Hashing Techniques

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Student Presentation Guidelines

- **Good summary, not full detail, of the paper**
  - **Talk about motivations of the work**
  - **Give a broad background on the related work**
  - **Explain main idea and results of the paper**
  - **Discuss strengths and weaknesses of the method**

- **Prepare an overview slide**
  - **Talk about most important things and connect them well**

High-Level Ideas

- Deliver most important ideas and results
  - Do not talk about minor details
  - Give enough background instead
- Deeper understanding on a paper is required
  - Go over at least two related papers and explain them in a few slides
- Spend most time to figure out the most important things and prepare good slides for them

Deliver Main Ideas of the Paper

- **Identify main ideas/contributions of the paper and deliver them**

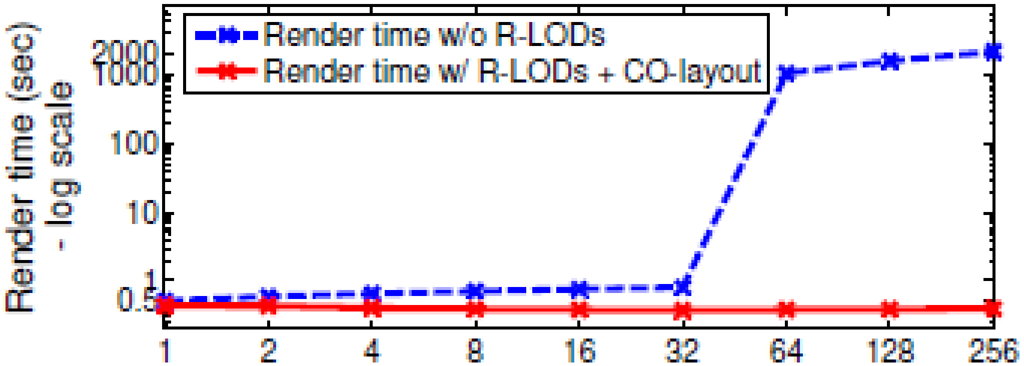
- **If there are prior techniques that you need to understand, study those prior techniques and explain them**
    - **For example, A paper utilizes B's technique in its main idea. In this case, you need to explain B to explain A well.**

Be Honest

- Do not skip important ideas that you don't know
  - Explain as much as you know and mention that you don't understand some parts
- If you get questions you don't know good answers, just say it
- In the end, you need to explain them before the semester ends at KLMS board

Result Presentation

- **Give full experiment settings and present data with the related information**
  - **What does the x-axis mean in the below image?**



- **After showing the data, give a message that we can pull of the data**
- **Show images/videos, if there are**

Utilizing Existing Resources

- **Use author's slides, codes, and video, if they exist**
- **Give proper credits or citations**
  - **Without them, you are cheating!**

Audience feedback form

Date:
Talk title:
Speaker:

1. Was the talk well organized and well prepared?
5: Excellent 4: good 3: okay 2: less than average 1: poor

2. Was the talk comprehensible? How well were important concepts covered?
5: Excellent 4: good 3: okay 2: less than average 1: poor

Any comments to the speaker

Prepare Quiz

- **Review most important concepts of your talk**
  - **Prepare two multiple-choices questions**

- **Example: What is the biased algorithm?**
  - **A: Given N samples, the expected mean of the estimator is I**
  - **B: Given N samples, the exp. Mean of the estimator is I + e**
  - **C: Given N samples, the exp. Mean of the estimator is I + e, where e goes to zero, as N goes to infinite**

- **Grade them in the scale of 0 to 10 and send it to TA**

Class Objectives

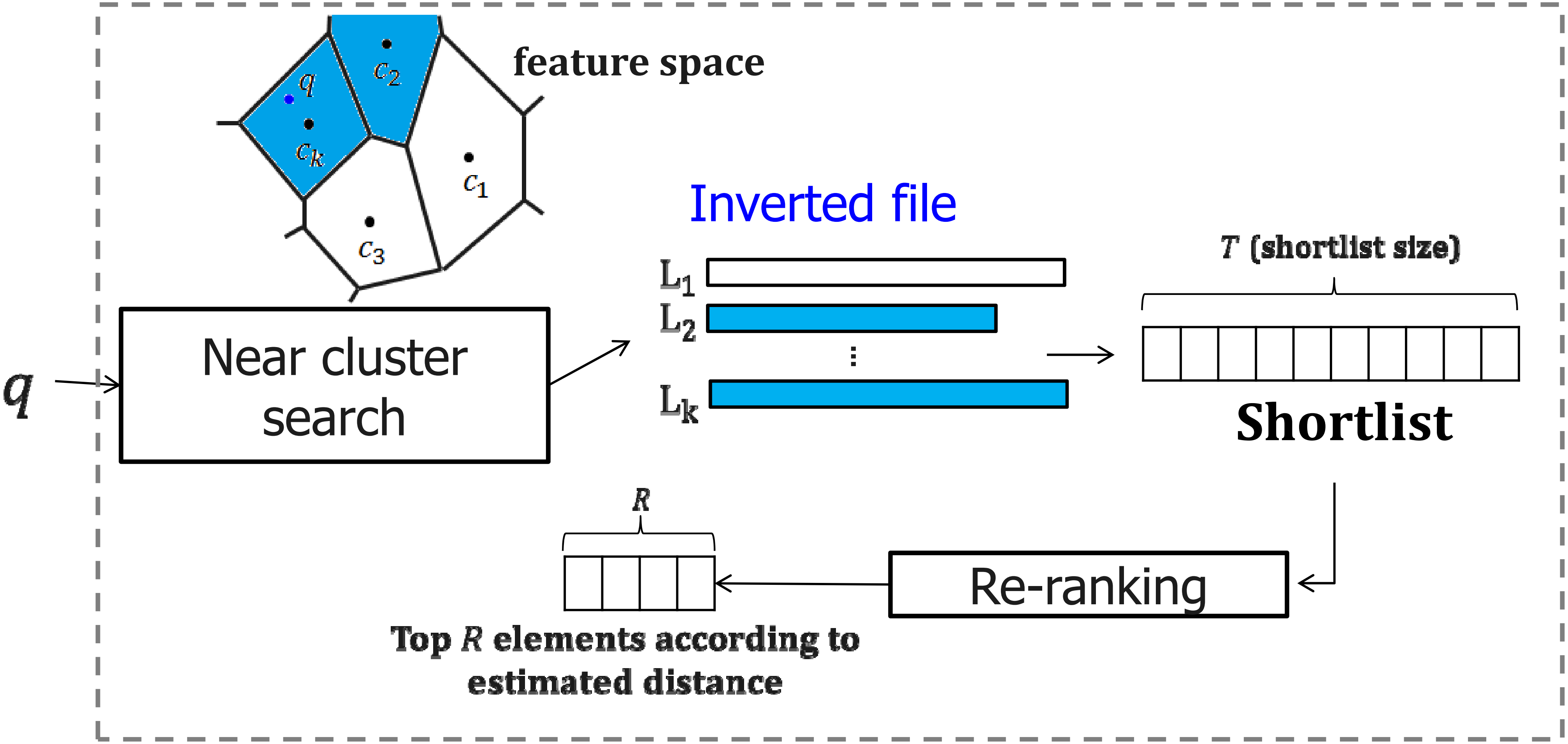
- **Understand the basic hashing techniques based on hyperplanes**
  - **Unsupervised approach**
- **Supervised approach using deep learning**

- **At the last class:**
  - **Discussed re-ranking methods: spatial verification and query expansion**
  - **Talked about inverted index**

Questions

- **When we talk about accuracy, I don't understand why we only think about the accuracy of matching victual point/patch/features. I think we should also concern about finding images with similar style, images with similar emotion, images reflecting similar activity...**

Review of Basic Image Search



Ack.: Dr. Heo

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Image Search

Finding visually similar images

Image Descriptor

High dimensional point

(BoW, GIST, Color Histogram, etc.)

