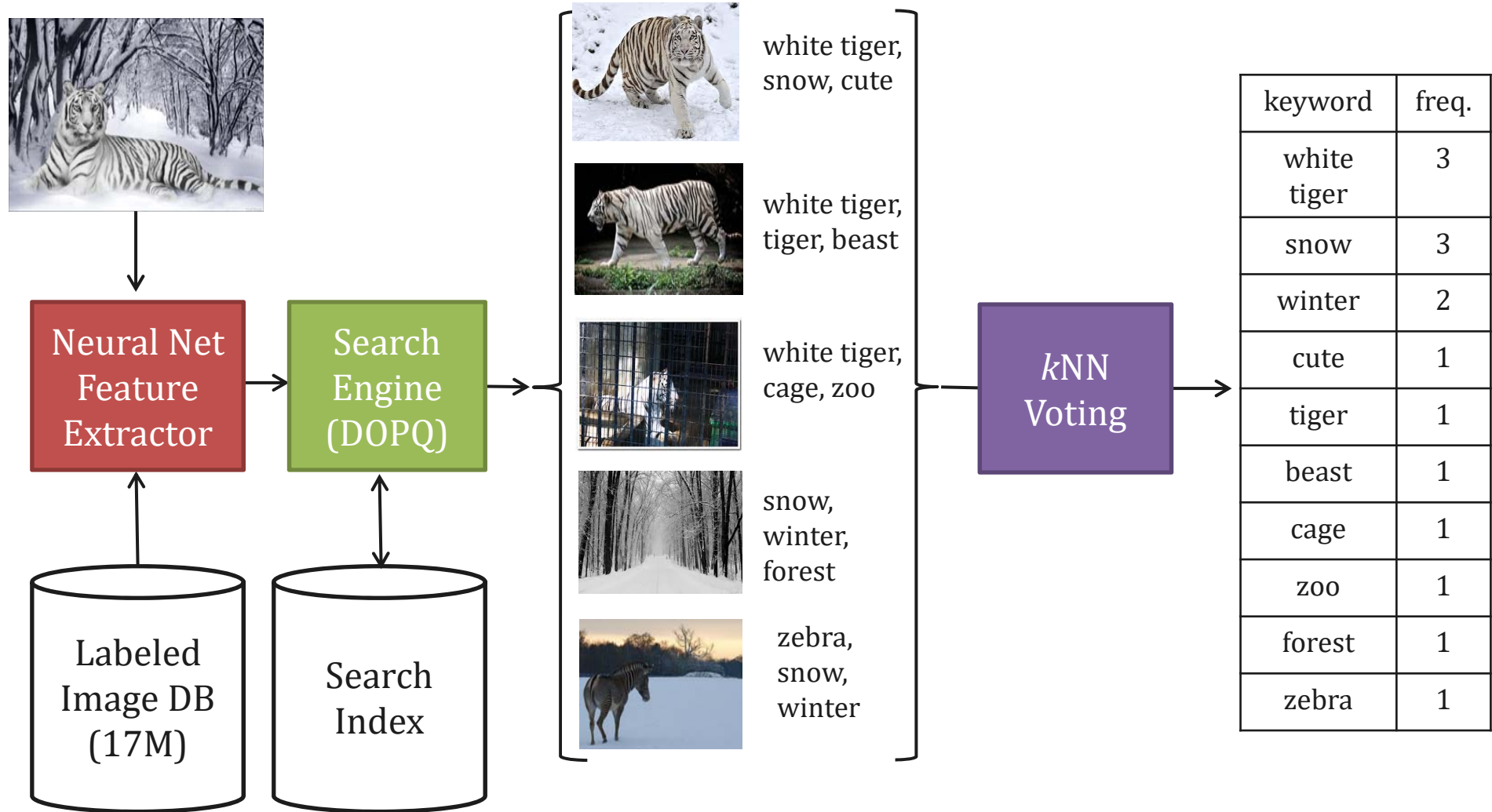
# Dataset

- 17 million Adobe stock images with tags

18k-100k tag vocabulary



# Deep-kNN Tagging System



# Discriminative Feature Learning

- Tag set similarities can reflect the **visual similarities**



cute, fluffy, domestic, one, playful, curious, portrait, funny, paw, young, spots, black, pets, puppy, adorable, pretty, sitting, charming, fur, hair, lovely, animals, look, heartwarming, delectable, cuddly, veterinarian, small, mammal, soft, exquisite, ears, black puppy

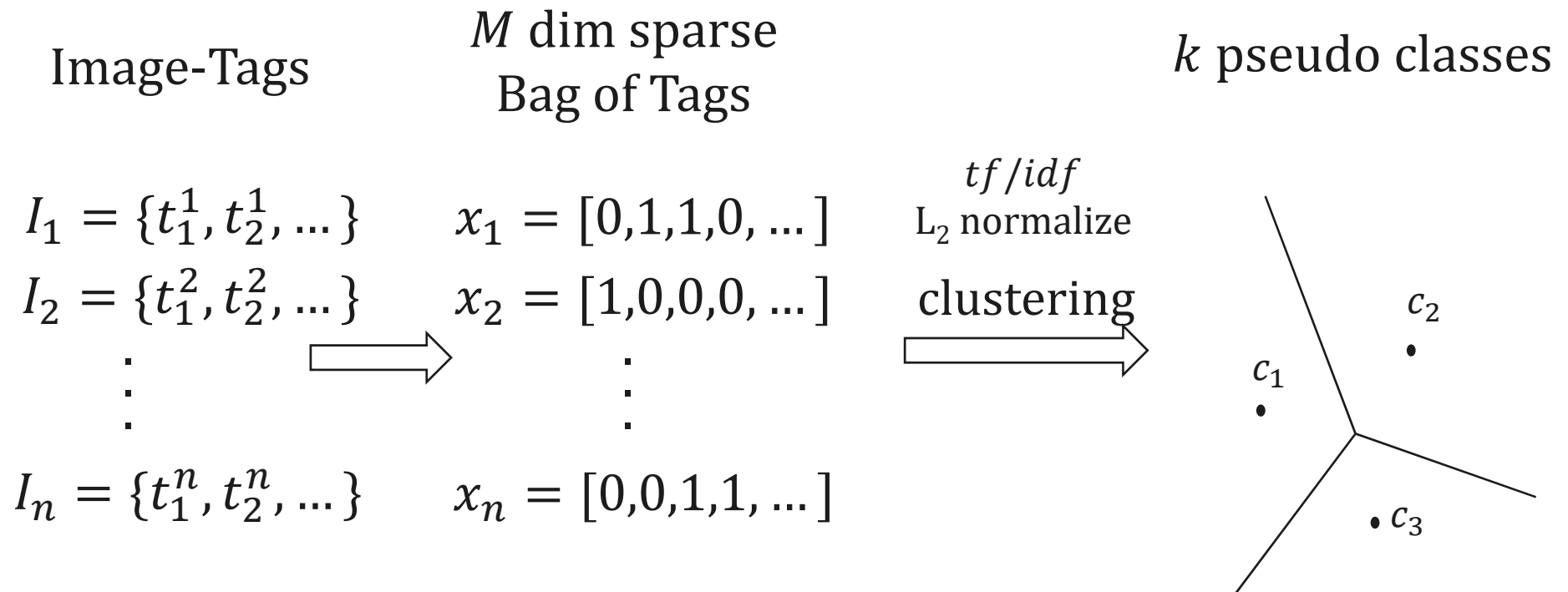


cute, wreath, domestic, one, playful, bright, young, spots, black, pretty, orange, lovely, hawaiian, sitting, motley, charming, fur, flowers, animals, look, heartwarming, cuddly, veterinarian, small, mammal, soft, exquisite, ears, fluffy, hair, portrait, curious, funny, paw, artificial, pets, puppy, adorable, delectable, small black, black puppy



# Tag Context Space






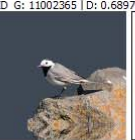
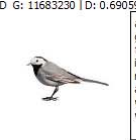





















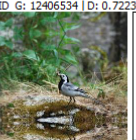


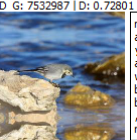




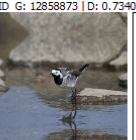

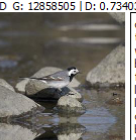






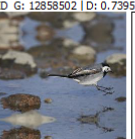
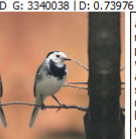

