# Number Recognition

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# Table of Contents

# What is it?

# Training and Recognition

- Training
  - Training sample $\rightarrow$ Data ($\in$ $n$-dimensional space)
  - Same number(training sample) $\rightarrow$ specific pattern
  - Building standard!
- Recognition
  - Determine class what test sample is in

# Training sample $\longrightarrow$ Data

The training sample(1, 0) in $4 \times 4$ form

$$\begin{matrix} 0 & x & 0 & 0 \\ 0 & x & 0 & 0 \\ 0 & x & 0 & 0 \\ 0 & x & 0 & 0 \end{matrix} \qquad \begin{matrix} 0 & x & x & x \\ 0 & x & 0 & x \\ 0 & x & 0 & x \\ 0 & x & x & x \end{matrix}$$

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convert...

$$\begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$$

can be mapped to 16-dimensional space

# Scheme

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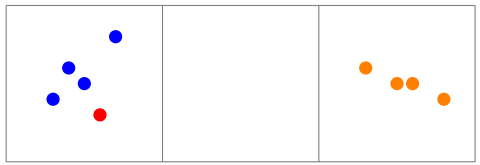

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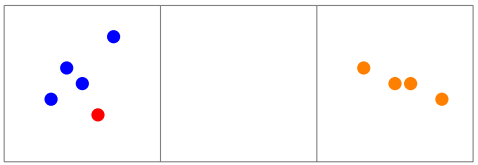

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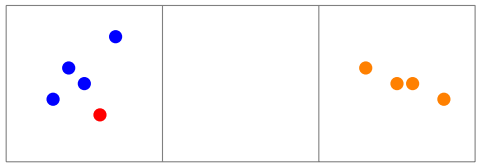

- Data(from training sample)

$$X_{\text{blue}} = [(0.5, 0.5), (0.4, 0.6), (0.3, 0.4), (0.7, 0.8)] \quad (1)$$
$$X_{\text{orange}} = [(2.6, 0.5), (2.3, 0.6), (2.5, 0.5), (2.8, 0.4)] \quad (2)$$

subscript of $X$ = the name of class
red point $(0.6, 0.3)$ = test sample

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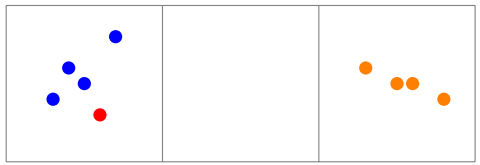

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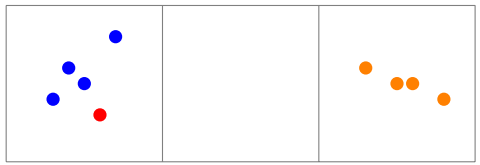

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- By training, standard = first value of data
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  between 2 and 3 $\rightarrow$ "orange" class
- By recognition, red point $\in$ "blue" class($\because 0 < 0.6 < 1$)

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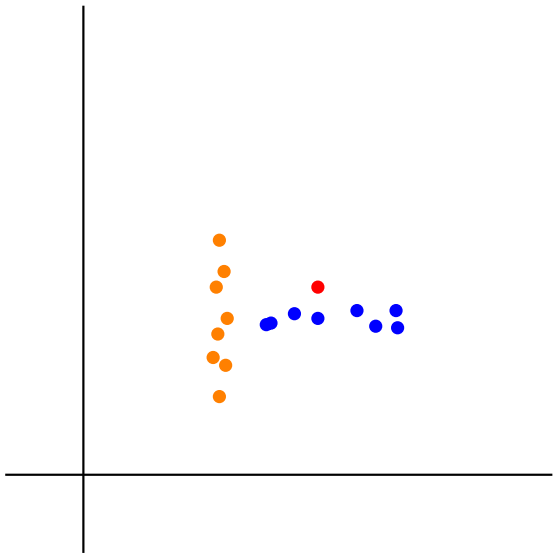

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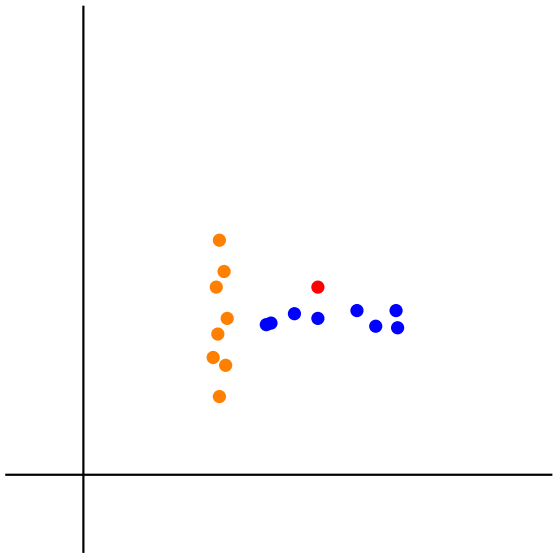