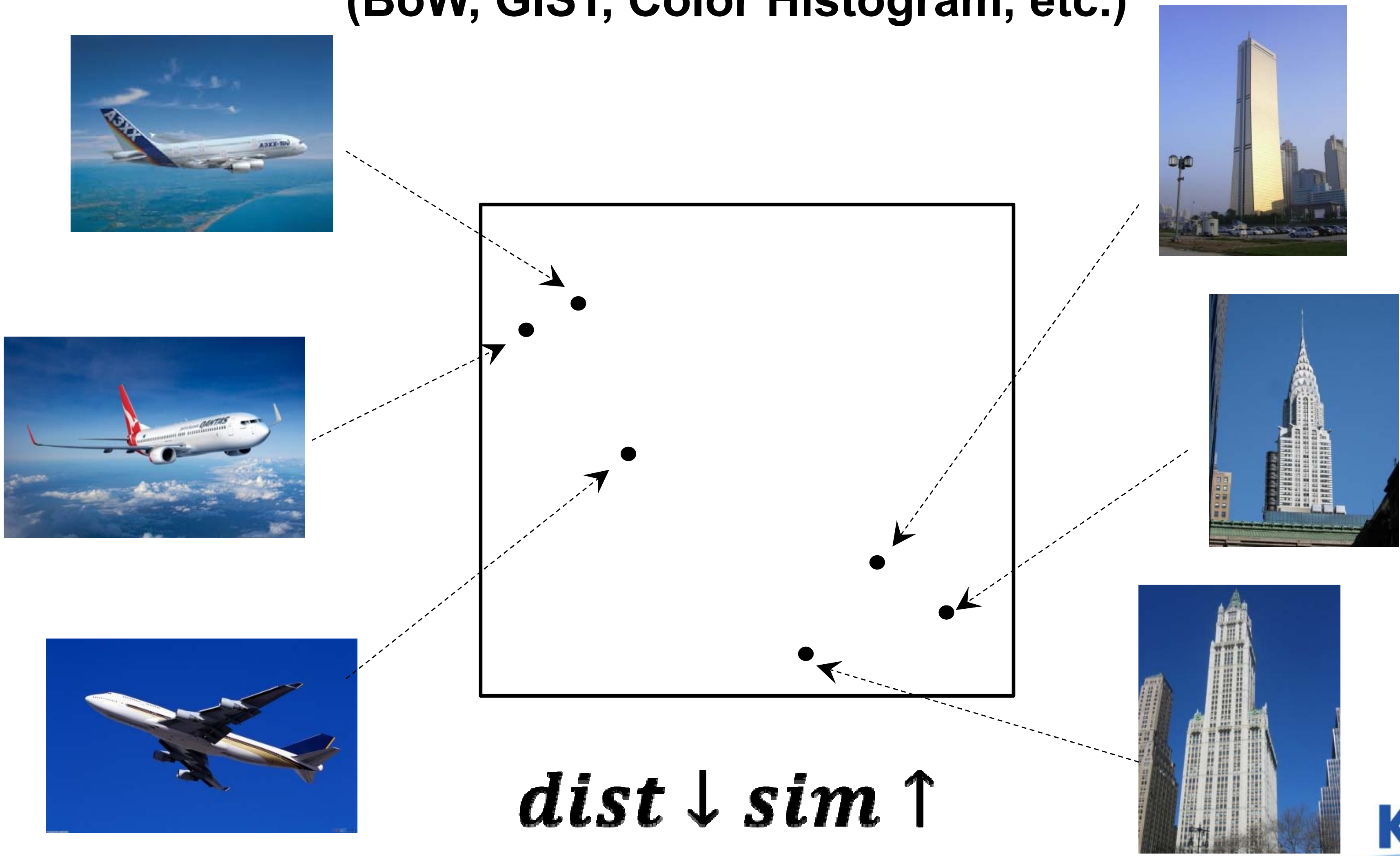
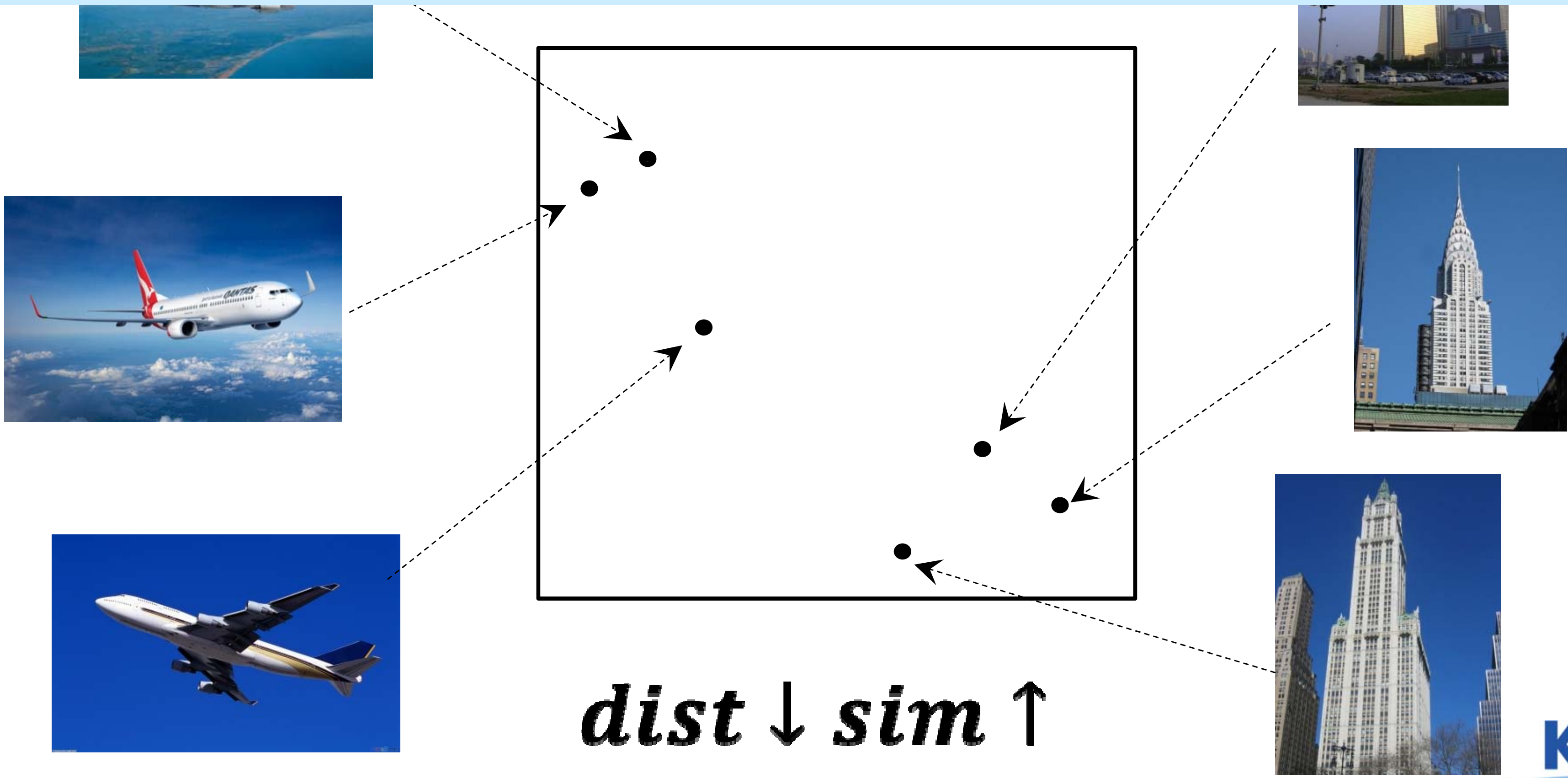


Image Descriptor

High dimensional point

Nearest neighbor search (NNS) in high dimensional space



$dist \downarrow sim \uparrow$

Challenge

	BoW	CNN
Dimensions	1000+	4000+
1 image	4 KB+	16 KB+
1B images	4 TB+	16 TB+

$$\frac{144\ GB\ memory}{1\ billion\ images} \approx \frac{128\ bits}{1\ image}$$

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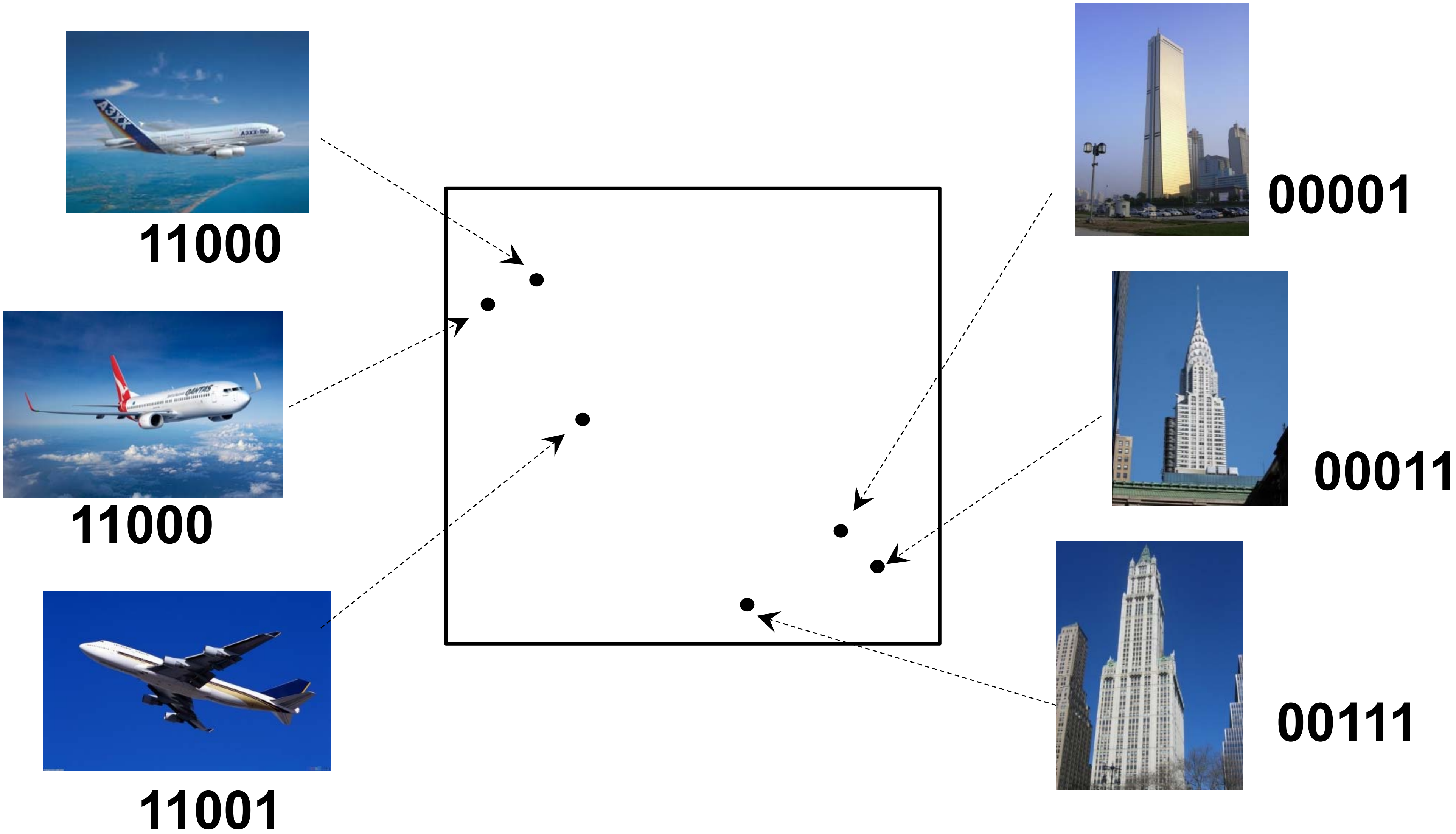
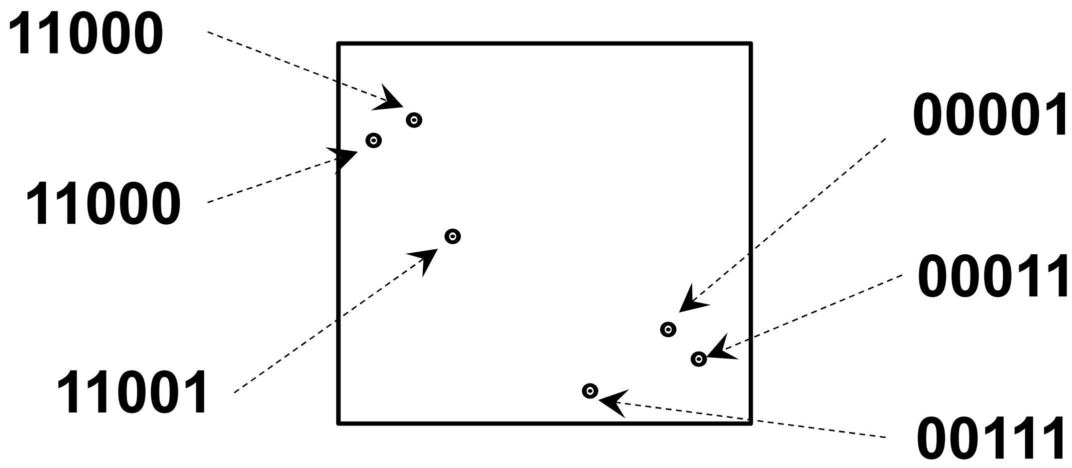
Binary Code



