NLP with Classification and Vector Spaces

Week 4.
Machine Translation and Document Search

From *Natural Language Processing Specialization* lectures on coursera

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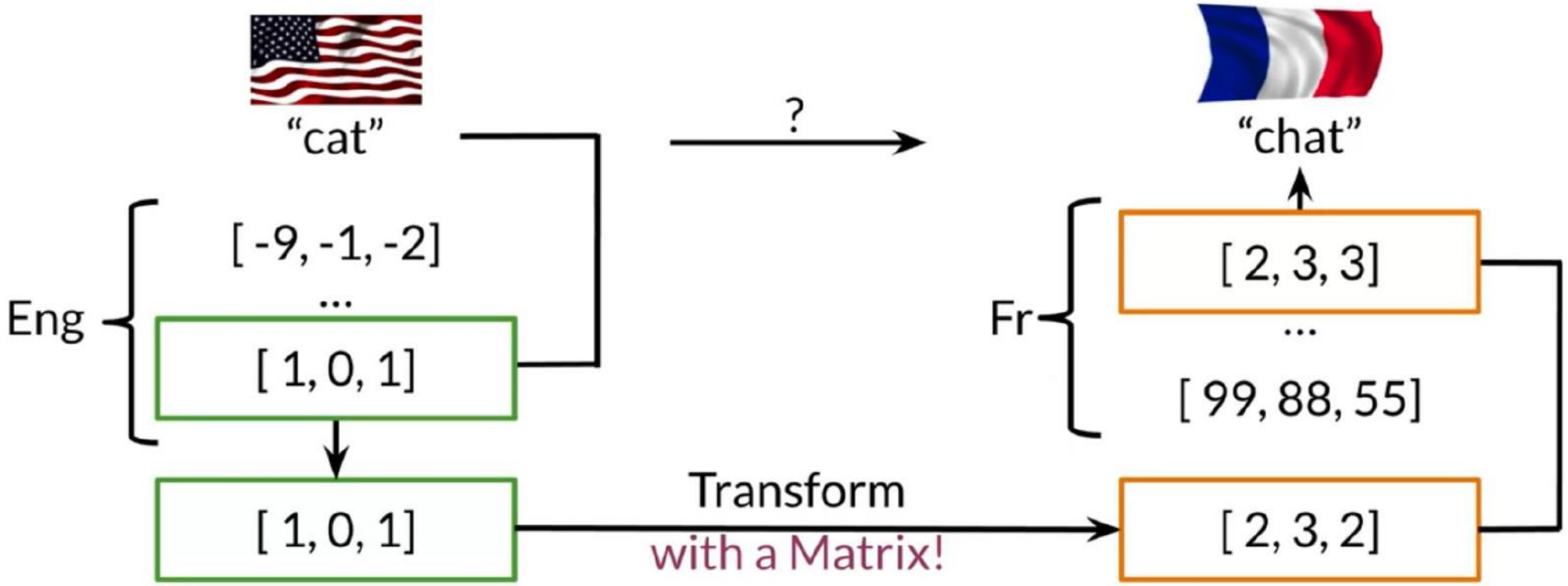
01 Transforming Word Vectors

Overview of Translation



01 Transforming Word Vectors

Transforming Vectors

```
R = np.array([[2,0],
              [0,-2]])

x = np.array([[1,1]])

np.dot(x,R)
```

```
array([[2,-2]])
```

01 Transforming Word Vectors

Align Word Vectors

- $XR \approx Y$
  - X, Y
    - Subsets of the full vocabulary

$$\begin{pmatrix} \text{["cat" } vector\text{]} \\ \text{[...} vector\text{]} \\ \text{["zebra" } vector\text{]} \end{pmatrix} \qquad \begin{pmatrix} \text{["chat" } vecteur\text{]} \\ \text{[...} vecteur\text{]} \\ \text{["zebresse" } vecteur\text{]} \end{pmatrix}$$

X Y

  - R
    - Transformation matrix
    - To get R

→Optimize the distance between XR and Y by minimizing the frobenius norm

01 Transforming Word Vectors

- Solving for R

initialize R

in a loop:

