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11.3.6 Solving the Linear Least-Squares Problem via QR Factorization

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Week 11 due Dec 22, 2023 21:12 IST Completed

11.3.6 Solving the Linear Least-Squares Problem via QR Factorization

Video

Start of transcript. Skip to the end.

Dr. Robert van de Geijn: We now look at how the QR factorization can be used to solve the linear least squares problem. So recall that we're given a system Ax equals b . Except that b is not necessarily in the column space of A , and therefore, the best we can hope for

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Reading Assignment

0 points possible (ungraded)
Read Unit 11.3.6 of the notes. [\[LINK\]](#)

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Calculator

Homework 11.3.6.1

4/4 points (graded)

In Homework 11.3.4.1 you were asked to consider $A = \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 1 \end{pmatrix}$ and compute an orthonormal basis for $\mathcal{C}(A)$.

In Homework 11.3.5.1 you were then asked to compute the QR factorization of that matrix. Of course, you could/should have used the results from Homework 11.3.4.1 to save yourself calculations. The result was the following factorization $A = QR$:

$$\left(\begin{array}{c|c} 1 & 0 \\ 0 & 1 \\ 1 & 1 \end{array} \right) = \left(\begin{array}{c|c} \frac{1}{\sqrt{2}} \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} & \frac{\sqrt{2}}{\sqrt{3}} \begin{pmatrix} -\frac{1}{2} \\ 1 \\ \frac{1}{2} \end{pmatrix} \end{array} \right) \left(\begin{array}{c|c} \sqrt{2} & \frac{1}{\sqrt{2}} \\ 0 & \frac{\sqrt{3}}{\sqrt{2}} \end{array} \right)$$

Now, compute the “best” solution (in the linear least-squares sense), \hat{x} , to

$$\begin{pmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 1 \end{pmatrix} \begin{pmatrix} x_0 \\ x_1 \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}.$$

(This is the same problem as in Homework 10.4.2.1.)

1/sqrt(2)

$\frac{1}{\sqrt{2}}$

1/sqrt(6)

$\frac{1}{\sqrt{6}}$

✓ Answer: 1/sqrt(2)

✓ Answer: sqrt(2)/(2 * sqrt(3))

$u = Q^T b =$

•

$$\left(\begin{array}{c|c} \frac{1}{\sqrt{2}} \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} & \frac{\sqrt{2}}{\sqrt{3}} \begin{pmatrix} -\frac{1}{2} \\ 1 \\ \frac{1}{2} \end{pmatrix} \end{array} \right)^T \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix} = \begin{pmatrix} \frac{1}{\sqrt{2}} \\ \frac{\sqrt{2}}{2\sqrt{3}} \\ 0 \end{pmatrix}$$

- The solution to $R\hat{x} = u$ is

1/3

$\frac{1}{3}$


1/3

$\frac{1}{3}$

✓ Answer: 1/3

✓ Answer: 1/3

$$\left(\begin{array}{c|c} \sqrt{2} & \frac{1}{\sqrt{2}} \\ 0 & \frac{\sqrt{3}}{\sqrt{2}} \end{array} \right) \begin{pmatrix} \hat{x}_0 \\ \hat{x}_1 \end{pmatrix} = \begin{pmatrix} \frac{1}{\sqrt{2}} \\ \frac{\sqrt{2}}{2\sqrt{3}} \end{pmatrix}$$

 Calculator

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3/4

or

$$\begin{pmatrix} \hat{x}_0 \\ \hat{x}_1 \end{pmatrix} = \begin{pmatrix} 1/3 \\ 1/3 \end{pmatrix}$$

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Calculator