- We define pseudo classes from tag information



# Sudo-Classes

Demo\_BoT\_Clustering

C-ID 1 Page # 1 Display 580 imgs (13 pgs) | wagtail (0.3571), motacilla (0.2300), white wagtail (0.1327), bird (0.1136), alba (0.1054), wildlife (0.0885), yellow wagtail (0.0865), plumage (0.0795), ornithology (0.0765), flava (0.0733)

















































<p>ID G: 560726   D: 0.67004   # Tags: 26</p>  <p>beautiful, ornithology, alba, plumage, birdwatching, migratory, environment, tail, black, animal,</p>	<p>ID G: 560699   D: 0.67004   # Tags: 26</p>  <p>beautiful, ornithology, alba, plumage, birdwatching, migratory, environment, tail, black, animal,</p>	<p>ID G: 3682519   D: 0.67840   # Tags: 11</p>  <p>nature, alba, wagtail, birds, animals, motacilla, animal, wild, white, bird, white wagtail</p>	<p>ID G: 12178134   D: 0.68216   # Tags: 11</p>  <p>blue, nature, alba, sky, motacilla, bird, wagtail, animal, white, fauna, white wagtail</p>	<p>ID G: 3949922   D: 0.68529   # Tags: 10</p>  <p>animals, nature, alba, motacilla, bird, wagtail, animal, white, birds, white wagtail</p>	<p>ID G: 11002365   D: 0.68976   # Tags: 13</p>  <p>alba, wildlife, wagtail, feather, singer, grey, motacilla, tail, animal, wild, white, bird, white wagtail</p>	<p>ID G: 11683230   D: 0.69059   # Tags: 14</p>  <p>alba, wildlife, grey, wagtail, sea, feather, singer, grey, motacilla, tail, animal, wild, white, bird, white wagtail</p>	<p>ID G: 11167454   D: 0.69694   # Tags: 16</p>  <p>alba, wildlife, wagtail, sea, feather, singer, grey, motacilla, tail, animal, rock, wild, white, bird, white wagtail</p>
<p>ID G: 4043607   D: 0.70427   # Tags: 12</p>  <p>plumage, wagtail, beak, bird, wildlife, bill, motacilla, flava, rock, wild, feather, wing</p>	<p>ID G: 4039577   D: 0.70427   # Tags: 12</p>  <p>plumage, wagtail, beak, bird, wildlife, bill, motacilla, flava, rock, wild, feather, wing</p>	<p>ID G: 4044755   D: 0.70427   # Tags: 12</p>  <p>plumage, wagtail, beak, bird, wildlife, bill, motacilla, flava, rock, wild, feather, wing</p>	<p>ID G: 4053078   D: 0.70427   # Tags: 12</p>  <p>plumage, wagtail, beak, bird, wildlife, bill, motacilla, flava, rock, wild, feather, wing</p>	<p>ID G: 4050686   D: 0.70427   # Tags: 12</p>  <p>plumage, wagtail, beak, bird, wildlife, bill, motacilla, flava, rock, wild, feather, wing</p>	<p>ID G: 1044959   D: 0.7078   # Tags: 50</p>  <p>cute, migratory, yellow, bath, environment, tail, black, feather, brown, life, colorful,</p>	<p>ID G: 8793678   D: 0.70949   # Tags: 17</p>  <p>ornithology, alba, spring, plumage, birds, birdwatching, autumn, wildlife, migratory,</p>	<p>ID G: 8873764   D: 0.70993   # Tags: 14</p>  <p>nature, alba, wildlife, one, water, wagtail, stone, sitting, motacilla, black, small, white, river, bird</p>
<p>ID G: 7605670   D: 0.70993   # Tags: 14</p>  <p>nature, alba, wildlife, one, water, wagtail, stone, sitting, motacilla, black, small, white, river, bird</p>	<p>ID G: 10834976   D: 0.71067   # Tags: 19</p>  <p>nature, alba, birch, wagtail, beak, monochrome, fauna, grey, wildlife, tree, motacilla,</p>	<p>ID G: 9204648   D: 0.71146   # Tags: 21</p>  <p>cute, ornithology, alba, resting, water, wagtail, closeup, background, dry,</p>	<p>ID G: 11167268   D: 0.71572   # Tags: 14</p>  <p>alba, wildlife, wagtail, feather, singer, grey, motacilla, field, tail, green, animal, wild, white, bird</p>	<p>ID G: 3770496   D: 0.71676   # Tags: 12</p>  <p>trunk, plumage, wagtail, beak, wildlife, bill, motacilla, flava, wild, feather, wing, bird</p>	<p>ID G: 13114065   D: 0.71725   # Tags: 10</p>  <p>gray, nature, alba, motacilla, straw, wagtail, black, white, bird, fauna</p>	<p>ID G: 13077467   D: 0.71725   # Tags: 10</p>  <p>gray, nature, alba, motacilla, straw, wagtail, black, white, bird, fauna</p>	<p>ID G: 3217512   D: 0.71911   # Tags: 23</p>  <p>ornithology, alba, plumage, birds, destination, tail, black, animal, white, feather, bird,</p>
<p>ID G: 3219382   D: 0.71911   # Tags: 23</p>  <p>ornithology, alba, plumage, birds, destination, tail, black, animal, white, feather, bird,</p>	<p>ID G: 3632395   D: 0.72090   # Tags: 12</p>  <p>plumage, wagtail, reed, beak, wildlife, bill, motacilla, flava, wild, feather, wing, bird</p>	<p>ID G: 4104572   D: 0.72160   # Tags: 13</p>  <p>plumage, wagtail, beak, bird, wildlife, bill, motacilla, flava, rock, wild, feather, wing, wagtail motacilla</p>	<p>ID G: 12406604   D: 0.72230   # Tags: 36</p>  <p>cute, eye, tail, fast, live, black, white, brown, life, wagtail, closeup, beak, feather,</p>	<p>ID G: 12406534   D: 0.72230   # Tags: 36</p>  <p>cute, eye, tail, fast, live, black, white, brown, life, wagtail, closeup, beak, feather,</p>	<p>ID G: 9734326   D: 0.72572   # Tags: 21</p>  <p>cute, eye, bathing, ornithology, alba, resting, water, wagtail, closeup, background,</p>	<p>ID G: 3416728   D: 0.72769   # Tags: 15</p>  <p>beauty, isolated, wagtail, one, feather, standing, gray, animals, grey, motacilla, tail, wild, white, wing, bird</p>	<p>ID G: 7532987   D: 0.72801   # Tags: 16</p>  <p>migratory, alba, spring, yellow, autumn, wagtail, birds, birdwatching, wildlife, nature,</p>
<p>ID G: 3982529   D: 0.73022   # Tags: 13</p>  <p>juvenile, nature, alba, young, wagtail, birds, animals, grey, motacilla, animal, wild, white, bird</p>	<p>ID G: 4570511   D: 0.73164   # Tags: 25</p>  <p>cute, non-urban, wilderness, alba, scene, one, plumage, small, tiny, songbird, animal,</p>	<p>ID G: 3729526   D: 0.73256   # Tags: 18</p>  <p>ornithology, alba, plumage, passerine, wagtail, closeup, birdwatching, gray,</p>	<p>ID G: 12859130   D: 0.73403   # Tags: 43</p>  <p>cute, eye, tail, fast, wings, live, black, feather, legs, brown, life, wagtail, closeup, beak, white,</p>	<p>ID G: 12858873   D: 0.73403   # Tags: 43</p>  <p>cute, eye, tail, fast, wings, live, black, feather, legs, brown, life, wagtail, closeup, beak, white,</p>	<p>ID G: 12858590   D: 0.73403   # Tags: 43</p>  <p>cute, eye, tail, fast, live, black, feather, legs, brown, life, wagtail, closeup, beak, wings,</p>	<p>ID G: 12858505   D: 0.73403   # Tags: 43</p>  <p>cute, eye, tail, fast, wings, live, black, feather, legs, brown, life, wagtail, closeup, beak, white,</p>	<p>ID G: 12858620   D: 0.73403   # Tags: 43</p>  <p>cute, eye, tail, fast, wings, live, black, feather, legs, brown, life, wagtail, closeup, beak, white,</p>
<p>ID G: 3861274   D: 0.73672   # Tags: 12</p>  <p>meadow, nature, alba, passerine, wagtail, motacilla, animal, grassland, white, grass, bird, white</p>	<p>ID G: 9433234   D: 0.73782   # Tags: 22</p>  <p>cute, ornithology, alba, resting, plumage, wagtail, closeup, background, migratory,</p>	<p>ID G: 9433240   D: 0.73826   # Tags: 25</p>  <p>beautiful, cute, ornithology, alba, plumage, winter, migratory, isolated, animal,</p>	<p>ID G: 5746522   D: 0.73902   # Tags: 45</p>  <p>cute, migratory, beak, standing, eye, environment, tail, black, feather, brown, life,</p>	<p>ID G: 5738853   D: 0.73902   # Tags: 45</p>  <p>cute, migratory, beak, standing, eye, environment, tail, black, feather, brown, life,</p>	<p>ID G: 12858502   D: 0.73951   # Tags: 44</p>  <p>cute, eye, white, tail, fast, live, black, feather, legs, brown, life, wagtail, closeup, beak, wings,</p>	<p>ID G: 3340038   D: 0.73976   # Tags: 14</p>  <p>animal, nature, alba, passerine, wagtail, adult, standing, motacilla, branch, grassland,</p>	<p>ID G: 6522656   D: 0.73983   # Tags: 9</p>  <p>wildlife, nature, yellow, motacilla, flava, wagtail, wild, bird, yellow wagtail</p>