$$Loss = \| \mathbf{XR} - \mathbf{Y} \|_F$$

$$g = \frac{d}{dR} Loss$$ gradient

$$R = R - \alpha g$$ update

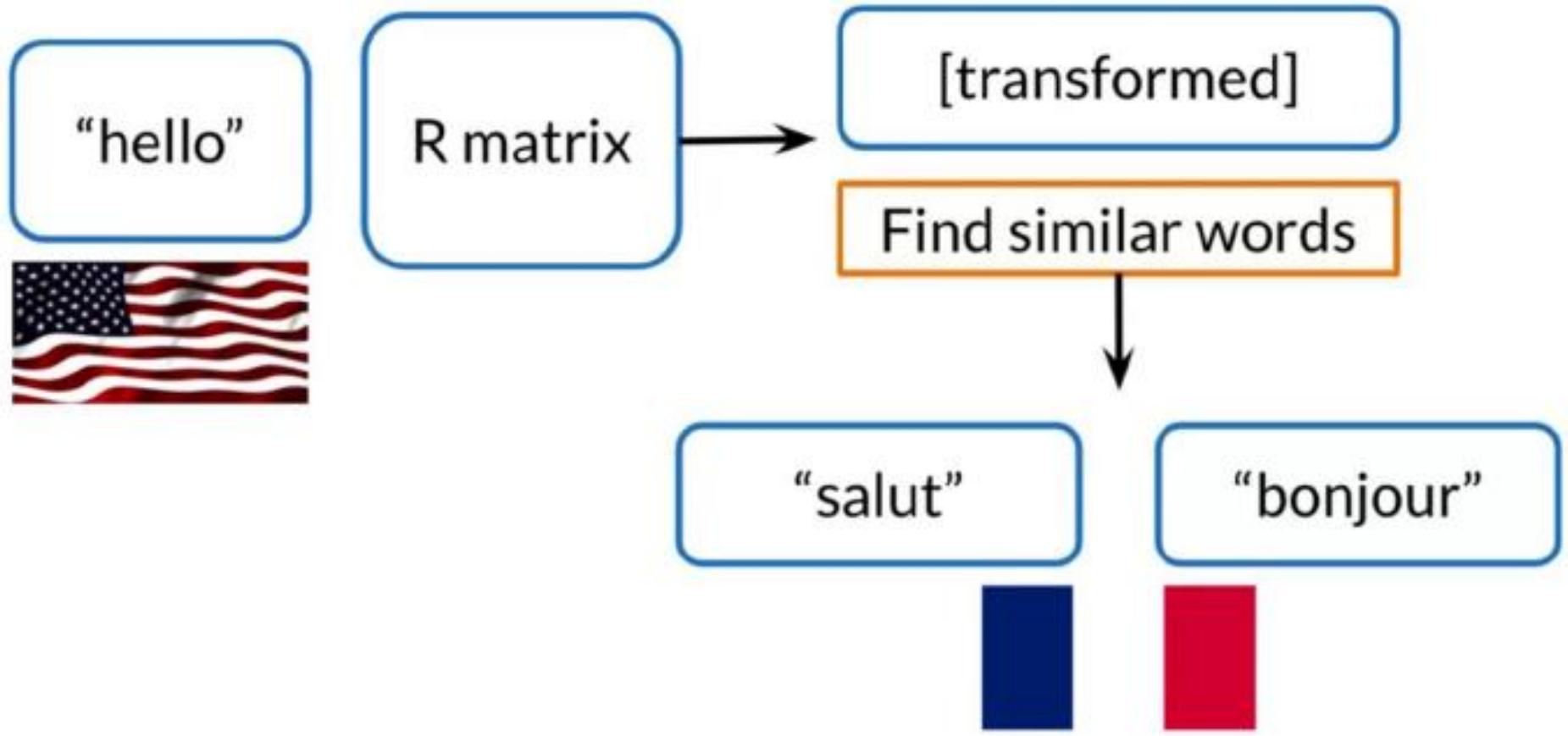
01 Transforming Word Vectors

Frobenius Norm

- Frobenius norm
  - $A = \begin{pmatrix} 2 & 2 \\ 2 & 2 \end{pmatrix}$
  - $\|A_F\| = \sqrt{2^2 + 2^2 + 2^2 + 2^2} = 4$
  - $\|A\|_F = \sqrt{\sum_{i=1}^{m} \sum_{j=1}^{n} |a_{ij}|^2}$
- Frobenius norm squared
  - $A = \begin{pmatrix} 2 & 2 \\ 2 & 2 \end{pmatrix}$
  - $\|A\|_F^2 = (\sqrt{2^2 + 2^2 + 2^2 + 2^2})^2 = 16$

