Building a Backdrivable Servo to Simulate a Spring

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Background

Haptics is the simulation of the feeling of touch. Interaction with an object in real life provides tactile feedback allowing people to determine how to touch or hold an object. Interacting with virtual objects such as items in a video game, or remotely controlling a device such as a rover, lacks this sense of touch. By designing ways to simulate touch, more information can be provided to users of a virtual interface.

Goals

- Simulate the dynamics of a spring using a servo motor
- Design a modification that allows the motion of the servo to be driven by applying a force to the servo horn
- Incorporate multiple servos into one control system to allow interactions between them

Components

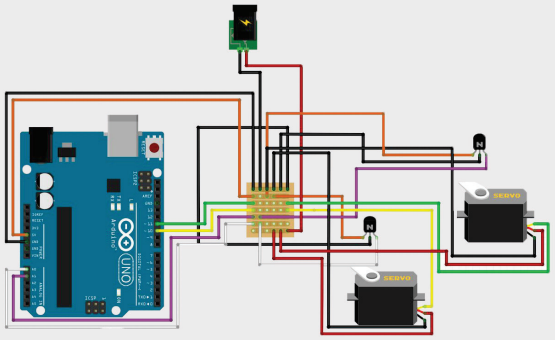
A servo is a motor with a gearbox and circuit designed to make precise movements. Servos are inherently *not* backdrivable.

A microcontroller is a miniature computer that can run user-written programs and interface with other electronic components.

A hall effect sensor is an electronic component used to measure changes in a magnetic field.

Procedure

The circuit diagram below shows how components were wired for the haptic device.

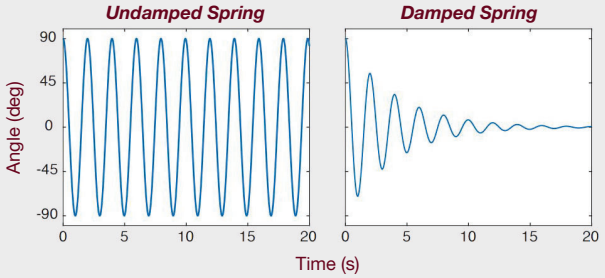


A magnet was embedded in the horn of each servo, and a hall effect sensor is mounted on each servo horn so it is a few millimeters above the magnet. By pushing on the horn, the magnet moves relative to the sensor proportional to the force applied.

The Program

- An Arduino samples the deflection detected by the hall effect sensor at about 50Hz.
- When the deflection surpasses a set threshold, the Arduino interprets it as an applied force and simulates the response of the mass-spring-damper.
- The motor is commanded to move to the position calculated at every time step of the simulation.
- When the force is released, the program returns the servo to center in the manner of a damped spring.

Spring Examples



Results

- Currently the servo properly returns to center and oscillates like a spring, and it resists forces pushing it away from its center.
- The way the hall effect sensor is mounted creates some error in balancing force for both direction of movement on the servo.
- An undetermined error creates a progressively increasing oscillation in the movement of the servo horn for prolonged impulses, ruining the effect.

Future Plans

- Find a solution that would fix the tendency for the servo to oscillate out of control under prolonged impulses.
- Add more servos to the system to allow for more types of interactions such as summing forces between servos
- Design more types of interfaces beyond a grabber such as a lifting platform.

Acknowledgements: The Office for the Vice Provost for Research, The Office for the Vice President of Diversity, Equity, and Multicultural Affairs, The Department of Psychological and Brain Sciences, and The Office of Engaged Learning