ME 639: Introduction to Robotics

Assignment 1

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Contents

1. Ubuntu setup,ROS2 and MuJoCo installation

I have setup Ubuntu 24.04 and installed ROS2 jazzy following the official documentation a few months ago. To install MuJoCo, I set up a virtual environment, since I was facing a issue of directly installing it in the base environment. As suggested by TA's, also cloned the mujoco menagerie github repository, which contains most of the model that are required for the assignment. For Turtlebot Waffle pi 3, I referred to another repository, Robotis mujoco Menagerie.

2. Environment Validation

To validate my mujoco installation, I launched a unitree Go 2 model in MuJoCo.

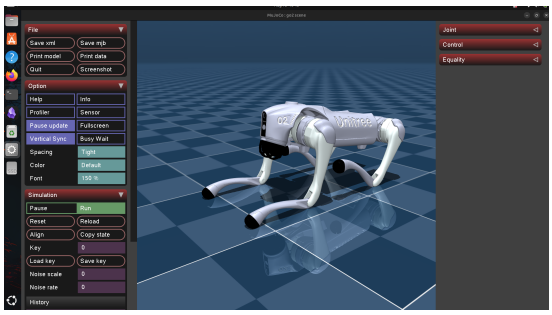

Figure 1. Unitree Go 2 in MuJoCo

3. Serial Chain Manipulator

The mujoco menagerie repository contains the Franka fr 3 model, which could be launched in mujoco using the below command.

```
python -m mujoco.viewer --mjcf franka_fr3/scene.xml
```

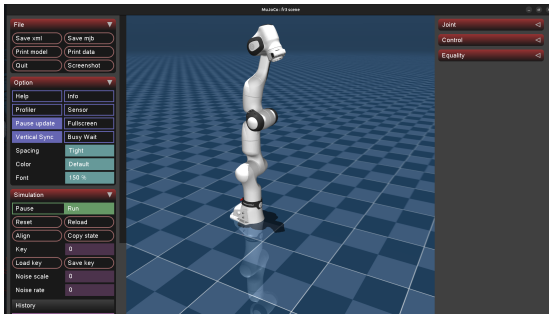

Figure 2. Franka Research 3

To observe the effect of gravity on the model we could use the Disable flag option under Physics section.

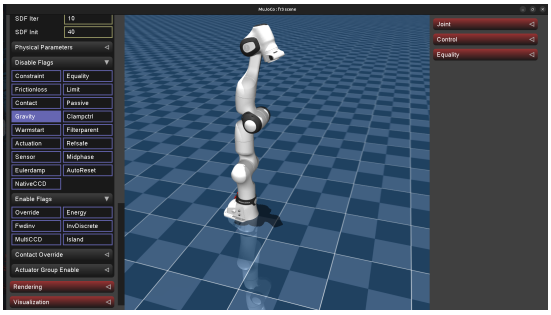

Figure 3. Gravity Disabled

We could observe the there is no change in the model, that is because initially the actuators were on so robot was able to maintain a certain state, now there is no effect of gravity, so even if we turn off the actuators the model will maintain the same state.

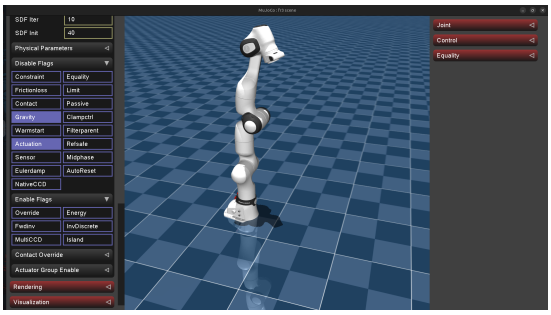

Figure 4. Disabled Gravity and actuators

Now, if we disable the actuators and keep the effect of gravity, we could observe the robot falling to the ground.