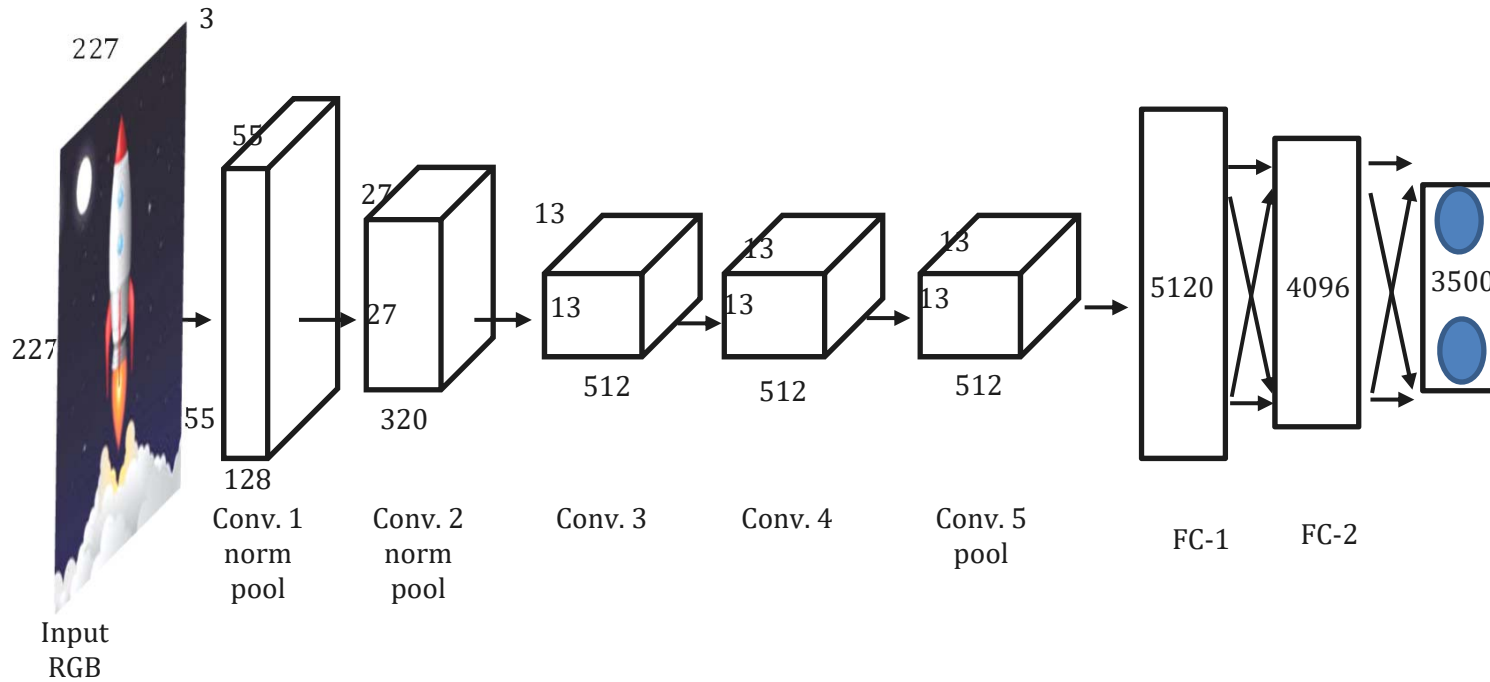
# Sudo-Classes

Demo\_BoT\_Clustering

C-ID 0 Page # 1 Display < > 30913 imgs (645 pgs) | tractor (0.2210), agriculture (0.1131), machinery (0.1061), agricultural (0.1057), farm (0.1034), farming (0.0984), machine (0.0864), farmer (0.0837), plow (0.0822), field (0.0751)