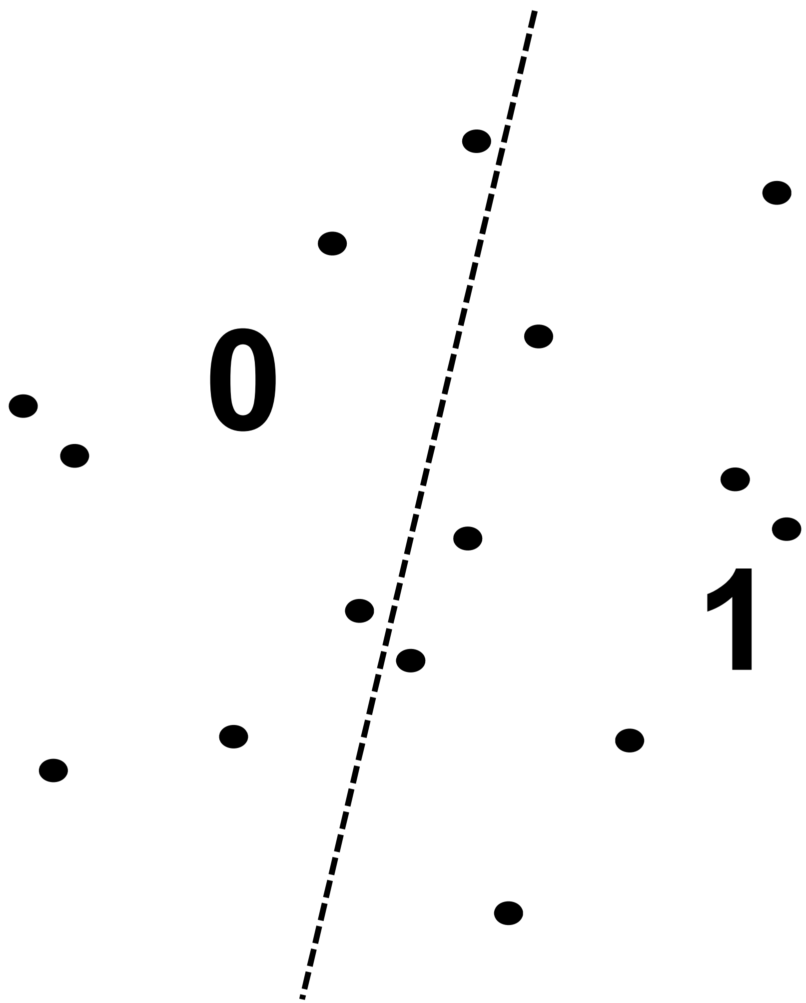
Binary Code



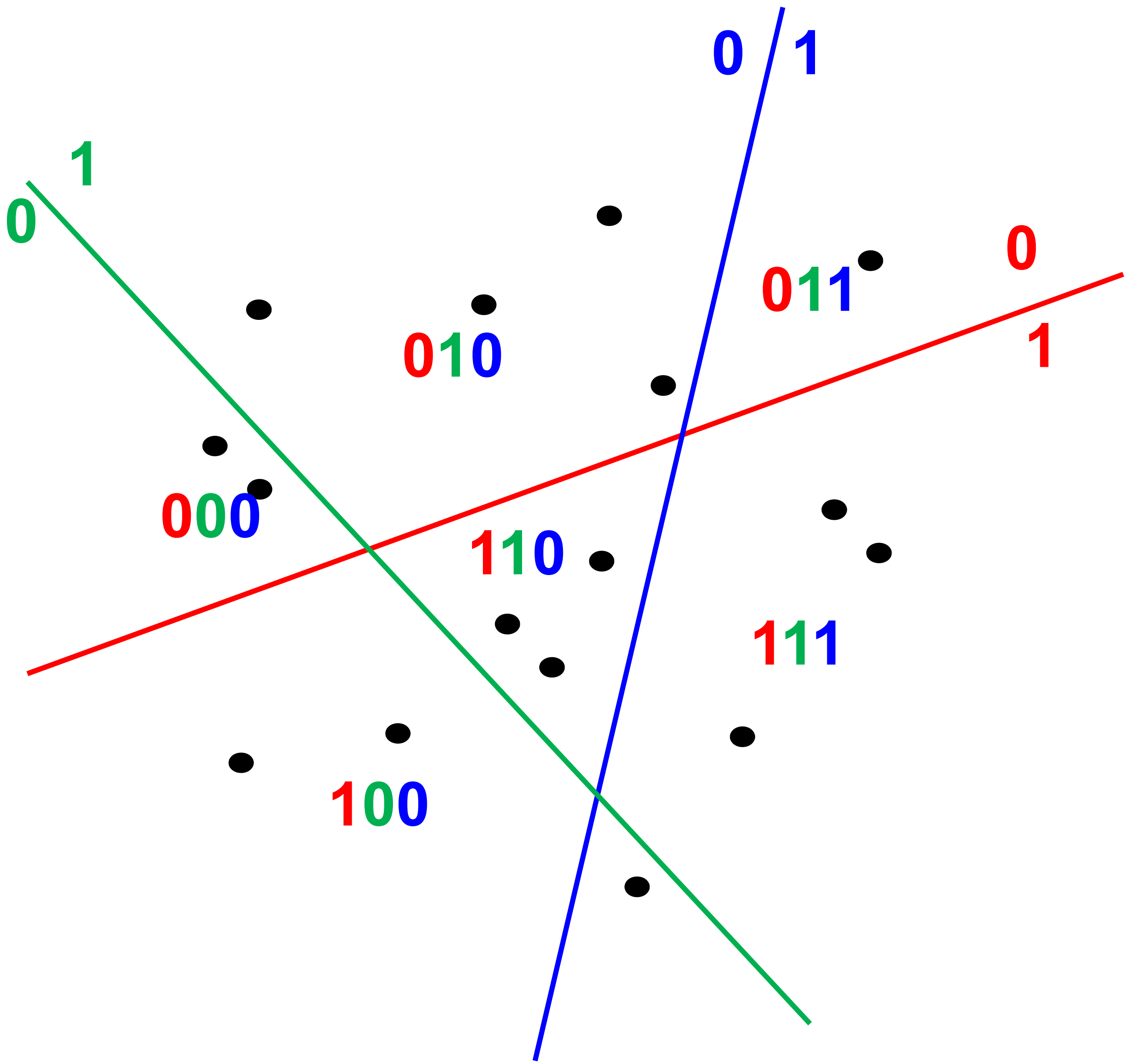
* Benefits

- Compression
- Very fast distance computation (Hamming Distance, XOR)