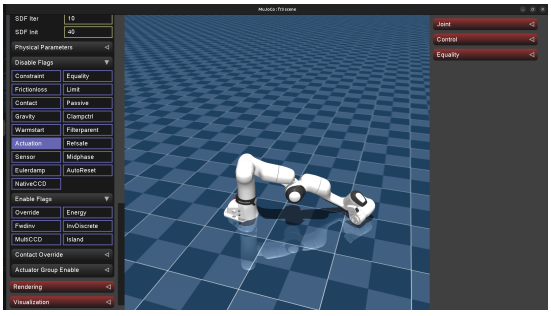

Figure 5. Disabled Actuation

4. Wheeled Mobile Robot

I launched the Turtlebot3 Waffle pi model from robotis-mujoco-menagerie using the below command.

```
python -m mujoco.viewer --mjcf /home/aech7/
    robotis/robotis_mujoco_menagerie/robotis_tb3
    /scene_turtlebot3_waffle_pi.xml
```

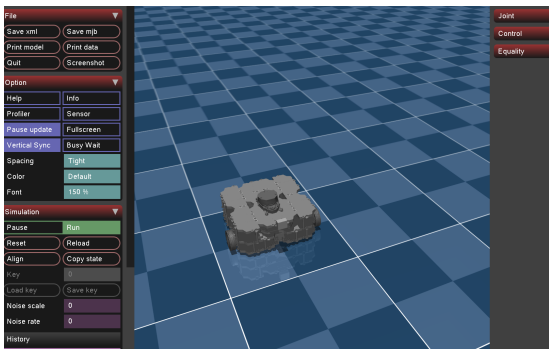

Figure 6. Turtlebot3 waffle pi

To apply a force I wrote a python script and used the MuJoCo API. I created a numpy array for force and torque, then used `mujoco.mj_applyFT()` function from the API to apply the force, I kept the values of torque to zero. The force was applied on the **base**, the name found from the xml file. Each body has a unique `name` attribute inside a xml file. The **base** is the name of the main chassis link. When applied a force of 90 Newton in X direction continuously we could observe the robot moving, but after brief time, it starts wobbling and loses contact with the ground. An increase in force magnitude causes its wheel to lose contact with the ground and it rolls and crashes onto the ground. A decrease in magnitude of the force causes it to move slowly, we could observe slight movement in the other direction because of slipping.

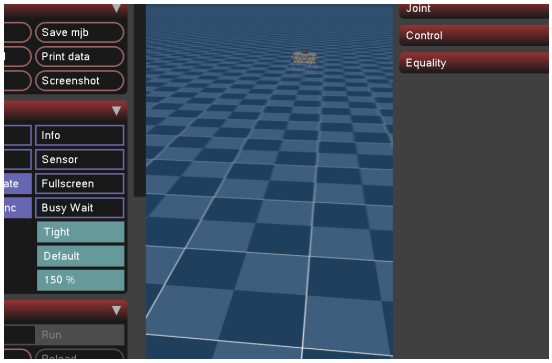

Figure 7. Turtlebot moving under the influence of the applied force

5. Quadruped Robot

I launched the Unitree Go 2 model from mujoco menagerie repository using the below command.

```
python -m mujoco.viewer --mjcf unitree_go2/scene.xml
```

To observe the effect of gravity, we disabled the gravity, and we could observe the robot floating.

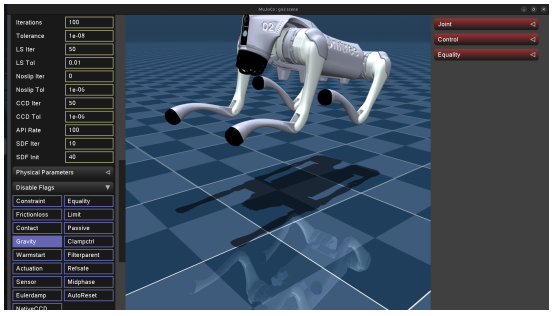

Figure 8. Without gravity

The commands in the controls section let us change the angle of the joints.

