ME 639: Introduction to Robotics

First Assignment

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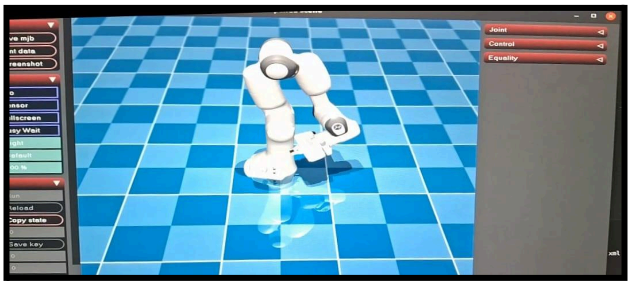
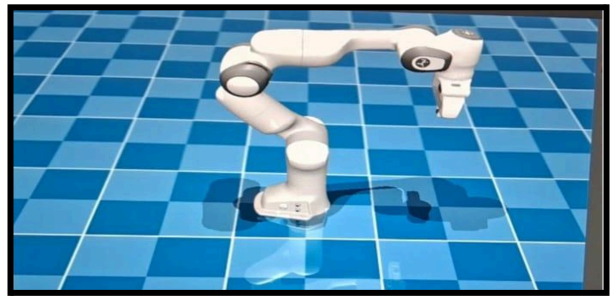
TASK 2: Serial Chain Manipulator – Franka Research 3





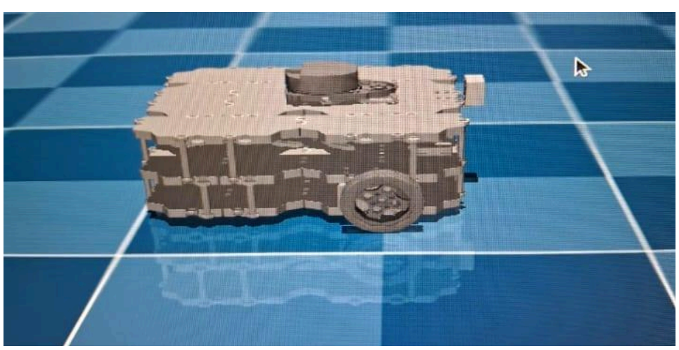
Observations:

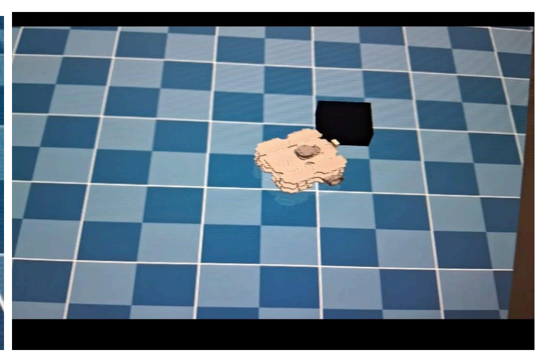
- **With gravity:** Arm moved naturally under weight; joints sagged when not actuated.

- **Without gravity:** Arm floated in the configuration it was initialised; no sagging occurred,

Challenges: Gravity was initially modified through the XML file; however, this approach required creating additional XML files for minor changes. This was later optimised by directly adjusting the gravity parameter within the simulation script, as indicated in the MuJoCo documentation.

TASK 3: Wheeled Mobile Robot – TurtleBot Waffle Pi





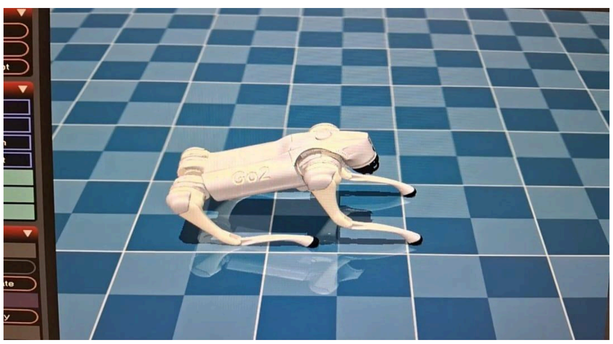
Procedure:
Simulated the robot in MuJoCo and applied lateral forces using the viewer interface. Wrote a script to actuate the motors to test physical behaviour. Slip was tested by setting the wheel–ground friction to `0`. Drift was tested by suddenly changing the robot's direction at high speed. Collision was tested by placing a black block in the robot's path.