Hyper-Plane based Binary Coding



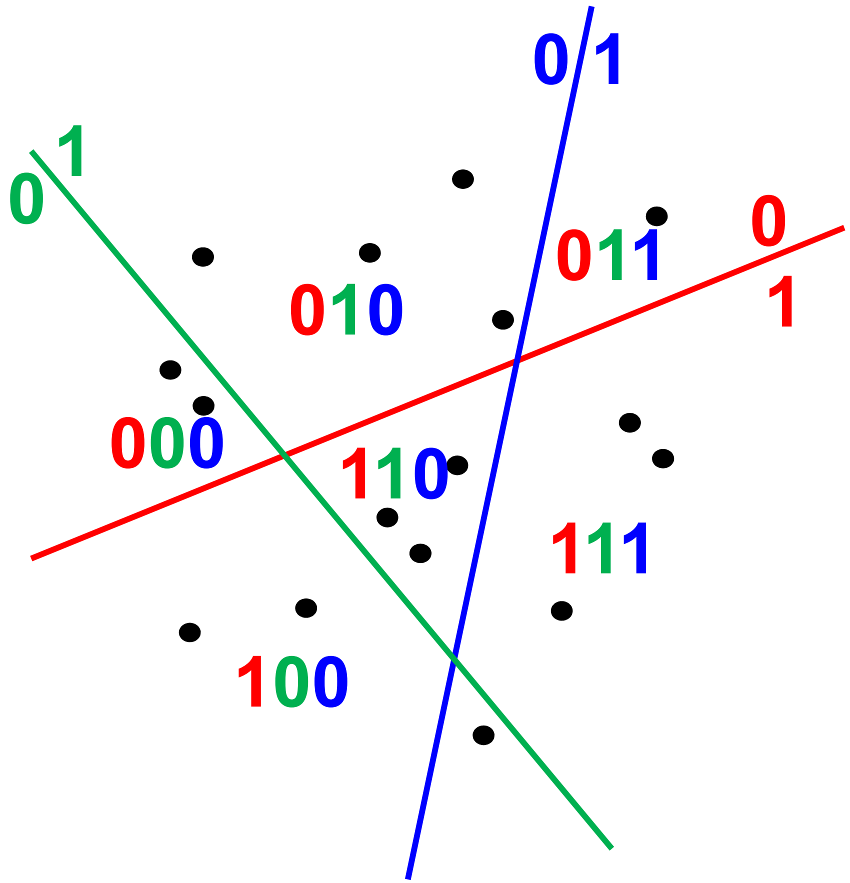
Hyper-Plane based Binary Coding



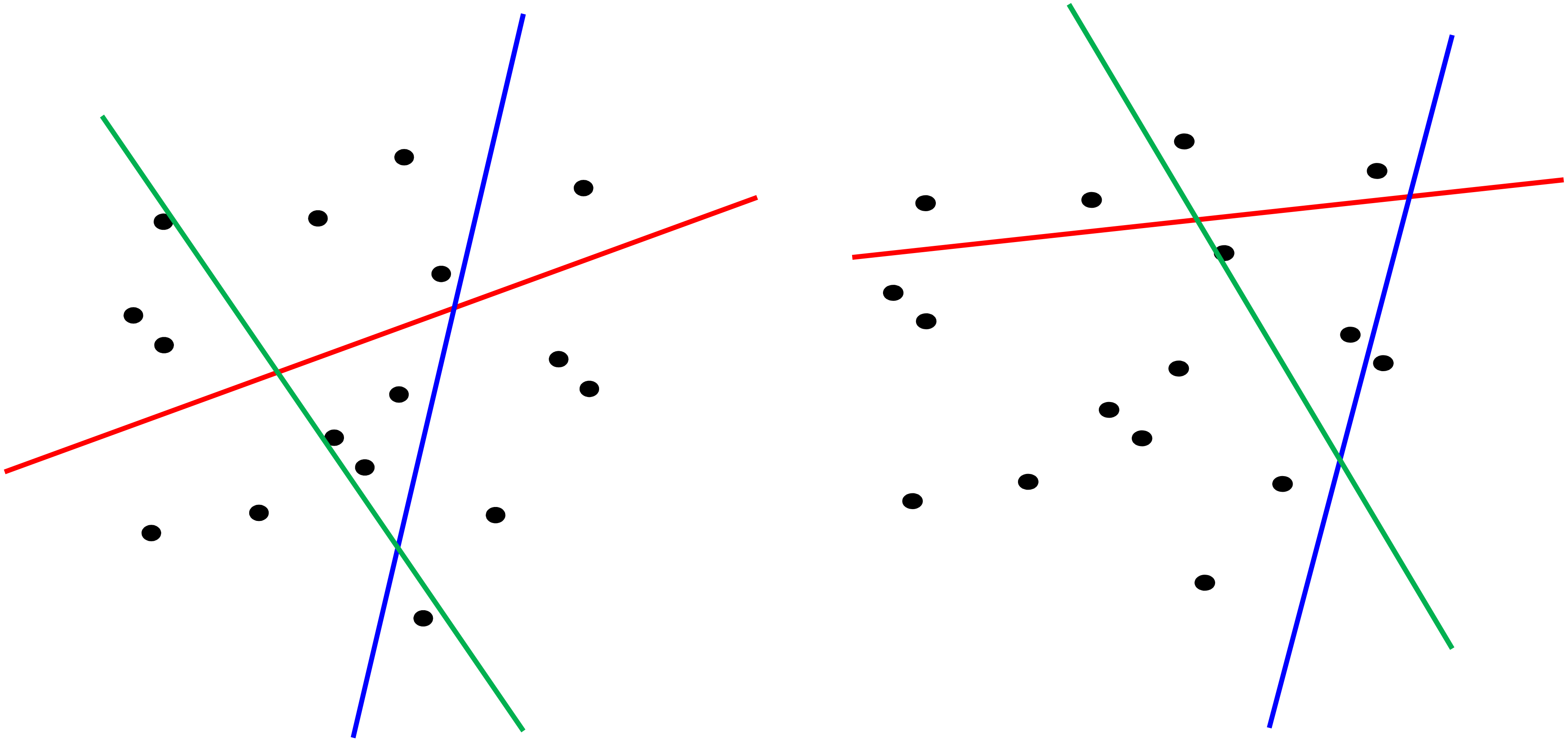
Distance between Two Points

- Measured by bit differences, known as Hamming distance
- Efficiently computed by XOR bit operations