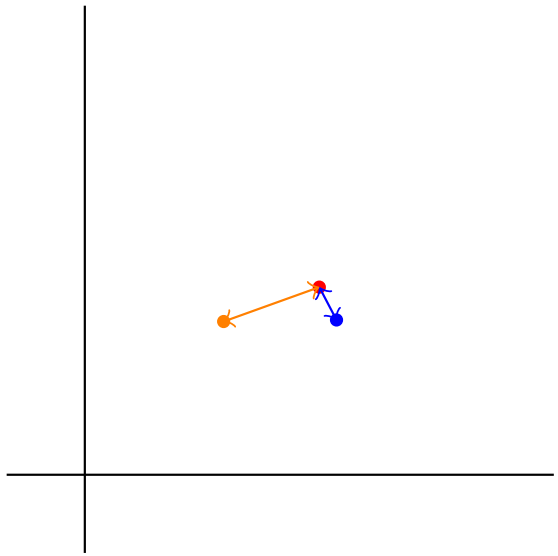

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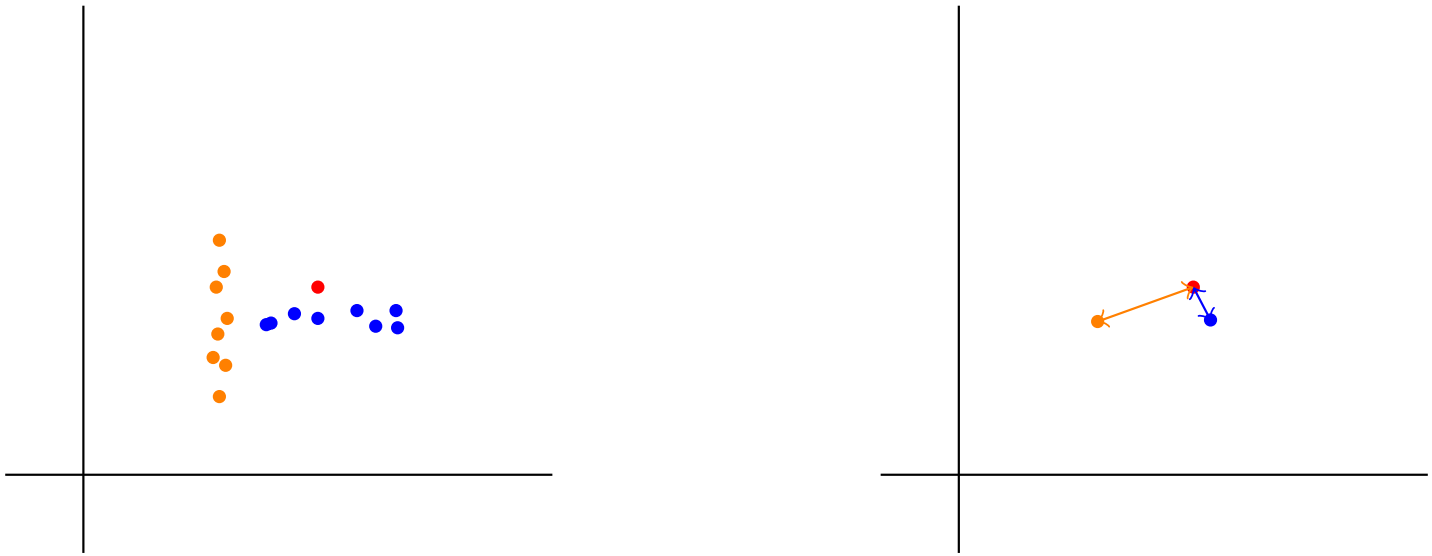

