Grasp Control of a Cable-Driven Robotic Hand Using a PVDF Slip Detection Sensor

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Abstract: Replicating the human hand grasp ability through robotic hands has been widely studied. Monitoring the object slippage is one of the common methods that has been used to enable a safe and reliable grasp. This method is usually implemented using optic, vibration, force, or pressure sensors. Among them, Polyvinylidene fluoride (PVDF), which is kind of Piezoelectric vibration sensor, is a flexible, thin, cheap, and highly sensitive material that can provide a compact design. Since it can only detect dynamic forces, it is usually used along with a force or electromyography sensor. Although different combinations of these sensors can provide detailed knowledge about the grasp status, it may lead to bulky designs and complicated control systems.

In this study, a PVDF sensor is used to perform reliable grasps using a cable-driven, single-actuated, and five-fingered robotic hand. The PVDF sensor is attached to the Dorsal phalange (fingertip) of the index finger to detect the vibrations due to the object slippage. The PVDF signal is read through a serial port and processed in a real time Simulink simulation. The signal processing algorithm includes a dead zone threshold function to detect the grasp stages, while preventing the frequently on-off switching of the actuator. A bend sensor is assembled on the little finger to monitor the direction of the fingers' movement. A proportional controller is implemented to control the grasp, based on the status of the grasp and hand movement. The functionality of the proposed control system is evaluated through experiments, where several objects with different geometry and weight are grasped and additional excitations are implemented manually with pulling, pushing, and rotating the grasped objects.

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