<p>ID G: 10589572   D: 0.72115   # Tags: 19</p>  <ul style="list-style-type: none"> <li>summer</li> <li>nature</li> <li>farm</li> <li>outdoors</li> <li>agricultural</li> <li>harvest</li> <li>landscape</li> <li>red</li> <li>environment</li> </ul>	<p>ID G: 10589621   D: 0.72528   # Tags: 24</p>  <ul style="list-style-type: none"> <li>summer</li> <li>agricultural</li> <li>landscape</li> <li>machine</li> <li>working</li> <li>equipment</li> <li>dir</li> <li>environment</li> </ul>	<p>ID G: 6320719   D: 0.72667   # Tags: 17</p>  <ul style="list-style-type: none"> <li>industrial</li> <li>farm</li> <li>new</li> <li>agricultural</li> <li>agriculture</li> <li>blue</li> <li>farming</li> <li>equipment</li> <li>industry</li> <li>sky</li> </ul>	<p>ID G: 9891935   D: 0.74058   # Tags: 38</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>agricultural</li> <li>landscape</li> <li>equipment</li> <li>sky</li> <li>environment</li> <li>farmer</li> </ul>	<p>ID G: 9892689   D: 0.74058   # Tags: 38</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>one</li> <li>agricultural</li> <li>landscape</li> <li>equipment</li> <li>sky</li> <li>environment</li> <li>farmer</li> </ul>	<p>ID G: 9967210   D: 0.74058   # Tags: 38</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>one</li> <li>agricultural</li> <li>landscape</li> <li>equipment</li> <li>environment</li> <li>farmer</li> </ul>	<p>ID G: 8721164   D: 0.74190   # Tags: 50</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>scene</li> <li>yellow</li> <li>earth</li> <li>landscape</li> <li>plow</li> <li>working</li> </ul>	<p>ID G: 8768780   D: 0.74225   # Tags: 45</p>  <ul style="list-style-type: none"> <li>industrial</li> <li>scene</li> <li>outdoor</li> <li>cultivated</li> <li>earth</li> <li>landscape</li> <li>ground</li> <li>equipment</li> <li>plow</li> </ul>
<p>ID G: 8797160   D: 0.74225   # Tags: 45</p>  <ul style="list-style-type: none"> <li>industrial</li> <li>scene</li> <li>outdoor</li> <li>cultivated</li> <li>earth</li> <li>landscape</li> <li>ground</li> <li>equipment</li> <li>plow</li> </ul>	<p>ID G: 8594074   D: 0.74973   # Tags: 45</p>  <ul style="list-style-type: none"> <li>industrial</li> <li>scene</li> <li>outdoor</li> <li>cultivated</li> <li>earth</li> <li>landscape</li> <li>ground</li> <li>equipment</li> <li>plow</li> </ul>	<p>ID G: 6627787   D: 0.75009   # Tags: 35</p>  <ul style="list-style-type: none"> <li>outdoor</li> <li>scene</li> <li>industrial</li> <li>agricultural</li> <li>landscape</li> <li>equipment</li> <li>environment</li> <li>spring</li> </ul>	<p>ID G: 4076209   D: 0.75067   # Tags: 47</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>scene</li> <li>outdoor</li> <li>earth</li> <li>cloud</li> <li>equipment</li> <li>plow</li> <li>cut</li> <li>field</li> <li>sky</li> <li>cultivation</li> </ul>	<p>ID G: 5985282   D: 0.75072   # Tags: 19</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>transportation</li> <li>country</li> <li>side</li> <li>farming</li> <li>plow</li> <li>vehicle</li> <li>agricultural</li> <li>agriculture</li> </ul>	<p>ID G: 7782484   D: 0.75106   # Tags: 37</p>  <ul style="list-style-type: none"> <li>one</li> <li>cultivated</li> <li>agricultural</li> <li>landscape</li> <li>plow</li> <li>working</li> <li>equipment</li> <li>sky</li> <li>cultivation</li> </ul>	<p>ID G: 7540410   D: 0.75126   # Tags: 46</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>country</li> <li>side</li> <li>yellow</li> <li>outdoor</li> <li>earth</li> <li>landscape</li> <li>plow</li> <li>sky</li> <li>cultivation</li> </ul>	<p>ID G: 7670799   D: 0.75126   # Tags: 46</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>country</li> <li>side</li> <li>yellow</li> <li>outdoor</li> <li>earth</li> <li>landscape</li> <li>plow</li> <li>sky</li> <li>cultivation</li> </ul>
<p>ID G: 7516340   D: 0.75126   # Tags: 46</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>country</li> <li>side</li> <li>yellow</li> <li>outdoor</li> <li>earth</li> <li>landscape</li> <li>plow</li> <li>sky</li> <li>cultivation</li> </ul>	<p>ID G: 7540405   D: 0.75126   # Tags: 46</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>country</li> <li>side</li> <li>yellow</li> <li>outdoor</li> <li>earth</li> <li>landscape</li> <li>plow</li> <li>sky</li> <li>cultivation</li> </ul>	<p>ID G: 7992849   D: 0.75126   # Tags: 46</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>country</li> <li>side</li> <li>yellow</li> <li>outdoor</li> <li>earth</li> <li>landscape</li> <li>plow</li> <li>sky</li> <li>cultivation</li> </ul>	<p>ID G: 10533151   D: 0.75441   # Tags: 26</p>  <ul style="list-style-type: none"> <li>summer</li> <li>scene</li> <li>crop</li> <li>agricultural</li> <li>agronomy</li> <li>agriculture</li> <li>landscape</li> <li>blue</li> <li>equipment</li> <li>driving</li> <li>field</li> </ul>	<p>ID G: 7763170   D: 0.75826   # Tags: 48</p>  <ul style="list-style-type: none"> <li>outdoor</li> <li>country</li> <li>side</li> <li>scene</li> <li>agricultural</li> <li>landscape</li> <li>plow</li> <li>ground</li> <li>working</li> <li>equipment</li> <li>sky</li> <li>spring</li> </ul>	<p>ID G: 6170066   D: 0.75827   # Tags: 53</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>country</li> <li>side</li> <li>scene</li> <li>outdoor</li> <li>earth</li> <li>landscape</li> <li>plow</li> <li>working</li> </ul>	<p>ID G: 6404629   D: 0.76301   # Tags: 39</p>  <ul style="list-style-type: none"> <li>summer</li> <li>country</li> <li>side</li> <li>gold</li> <li>scene</li> <li>earth</li> <li>landscape</li> <li>equipment</li> <li>sky</li> <li>farmer</li> <li>farming</li> <li>food</li> </ul>	<p>ID G: 3050566   D: 0.76301   # Tags: 39</p>  <ul style="list-style-type: none"> <li>summer</li> <li>country</li> <li>side</li> <li>gold</li> <li>scene</li> <li>earth</li> <li>landscape</li> <li>equipment</li> <li>sky</li> <li>farmer</li> <li>farming</li> <li>food</li> </ul>