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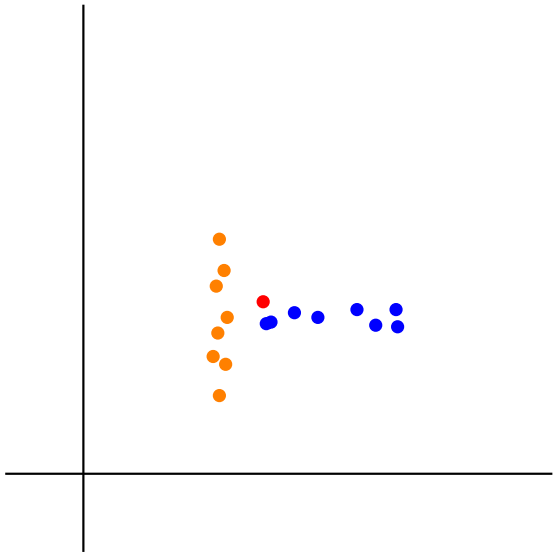
# Limitation



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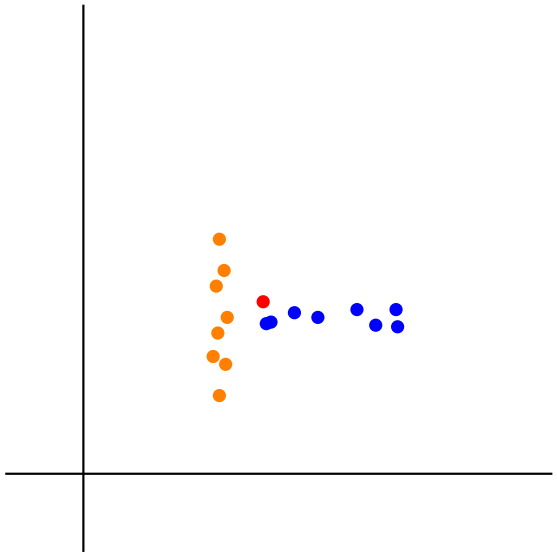

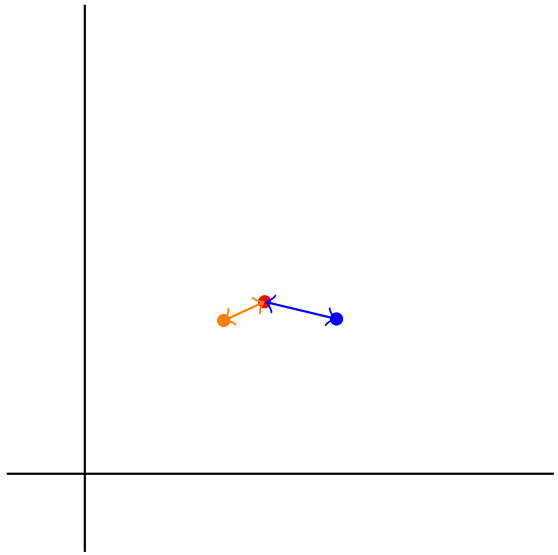

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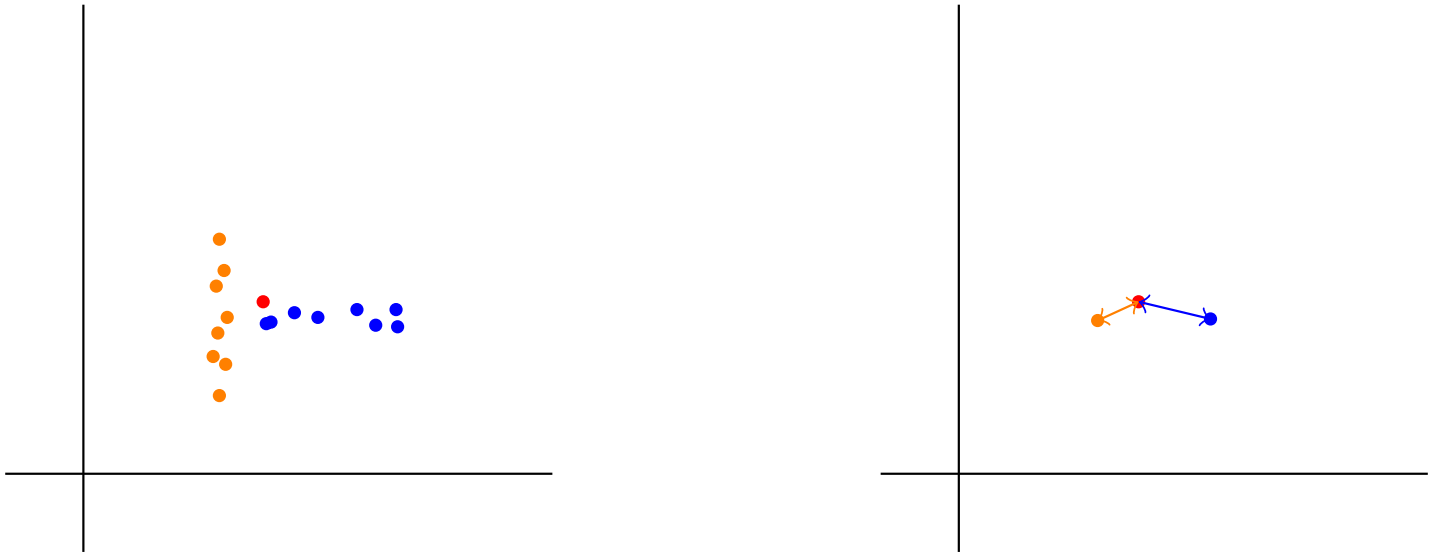

