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Next >

<u>Course</u> <u>Progress</u> <u>Dates</u> <u>Discussion</u> <u>Syllabus</u> <u>Outline</u> <u>laff routines</u> <u>Community</u>

☆ Course / Week 11: Orthogonal Projection, Low Rank Appro... / 11.2 Projecting a Vector ...

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11.2.3 Projection onto a Subspace

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< Previous

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

## 11.2.3 Projection onto a Subspace

#### No video for this unit.

### Reading Assignment

0 points possible (ungraded) Read Unit 11.2.3 of the notes. [LINK]



Done



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✓ Correct

#### Discussion

**Topic:** Week 11 / 11.2.3

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#### Homework 11.2.3.1

7/7 points (graded)

Consider 
$$A=egin{pmatrix}1&1\1&-1\-2&4\end{pmatrix}$$
 and  $b=egin{pmatrix}1\2\7\end{pmatrix}$  .

1. Find the projection of  $\boldsymbol{b}$  onto the column space of  $\boldsymbol{A}$ .

2.090909

✓ Answer: 92/44

-1.272727

✓ Answer: -56/44

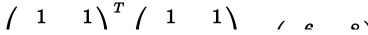
5.909091

✓ Answer: 260/44

The formula for the projection, when  $m{A}$  has linearly independent columns, is

$$A(A^TA)^{-1}A^Tb.$$

Now





$$A^{T}A = \begin{pmatrix} 1 & -1 \\ -2 & 4 \end{pmatrix} \begin{pmatrix} 1 & -1 \\ -2 & 4 \end{pmatrix} = \begin{pmatrix} 0 & -8 \\ -8 & 18 \end{pmatrix}$$

$$(A^{T}A)^{-1} = \frac{1}{(6)(18) - (-8)(-8)} \begin{pmatrix} 18 & 8 \\ 8 & 6 \end{pmatrix} = \frac{1}{44} \begin{pmatrix} 18 & 8 \\ 8 & 6 \end{pmatrix}$$

$$A^{T}b = \begin{pmatrix} 1 & 1 \\ 1 & -1 \\ -2 & 4 \end{pmatrix}^{T} \begin{pmatrix} 1 \\ 2 \\ 7 \end{pmatrix} = \begin{pmatrix} -11 \\ 27 \end{pmatrix}$$

$$(A^{T}A)^{-1}A^{T}b = \frac{1}{44} \begin{pmatrix} 18 & 8 \\ 8 & 6 \end{pmatrix} \begin{pmatrix} -11 \\ 27 \end{pmatrix} = \frac{1}{44} \begin{pmatrix} 18 \\ 74 \end{pmatrix}$$

$$A(A^{T}A)^{-1}A^{T}b = \frac{1}{44} \begin{pmatrix} 1 & 1 \\ 1 & -1 \\ -2 & 4 \end{pmatrix} \begin{pmatrix} 18 \\ 74 \end{pmatrix} = \frac{1}{44} \begin{pmatrix} 92 \\ -56 \\ 260 \end{pmatrix}$$

which I choose not to simplify...

2. Split b into z + w where z is in the column space and w is perpendicular (orthogonal) to that space.

Notice that  $z = A{(A^TA)}^{-1}A^Tb$  so that

$$w = b - A{(A^TA)}^{-1}A^Tb = egin{pmatrix} 1 \ 2 \ 7 \end{pmatrix} - rac{1}{44} egin{pmatrix} 92 \ -56 \ 260 \end{pmatrix}.$$

3. Which of the four subspaces  $C\left(A\right)$ ,  $R\left(A\right)$ ,  $\mathcal{N}\left(A\right)$ ,  $\mathcal{N}\left(A^{T}\right)$  contains w?



This vector is orthogonal to the column space and therefore is in the left null space of A:  $w\in\mathcal{N}\left(A^{T}
ight)$ .

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• Answers are displayed within the problem

Previous

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