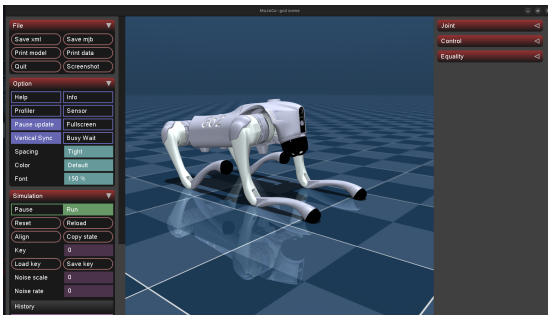

Figure 9. Under the effect of gravity

Each joint has an angle constraint. We can't rotate any joint by 360 degrees. While moving the joints the legs or body parts collide with the ground and we could observe the effect of that collision on the robot model.

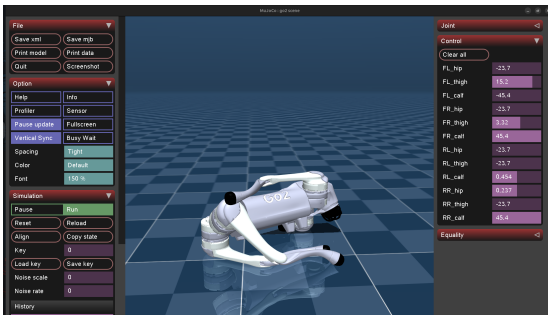

Figure 10. State of the robot under different joint angles

6. Inverted pendulum

I wrote the code in the MJCF, MuJoCo XML format. I referred to internet for syntax and commands. I made a box, a base, a pole and a hinge joint in y direction that connects the box and the pole. To launch the file I created a launch file in python. When we give angel zero as the initial condition, the pendulum stay as it is, it is in a unstable equilibrium a slight perturbation will make it fall to either of the side. For initial condition of 0.1 radians the pendulum fell on the ground while following the hinge constraint. This happened because of the gravitational force. For any value other than 0 radians of the initial angle the pendulum fell on the ground.

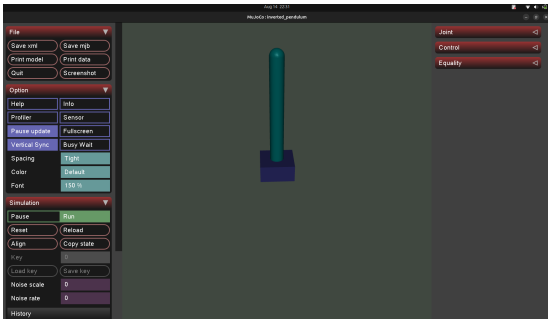

Figure 11. Pendulum state for IC = 0 radians

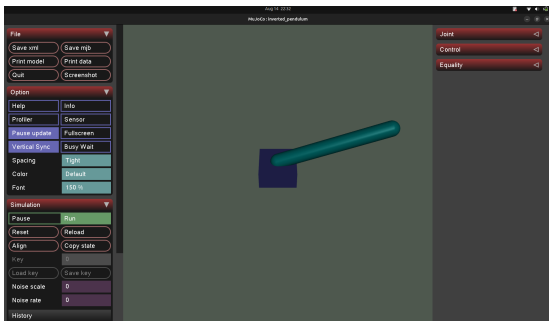

Figure 12. Pendulum state for Initial condition = 0.1 radians

When I applied the initial condition of π, the pendulum is pointing vertically downwards through the ground, in other initial condition we can observe the collision between the pendulum and ground but giving a initial condition that is geometrical impossible for the designed pendulum makes it pass through the objects. So the collision solver can detect the collision if they happen during the simulation an unrealistic initial condition causes a error as depicted in the image below.

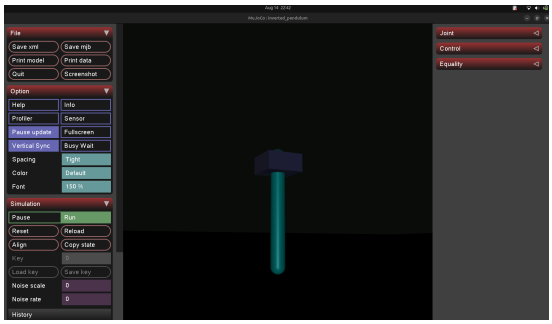

Figure 13. Pendulum state with initial condition= π