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$$\text{red point} \in \text{"blue" class}$$

# Covariance Matrix

- Definition of covariance matrix

$$C_{ij} = E\left[\left(X_i - E\left(X_i\right)\right)\left(X_j - E\left(X_j\right)\right)\right] \tag{3}$$

  Set

$$\lambda_{ik}, \lambda_{jk}, V_{ik}, V_{jk} \tag{4}$$

  as eigenvalue of $X_i$, $X_j$ and eigenvector of $X_i$, $X_j$ respectively.
- Large $\lambda_{ik} \longrightarrow$ sample data is well distributed along eigenvector $V_{ik}$ through long range.
- Dominant eigenvector : its eigenvalue largest one

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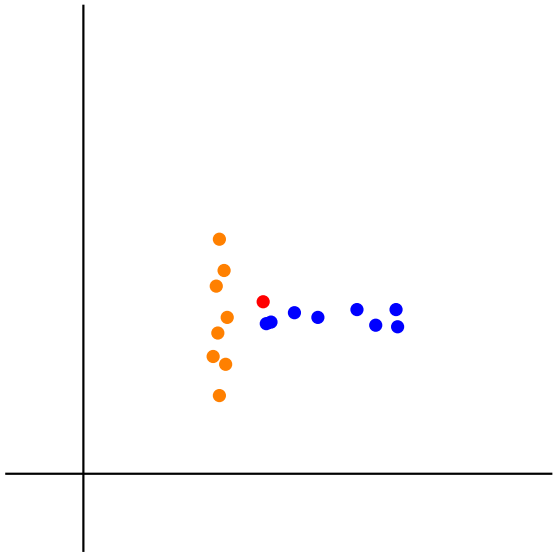

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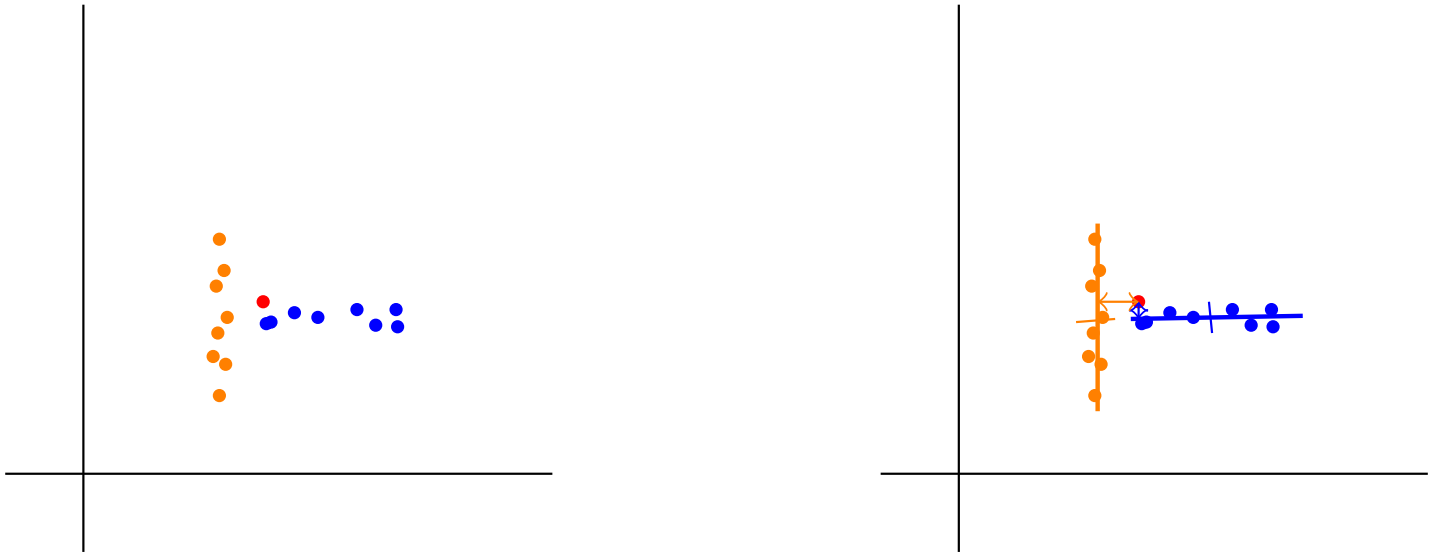

