Humanoid Robotics. Exercise Sheet 9 - Reachability maps and bipedal walking

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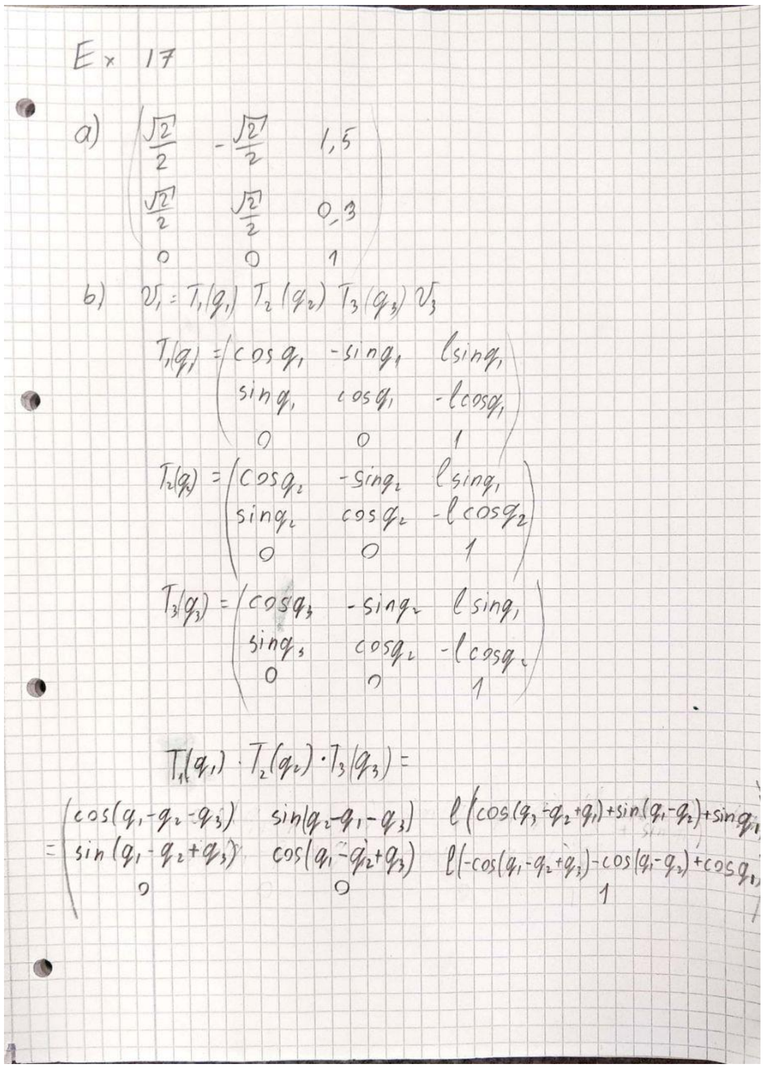
1 Exercise 17



Ex 17

a) $\begin{pmatrix} \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & 1{,}5 \\ \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & 0{,}3 \\ 0 & 0 & 1 \end{pmatrix}$

b) $v_1 = T_1(q_1)\, T_2(q_2)\, T_3(q_3)\, v_3$

$$T_1(q_1) = \begin{pmatrix} \cos q_1 & -\sin q_1 & l \sin q_1 \\ \sin q_1 & \cos q_1 & -l \cos q_1 \\ 0 & 0 & 1 \end{pmatrix}$$

$$T_2(q_2) = \begin{pmatrix} \cos q_2 & -\sin q_2 & l \sin q_1 \\ \sin q_2 & \cos q_2 & -l \cos q_2 \\ 0 & 0 & 1 \end{pmatrix}$$

$$T_3(q_3) = \begin{pmatrix} \cos q_3 & -\sin q_2 & l \sin q_1 \\ \sin q_3 & \cos q_2 & -l \cos q_2 \\ 0 & 0 & 1 \end{pmatrix}$$

$$T_1(q_1) \cdot T_2(q_2) \cdot T_3(q_3) =$$

$$= \begin{pmatrix} \cos(q_1 - q_2 - q_3) & \sin(q_2 - q_1 - q_3) & l(\cos(q_3 - q_2 + q_1) + \sin(q_1 - q_2) + \sin q_1 \\ \sin(q_1 - q_2 + q_3) & \cos(q_1 - q_2 + q_3) & l(-\cos(q_1 - q_2 + q_3) - \cos(q_1 - q_2) + \cos q_1 \\ 0 & 0 & 1 \end{pmatrix}$$

Figure 1: Exercise 17

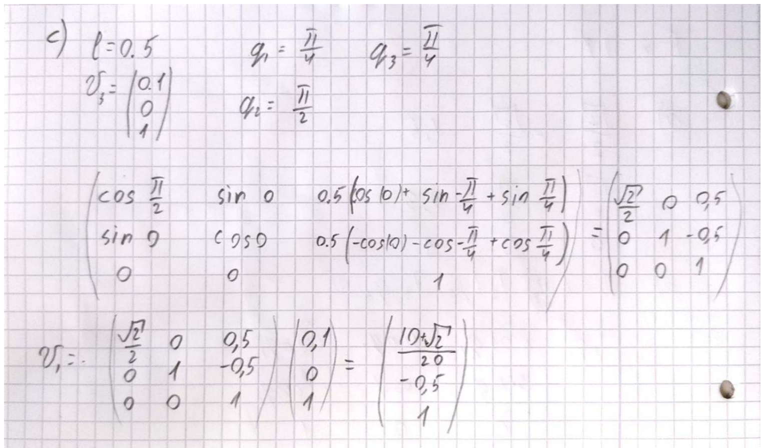


Figure 2: Exercise 17

2 Exercise 18

- a) What observation can you make in the [0-1] second range?