<p>ID G: 7312123   D: 0.76434   # Tags: 53</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>bright</li> <li>outdoor</li> <li>earth</li> <li>cloud</li> <li>equipment</li> <li>plow</li> <li>field</li> <li>sky</li> <li>texture</li> <li>environment</li> </ul>	<p>ID G: 7491385   D: 0.76434   # Tags: 53</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>bright</li> <li>outdoor</li> <li>earth</li> <li>cloud</li> <li>equipment</li> <li>plow</li> <li>field</li> <li>sky</li> <li>texture</li> <li>environment</li> </ul>	<p>ID G: 7492521   D: 0.76434   # Tags: 53</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>bright</li> <li>outdoor</li> <li>earth</li> <li>cloud</li> <li>equipment</li> <li>plow</li> <li>field</li> <li>sky</li> <li>texture</li> <li>environment</li> </ul>	<p>ID G: 1344731   D: 0.76445   # Tags: 22</p>  <ul style="list-style-type: none"> <li>ploughing</li> <li>plough</li> <li>agricultural</li> <li>agriculture</li> <li>equipment</li> <li>cloud</li> <li>working</li> <li>machine</li> </ul>	<p>ID G: 4297710   D: 0.76495   # Tags: 44</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>straw</li> <li>yellow</li> <li>agricultural</li> <li>equipment</li> <li>working</li> <li>field</li> <li>sky</li> </ul>	<p>ID G: 5587576   D: 0.76709   # Tags: 43</p>  <ul style="list-style-type: none"> <li>industrial</li> <li>cultivated</li> <li>agricultural</li> <li>landscape</li> <li>ground</li> <li>equipment</li> <li>plow</li> <li>working</li> <li>field</li> <li>spring</li> </ul>	<p>ID G: 9881237   D: 0.76831   # Tags: 29</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>autumn</li> <li>weather</li> <li>agricultural</li> <li>agriculture</li> <li>landscape</li> <li>environment</li> <li>field</li> </ul>	<p>ID G: 9881232   D: 0.76831   # Tags: 29</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>autumn</li> <li>weather</li> <li>agricultural</li> <li>agriculture</li> <li>landscape</li> <li>environment</li> <li>field</li> </ul>
<p>ID G: 9881227   D: 0.76831   # Tags: 29</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>autumn</li> <li>weather</li> <li>agricultural</li> <li>agriculture</li> <li>landscape</li> <li>environment</li> <li>field</li> </ul>	<p>ID G: 4074549   D: 0.76983   # Tags: 47</p>  <ul style="list-style-type: none"> <li>summer</li> <li>country</li> <li>side</li> <li>yellow</li> <li>bright</li> <li>earth</li> <li>landscape</li> <li>plow</li> <li>working</li> <li>equipment</li> </ul>	<p>ID G: 8807536   D: 0.77120   # Tags: 50</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>gold</li> <li>scene</li> <li>yellow</li> <li>bright</li> <li>earth</li> <li>landscape</li> <li>equipment</li> <li>plow</li> <li>field</li> </ul>	<p>ID G: 8808705   D: 0.77120   # Tags: 50</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>gold</li> <li>scene</li> <li>yellow</li> <li>bright</li> <li>earth</li> <li>landscape</li> <li>equipment</li> <li>plow</li> <li>field</li> </ul>	<p>ID G: 9881269   D: 0.77221   # Tags: 30</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>autumn</li> <li>weather</li> <li>agricultural</li> <li>agriculture</li> <li>landscape</li> <li>environment</li> <li>field</li> <li>sun</li> </ul>	<p>ID G: 6481988   D: 0.77264   # Tags: 25</p>  <ul style="list-style-type: none"> <li>seasonal</li> <li>soil</li> <li>crop</li> <li>plough</li> <li>agricultural</li> <li>cultivate</li> <li>agriculture</li> <li>landscape</li> <li>equipment</li> <li>plow</li> </ul>	<p>ID G: 1481649   D: 0.77284   # Tags: 41</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>one</li> <li>outdoor</li> <li>agricultural</li> <li>landscape</li> <li>equipment</li> <li>field</li> <li>sky</li> <li>environment</li> </ul>	<p>ID G: 1788085   D: 0.77284   # Tags: 41</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>one</li> <li>outdoor</li> <li>agricultural</li> <li>landscape</li> <li>equipment</li> <li>field</li> <li>sky</li> <li>environment</li> </ul>
<p>ID G: 9829293   D: 0.77450   # Tags: 34</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>earth</li> <li>landscape</li> <li>equipment</li> <li>field</li> <li>sky</li> <li>farmer</li> <li>farming</li> <li>engine</li> </ul>	<p>ID G: 9279678   D: 0.77450   # Tags: 34</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>earth</li> <li>landscape</li> <li>equipment</li> <li>field</li> <li>sky</li> <li>farmer</li> <li>farming</li> <li>engine</li> </ul>	<p>ID G: 7708839   D: 0.77476   # Tags: 45</p>  <ul style="list-style-type: none"> <li>summer</li> <li>outdoor</li> <li>earth</li> <li>landscape</li> <li>equipment</li> <li>field</li> <li>sky</li> <li>cultivation</li> <li>farmer</li> <li>farming</li> </ul>	<p>ID G: 9427154   D: 0.77509   # Tags: 44</p>  <ul style="list-style-type: none"> <li>summer</li> <li>scene</li> <li>earth</li> <li>landscape</li> <li>ground</li> <li>working</li> <li>equipment</li> <li>environment</li> <li>farmer</li> <li>farming</li> </ul>	<p>ID G: 8789887   D: 0.77609   # Tags: 44</p>  <ul style="list-style-type: none"> <li>summer</li> <li>scene</li> <li>windy</li> <li>earth</li> <li>landscape</li> <li>occupation</li> <li>plow</li> <li>working</li> <li>equipment</li> </ul>	<p>ID G: 2475127   D: 0.77777   # Tags: 34</p>  <ul style="list-style-type: none"> <li>engine</li> <li>industrial</li> <li>agricultural</li> <li>equipment</li> <li>vehicle</li> <li>farming</li> <li>engine</li> <li>farmer</li> </ul>	<p>ID G: 10670719   D: 0.77849   # Tags: 27</p>  <ul style="list-style-type: none"> <li>summer</li> <li>industrial</li> <li>agricultural</li> <li>agriculture</li> <li>transport</li> <li>outdoor</li> <li>sow</li> <li>earth</li> <li>landscape</li> <li>occupation</li> <li>plow</li> <li>busy</li> <li>working</li> </ul>	<p>ID G: 1804423   D: 0.77913   # Tags: 51</p>  <ul style="list-style-type: none"> <li>industrial</li> <li>country</li> <li>side</li> <li>scene</li> <li>outdoor</li> <li>earth</li> <li>landscape</li> <li>occupation</li> <li>plow</li> <li>busy</li> <li>working</li> </ul>

