4. Motivation for Kernels: Computational Efficiency

Motivation for Kernels: Computational Efficiency

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Kernels as Dot Products 1

1/1 point (graded)
Let us go through the computation in the video above. Assume we map x and $x' \in \mathbb{R}^2$ to feature vectors $\phi(x)$ and $\phi(x')$ given by

$$\begin{aligned}\phi(x) &= \left[x_1,\, x_2,\, {x_1}^2,\, \sqrt{2}x_1x_2,\, {x_2}^2\right] \\ \phi(x') &= \left[x'_1,\, x'_2,\, {x'_1}^2,\, \sqrt{2}x'_1x'_2,\, {x'_2}^2\right].\end{aligned}$$

Which of the following equals the dot product $\phi(x) \cdot \phi(x')$?

- $x \cdot x'$
- $x \cdot x' + (x \cdot x')^2$
- $(x \cdot x')^2$
- $2(x \cdot x')^2$
- None of the above

✔

Solution:

Expand $\phi(x) \cdot \phi(x')$ to get

$$\begin{aligned}\phi(x) \cdot \phi(x') &= x_1x'_1 + x_2x'_2 + {x_1}^2{x'_1}^2 + 2x_1x'_1x_2x'_2 + {x_2}^2{x'_2}^2 \\ &= (x_1x'_1 + x_2x'_2) + (x_1x'_1 + x_2x'_2)^2\end{aligned}$$

$$= x \cdot x' + (x \cdot x')^2.$$

Remark: Notice the coefficient $\sqrt{2}$ of the $x_1 x_2$ terms is necessary for rewriting $\phi(x) \cdot \phi(x')$ as the function above of $x \cdot x'$.

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Answers are displayed within the problem

Kernels as Dot Products 2

1/1 point (graded)

Which of the following feature vectors $\phi(x)$ produces the kernel

$$K(x, x') = \phi(x) \cdot \phi(x') = x_1 x_1' + x_2 x_2' + x_3 x_3' + x_2 x_3' + x_3 x_2'$$

(Choose all that apply.)

- $\phi(x) = [x_1, x_2, x_3]$
- $\phi(x) = [x_1 + x_2 + x_3]$
- $\phi(x) = [x_1, x_2 + x_3]$
- $\phi(x) = [x_1 + x_3, x_1 + x_2]$

Solution:

Directly expand to see the answer. The fact that there are mixed terms in the kernel, e.g. $x_2 x_3'$, indicates that some coordinates of the feature vector must be mixed, i.e.

contain different x_i's.

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Kernels as Dot Products 2

The exercice mention "(Choose all that apply.)" while the answer is in a single answer form. T...

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