  In first second we can observe, that Linearized Inverted Pendulum Model (LIPM) makes bad prediction, but Locally Linearized Inverted Pendulum Model (LLIPM) still has good results.

- b) What observation can you make in the [1-3] second range?

  In first 3 seconds we can observe, that both models cannot predict the angle after three seconds.

- c) Now change the initial angle to theta = 1.2 and repeat the experiment. Produce a second plot. In what way did the outcome change? Insert the plot in the pdf.

  Now both model cannot predict the angle even after a second.

- d) Still using C = 10, assume a 2D linear inverted pendulum model with an initial state of (x=-1.0, dot x = 1.0; y = 1.0, dot y = -1.0). At what time is the pendulum going to reach a lateral position of y = 2.0?

  Newer, because if it is in the state (-1, 1), then the radius of the pendulum is $\sqrt{2}$

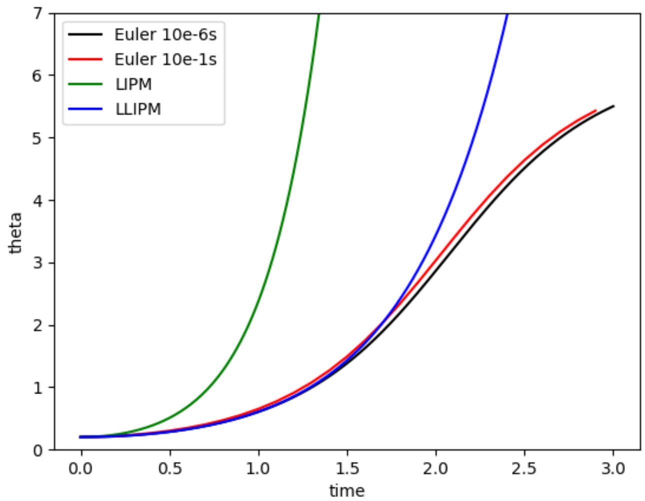


Figure 3: Theta = 0.2

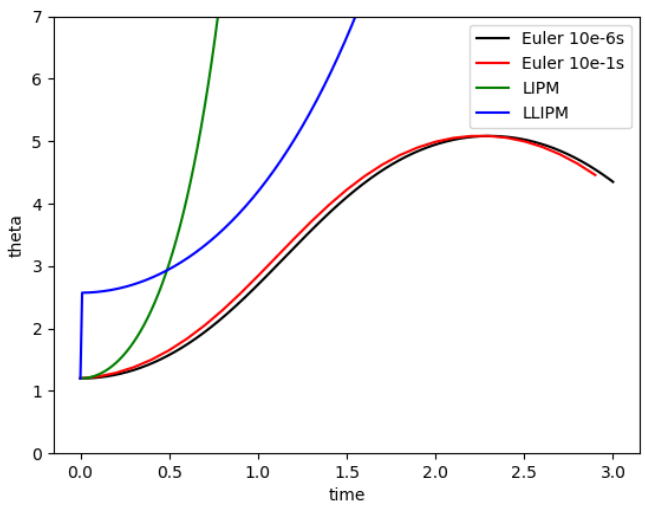


Figure 4: Theta = 1.2

3 Exercise 19

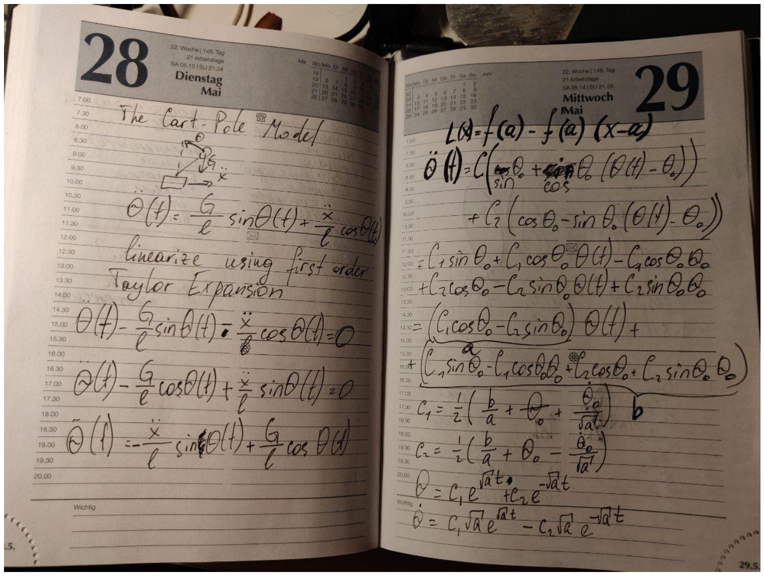


Figure 5: Exercise 19