# Deep Feature Learning



	100 Tags	
	<u>P@100</u>	<u>R@100</u>
ImageNet Feat (1000)	0.196	0.552
Deep Tagging Feat (1000)	0.204	0.573
Deep Tagging Feat (3500)	<b>0.220</b>	<b>0.616</b>



# Automatic Image Tagging

# 2950223



Tags (50)

cat, animal, feline, pet, cute, fur, domestic, kitten, kitty, orange, young, beautiful, white, adorable, mammal, portrait, red, eyes, furry, background.

# 70333



fluffy, ginger, sleep, gang, door, stalk, still, doorstep, cream, stare, plot, pet, furry, two, nap, cats, prey, pets,

# 4628709



cute, love, pussy, indoor, domestic, yellow, one, playful, stare, little, furry, pedigree, breed, long, pretty, white,

# 5989680



beautiful, cute, breed, sweet, shorthair, domestic, one, hair, little, pet, furry, feline, young, tall, animal, white,

# 413361



profile, pose, whiskers, poinsettias, shorthair, perched, portrait, handsome, pet, furry, cat, orange, kitten, holiday, christmas

# 873189



cute, plant, feline, cat, poinsettias, kitten, portrait, holiday, christmas, red

# 3404369



beautiful, cute, outdoor, golden, yellow, portrait, stare, pet, feline, young, outside, pretty, orange,

# 2303551



apple, color, pussy, yellow, female, breed, tail, black, white, friend, head, dark, background, kitten, tabby, cat, small,

# 14294926



cute, peace, family, color, scratch, indoor, yellow, newborn, bright, smart, catfight, eye, chinese, thinking, fight,

# 15177550



cute, fluffy, domestic, attitude, home, arrogant, pet, furry, feline, looking, cats, pets, orange, main, resting,

# 4440820



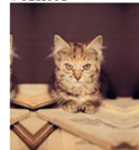
and, lazy, nature, colors, flowers, happiness, muzzle, animals, sun, cat, pets, pleasure, the, red, the sun

# 6143486



beautiful, cute, household, domestic, ginger, young, hair, portrait, paw, pet, furry, feline, isolated,

# 9215901



beautiful, cute, concept, sweet, fluffy, books, education, furry, pet, furry, feline, animal, reading,

# 16104536



cute, domestic, ginger, pussycat, pet, furry, feline, whiskas, animal, friend, eyes, kitty, predator, fur, calyeye, cat, thought, red, expression

# 10555978



cute, love, domestic, down, pedigree, tiny, tail, spitz, white, brown, head, reverie, kitty, muse, neutral, kitten,

# 12791165



companionship, feline, domestic, cat, tiger, tenderness, red, animal, puppy, mustache, red cat

# 7885366



cute, sweet, follow, pet, relax, young, animal, tom, white, red, nice, lonely, pretty, nature, alone, fur,

# 1827144



and, domestic, one, down, indoors, portrait, lying, elegance, textile, cats, animal, orange, white, red, body,

# 10834674



feathers, kitty, home, animals, pet, siberian, cat, black, boa, red

# Improving Tag Prediction

fish ?



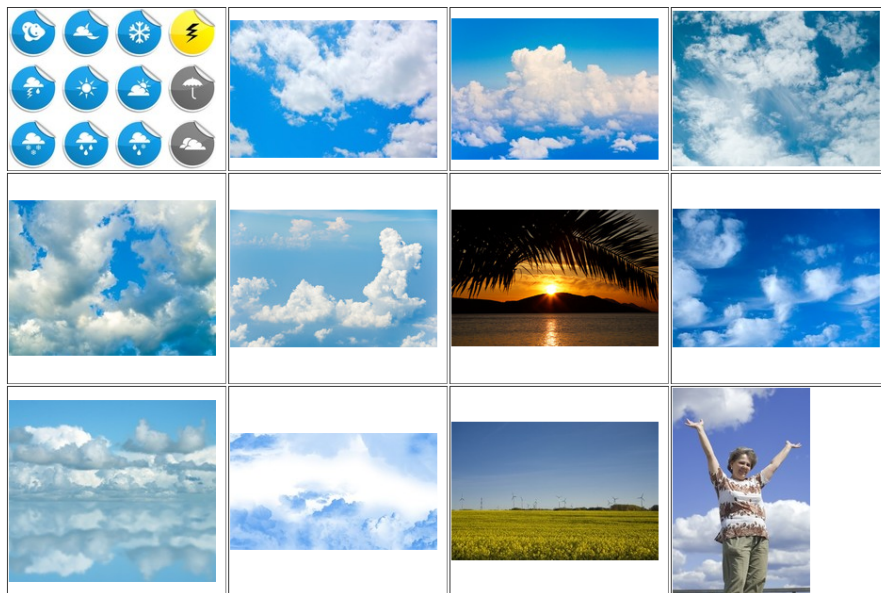
Highly Similar User Tags

- fish
- cook
- cooking
- man
- food
- kitchen
- homework
- ....