$$d_{hd}(b_i, b_j) = |b_i \oplus b_j|$$



Good and Bad Hyper-Planes



Previous work focused on how to determine good hyper-planes

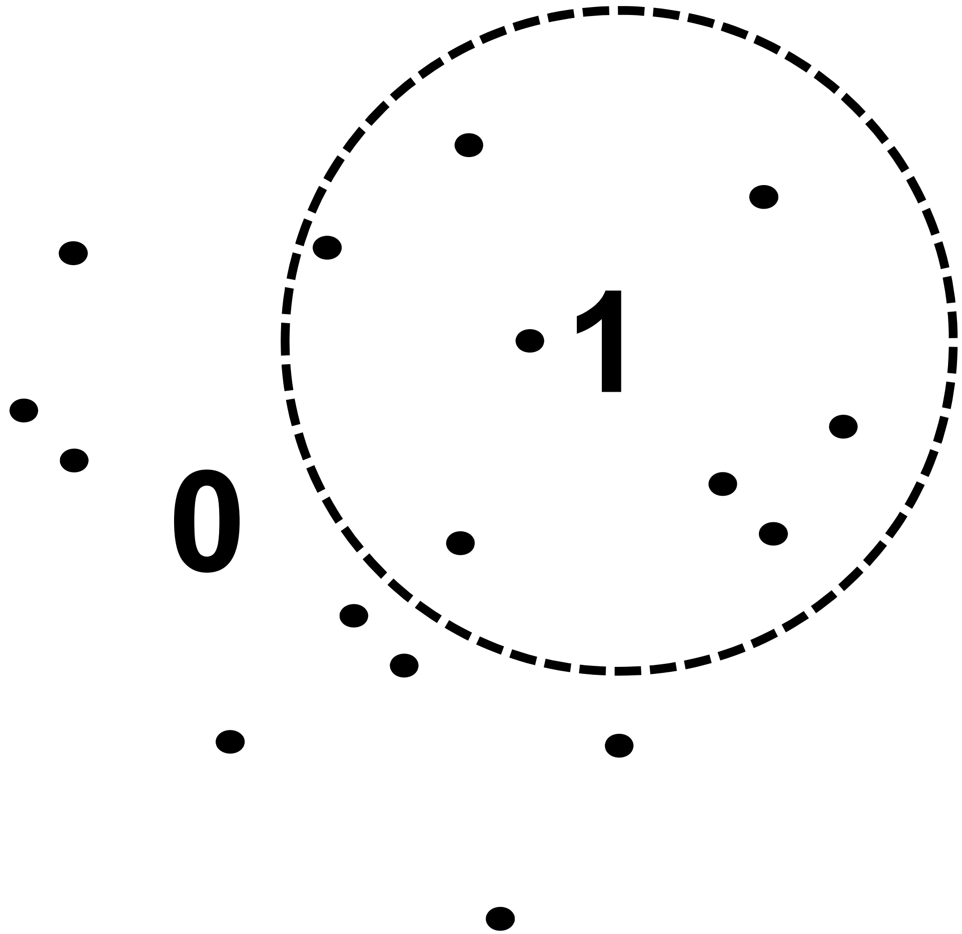
Components of Spherical Hashing

- Spherical hashing
- Hyper-sphere setting strategy
- Spherical Hamming distance

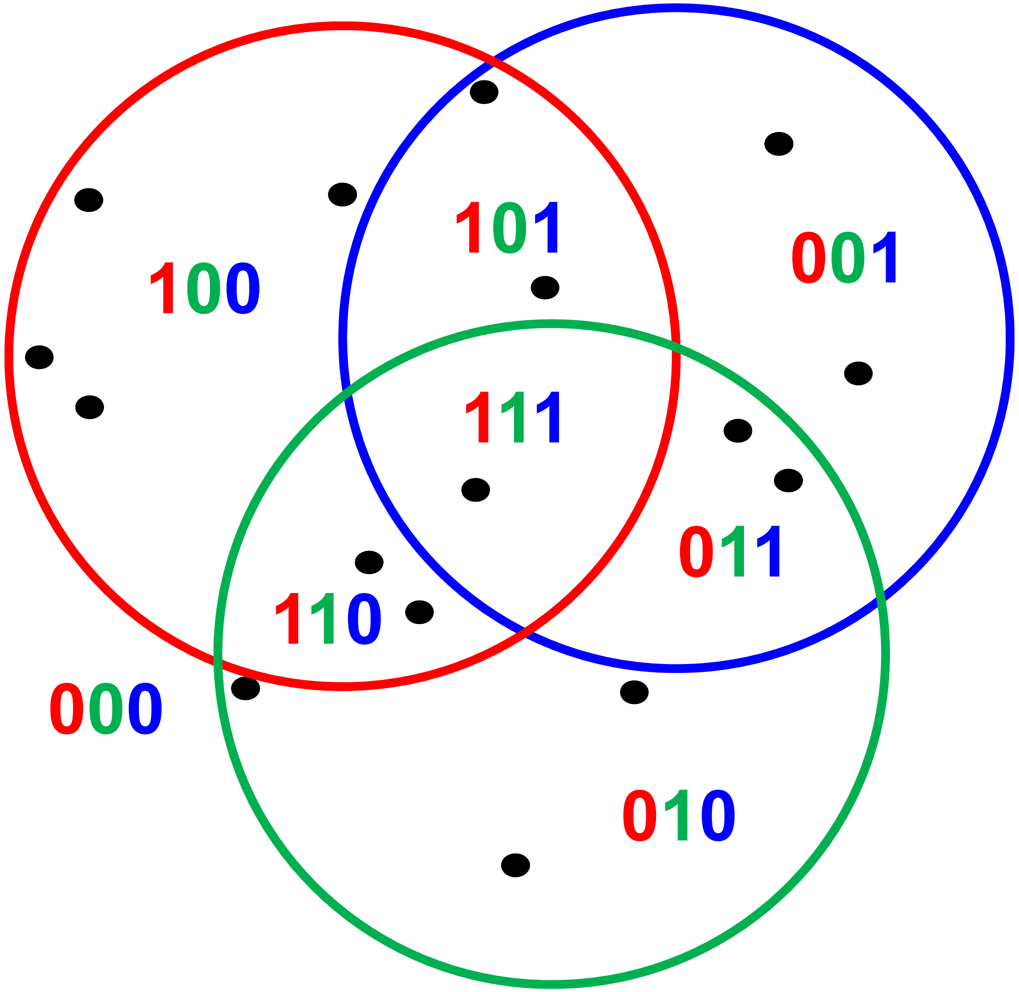
Components of Spherical Hashing

- **Spherical hashing**
- Hyper-sphere setting strategy
- Spherical Hamming distance

Spherical Hashing [Heo et al., CVPR 12]



Spherical Hashing [Heo et al., CVPR 12]



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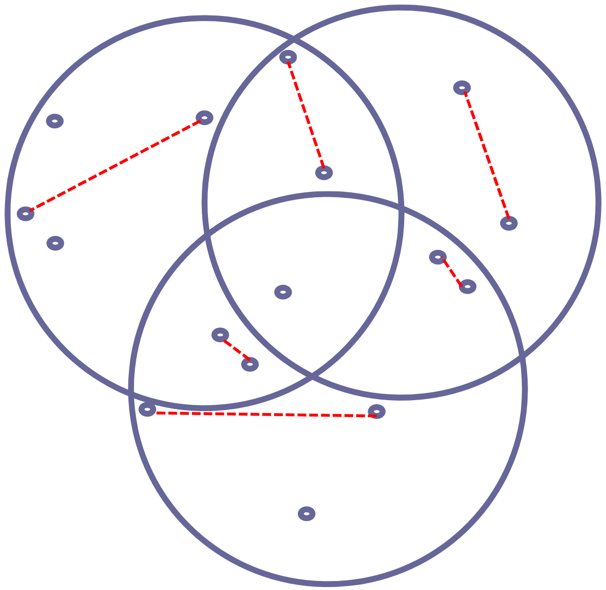
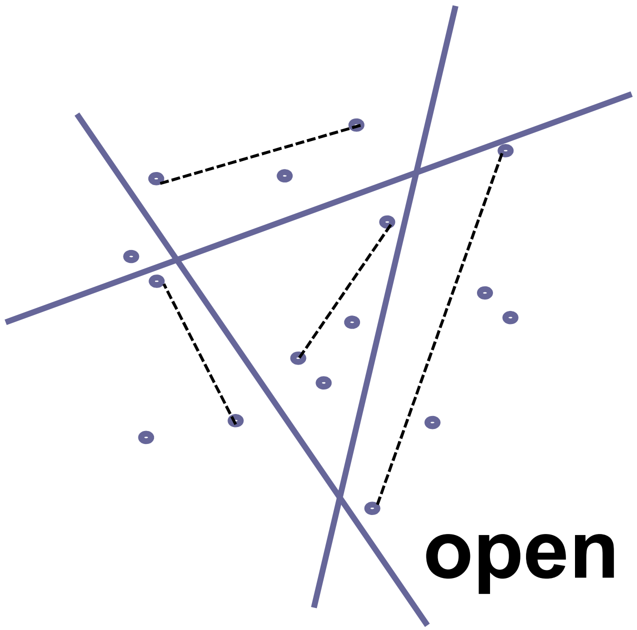
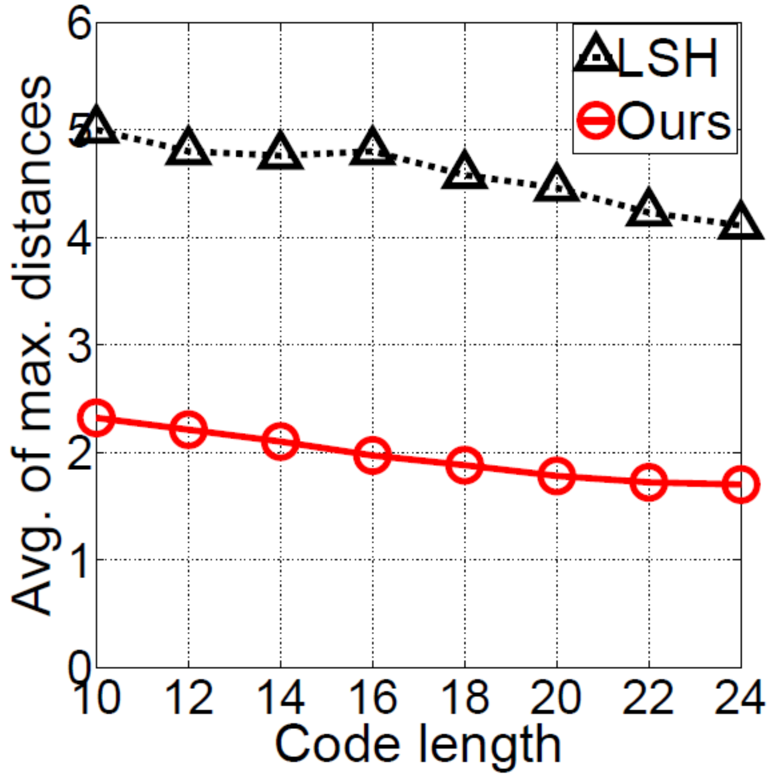
Hyper-Sphere vs Hyper-Plane







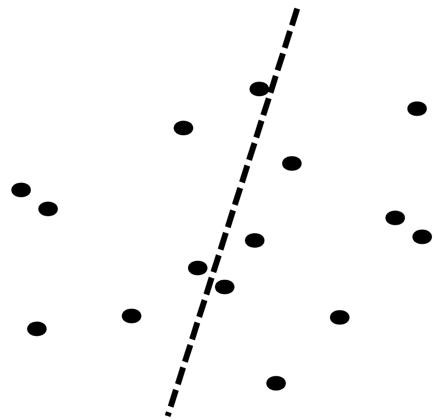
Average of maximum distances within a partition:
- Hyper-spheres gives tighter bound!

Components of Spherical Hashing

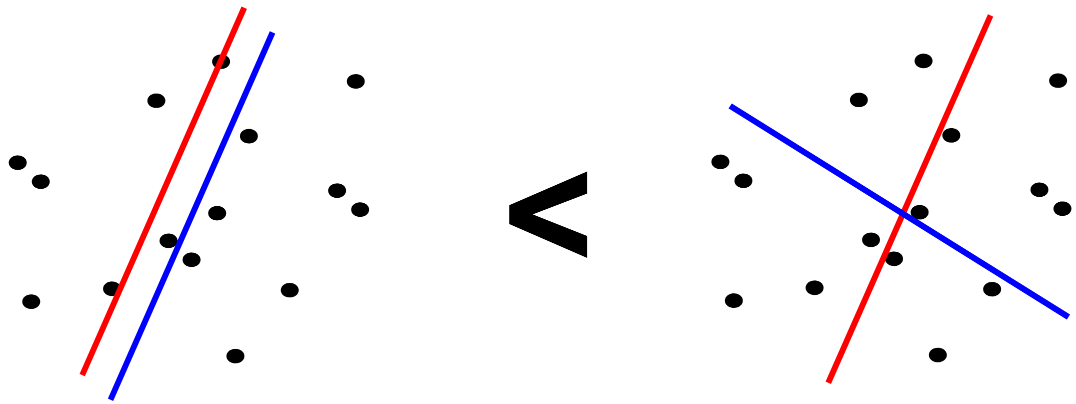
- Spherical hashing
- **Hyper-sphere setting strategy**
- Spherical Hamming distance

Good Binary Coding [Yeiss 2008, He 2011]

