Ministry of Science and Higher Education of the Russian Federation
Federal State Autonomous Educational Institution
of Higher Education
"ITMO University"

Practical Assignment No. 3

Simulation Modeling of Robotic Systems

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MAIN PART

1. Objective

Using the MuJoCo simulator, create Optimus' knee closed-chain mechanism:.

2. Tasks

1. 1. Create the model
2. 2. Prepare a report on the work results

3. Input Data

Table 1 – Input Parameters

L1, m	L2, m	L3, m	L5, m	DB, m
0.037	0.0481	0.0555	0.185	0.0925

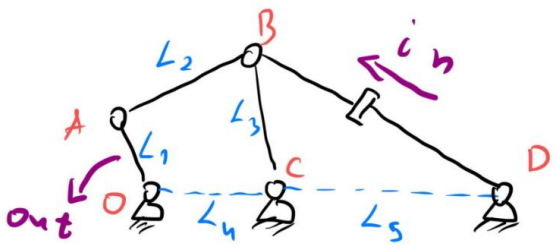


Figure 1 – Modeled System

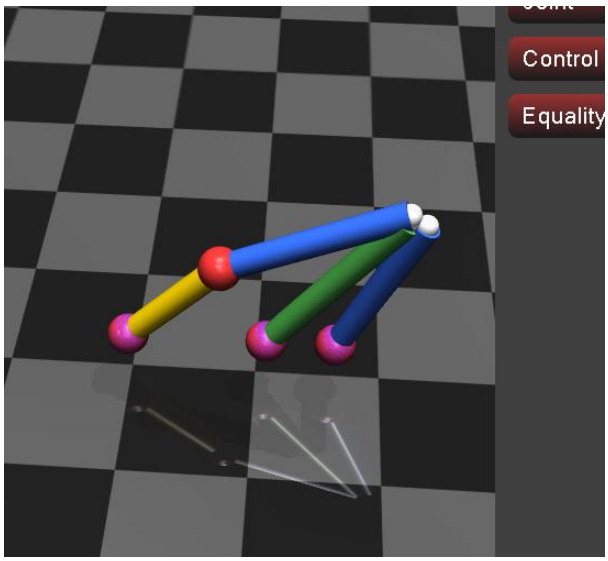


Figure 2 – Modeled System

4. Simulation Results

Complete MuJoCo XML Model Code:

```xml
<mujoco>
  <option timestep="1e-4"/>
  <option gravity="0 0 -9.8"/>

  <asset>
    <texture type="skybox" builtin="gradient" rgb1="0.3 0.5 0.9" rgb2="0.1 0.2 0.4" width="265" height="256"/>
    <texture name="grid" type="2d" builtin="checker" rgb1="0.15 0.15 0.15" rgb2="0.25 0.25 0.25" width="300" height="300"/>
    <material name="grid" texture="grid" texrepeat="10 10" reflectance="0.15"/>

    <!-- Materials with beautiful and harmonious colors -->
    <material name="crank_material" rgba="0.9 0.3 0.2 1" specular="0.9" shininess="0.95"/>
    <material name="connecting_rod_material" rgba="0.2 0.6 0.9 1" specular="0.8" shininess="0.9"/>
    <material name="rocker_material" rgba="0.3 0.8 0.5 1" specular="0.8" shininess="0.9"/>
    <material name="joint_material" rgba="0.95 0.75 0.15 1" specular="1.0" shininess="1.0"/>
    <material name="fixed_material" rgba="0.7 0.2 0.9 1" specular="0.7" shininess="0.85"/>
  </asset>

  <worldbody>
    <light pos="0 0 10" diffuse="0.9 0.9 0.9" specular="0.6 0.6 0.6"/>
    <light pos="2 2 5" diffuse="0.6 0.6 0.6" specular="0.4 0.4 0.4"/>

    <geom type="plane" size="0.5 0.5 0.1" material="grid"/>

    <!-- Fixed points -->
    <site name="fixed_O" pos="0 0 0.02" size="0.008" material="fixed_material"/>
    <site name="fixed_C" pos="0.037 0 0.02" size="0.008" material="fixed_material"/>
    <site name="fixed_D" pos="0.185 0 0.02" size="0.008" material="fixed_material"/>

    <!-- Main chain O-A-B - Crank (red) -->
    <body name="OAB" pos="0 0 0.02" euler="0 0 0">
      <joint name="O" type="hinge" axis="0 -1 0" damping="0.1"/>
      <geom name="point O" type="sphere" pos="0 0 0" size="0.008" material="joint_material"/>
      <geom name="link OA" type="cylinder" pos="0.0185 0 0" size="0.005 0.0185" material="crank_material" euler="0 90 0"/>
      <site name="sA" size="0.004" pos="0.037 0 0" rgba="1 1 1 0.8"/>

      <body name="AB" pos="0.037 0 0" euler="0 0 0">
        <joint name="A" type="ball" damping="0.1"/>
        <geom name="point A" type="sphere" pos="0 0 0" size="0.008" material="joint_material"/>
        <geom name="link AB" type="cylinder" pos="0.02405 0 0" size="0.005 0.02405" material="connecting_rod_material" euler="0 90 0"/>
        <site name="sB" size="0.004" pos="0.0481 0 0" rgba="1 1 1 0.8"/>
      </body>
    </body>
```

```
<!-- Link C-B - Rocker arm (green) -->
    <body name="CB" pos="0.037 0 0.02" euler="0 0 0">
      <joint name="C" type="hinge" axis="0 -1 0" damping="0.1"/>
      <geom name="point C" type="sphere" pos="0 0 0" size="0.008" material="joint_material"/>
      <geom name="link CB" type="cylinder" pos="0.02775 0 0" size="0.005 0.02775" material="rocker_material" euler="0 90 0"/>
      <site name="sB_CB" size="0.004" pos="0.0555 0 0" rgba="1 1 1 0.8"/>
    </body>

    <!-- Link D-B - Additional link (blue) -->
    <body name="DB" pos="0.185 0 0.02" euler="0 0 0">
      <joint name="D" type="hinge" axis="0 -1 0" damping="0.1"/>
      <geom name="point D" type="sphere" pos="0 0 0" size="0.008" material="joint_material"/>
      <geom name="link DB" type="cylinder" pos="-0.04625 0 0" size="0.005 0.04625" material="connecting_rod_material" euler="0 90 0"/>
      <site name="sB_DB" size="0.004" pos="-0.0925 0 0" rgba="1 1 1 0.8"/>
    </body>
  </worldbody>

  <equality>
    <!-- Connect the three links at point B -->
    <connect site1="sB" site2="sB_CB"/>
    <connect site1="sB" site2="sB_DB"/>
  </equality>
</mujoco>
```