02 K-Nearest Neighbors

- Finding the Translation



02 K-Nearest Neighbors

Nearest Neighbors

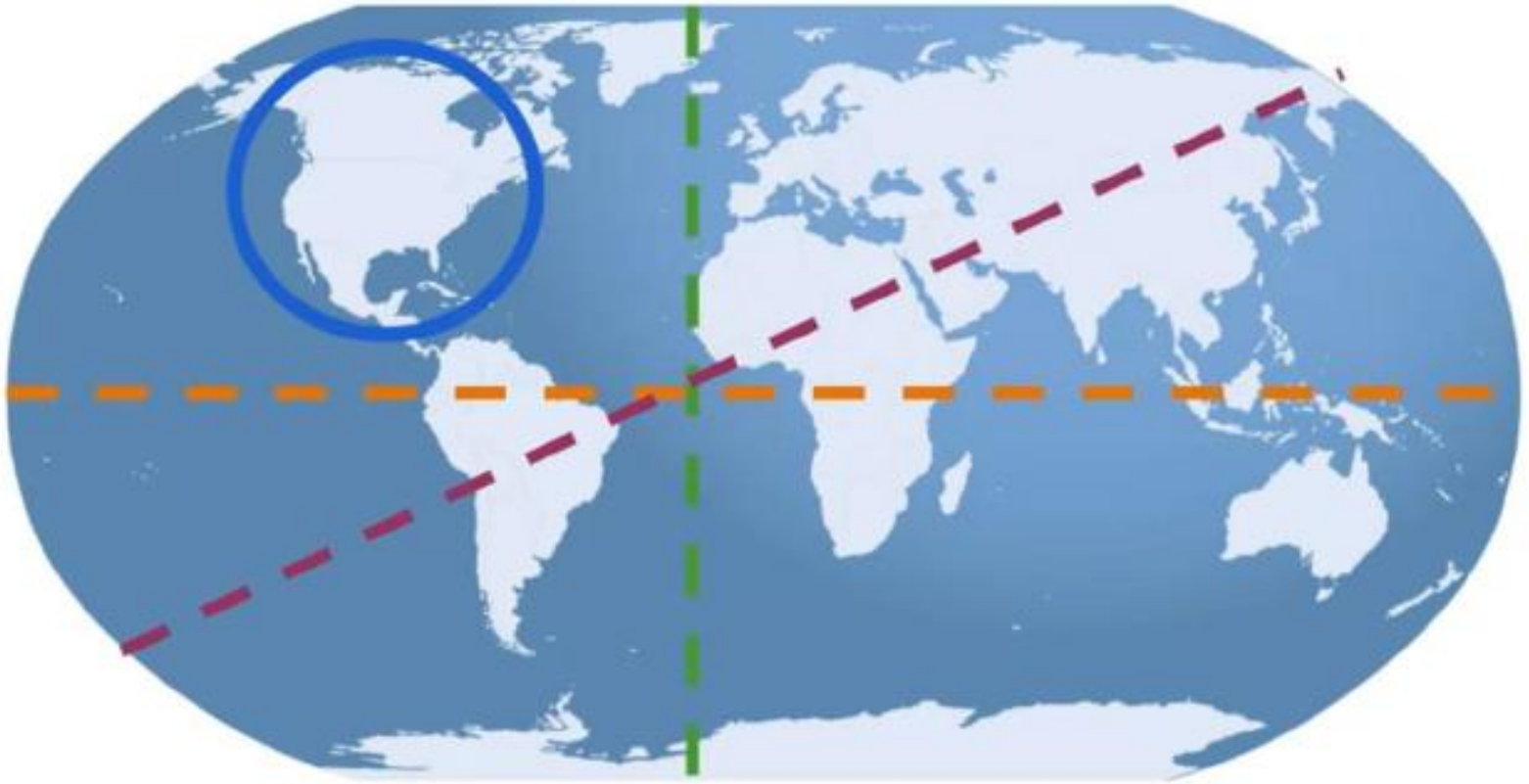
You

San Francisco

Friend	Location	Nearest
	Shanghai	2
	Bangalore	3
	Los Angeles	1

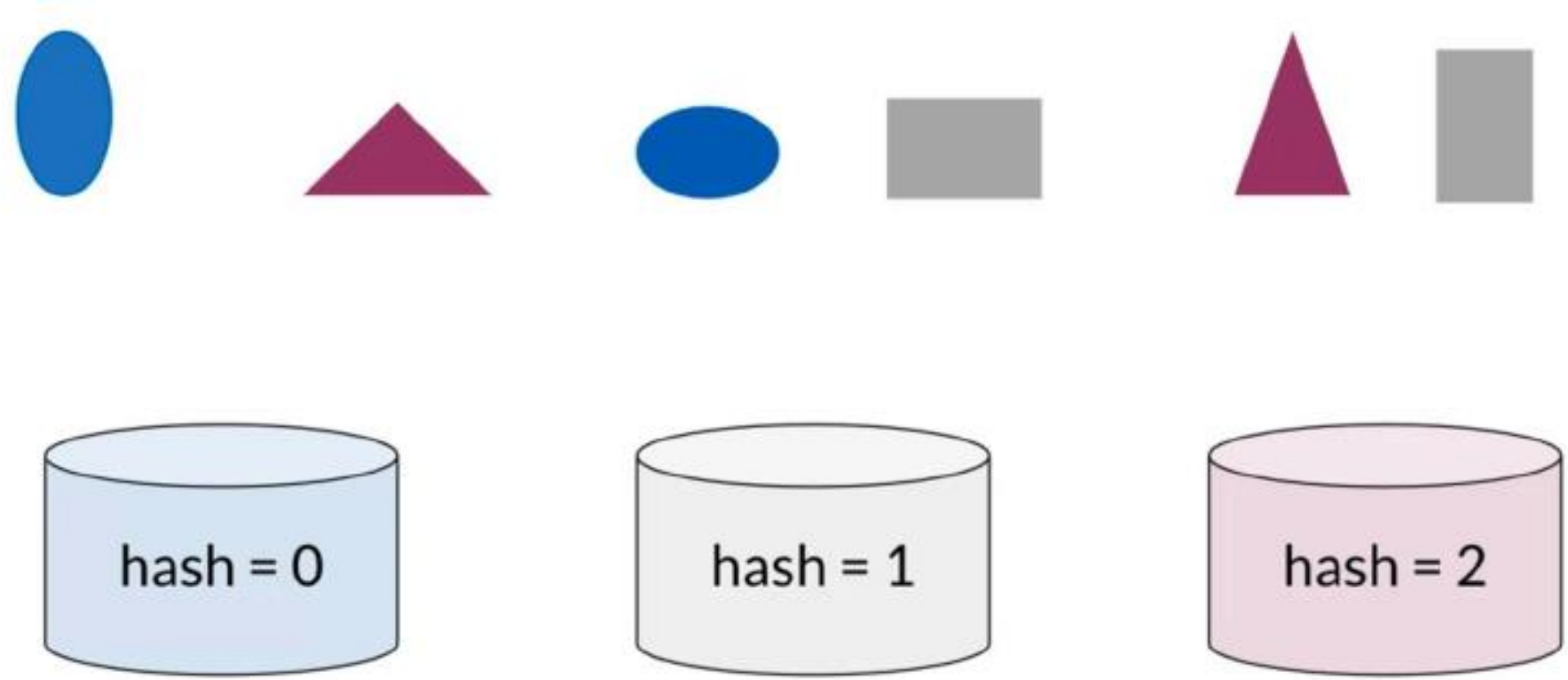