1. Balanced partitioning

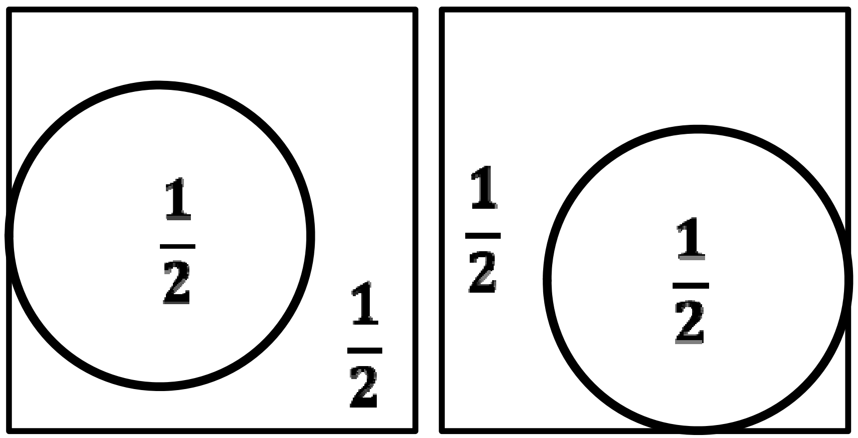


2. Independence

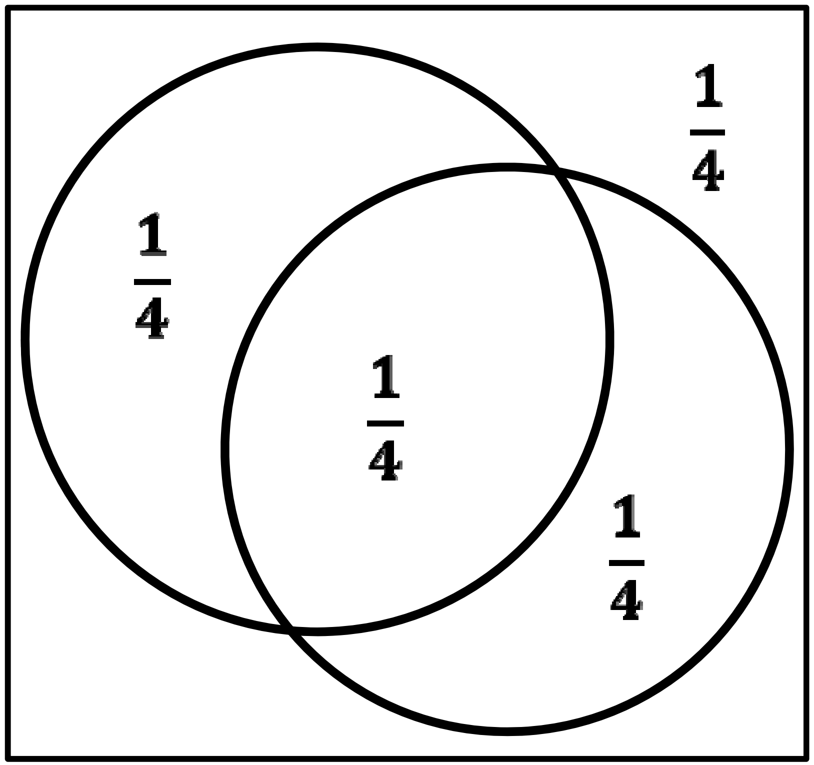


Intuition of Hyper-Sphere Setting

1. Balance

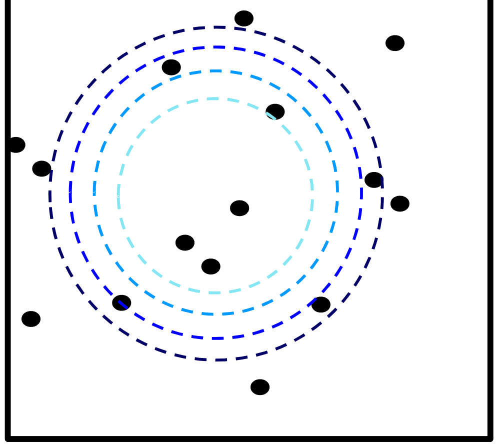


2. Independence

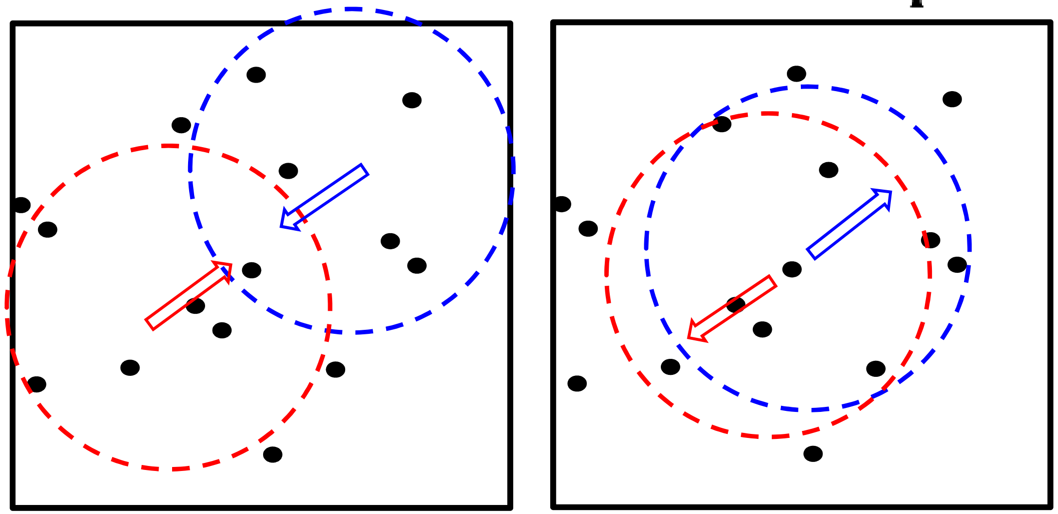


Hyper-Sphere Setting Process

1. Balance
- by controlling radius for $n(S) = \frac{N}{2}$



2. Independence
- by moving two hyper-spheres for $n(S_1 \cap S_2) = \frac{N}{4}$

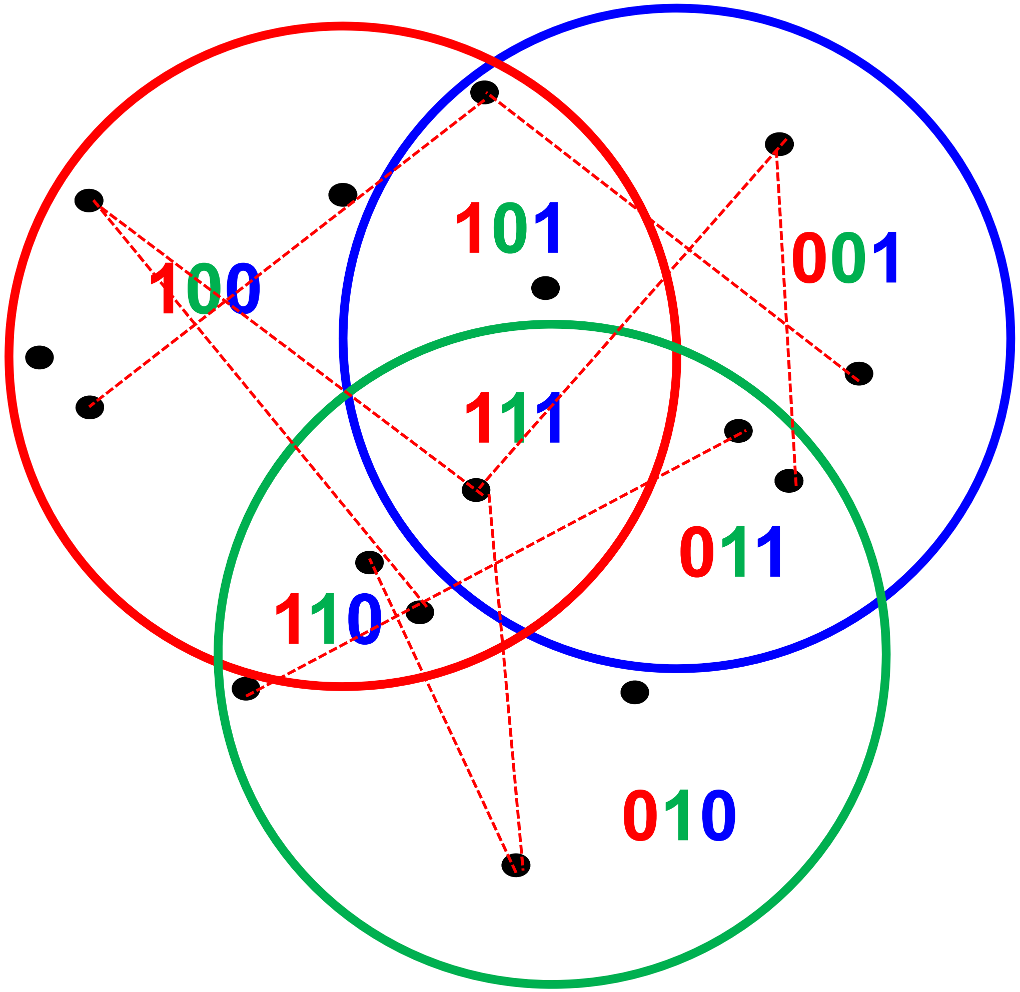


Iteratively repeat step 1, 2 until convergence.

