Assignment - 2

1

(a) The screw axes S_i in $\{0\}$ are

	ω_i	v_i
$\{0\}$	$(0,0,0)$	$(0,0,0)$
$\{1\}$	$(0,0,1)$	$(0,0,0)$
$\{2\}$	$(0,0,1)$	$(l_1,0,0)$
$\{3\}$	$(0,0,1)$	$(l_1+l_2,0,0)$
$\{b\}$	$(0,0,0)$	$(0,0,1)$.

& M is

$$M=\begin{bmatrix}1&0&0&0\\0&1&0&l_1+l_2\\0&0&1&l_0\\0&0&0&1\end{bmatrix}$$

The screw axes in $\{b\}$ are

	ω_i	v_i
$\{b\}$	$(0,0,0)$	$(0,0,1)$
$\{3\}$	$(0,0,1)$	$(0,0,0)$
$\{2\}$	$(0,0,1)$	$(-l_2,0,0)$
$\{1\}$	$(0,0,1)$	$(0-l_1-l_2,0,0)$
$\{0\}$	$(0,0,0)$	$(-l_1-l_2,0,0)$

(b) The final answer obtained using matlab is

$$T=\begin{bmatrix}1&0&0&-1\\0&1&0&1\\0&0&1&2\\0&0&0&1\end{bmatrix}$$

(2)

(a) The screw axes for the RRP robot are

	w_i	v_i
{1}	(0, 0, 1)	(0, 0, 0)
{2}	(1, 0, 0)	(0, 2, 0)
{3}	(0, 0, 0)	(0, 1, 0)

By Inspection $M = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 3 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ — (1)

The forward kinematics computed are.

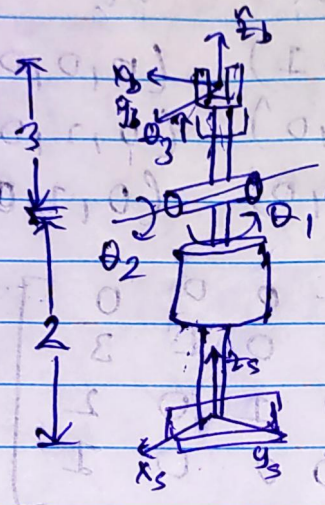
when $\theta = (90, 90, 1)$ the forward kinematics are

$$T(\theta) = e^{[S_2]\theta} e^{[S_1]\theta} e^{[S_3]\theta} M$$

evaluating this expression in matlab gives

$$T(\theta) = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 6 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

(a) The Space Jacobian for this configuration is the screw axes when the robot is in the configuration



for $J_s(\theta)$: ω_i v_i

$\{1\}$ $(0,0,1)$ $(0,0,0)$

$\{2\}$ $(0,1,0)$ $(-2,0,0)$

$\{3\}$ $(0,0,0)$ $(0,0,1)$

$$J_s(\theta) = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

(b) The forward kinematics at $\theta = (90, 90,$ in the body frame are

w_i $\quad v_i = \vec{q} \times \vec{\omega}$

	w_i	v_i
{1}	(0, 1, 0)	(3, 0, 0)
{2}	(-1, 0, 0)	(0, 3, 0)
{3}	(0, 0, 0)	(0, 0, 1)

The forward kinematics computed on matlab are $\theta = (90, 90, 1)$

$$T(\theta) = M e^{[B_1]\theta_1} e^{[B_2]\theta_2} e^{[B_3]\theta_3}$$

$$T(\theta) = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 6 \\ 0 & 0 & 0 & 1 \end{bmatrix} \text{ for } M \text{ in (2)}$$

The space Jacobian J_b is

		w_i	v_i
$V_b = J_b(\theta)$	{1}	(0, 0, 1)	(0, 0, 0)
	{2}	(-1, 0, 0)	(0, 3, 0)
	{3}	(0, 0, 0)	(0, 0, 1)

$$\therefore J_b(\theta) = \begin{bmatrix} 0 & -1 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \\ 6 & 3 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

(8) Member of Project

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% Assignment 2 - Question 1, Forward Kinematics
clear all;
%lengths
l0 = 1;
l1 = 1;
l2 = 1;
%M
M = [1, 0, 0, 0;
    0, 1, 0, l1+l2;
    0, 0, 1, l0;
    0, 0, 0, 1];
%Screw Axes
S1 = [0,0,1,0,0,0];
S2 = [0,0,1,l1,0,0];
S3 = [0,0,1,l1+l2,0,0];
S4 = [0,0,0,0,0,1];
Slist = [S1', S2', S3', S4'];
%Body Axes
B1 = [0,0,1,-(l1+l2),0,0];
B2 = [0,0,1,-l2,0,0];
B3 = [0,0,1,0,0,0];
B4 = [0,0,0,0,0,1];
Blist = [B1', B2', B3', B4'];
%thetalist
thetalist = [0;pi/2;-pi/2;1];
%Configuration Space frame
Ts = FKinSpace(M,Slist,thetalist);
%Configuration Body Frame
Tb = FKinBody(M,Blist,thetalist);

% OUTPUT
% Ts =
%
%      1     0     0    -1
%      0     1     0     1
%      0     0     1     2
%      0     0     0     1
%
%
% Tb =
%
%      1     0     0    -1
%      0     1     0     1
%      0     0     1     2
%      0     0     0     1
```

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```
% Assignment 2 - Question 2, Forward Kinematics
clear all;
%M
M = [-1, 0, 0, 0;
    0, 0, 1, 3;
    0, 1, 0, 2;
    0, 0, 0, 1];
%Screw Axes w,v
S1 = [0,0,1, 0,0,0];
S2 = [1,0,0, 0,2,0];
S3 = [0,0,0, 0,1,0];

Slist = [S1',S2',S3'];
%Body Axes
B1 = [0,1,0,3,0,0];
B2 = [-1,0,0,0,3,0];
B3 = [0,0,0,0,0,1];

Blist = [B1',B2',B3'];
%thetalist
thetalist = [pi/2;pi/2;1];
%Configuration Space frame
Ts = FKinSpace(M,Slist,thetalist);
%Configuration Body Frame
Tb = FKinBody(M,Blist,thetalist);

% OUTPUT:
%
%
% Tb =
%
%    -0.0000    1.0000   -0.0000   -0.0000
%    -1.0000   -0.0000    0.0000    0.0000
%          0    0.0000    1.0000    6.0000
%          0         0         0    1.0000
%
%
% Ts =
%
%    -0.0000    1.0000   -0.0000   -0.0000
%    -1.0000   -0.0000    0.0000    0.0000
%          0    0.0000    1.0000    6.0000
%          0         0         0    1.0000
```

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