Week 10 Lecture

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Explanation: Connection between the optimization problem and eigendecomposition (lec. 19 p 5)

discussion posted 2 days ago by **TingxunShi**

Hi all,

In the 5th slide of Lecture 19, after giving the final description of the optimization problem the professor directly jumps to the eigendecomposition problem. Although it might be very obvious, for me such a math noob cannot get the point. So I asked a friend who is majored in math (special thanks to him!) and get an explanation here, hope it could help:

Given the original optimization problem

$$q = \arg\max_q q^T(XX^T)q \quad \text{subject to } q^T q = 1$$

Let us introduce the Lagrange multiplier, so it turns to

$$\mathcal{L} = q^T(XX^T)q + \lambda(1 - q^T q)$$

Differentiate on q we get

$$\nabla\mathcal{L}_q = 2XX^T q - 2q\lambda$$

Therefore the solution on q satisfies

$$XX^T q = \lambda q$$

which is also the definition of eigenvalue and eigenvector. Besides since

Quiz due Apr 11, 2017 05:00 IST

Week 10 Discussion Questions

$$\begin{aligned} q^T(XX^T)q &= q^T\lambda q \;\; (\because (XX^T)q = \lambda q) \\ &= \lambda q^T q \\ &= \lambda \;\; (\because q^T q = 1) \end{aligned}$$

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2 responses

sakigami
2 days ago

Thx for sharing this. It helps me so much.

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TingxunShi
2 days ago

So if we want to maximize $q^T(XX^T)q$ we just need to maximize λ, thus we get the biggest eigenvalue ■

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