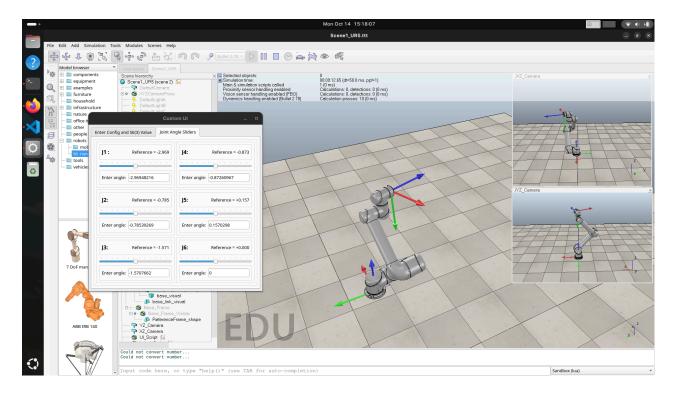
Screenshot of UI Script. Title of configuration box has been changed to 'Custom Configuration'

```
Simulation script "/UI_Script"
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                   <tabs>
                       <tab title="Enter Config and SE(3) Value">
                              <group layout="vbox">
                                   <label text="<big> Custom Configuration:</big>" wordwrap="false" style="font-weight"
                                <label text="Enter 6 comma-separated angles" />
<edit value="" id="7006" oneditingfinished="fulljointEntry" />
<label value="" id="5006" wordwrap="false" />
<label text="<big> Current configuration:</big> id="6007" wordwrap="false" style='
                                      <label value="" id="1237" wordwrap="true" />
                                 </group>
                                 <label text="<big> Messages:</big>" id="6006" wordwrap="false" style="font-weight:
                                 <group layout="vbox">
  <label value="" id="1236" wordwrap="true" />
                                 </group>
                             </group>
                              <group>
                                   <label text="<big> Current SE(3):</big>" id="6008" wordwrap="false" style="font-v
<!-- <button text="Calculate SE(3) transform:" on-click="calcSE3" id="1235"/> -->
<label text="T(?) = " wordwrap="false" />
<label text="" id="1234" wordwrap="false" />
                                <!-- </group> -->
<!-- <group> -->
                                  <!-- <lack text="<big> Settings:</big>" wordwrap="false" style="font-weight: bc
<!-- <checkbox text="Use degrees instead of radians?" checked="false" on-change=
<!-- </group> -->
                              <stretch />
                          </group>
                       </tab>
                        <group layout="grid"</pre>
```

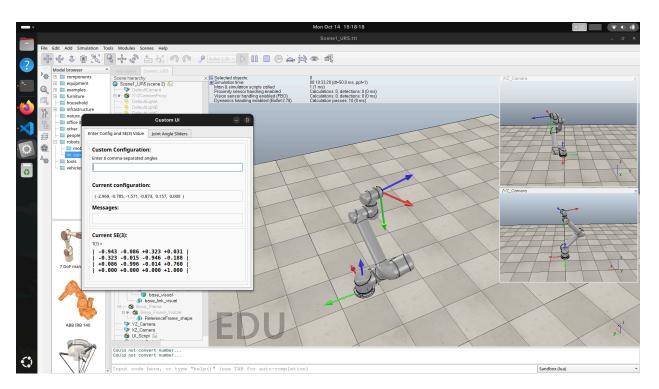
Screenshot of UI Script. Joint names have been changed from **Joint**_i to **J**_i

```
Simulation script "/UI_Script"
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                    <tab title="Joint Angle Sliders">
                       <group layout="grid"</pre>
                             <group layout="grid">
                                <label text="slips J1 :</pre>
id="6000" wordwrap="false" style="font-weight: bol
<label text="Reference = 0.000" id="3000" wordwrap="false" />
<!-- <label text="Actual = 0.000" id="5000" wordwrap="false" /> -->
                             </group>
<hslider id="4000" tick-position="above" tick-interval="1000" minimum="-6280" maxim</pre>
                             <group layout="grid">
  <label text="Enter angle:" />
  <edit value="" id="7000" oneditingfinished="jointEntry" />
                          </group>
                              <group layout="grid">
                                clabel text="kpig> J4:
dabel text="kpig> J4:
diabel text="Reference = 0.000" id="3003" wordwrap="false" />
<!-- <label text="Actual = 0.000" id="5003" wordwrap="false" /> -->
                             <hslider id="4003" tick-position="above" tick-interval="1000" minimum="-6280" maxin</pre>
                             </group>
                           </group>
                           <br/>
                             <group layout="grid">
                                 <label text="chig> J2:</big>" id="6001" wordwrap="false" style="font-weight: bold
<label text="Reference = 0.000" id="3001" wordwrap="false" />
<!-- <label text="Actual = 0.000" id="5001" wordwrap="false" /> -->
                              </group>
<hslider id="4001" tick-position="above" tick-interval="1000" minimum="-6280" maxim
</pre>
```

Screenshot of the scene with robot configuration, modified UI and calculated joint angles as input.