# Search Results

cloudy

KNN



Div-KNN

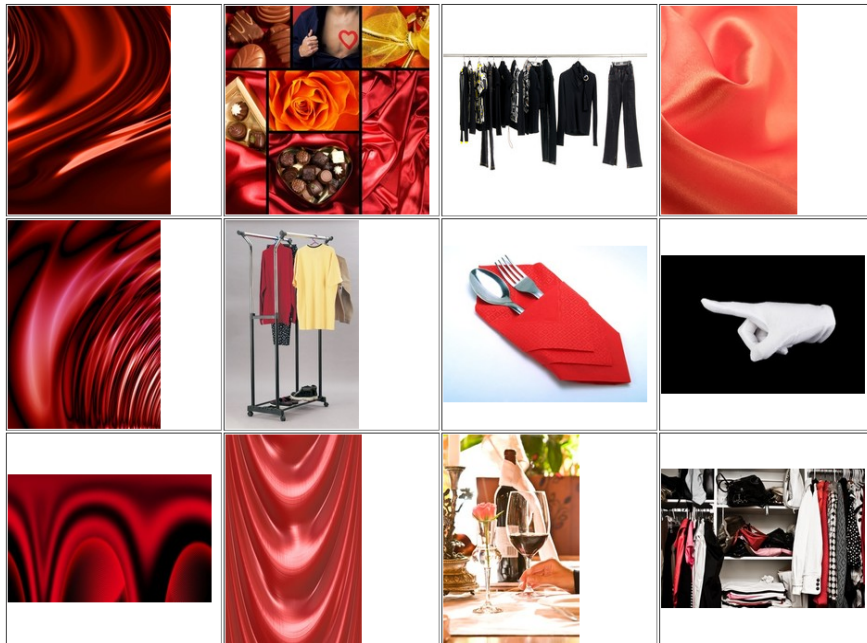




# Search Results

cloth

KNN

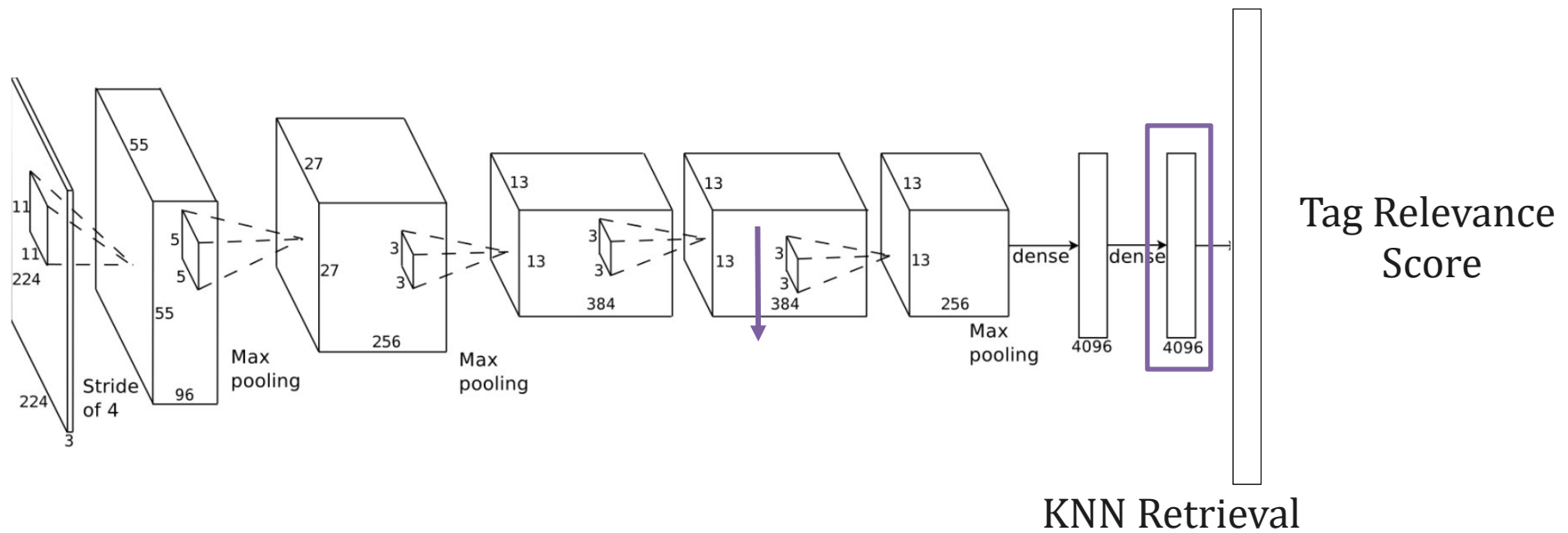


Div-KNN





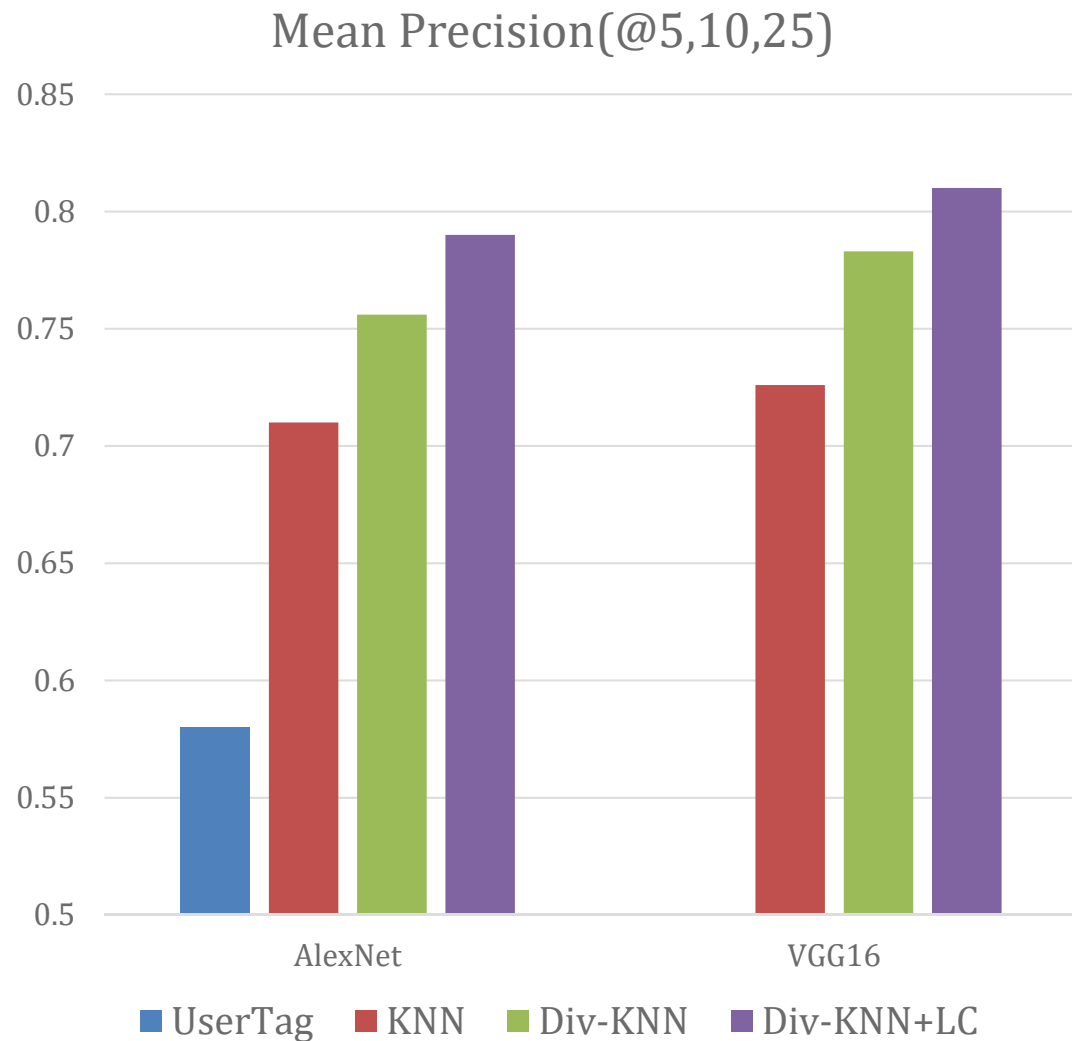
# KNN + Linear Classifier



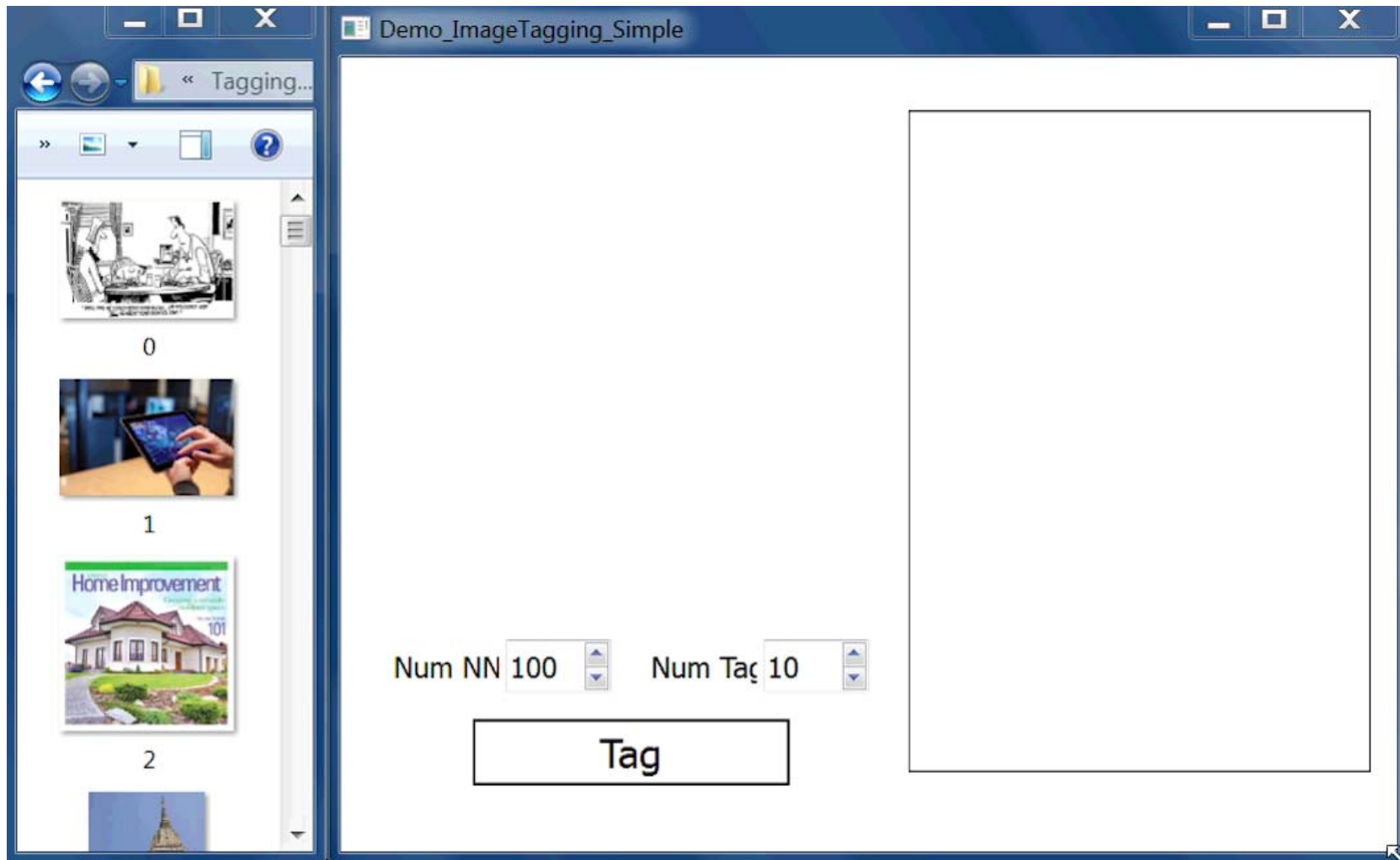
Linearly combine the scores from KNN-retrieval and Logistic classifier

# Evaluation

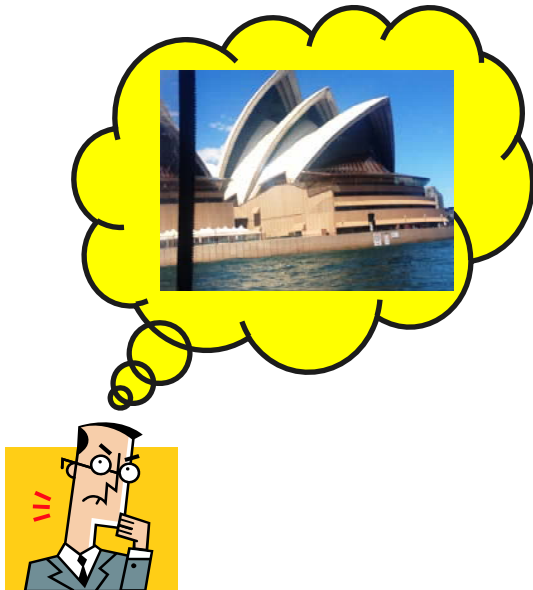
- Evaluation set
  - 82 tags: 30~50 images/tag
  - Include hard negatives
  - Top N Precision