02 K-Nearest Neighbors

- Nearest Neighbors



03 Hash Tables and Hash Functions

Hash Tables



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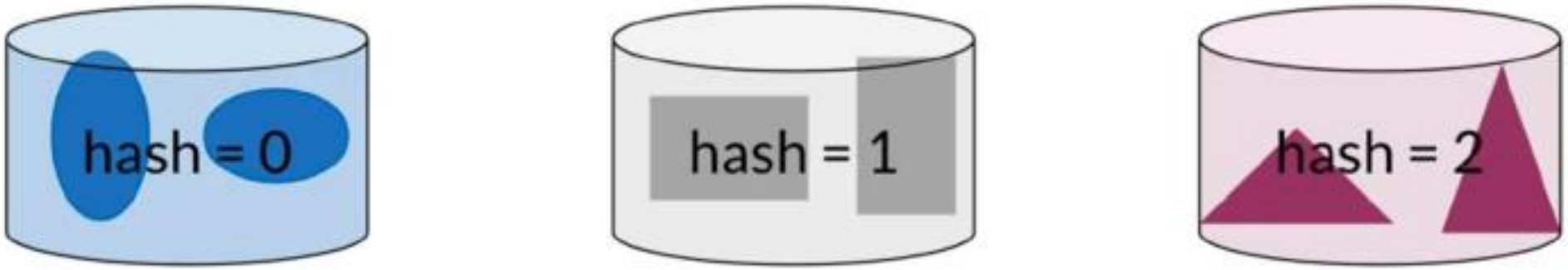
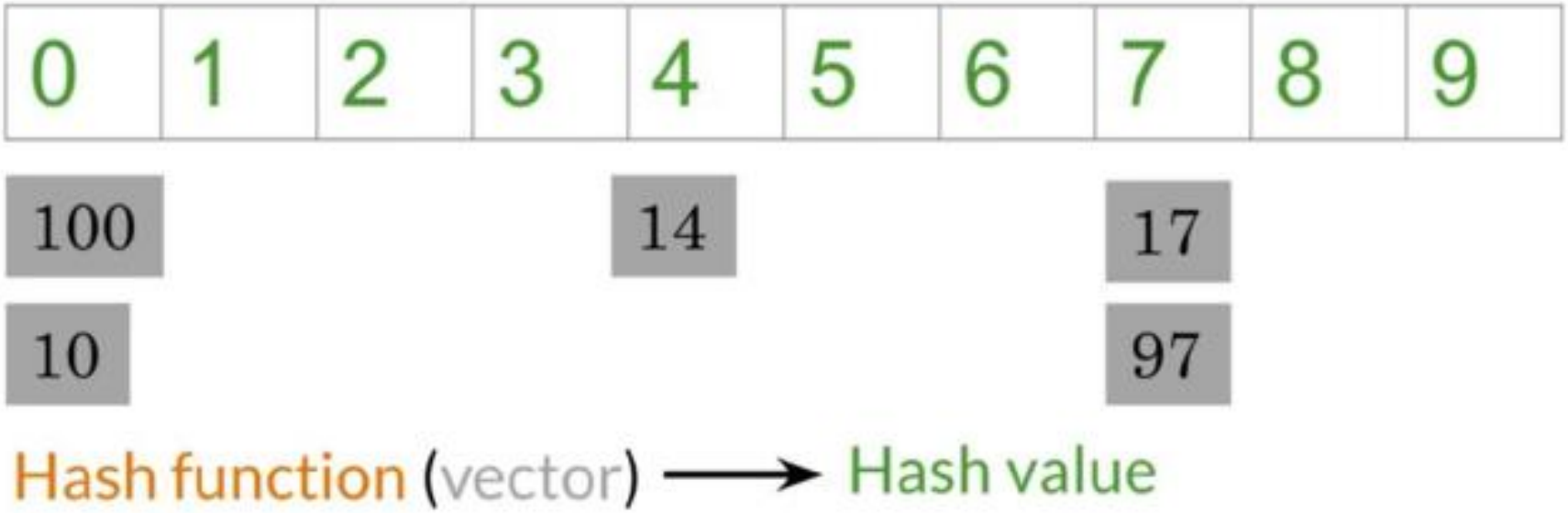
Hash Tables