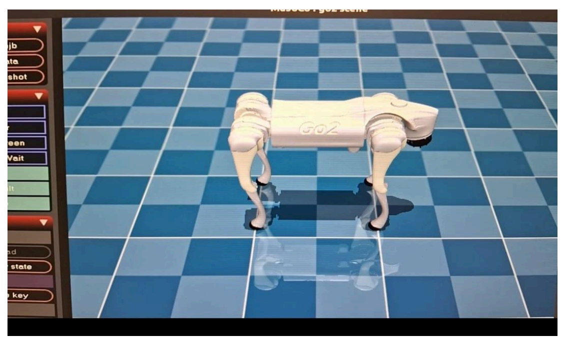
Observations:

- **Slip:** Wheels spun without forward movement when the friction was set to zero.
- **Drift:** A Sudden change in direction at high speed caused the robot to slide sideways as the required centripetal force exceeded the available friction, leading to deviation from its path.
- **Collisions:** On hitting the block's corner, the robot stopped moving forward. The rear lifted slightly, and it rotated about the point of contact, deviating from its path.

Challenges: Faced difficulties in changing the friction values through the code, hence made changes directly in the XML files. Friction parameters were not initially included in the geom definitions of the wheels and ground plane. Added these parameters and created separate XML files for the zero-friction and friction cases. Later encountered issues when trying to apply impulse forces programmatically; while manual force application through the viewer interface worked, motion was eventually generated using data.ctrl.

<u>TASK 4: Quadruped Robot – Unitree Go2 EDU</u>





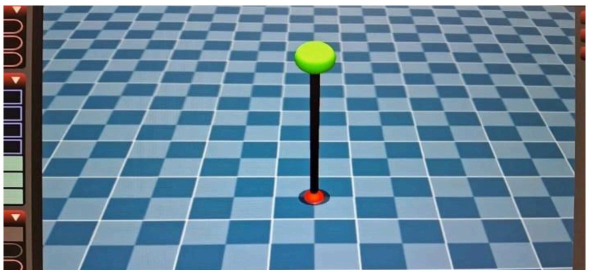
Procedure:
Loaded the Unitree Go2 URDF in MuJoCo. Observed its idle stance and manually moved joints to check their range.

Observations:

- **Gravity stability:** Without gravity, the robot remained upright on all four legs. With gravity enabled, it bent backwards as the weight pulled it down because the joints were not in gravity compensation mode.
- **Joint limits:** Using the control panel, the hip, thigh, and calf joints were moved within their predefined limits. No self-collision occurred as all the joint movements were within its control range.
- **Constraints:** All constraints were respected; no joint moved independently of the robot's structure.
- **Ground interaction:** Feet maintained proper contact with the ground without sinking.

Challenges:
Faced difficulty adding gravity compensation to the joints to make it stable in the presence of gravity and was unable to implement it successfully.

TASK 5: Inverted Pendulum




Procedure:
Designed a single rigid rod hinged at the base in MJCF. Tested the pendulum with gravity on and off, and varied the initial tilt angles (10°, −10°, 0°).

Observations:

- **With gravity:** The pendulum remained upright when initialized at a 0° angle between the vertical and the rod. Even a slight deviation from 0° caused it to fall.
- **Without gravity:** The pendulum stayed fixed at any position in which it was initialized

Challenges: No significant issues were encountered while creating and simulating the inverted pendulum model, except for an incorrect hinge joint axis definition that caused the pendulum to rotate in the wrong plane.