A small biomimetic quadruped robot driven by multistacked dielectric elastomer actuators

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Abstract

A kind of dielectric elastomer (DE) material, called ‘synthetic elastomer’, has been developed based on acrylonitrile butadiene rubber (NBR) to be used as a dielectric elastomer actuator (DEA). By stacking single layers of synthetic elastomer, a linear actuator, called a multistacked actuator, is produced, and used by mechatronic and robotic systems to generate linear motion. In this paper, we demonstrate the application of the multistacked dielectric elastomer actuator in a biomimetic legged robot. A miniature robot driven by a biomimetic actuation system with four 2-DOF (two-degree-of-freedom) legged mechanisms is realized. Based on the experimental results, we evaluate the performance of the proposed robot and validate the feasibility of the multistacked actuator in a locomotion system as a replacement for conventional actuators.

Keywords: biomimetic, legged robot, multistacked dielectric elastomer actuators

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(Some figures may appear in colour only in the online journal)

1. Introduction

A wide variety of biomimetic legged robots, mostly driven by servomotors and hydraulic actuators, have been developed. These actuators show acceptable performance and produce great results in robots such as BigDog [1], AiDin [2], and Cheetah [3]. One of these robots, BigDog, developed by Boston Dynamics, has a variety of locomotion behaviors and can adapt to different terrains. However, it is limited by its large size, heavy weight and complex transmission mechanisms [4]. Compared with these robots, small-scale robots offer several advantages, such as high mobility, light weight, miniature size, simple mechanical structure and low cost [5–7]. Therefore, they can be more effectively employed in certain missions for navigation, exploration and rescue in tight spaces or confined environments, such as caves or collapsed buildings, than the larger robots.

According to [5–7], various small legged robots, such as CWRU’s cricket microrobot, Standford’s iSprawl, a mesoscale robot quadruped, HAMR3, a centipede-inspired millirobot, an SMA-actuated jumping robot, and SRI’s walking robots have been studied. To control and drive their legs, these robots use several technologies, drive their legs, these robots use several technologies, including pneumatics, piezoelectrics, shape memory alloys and electroactive polymers (EAPs), which have been developed as artificial muscle actuators for robotic applications. Among these technologies, electronic EAPs have recently attracted the attention of many researchers due to their capability of changing shape or size in response to electrical stimulation. After almost two decades of development, EAP actuators have improved rapidly [9, 11, 13].