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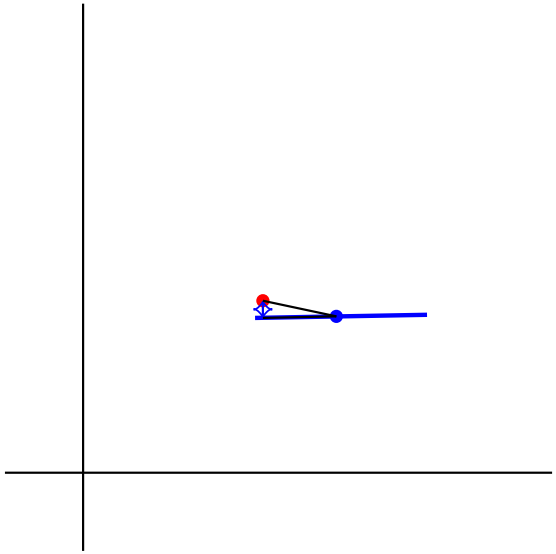

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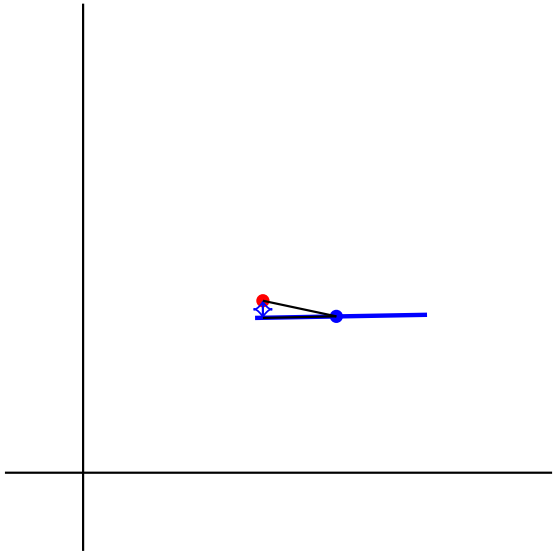

$$d^2 = |X - E(X_i)|^2 - \left(X \cdot V_{i(dominant)}\right)^2 \quad (5)$$

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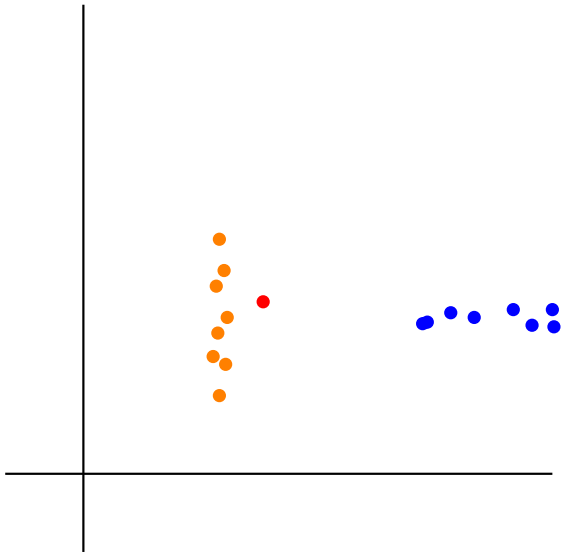