Components of Spherical Hashing

- Spherical hashing
- Hyper-sphere setting strategy
- **Spherical Hamming distance**

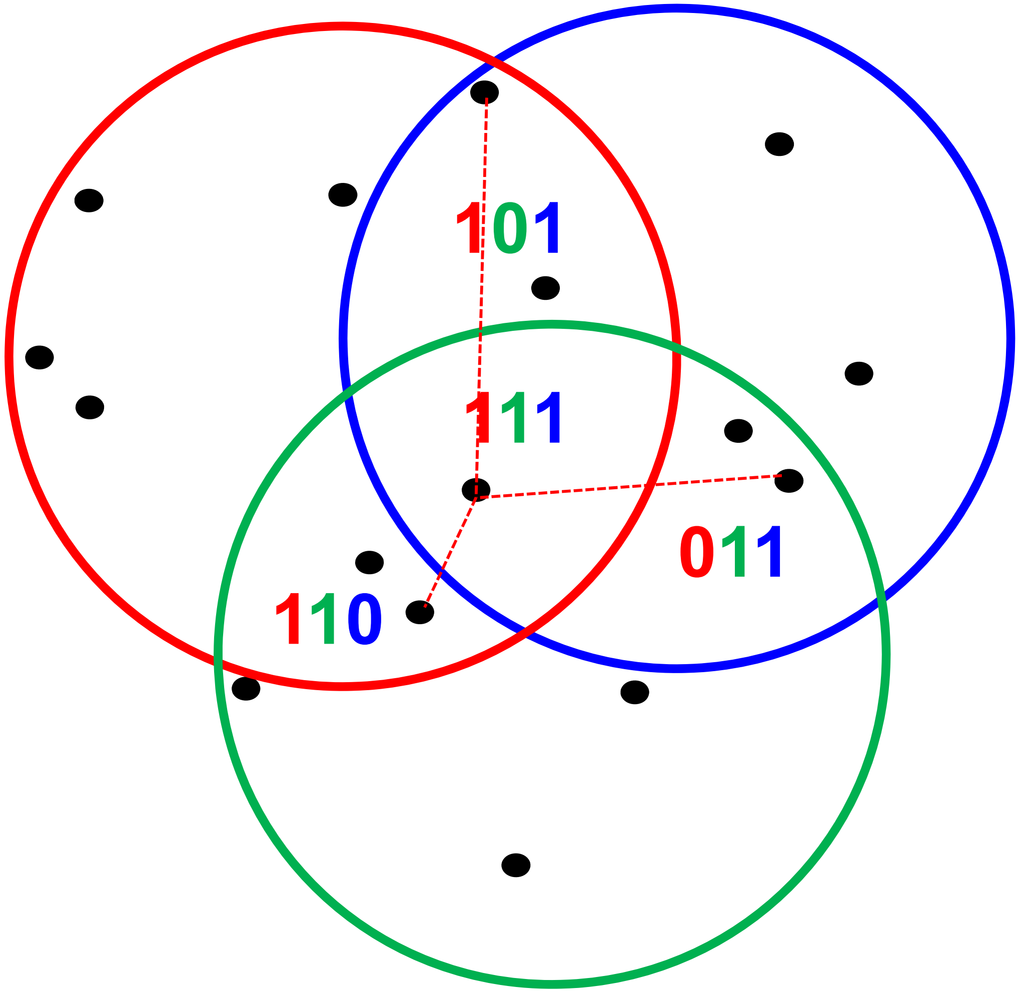
Max Distance and Common ‘1’



Common ‘1’s

: 1

Max Distance and Common '1'

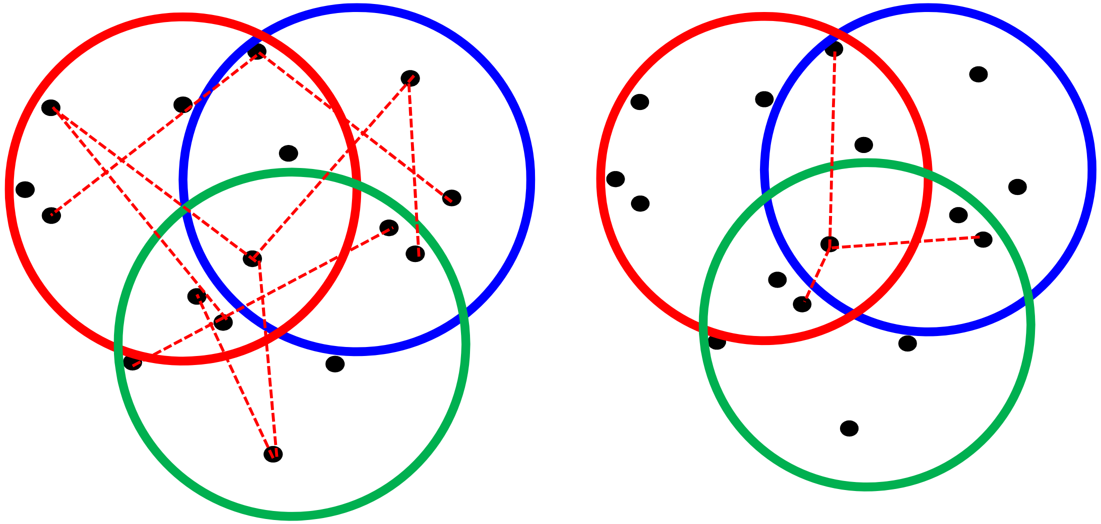


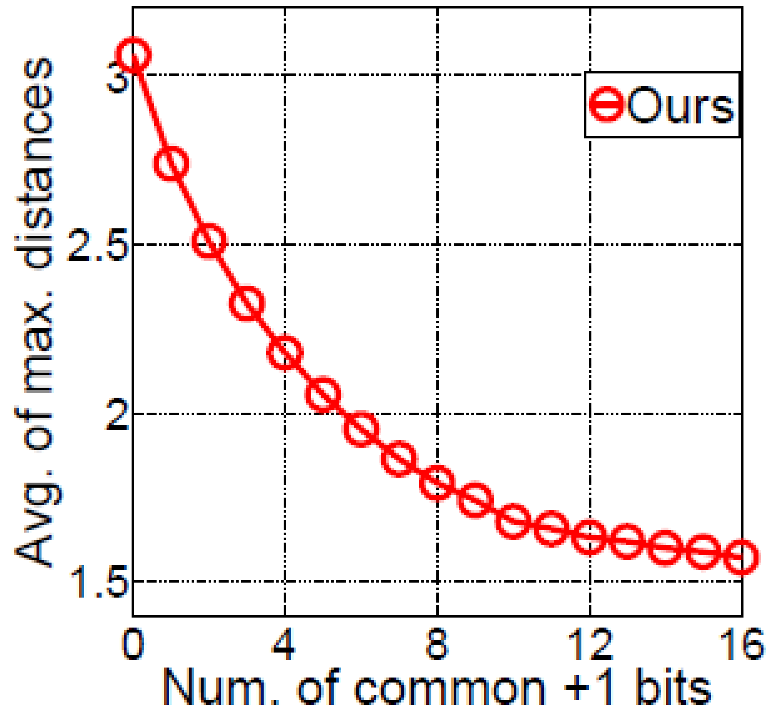
Common '1's

: **2**

Max Distance and Common ‘1’

Common ‘1’s: **1** Common ‘1’s: **2**





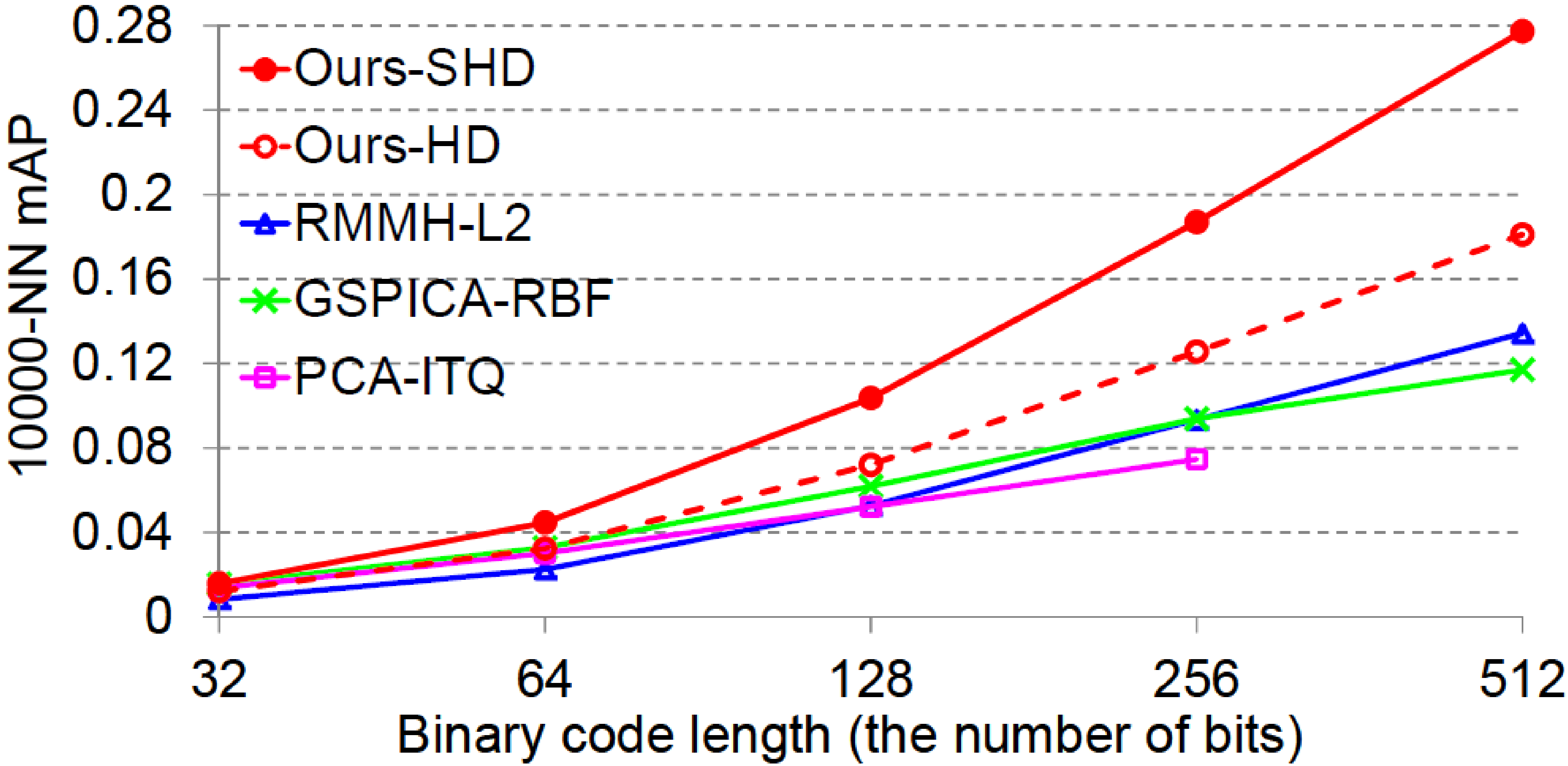
Average of maximum distances between two partitions: decreases as number of common ‘1’

