

# Principal component analysis

Principal component analysis is essentially boiling down multidimensional data with a lot of dimensions (aka columns) into a few dimensions while keeping **most** of the information.

Given  $n$   $m$ -dimensional vectors, steps to find the top  $k$  principal components:

1. Calculate the component-wise average of all of the vectors  $\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$
2. Form  $m \times m$  matrix  $S = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})(x_i - \bar{x})^T$
3. Calculate the  $m$ -dimensional eigenvectors associated with the largest  $k$  eigenvalues of  $S$ :  $v_1, \dots, v_k$  associated with  $\lambda_1, \dots, \lambda_k$
4. The  $k$  dimensional representation of  $x_i$  is then  $\hat{x}_i = (x_i^T v_1, \dots, x_i^T v_k)$

Another way to state the objective:

$$\min \sum_{i=1}^n \|x_i - \hat{x}_i\|^2$$

$$\max \sum_{i=1}^n \|\hat{x}_i\|^2$$

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