Compliant Control of a Hydraulic Humanoid Joint

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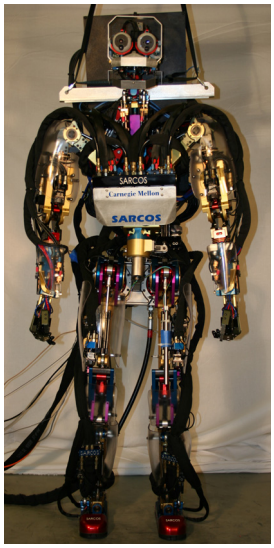
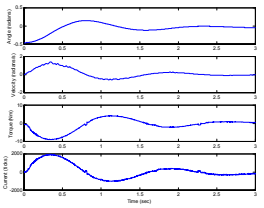
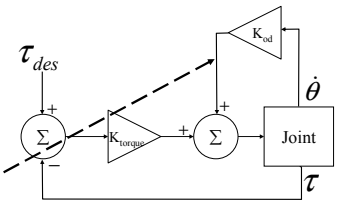


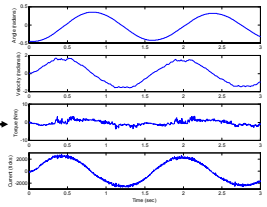
- We are investigating the use of hydraulic actuators to provide the strength, speed, and compliance needed for a humanoid robot.
- We conducted an analysis of a hydraulic joint (hip pitch) on a humanoid robot.
  - –Various controllers have been designed that allow the limb to have a range of characteristics such as being stiff or compliant.
- Advantages and disadvantages of hydraulic actuation
  - –Actuators are small relative to the power they provide. This allows limbs to be strong and light weight.
  - –The oil must be routed to each actuator through hydraulic hoses. If the hoses are not large enough, speed and strength be limited.
  - –There must exist a pump to supply the high pressure oil.



Actuator Dynamics Compensation

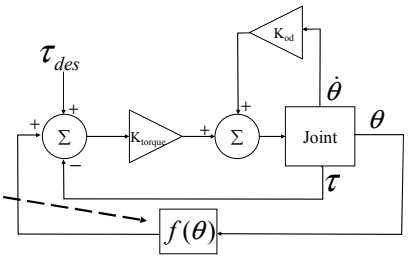
- Even though the desired torque is 0, there is a significant amount of torque that slows the limb down when it is released.
- Actuator Dynamics Compensation (K_{od}) is added to the controller.
- The Actuator Dynamics Compensation helps to keep the joint at the desired torque. At 0 desired torque the leg will swing like a nearly frictionless pendulum.

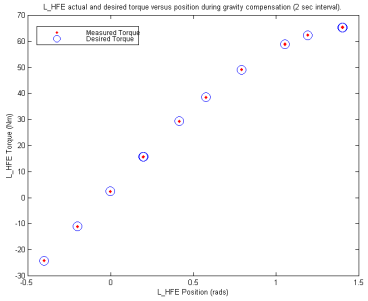




Gravity Compensation

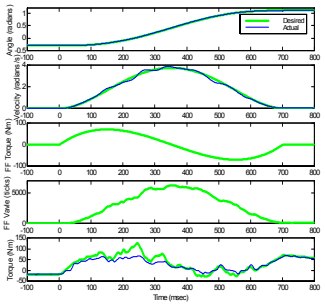
- To compensate for gravity, the torque must be set to support the leg.
- Data collected from the robot is used to create a model of the gravity compensation torque.
- Results of using the gravity compensation model are shown on the right.

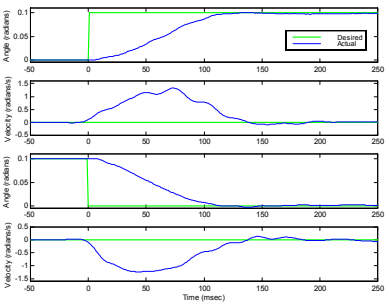




Trajectory Following

- A controller that computes a desired torque from position and velocity is used to have the limb follow a trajectory.
- A feed forward torque is computed from the desired acceleration and an estimate of the limb's inertia.
- The graph on the right shows the limb's reaction to a 0.1 radian step change.





Conclusion

We have created a variety of controllers that satisfy constraints from very compliant to very stiff. We are continuing to design controllers for the other joints of our humanoid robot and are investigating and implementing controllers that operate over multiple joints.