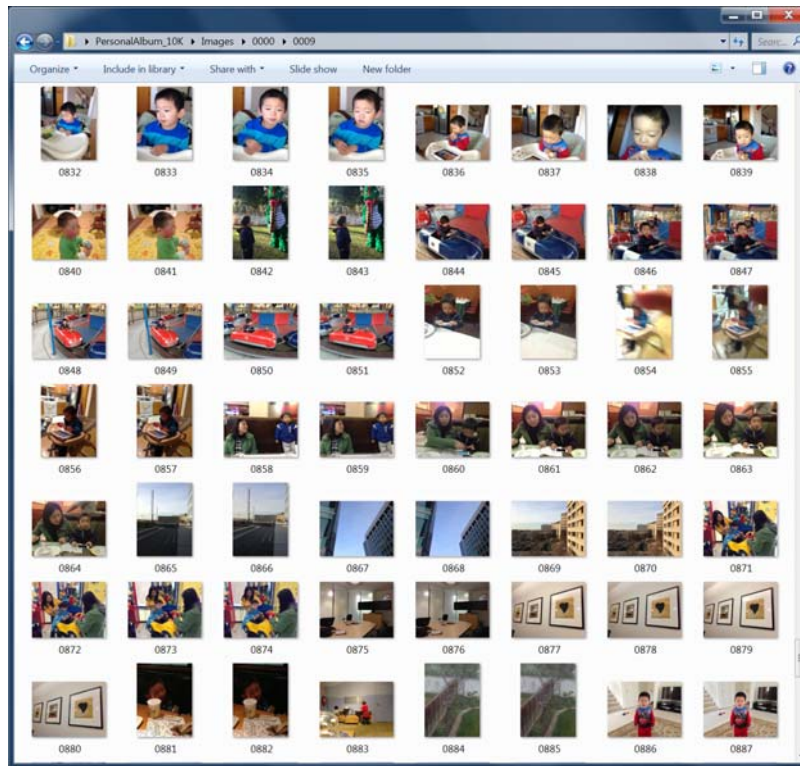
# Demo




# Free-Text Image Search



 sydney opera house



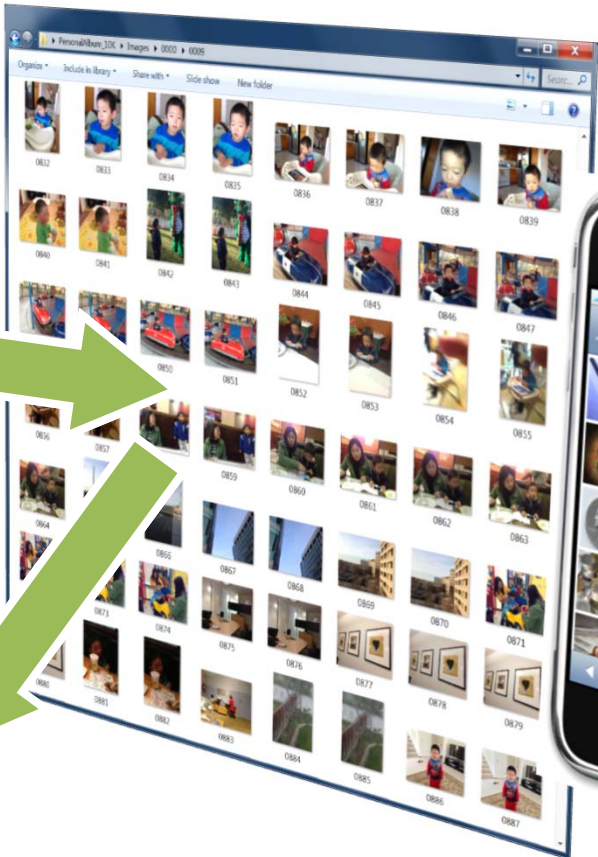
# Free-Text Image Search

 **Baseball game**

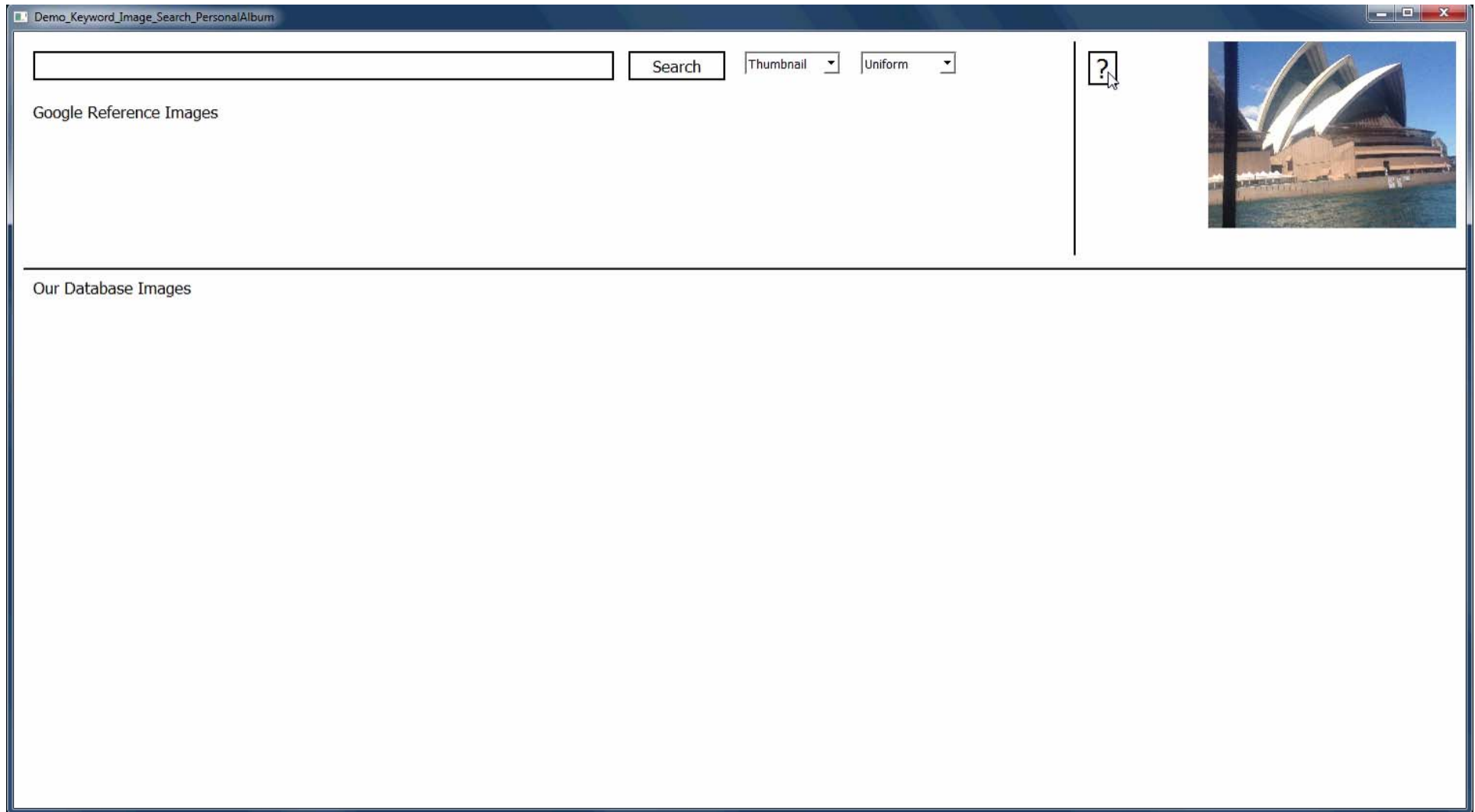
❑ Internet Image Search → Crawl Examples



❑ Multi-Query Visual Search → Retrieve Images



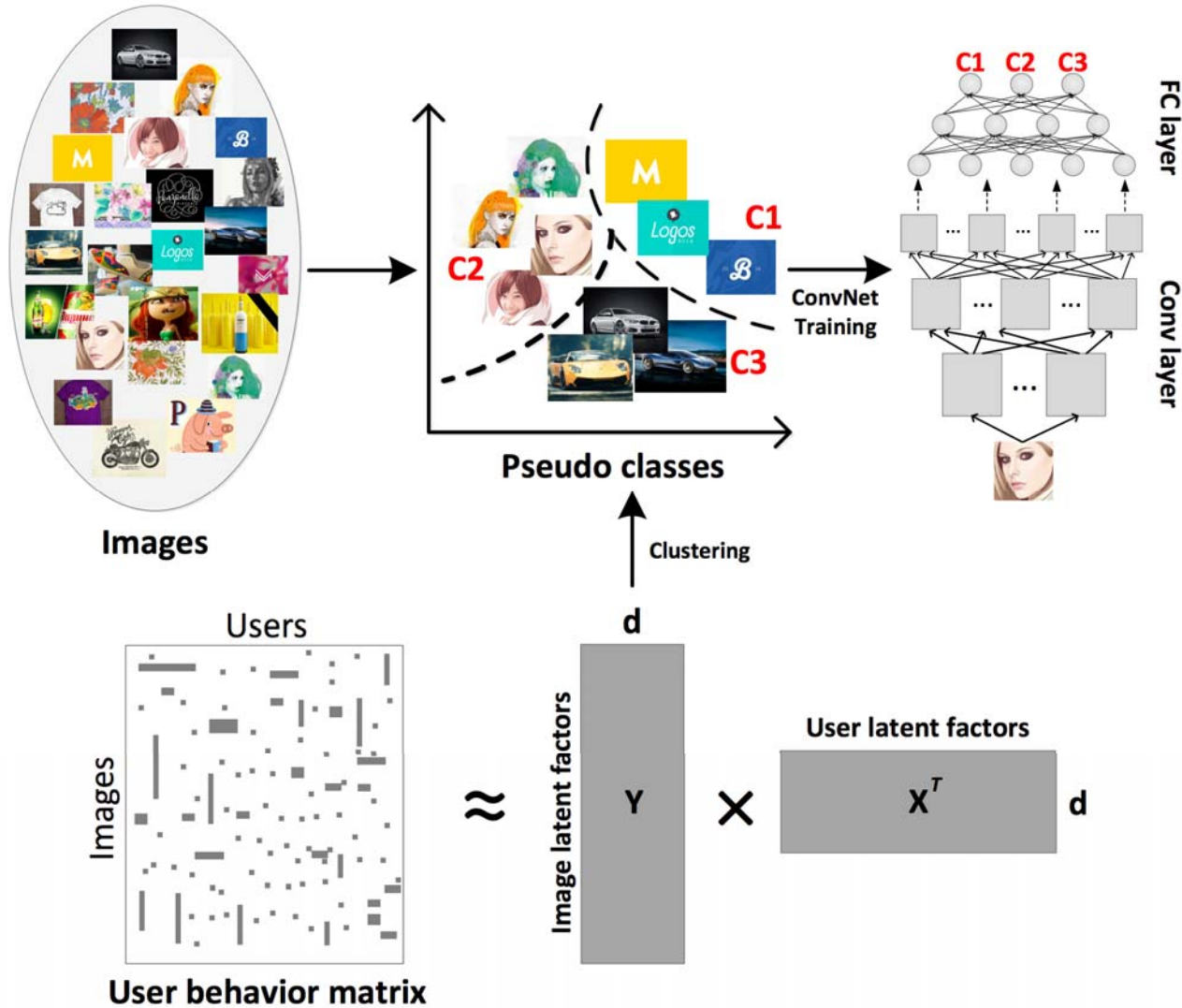
# Demo














# Image Recommendation

[C. Fang et al. CVPR 2015]



# Image Recommendation

[C. Fang et al. CVPR 2015]

	Query	Tags	Nearest neighbors in latent factor space							
1		beauty portrait woman hair								
2		wedding photography								
3		elegant graceful neat refined								
4		automotive classic								
5		automotive design industrial transportation								
6		Casa La Encantada house								
7		mascot logo gaming sport								
8		shoe footwear								
9		food pie food photography								