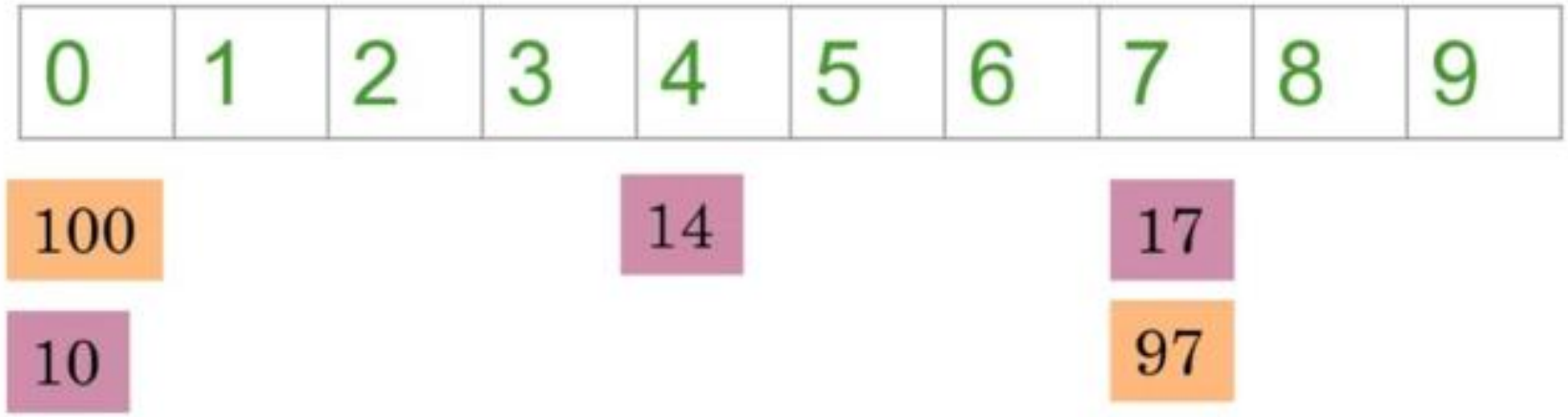
03 Hash Tables and Hash Functions

Hash Function



03 Hash Tables and Hash Functions

- Hash Function



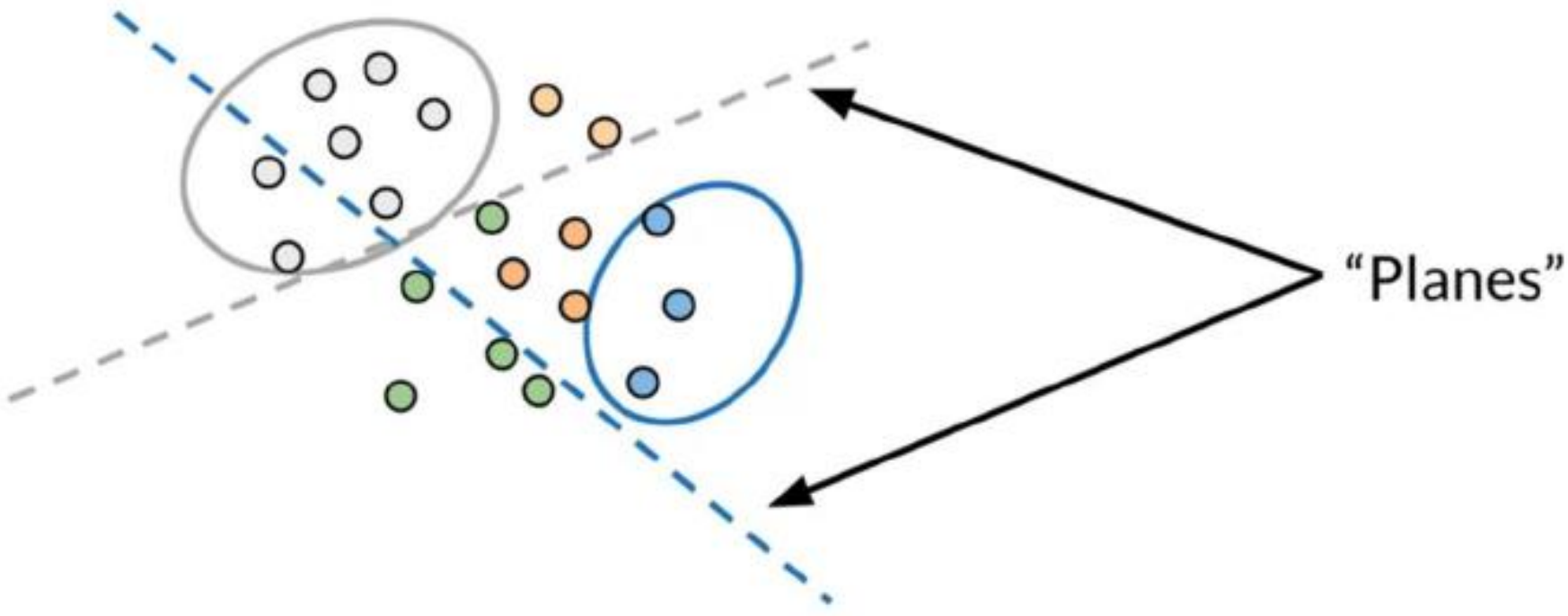
04 Locality Sensitive Hashing

Hash Function by Location

- Locality sensitive hashing
  - Hashing method that cares very deeply about assigning items based on where they're located in vector space

