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Concept Review

Hardware Interfacing

Why Study Hardware Interfacing?

Having the ability to interface with hardware enables users to safely command a mechatronics device to complete a task. Depending on the mechanical and electrical properties of a system, sending direct voltage commands can have adverse effects. The purpose of this document is to study different techniques which users can adopt when interfacing with hardware to complete a specific task.

Saturation

To ensure safe performance of an actuator different command modification techniques exist. A control system may output a series of commands which could damage/be outside the acceptable range for safe operation. This is where command saturation can be applied. Practically, saturation limits the maximum and minimum values on a signal. If the signal's value exceeds the maximum, saturation sets it to the maximum itself, and vice versa for the minimum. Saturation can have numerous advantages depending on the context and where it is applied.

In manipulator control, commanding a joint position outside the range of the joint limits may cause damage to the device itself or cause unsafe operation. If a device is continuously applying a command outside of it's rated electrical limits the outcome could also propagate to the power supply and cause a brown out. In this example applying a saturating limit to the position commands w.r.t the maximum and minimum joint limits will prevent this even if the user accidentally commands a value outside this range. Similarly, saturating the PWM command output from a controller with respect to the capabilities of the power supply will ensure that it does not brown out.

Rate-limits

Sending a constant command to a device can visually look like a step input. Sending step inputs can cause large spikes in current which can damage the electronic components of a device. One method for controlling how fast the step input is applied is called rate limitation.

Rate limitation can act like a damper to the input command and control how fast the control input reaches the commanded value. This can be beneficial in applications involving robotic manipulators, mobile vehicles, smart appliances.

Looking at a robotic arm, to move a joint from -90 to 90 degrees, a controller might see an instantaneous error of 180 degrees. Putting this through a rate limiter of 90 degrees per second allows the desired signal to go through the 180 degrees of change over 2 seconds, improving the controller's position tracking performance. Similarly, passing a discrete change in commanded velocity through a rate limit will saturate the maximum acceleration, providing a gradual speed change. Rate limiting a PWM command also saturates the maximum current draw, thereby limiting the maximum acceleration.

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