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4. Robot Arm 2

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Problem Set B due Sep 15, 2021 20:30 IST



Practice

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Use the matrix 1

2/2 points (graded)

Use your linearization to answer the following questions. Enter exact expressions, or round to three decimal places.

1. How much will the tip of the robot move horizontally to the right if $heta_1$ is increased by 0.1, with $heta_2$ left alone?

-0.1- 0.1*sqrt(2)

✓ Answer: 1/10*(-sqrt(2)-1)

2. How much will the tip of the robot move vertically upwards if θ_1 is increased by 0.1, with θ_2 left alone?

0.1*sqrt(2)

✓ Answer: sqrt(2)/10

Solution:

The resulting changes in \boldsymbol{x} and \boldsymbol{y} are obtained by the matrix product:

$$\begin{pmatrix} -\sqrt{2} - 1 & -1 \\ \sqrt{2} & 0 \end{pmatrix} \begin{pmatrix} 0.1 \\ 0 \end{pmatrix} = \begin{pmatrix} -0.1\sqrt{2} - 0.1 \\ 0.1\sqrt{2} \end{pmatrix}$$
 (5.223)

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You have used 1 of 3 attempts

1 Answers are displayed within the problem

Use the matrix 2

2/2 points (graded)

Use your linearization to answer the following questions. Enter exact expressions, or round to three decimal places.

1. How much will the tip of the robot move horizontally to the right if $heta_1$ is increased by 0.1 and $heta_2$ is also increased by 0.1?

-0.2- 0.1*sqrt(2)

✓ Answer: 1/10*(-sqrt(2)-2)

2. How much will the tip of the robot move vertically upwards if $heta_1$ is increased by 0.1 and $heta_2$ is also increased by 0.1?

14cart(2)

✓ Answer: sart(2)/10

■ Calculator

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Solution:

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The resulting changes in x and y are obtained by the matrix product:

$$\begin{pmatrix} \sqrt{2} - 1 & -1 \\ \sqrt{2} & 0 \end{pmatrix} \begin{pmatrix} 0.1 \\ 0.1 \end{pmatrix} = \begin{pmatrix} -0.1\sqrt{2} - 0.2 \\ 0.1\sqrt{2} \end{pmatrix}$$
 (5.224)

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Use the matrix 3

1/1 point (graded)

Your linearization matrix should have exactly one zero in it. Which of the following is the correct interpretation of this zero?

- If $heta_1$ changes a little bit, the robot's $m{y}$ coordinate will stay almost constant.
- If $heta_2$ changes a little bit, the robot's $m{x}$ coordinate will stay almost constant.
- If $heta_1$ changes a little bit, the robot's $m{x}$ coordinate will stay almost constant.
- If $oldsymbol{ heta_2}$ changes a little bit, the robot's $oldsymbol{y}$ coordinate will stay almost constant.



Solution:

The zero is in the lower-right entry of the matrix $m{M}$. This means that when we apply the matrix to a vector such $m{k}$), the resulting vector will have its second entry equal to zero, for any $m{k}$. In terms of the problem, this means that when $heta_2$ changes, the y coordinate will stay almost constant.

Looking at it another way, when $(\theta_1,\theta_2)=(\pi/4,\pi/4)$, the robot tip is pointing straight up. Therefore, we could say that the y-coordinate of the robot is at a local maximum with respect to $heta_2$. This explains why that derivative would be zero at that point.

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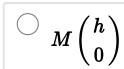
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Use the matrix 4

1/1 point (graded)

Let $m{M}$ be the linearization computed above. Suppose we wish to move the tip of the robot arm straight up by a small amount, h. We will need to change $heta_1$ and $heta_2$ by small amounts, $\Delta heta_1$ and $\Delta heta_2$. Which of the following gives

the desired value of $\left(rac{\Delta heta_1}{\Delta heta_2}
ight)$?







$$\bigcap_{M^{-1}} \binom{h}{0}$$

$$\bullet _{M^{-1}} \left(\begin{smallmatrix} 0 \\ h \end{smallmatrix} \right)$$



Solution:

Since we want $\Delta x=0$ and $\Delta y=h$, we know that we want Mec v to equal $\begin{pmatrix} 0 \\ h \end{pmatrix}$ for some ec v. Therefore, the value of ec v is given by $M^{-1}\begin{pmatrix} 0 \\ h \end{pmatrix}$.

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Use the matrix 5

2/2 points (graded)

Find the values of $\Delta\theta_1$ and $\Delta\theta_2$ that will cause the tip of the robot arm to move 0.2 units straight up. This is a special case h=0.2 of the previous problem.

Solution:

The inverse of $oldsymbol{M}$ is given by

$$M^{-1} \frac{1}{\sqrt{2}} \begin{pmatrix} 0 & 1 \\ -\sqrt{2} & -\sqrt{2} - 1 \end{pmatrix} \tag{5.225}$$

From the matrix product,

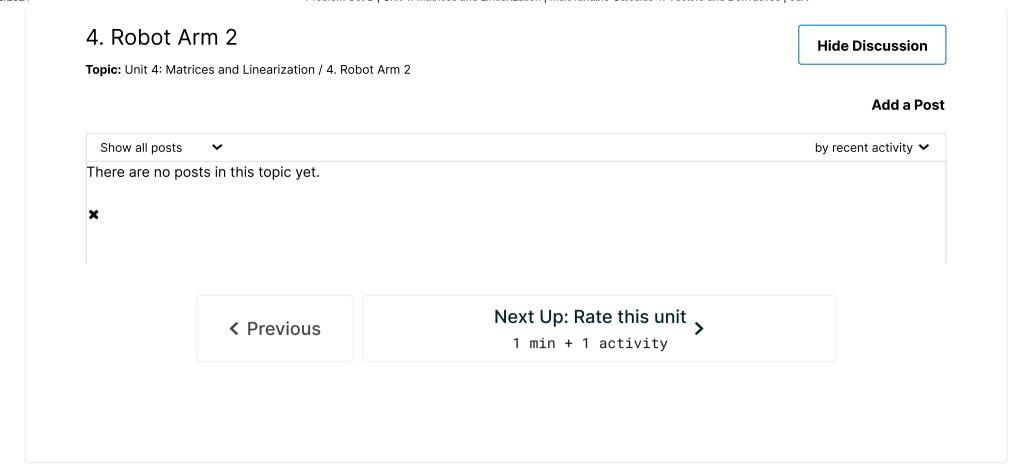
$$M^{-1}\begin{pmatrix}0\\0.2\end{pmatrix} = \frac{1}{\sqrt{2}}\begin{pmatrix}0.2\\-0.2\sqrt{2} - 0.2\end{pmatrix}$$
 (5.226)

we see that $\Delta heta_1$ should be $0.2/\sqrt{2}$ and $\Delta heta_2$ should be $\frac{-0.2\sqrt{2}-0.2}{\sqrt{2}}$.

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