Spherical Hamming Distance (SHD)

$$d_{shd}(b_i, b_j) = \frac{|b_i \oplus b_j|}{|b_i \wedge b_j|}$$

SHD: Hamming Distance divided by the number of common '1's.

Results



384 dimensional 75 million GIST descriptors

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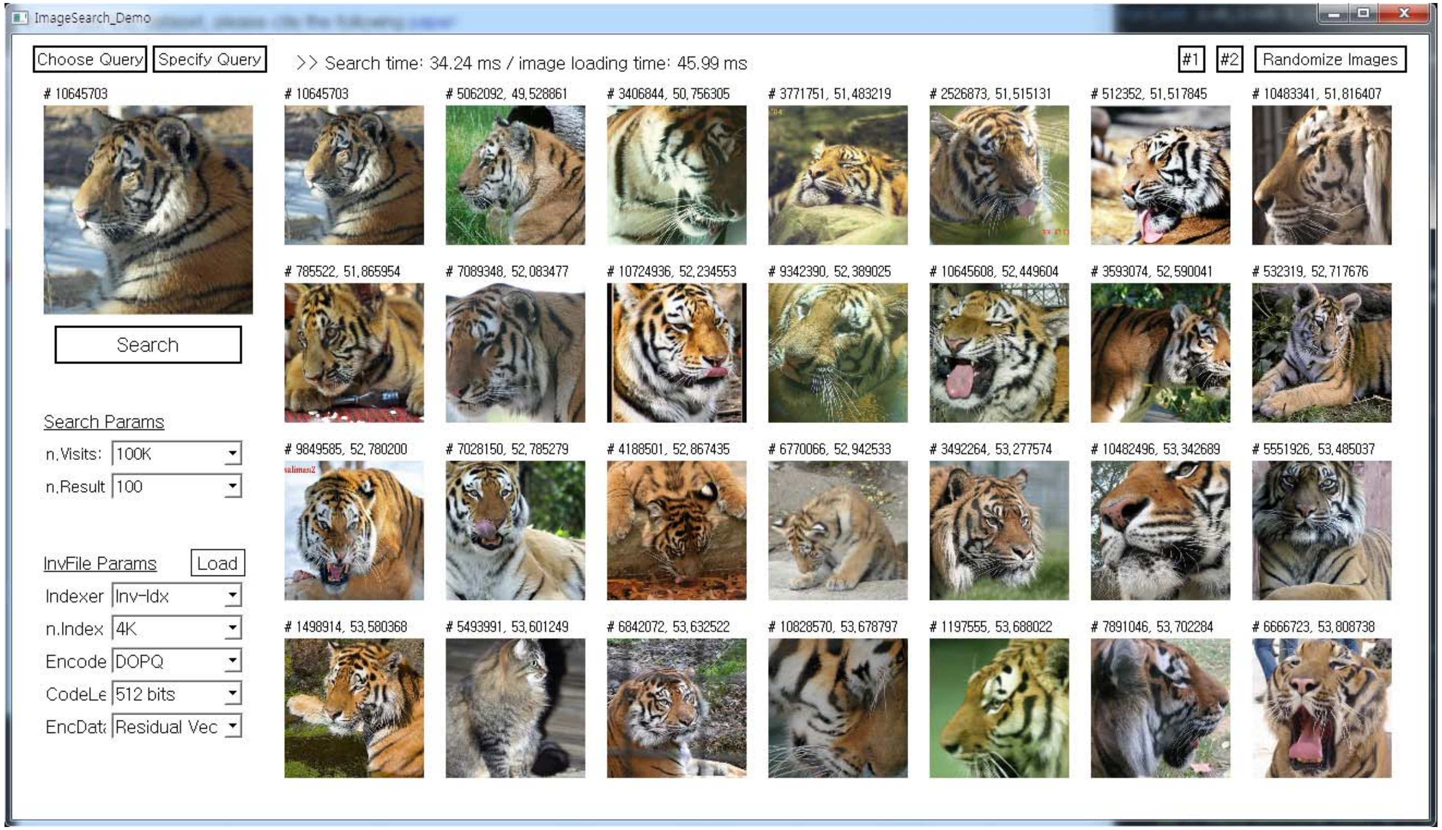
Results of Image Retrieval

- **Collaborated with Adobe**
  - **11M images**
  - **Use deep neural nets for image representations**
  - **Spend only 35 ms for a single CPU thread**



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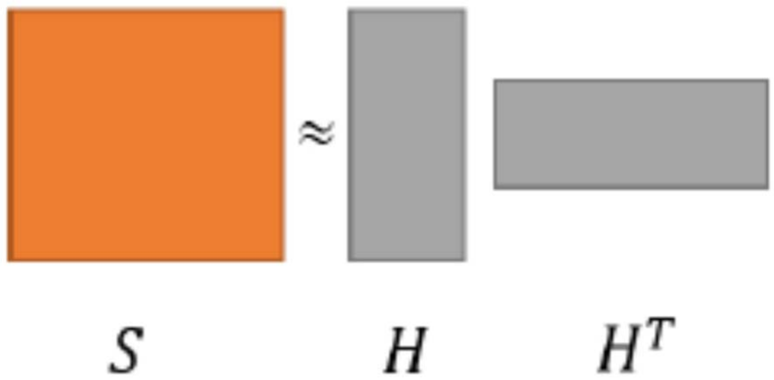
Supervised Hashing

- **Utilize image labels**
  - **Conducted by using deep learning**

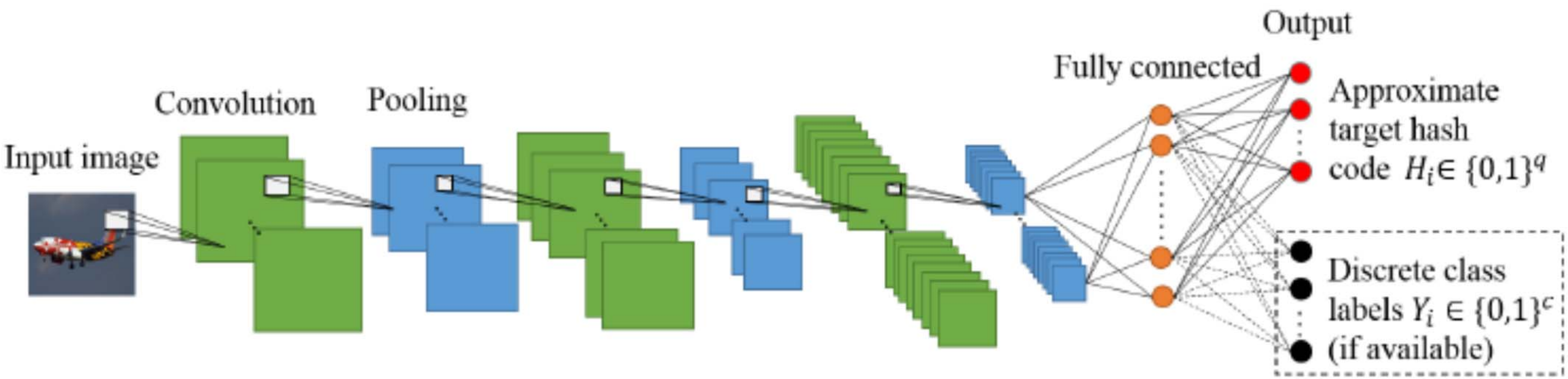
Supervised hashing for image retrieval via image representation learning, AAA 14

- **First step: approximate hash codes**
  - **S (similarity matrix, i.e., 1 when two images i & j have same label)**
  - **H (Hamming embedding, binary codes): dot products between two similar codes gives 1**
  - **Minimize the reconstruction error between S and similarity between codes**



Supervised hashing for image retrieval via image representation learning, AAA 14

- **Second step: learning image features and hash functions**
  - **Use Alexnet by utilizing approximate target hash codes and optionally class labels**
  - **Once the network is trained, it is used for test images**



Class Objectives were:

- **Understand the basic hashing techniques based on hyperplanes**
  - **Unsupervised approach**
- **Supervised approach using deep learning**

- **Codes are available**

  http://sglab.kaist.ac.kr/software.htm

Homework for Every Class

- **Go over the next lecture slides**
- **Come up with one question on what we have discussed today**
  - **Write questions three times**
- **Go over recent papers on image search, and submit their summary before Tue. class**

Next Time…

- **CNN based image search techniques**

Fig