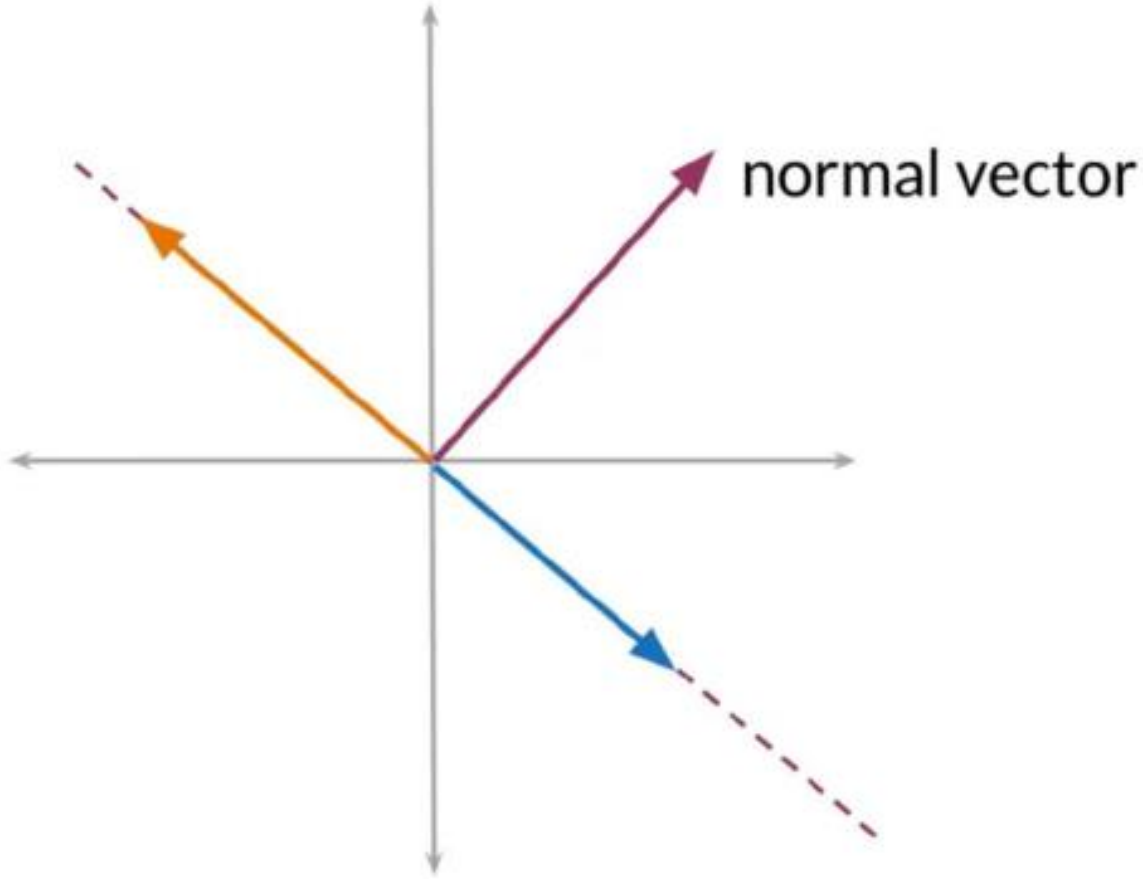
04 Locality Sensitive Hashing

Locality Sensitive Hashing



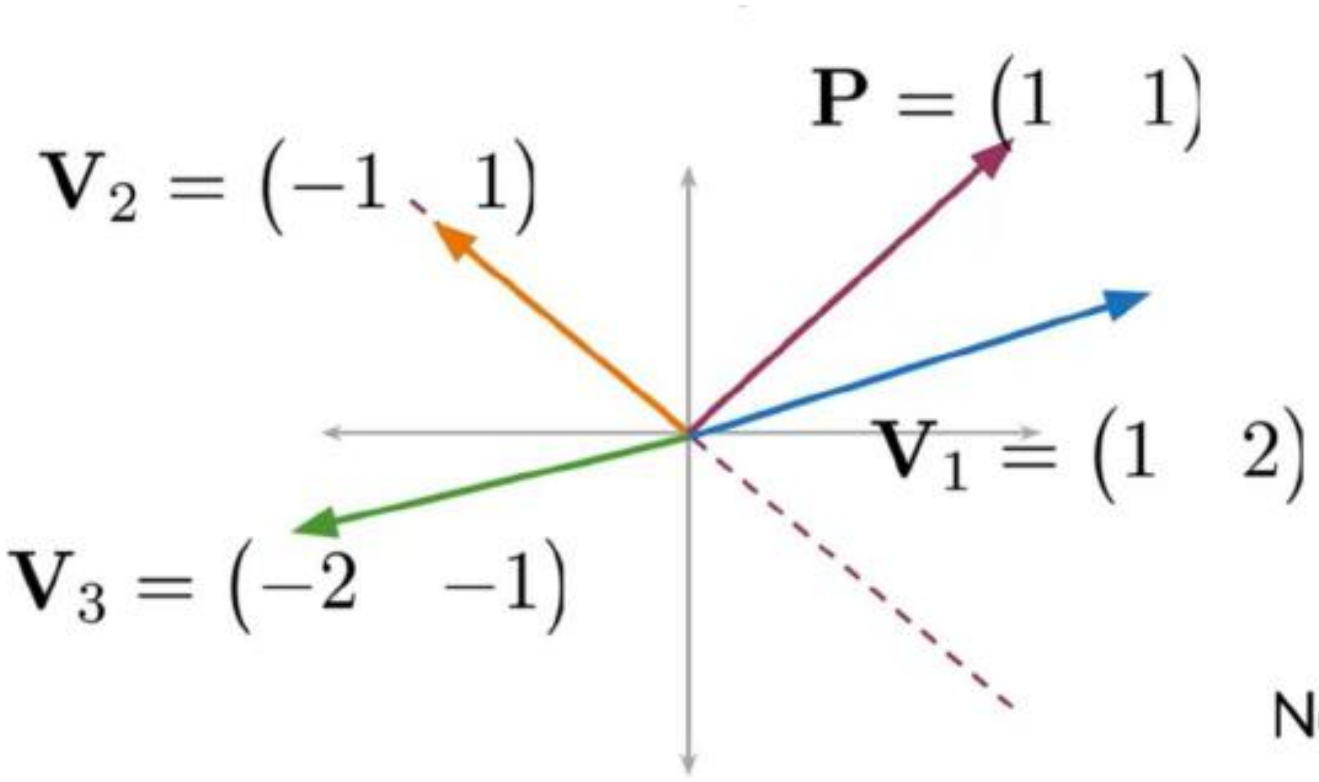
04 Locality Sensitive Hashing

- Planes



