11.3.5 The QR Factorization

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

11.3.5 The QR Factorization

Video

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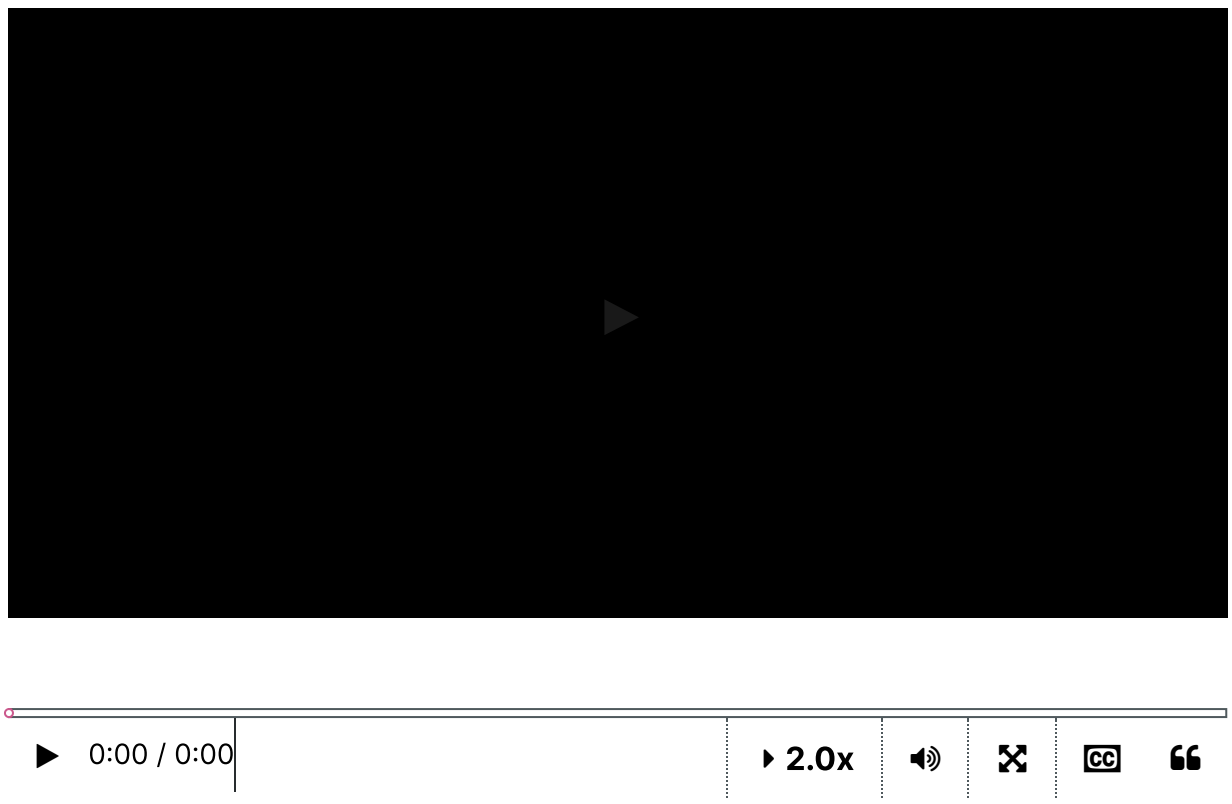

Dr. Robert van de Geijn
We saw the LU factorization in week six.
We then modified that to become the LU factorization
with partial pivoting in week seven.
And then the enrichment for week eight, we
talked about the Cholesky factorization.

Video

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Reading Assignment

0 points possible (ungraded)
Read Unit 11.3.5 of the notes. [LINK]

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Homework 11.3.5.1

11/11 points (graded)

Consider $A = \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 1 \end{pmatrix}$.

- Compute the QR factorization of this matrix.

$Q =$

1/sqrt(2) ✔

Answer: 1/sqrt(2)

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

0 ✔

Answer: 0

0

1/sqrt(2) ✔

Answer: 1/sqrt(2)

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

-1/sqrt(6) ✔

Answer: -sqrt(2)/(2*sqrt(3))

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

sqrt(2/3) ✔

Answer: sqrt(2)/sqrt(3)

$\sqrt{\frac{2}{3}}$

1/sqrt(6) ✔

Answer: sqrt(2)/(2*sqrt(3))

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

$R =$

sqrt(2) ✔

Answer: sqrt(2)

$\sqrt{2}$

0 ✔ Answer: 0

0

1/sqrt(2) ✔

Answer: 1/sqrt(2)

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

sqrt(3/2) ✔

Answer: sqrt(3)/sqrt(2)

$\sqrt{\frac{3}{2}}$

Notice that this is the same matrix as in Homework 11.3.4.1. Thus, it is a matter of taking the results and plugging them into the matrices Q and R:

$$\begin{pmatrix} a_0 & a_1 \end{pmatrix} = \begin{pmatrix} q_0 & q_1 \end{pmatrix} \begin{pmatrix} \rho_{0,0} & \rho_{0,1} \\ 0 & \rho_{1,1} \end{pmatrix}.$$

From Homework 11.3.4.1 we then get that

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

- Check that $QR = A$.

☑ Done

Calculator

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Answers are displayed within the problem

Homework 11.3.5.2

11/11 points (graded)

Consider $A = \begin{pmatrix} 1 & 1 \\ 1 & -1 \\ -2 & 4 \end{pmatrix}$.

- Compute the QR factorization of this matrix.

$Q =$

1/sqrt(6) ✔ Answer: 1/sqrt(6)

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

7/sqrt(66) ✔ Answer: 7/sqrt(66)

$\frac{7}{\sqrt{66}}$

1/sqrt(6) ✔ Answer: 1/sqrt(6)

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

1/sqrt(66) ✔ Answer: 1/sqrt(66)

$\frac{1}{\sqrt{66}}$

-2/sqrt(6) ✔ Answer: -2/sqrt(6)

$-\frac{2}{\sqrt{6}}$

4/sqrt(66) ✔ Answer: 4/sqrt(66)

$\frac{4}{\sqrt{66}}$

$R =$

sqrt(6) ✔ Answer: sqrt(6)

$\sqrt{6}$

-8/sqrt(6) ✔ Answer: -8/sqrt(6)

$-\frac{8}{\sqrt{6}}$

0 ✔ Answer: 0

0

sqrt(66)/3 ✔ Answer: sqrt(66)/3

$\frac{\sqrt{66}}{3}$

Notice that this is the same matrix as in Homework 11.3.4.3. Thus, it is a matter of taking the results and plugging them into the matrices Q and R:

$$\begin{pmatrix} a_0 & a_1 \end{pmatrix} = \begin{pmatrix} q_0 & q_1 \end{pmatrix} \begin{pmatrix} \rho_{0,0} & \rho_{0,1} \\ 0 & \rho_{1,1} \end{pmatrix}.$$

From Homework 11.3.4.3 we then get that

$$\left(\begin{array}{c|c} 1 & 1 \\ 1 & -1 \\ -2 & 4 \end{array}\right) = \left(\begin{array}{c|c} \frac{1}{\sqrt{6}}\begin{pmatrix} 1 \\ 1 \\ -2 \end{pmatrix} & \frac{1}{\sqrt{66}}\begin{pmatrix} 7 \\ 1 \\ 4 \end{pmatrix} \end{array}\right) \left(\begin{array}{c|c} \sqrt{6} & \frac{-8}{\sqrt{6}} \\ \hline 0 & \frac{\sqrt{66}}{3} \end{array}\right)$$

Calculator

- Check that $QR = A$.

Done

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