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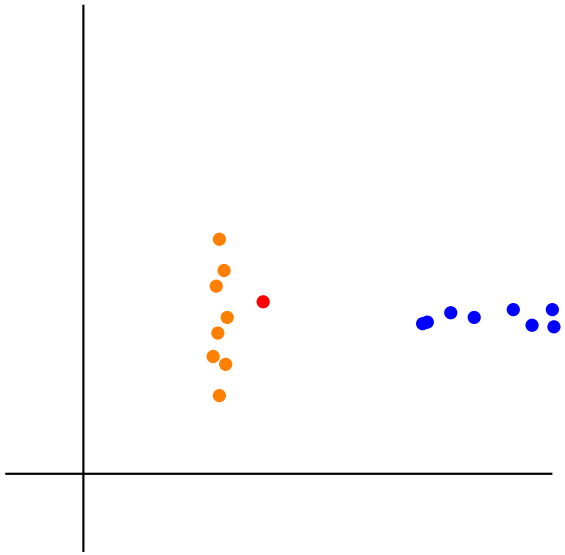

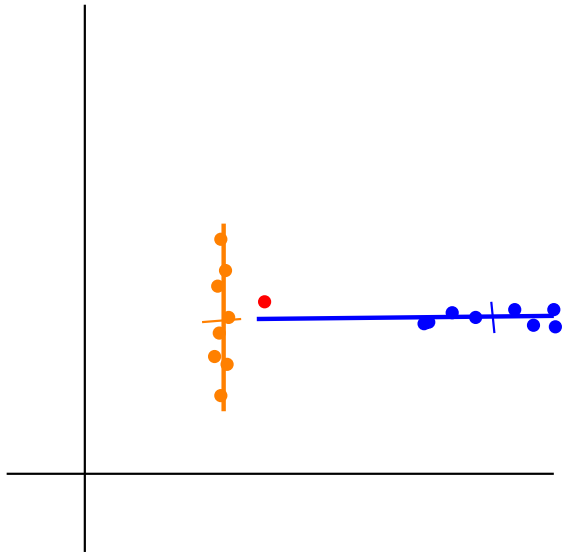

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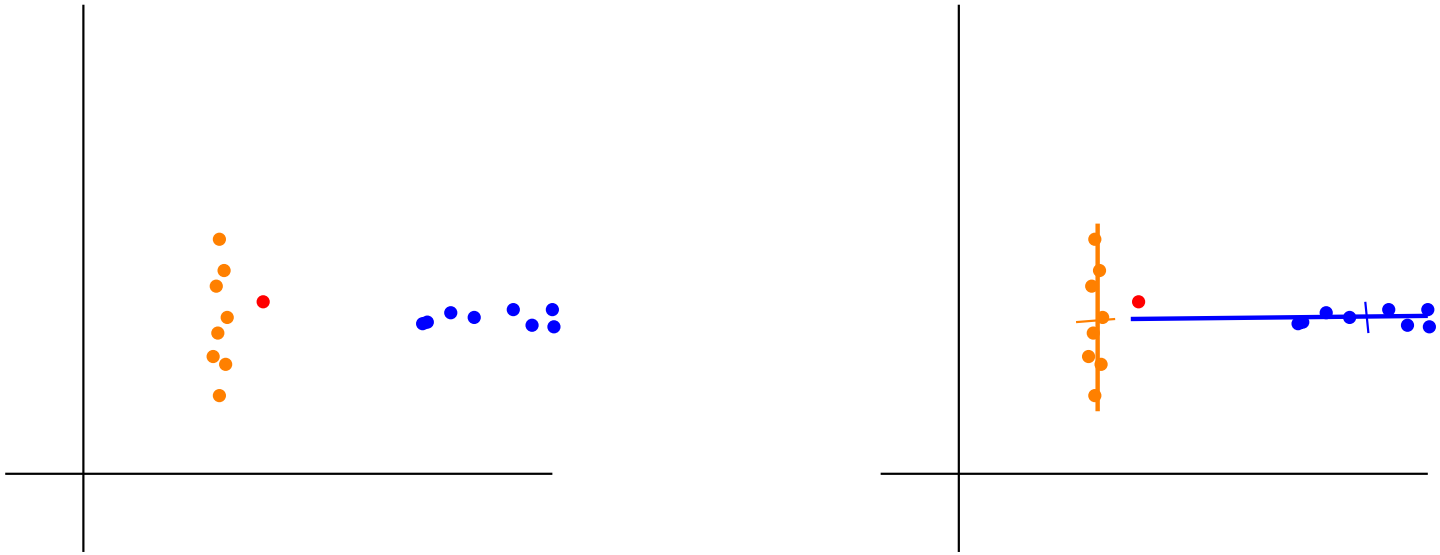

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$$\text{red point} \in \text{"blue" class}$$

The method using all eigenvectors will be give the solution of this problem.

# Probable application

Handwriting or any analogue data can be stored in electronic devices as meaningful code.