

<u>Help</u> smitha_kannur -

Course

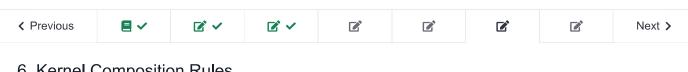
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☆ Course / Unit 2 Nonlinear Classification, Linear regression, Collaborative Filtering (2 weeks) / Lecture 6. Nonlinear Classification



6. Kernel Composition Rules

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Kernel Composition Rules



 <u>Start of transcript. Skip to the end.</u>

Now instead of directly constructing feature vectors

by adding coordinates and then taking it in the product

and seeing how it collapses into a kernel,

we can construct kernels directly from simpler kernels.

So here are simple composition rules for kernels.

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Kernel Composition Rules 1

1/1 point (graded)

Recall from the video above that if $f:\mathbb{R}^d o\mathbb{R}$ and K(x,x') is a kernel, so is

$$\widetilde{K}\left(x,x^{\prime}
ight)=f\left(x
ight)K\left(x,x^{\prime}
ight)f\left(x^{\prime}
ight).$$

If there exists $\phi\left(x\right)$ such that

$$K(x, x') = \phi(x) \cdot \phi(x'),$$

then which of the following arphi gives

$$\widetilde{K}\left(x,x'
ight)=arphi\left(x
ight)\cdotarphi\left(x'
ight)?$$

$$\bigcirc arphi \left(x
ight) =f\left(x
ight) K\left(x,x
ight)$$

$$\bigcirc \varphi \left(x
ight) =f\left(x
ight) K\left(x,x^{\prime }
ight)$$

$$\bigcirc \varphi \left(x
ight) =f\left(x
ight)$$

$$\bigcirc \varphi \left(x\right) =f\left(x\right) \phi \left(x\right)$$

Solution:

As $f\left(x\right),f\left(x'\right)\in\mathbb{R}, \text{ we have } \left(f\left(x\right)\phi\left(x\right)\right)\cdot\left(f\left(x'\right)\phi\left(x'\right)\right)=\widetilde{K}\left(x,x'\right). \text{ Hence } \varphi\left(x\right)=f\left(x\right)\phi\left(x\right) \text{ gives } \widetilde{K}\left(x,x'\right)=\varphi\left(x\right)\cdot\varphi\left(x'\right).$

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You have used 1 of 2 attempts

1 Answers are displayed within the problem

Kernel Composition Rules 2

1/1 point (graded)

Let x and x' be two vectors of the same dimension. Use the the definition of kernels and the kernel composition rules from the video above to decide which of the following are kernels. (Note that you can use feature vectors $\phi\left(x\right)$ that are not polynomial.)

(Choose all those apply.)





$$\checkmark 1 + x \cdot x'$$

$$\checkmark (1 + x \cdot x')^2$$

$$arphi \exp{(x+x')}$$
, for x , $x' \in \mathbb{R}$

$$igcap \min{(x,x')}$$
 , for x , $x'\in\mathbb{Z}$



Solution:

We go through the choices in order:

- Yes, for $\phi(x) = 1$.
- Yes, for $\phi(x) = x$.
- ullet Yes, since the sum of kernels are kernels. In this case, we can also easily see $\phi\left(x
 ight)=\left[1,x
 ight]^T$ works.
- Yes, since the product of kernels are kernels. (In this case, factoring the kernel as dot products are more involved, and the composition rule saves this work.)
- Yes, for $\phi(x) = \exp(x)$.
- ullet No. For example, $\min{(-1,-1)}=-1<0$ and hence cannot be written as a dot product and is not a valid kernel

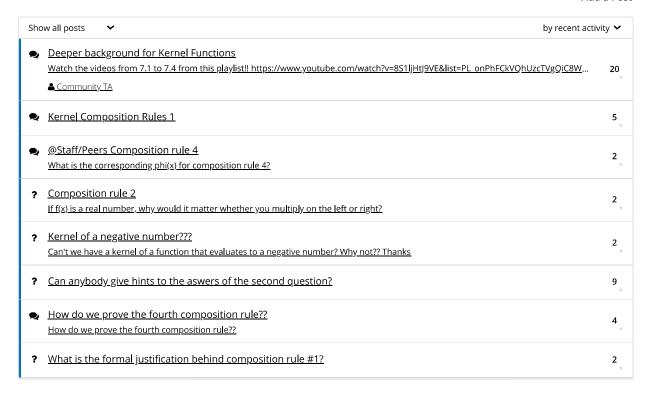
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