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FACULTY OF CONTROL SYSTEMS AND ROBOTICS

PROGRAM:
ROBOTICS AND ARTIFICIAL INTELLIGENCE

PROJECT REPORT
SIMULATION OF ROBOTIC SYSTEMS

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INTRODUCTION

This report provides a detailed explanation of a simulation script implemented in Python using the MuJoCo physics engine. The model attempts to replicate a belt conveyor transporting objects.

I. MODEL STRUCTURE

Rollers

Two cylindrical rollers (roller1, roller2) are placed at the ends of the belt. Each features a rotational hinge joint, allowing rotation around the Y-axis. A site (marker) named site1 on roller1, used to measure its tangential velocity.

Belt

A black box (belt) is positioned between the rollers to simulate the contact surface.

Transported Objects

Six red boxes, each equipped with a free joint, allowing full 6-DOF motion.

Support Structure

A set of box geometries forms a fixed frame on the right side of the scene.

II. SCRIPT AND RESULT

1. XML MODEL

```
<mujoco>
 <option timestep="0.001"/>
  <option gravity="0 0 -9.8"/>

<asset>
     <texture type="skybox" builtin="gradient" rgb1="1 1 1" rgb2="0.5
0.5 0.5" width="265" height="256"/>
    <texture name="grid" type="2d" builtin="checker" rgb1="0.1 0.1 0.1"
rgb2="0.6 0.6 0.6" width="300" height="300"/>
          <material name="grid" texture="grid" texrepeat="10 10"
reflectance="0.2"/>
  </asset>

    <worldbody>
      <light pos="0 0 10"/>
```

```
      <geom type="plane" size="2 1 0.1" material="grid"/>

      <body name="roller1" pos="1 -0.3 0.3" euler="-90 0 0">
            <joint name="roller1_joint" type="hinge" damping="0.01"/>
             <geom type="box" size="0.05 0.05 0.001" pos="0 0 0" rgba="1
0 0 1"/>
                  <geom name="cylinder1" type="cylinder" pos="0 0 0.3"
size="0.05 0.3" rgba="0.2 0.4 0.9 0.7"/>
             <site name="site1" type="sphere" rgba="1 0 0 1" size="0.01"
pos="0 0.05 0.3"/>
        </body>
        <body name="roller2" pos="-1 -0.3 0.3" euler="-90 0 0">
            <joint name="roller2_joint" type="hinge" damping="0.01"/>
             <geom type="box" size="0.05 0.05 0.001" pos="0 0 0" rgba="1
0 0 1"/>
                  <geom name="cylinder2" type="cylinder" pos="0 0 0.3"
size="0.05 0.3" rgba="0.2 0.4 0.9 0.7"/>
       </body>

        <body name="belt" pos="0 0 0.365">
                <geom type="box" size="1 0.25 0.01" rgba="0 0 0 1"
friction="0.001 0.001 0.001"/>
       </body>

          <body pos="-0.3 0.1 1">
                <geom type="box" size="0.05 0.05 0.05" rgba="1 0 0 1"
friction="0.001 0.001 0.001"/>
             <joint name="box1_joint" type="free"/>
           </body>

           <body pos="-0.6 0.1 1">
                <geom type="box" size="0.05 0.05 0.05" rgba="1 0 0 1"
friction="0.001 0.001 0.001"/>
             <joint name="box2_joint" type="free"/>
           </body>

           <body pos="-0.9 0.1 1">
                <geom type="box" size="0.05 0.05 0.05" rgba="1 0 0 1"
friction="0.001 0.001 0.001"/>
             <joint name="box3_joint" type="free"/>
           </body>

           <body pos="-0.3 -0.1 1">
```