04 Locality Sensitive Hashing

- Planes

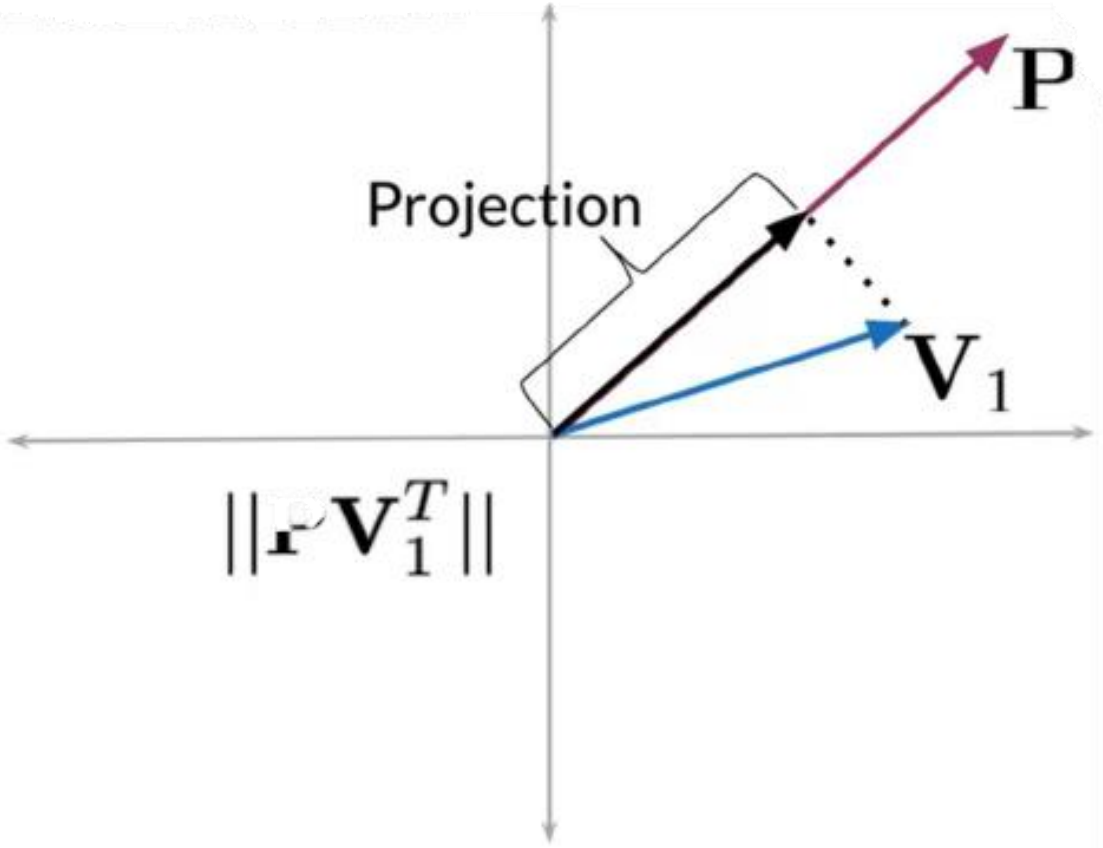


$$\mathbf{PV}_1^T = 3$$
$$\mathbf{PV}_2^T = 0$$
$$\mathbf{PV}_3^T = -3$$

Notice the signs?

