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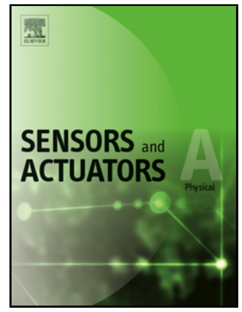

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Hybrid Actuator Combining Shape Memory Alloy with DC Motor for Prosthetic Fingers

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Abstract
Direct Current (DC) motors are widely used in prosthetic hands. Since the power to weight ratio of DC motors is relatively low, the driving systems are usually bulky and heavy to meet the requirements for the grasping speed and force. However, high grasping speed is a basic requirement for the grasping reflex to prevent the grasped object from slipping. With increasing force, the possibility that grasped objects will slip off is significantly reduced. This study proposes a hybrid actuator combining shape memory alloy (SMA) with a micro DC motor for a prosthetic finger. The SMA is used to improve reflex speed. Rapid response can be achieved when SMA is subjected to high voltage. Experimental results show that in the grasping reflex, the rate of force is increased four times, and the sliding displacement of the grasped object subjected to unexpected disturbances is reduced from 10 mm to 5.7 mm.

Keywords: Prosthetic finger; Hybrid actuator; Grasping reflex; Shape memory alloy

1. Introduction

The recent rapid increase in the number of prosthesis wearers has made artificial anthropomorphic hands one of the most promising fields. Thus, many novel prosthetic hands have been proposed.

Given their high-efficiency and easy-to-control mechanism, DC motors are widely used as actuators for prosthetic hands [1-4]. Since the power to weight ratio of DC motors is relatively low, the driving systems are usually bulky and heavy to meet the requirements for the grasping speed and force [13]. To downsize and lighten prosthetic hands, shape memory alloy (SMA) is an alternative for DC motors [5-8]. SMA has numerous advantages, such as high power-to-weight ratio and low driving voltages. Nevertheless, the recoverable deformation of SMA is small (4%-8%). Moreover, SMA length is considerably long and thus provides sufficient displacement for prosthetic hands and further increasing energy consumption. Consequently, the working time of prosthetic hands powered by mobile energy significantly decreases. Other types of artificial anthropomorphic hands, such as pneumatic prosthetic hands [9] and hydraulic drive prosthetic hands [10], have recently been designed. However, both these prosthesis types are equipped with a bulky actuation system. A robot finger that uses electro-conjugate fluid (ECF) was proposed in [11, 12], but a high DC voltage of approximately 2 kv–6 kv is required for powering ECF.

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