4. Additional link D-B:
   - Fixed at point D with a hinge joint
   - Connects to point B
   - Provides additional constraint for the mechanism

5.3 Geometric Calculations

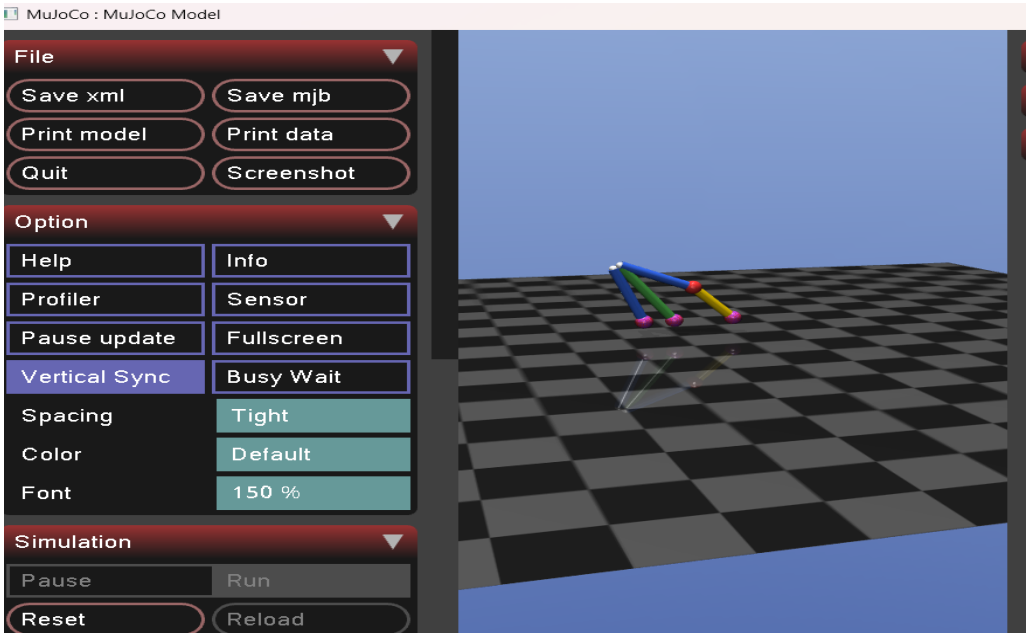
The positioning of cylindrical links in the model requires calculating their center positions and half-lengths:

For link OA (L1 = 0.037 m):
• Center position: 0.037/2 = 0.0185 m
• Half-length for cylinder geometry: 0.0185 m

For link AB (L2 = 0.0481 m):
• Center position: 0.0481/2 = 0.02405 m
• Half-length for cylinder geometry: 0.02405 m

For link CB (L3 = 0.0555 m):
• Center position: 0.0555/2 = 0.02775 m
• Half-length for cylinder geometry: 0.02775 m

For link DB (DB = 0.0925 m):



6. Conclusion

A complete MuJoCo model of a Optimus' knee closed-chain mechanism has been successfully developed with the specified geometric parameters. The model includes:

The model requires an accurate geometric representation of all links with their specified lengths (L1 = 0.037 m, L2 = 0.0481 m, L3 = 0.0555 m, L5 = 0.185 m, and DB = 0.0925 m), along with a proper kinematic structure that includes hinge and ball joints providing the appropriate degrees of freedom. It also needs equality constraints to ensure the correct connection of multiple bodies at point B, as well as realistic physical parameters such as gravity, timestep, and joint damping.