04 Locality Sensitive Hashing

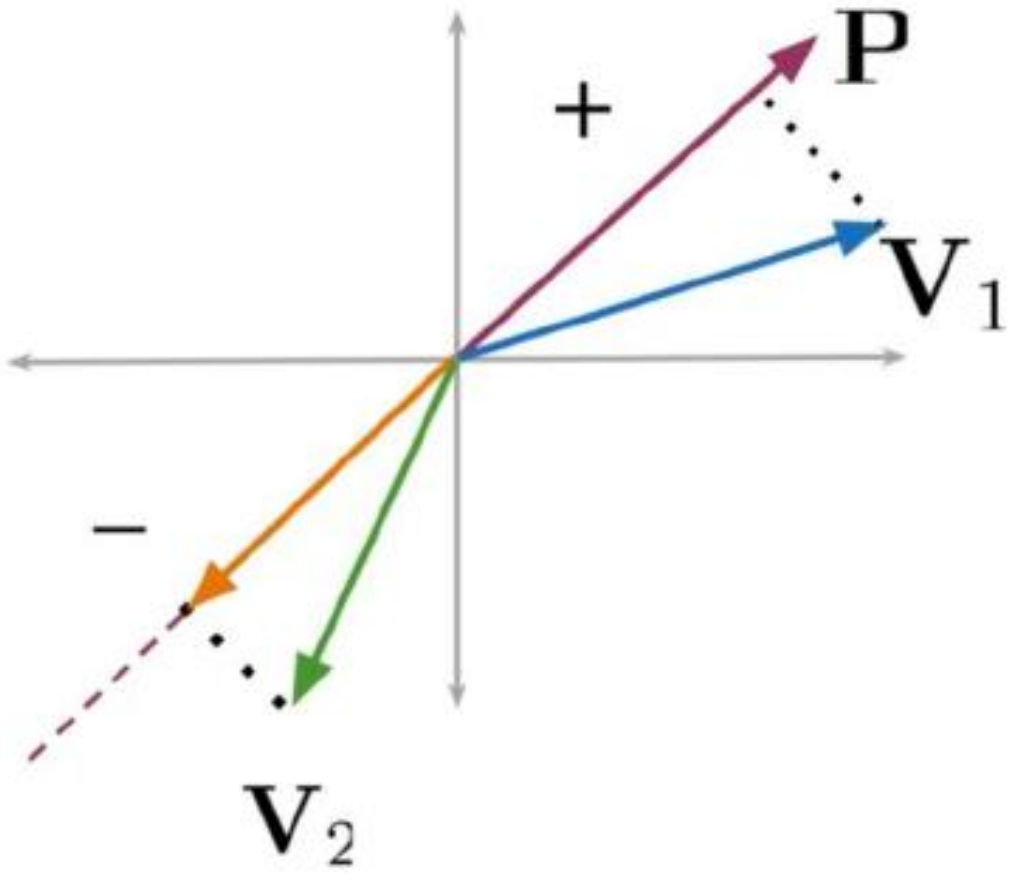
- Dop Product



04 Locality Sensitive Hashing

Dop Product

- Sign indicates direction

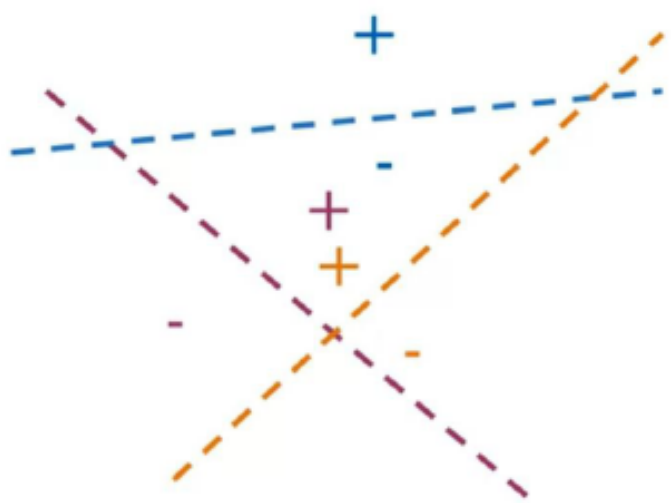


05 Multiple Planes

Multiple Planes

Single hash value

- $hash = \sum_i^H 2^i \times h_i$
  - $sign_i \geq 0 \rightarrow h_i = 1$
  - $sign_i < 1 \rightarrow h_i = 0$



$$\mathbf{P}_1\mathbf{v}^T = 3, sign_1 = +1, h_1 = 1$$

$$\mathbf{P}_2\mathbf{v}^T = 5, sign_2 = +1, h_2 = 1$$

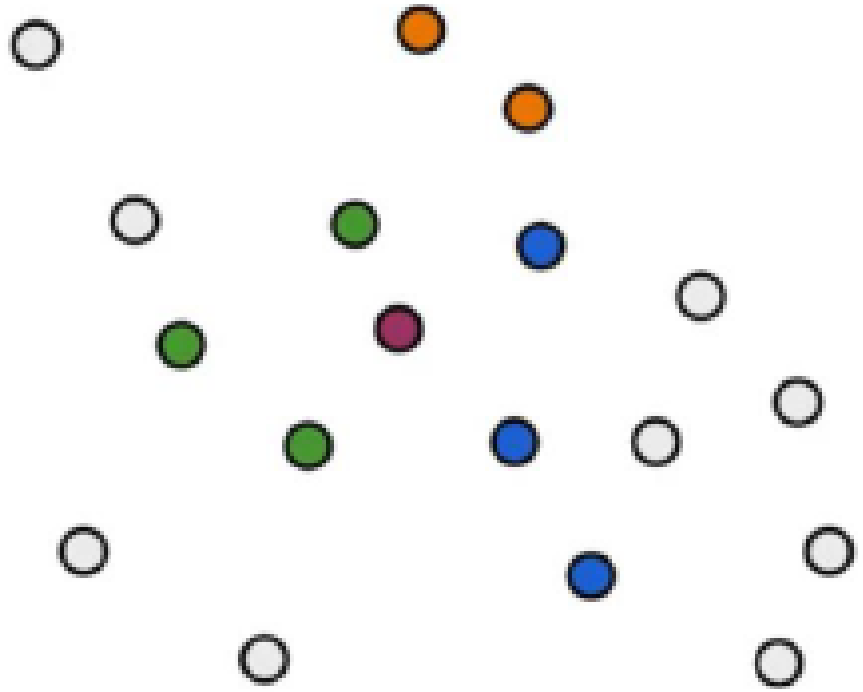
$$\mathbf{P}_3\mathbf{v}^T = -2, sign_3 = -1, h_3 = 0$$

$$hash = 2^0 \times h_1 + 2^1 \times h_2 + 2^2 \times h_3$$
$$= 1 \times 1 + 2 \times 1 + 4 \times 0$$
$$= 3$$

06 Approximated Nearest Neighbors

Multiple Sets of Random Planes

- Approximate nearest (friendly) neighbors



07 Searching Documents

Document Representation