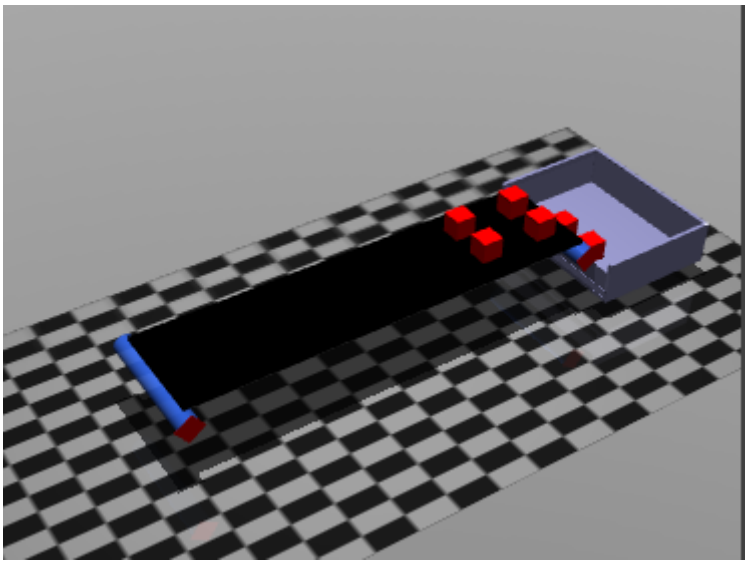
```
                <geom type="box" size="0.05 0.05 0.05" rgba="1 0 0 1"
friction="0.001 0.001 0.001"/>
              <joint name="box4_joint" type="free"/>
            </body>

            <body pos="-0.6 -0.1 1">
                 <geom type="box" size="0.05 0.05 0.05" rgba="1 0 0 1"
friction="0.001 0.001 0.001"/>
              <joint name="box5_joint" type="free"/>
            </body>

            <body pos="-0.9 -0.1 1">
                 <geom type="box" size="0.05 0.05 0.05" rgba="1 0 0 1"
friction="0.001 0.001 0.001"/>
              <joint name="box6_joint" type="free"/>
            </body>

            <body pos="1.05 0 0">
                  <geom type="box" size="0.3 0.4 0.01" pos="0.3 0 0.1"
rgba="0.6 0.6 0.8 1" />
                <geom type="box" size="0.3 0.01 0.1" pos="0.3 0.39 0.2"
rgba="0.6 0.6 0.8 1"/>
               <geom type="box" size="0.3 0.01 0.1" pos="0.3 -0.39 0.2"
rgba="0.6 0.6 0.8 1"/>
                 <geom type="box" size="0.01 0.4 0.1" pos="0.59 0 0.2"
rgba="0.6 0.6 0.8 1"/>
                <geom type="box" size="0.01 0.4 0.05" pos="0.01 0 0.2"
rgba="0.6 0.6 0.8 1"/>
            </body>

    </worldbody>

   <equality>
     <joint joint1="roller1_joint" joint2="roller2_joint"/>
   </equality>

   <actuator>
     <velocity name="roller_vel" joint="roller2_joint" />
     <velocity name="box1_vel" joint="box1_joint" />
     <velocity name="box2_vel" joint="box2_joint" />
     <velocity name="box3_vel" joint="box3_joint" />
     <velocity name="box4_vel" joint="box4_joint" />
     <velocity name="box5_vel" joint="box5_joint" />
```

```
    <velocity name="box6_vel" joint="box6_joint" />
  </actuator>

  <sensor>
    <velocimeter site="site1"/>
  </sensor>


</mujoco>
```

2. PYTHON CODE

```
import mujoco
import mujoco.viewer
import time


model = mujoco.MjModel.from_xml_path('conveyor.xml')
data = mujoco.MjData(model)

with mujoco.viewer.launch_passive(model, data) as viewer:
    start = time.time()

    while viewer.is_running() and time.time() - start < 100:

        vx = data.sensordata[0]
        data.ctrl[0] = 0.4
        data.ctrl[1] = -vx
        data.ctrl[2] = -vx
        data.ctrl[3] = -vx
        data.ctrl[4] = -vx
        data.ctrl[5] = -vx
        data.ctrl[6] = -vx


        mujoco.mj_step(model, data)
        viewer.sync()
```

3. SIMULATION RESULT



CONCLUSION

In summary, this script demonstrates a simple yet clever algorithmic workaround to simulate a conveyor in a constrained environment, at the cost of partial physical realism. Indeed, The belt itself is fixed, and object transport is achieved not through friction or dynamic contact, but through a loop control strategy that directly imposes on the boxes a velocity identical to that of the theoretical conveyor surface.