Screenshot of the scene with robot configuration and SE(3) calculation



```
Calculated joint angles: (\theta_1, \theta_2, \theta_3, \theta_4, \theta_5, \theta_6): [-2.969, -0.785, -1.570, -0.872, 0.157, 9.047e-07] (Note: the last value is small enough to be approximated as zero) Calculated SE(3) Matrix: [[-0.9418 -0.0859 0.3249] [-0.3249 -0.0151 -0.9456] [ 0.0861 -0.9962 -0.0136]]
```

Code:

```
import modern robotics as mr
import numpy as np
# provided rotation matrices
R13 = np.asanyarray([[-0.7071, 0, -0.7071], [0, 1, 0], [0.7071, 0, ])
-0.7071]])
Rs2 = np.asanyarray([[-0.6964, 0.1736, 0.6964], [-0.1228, -0.9848,
0.1228], [0.7071, 0, 0.7071]])
R25 = np.asanyarray([[-0.7566, -0.1198, -0.6428], [-0.1564, 0.9877, 0],
[0.6348, 0.1005, -0.7661]])
R12 = np.asanyarray([[0.7071, 0, -0.7071], [0, 1, 0], [0.7071, 0, ])
0.7071]])
R34 = np.asanyarray([[0.6428, 0, -0.7660], [0, 1, 0], [0.7660, 0,
0.6428]])
Rs6 = np.asanyarray([[0.9418, 0.3249, -0.0859], [0.3249, -0.9456,
-0.0151], [-0.0861, -0.0136, -0.9962]])
R6b = np.asanyarray([[-1, 0, 0], [0, 0, 1], [0, 1, 0]])
# rotation axes for the joints
w1 = np.asanyarray([0, 0, 1])
w2 = np.asanyarray([0, 1, 0]) # w3, w4, w6 have the same axis as w2
w5 = np.asanyarray([0, 0, -1])
Rs1 = np.matmul(Rs2, mr.RotInv(R12))
# Next sequential R
R23 = np.matmul(mr.RotInv(R12),R13)
Rs3 = np.matmul(Rs2, R23)
```

```
# Intermediate steps to find R45
R41 = np.matmul(mr.RotInv(R34),mr.RotInv(R13))
R15 = np.matmul(R12, R25)
R45 = np.matmul(R41, R15)
Rs4 = np.matmul(Rs3,R34)
Rs5 = np.matmul(Rs4, R45)
# Intermediate steps to find R56
R26 = np.matmul(mr.RotInv(Rs2), Rs6)
R56 = np.matmul(mr.RotInv(R25),R26)
# calculating the vectors after taking matrix log of the rotation matrices
between the links
omega 1 = mr.so3ToVec(mr.MatrixLog3(Rs1))
omega 2 = mr.so3ToVec(mr.MatrixLog3(R12))
omega 3 = mr.so3ToVec(mr.MatrixLog3(R23))
omega 4 = mr.so3ToVec(mr.MatrixLog3(R34))
omega 5 = mr.so3ToVec(mr.MatrixLog3(R45))
omega 6 = mr.so3ToVec(mr.MatrixLog3(R56))
theta 1 = omega 1 * w1
theta 2 = omega 2 * w2
theta 3 = omega 3 * w2
theta 4 = omega 4 * w2
theta 5 = omega 5 * w5
theta 6 = omega 6 * w2
\mathsf{print}(\mathsf{theta}\ 1[2], \mathsf{theta}\ 2[1], \mathsf{theta}\ 3[1], \mathsf{theta}\ 4[1], \mathsf{theta}\ 5[2],
theta 6[1])
# calculating Rsb
Rsb = np.matmul(Rs6, R6b)
print(Rsb)
```

Code Explanation:

ME449 Assignment 1 - Pushkar Dave

Based on the given rotation matrices, the code first calculates the rotation matrices Rs1, R12, R34 (already given), R45 and R56 using the subscript cancellation rule (and matrix multiplication).

Then, we find the Matrix Log of these matrices and convert them into the vector form. When we multiply this vector with the vector representing the axis of rotation of the joint, we get the Joint Angle with appropriate sign.

For calculating Rsb, we multiply the given matrices Rs6 and R6b, and which gives us the matrix Rsb (based on subscript cancellation rule).