Investigating the Use of a Piezoelectric Actuator for the Appendages of a Microrobot

Justin V. Clark and Jason V. Clark
Purdue University
clarkjv@purdue.edu

INTRODUCTION

We investigate the use of a piezoelectric actuator for the appendages of a microrobot. Possible uses may include micro assembly, mobile surveillance, etc. What is different about this microrobot is that it uses 2 degree of freedom, low powered piezoelectric flexures, while attempting to mimic the maneuverability of an ant-like insect. Figure 1a shows the configuration of our microrobot. The microrobot consists of six legs and two mandibles. All such appendages operate under the same piezoelectric actuation technology that is shown in Figure 1b. Figure 1b shows a magnification of a knee of a microrobot. As seen in Figure 1b, the thigh of the microrobot consists of three piezoelectric flexures, which elongate and contract upon an applied voltage. This piezoelectric concept is exemplified in Figure 1c. In essence, applying a voltage to a piezoelectric flexure extends the flexure a small fraction of its length (on the order of 0.1%). These applied voltages are depicted in Figure 2a. Simulations show that by applying +/- 10 volts, a 300 micron long thigh axially deflects ~0.3 microns while laterally deflecting ~30 microns. This implies that the microrobot has about a 60 micron stride and a 60 micron stepping height. For example, Figures 2b to 2d show simulations of a thigh deflecting in the y-direction, z-direction, and diagonally in the yz-direction respectively. In the paper, we use COMSOL to characterize this type of piezoelectric actuator in terms of microrobotic locomotion, load carrying capacity, and power consumption per stride.

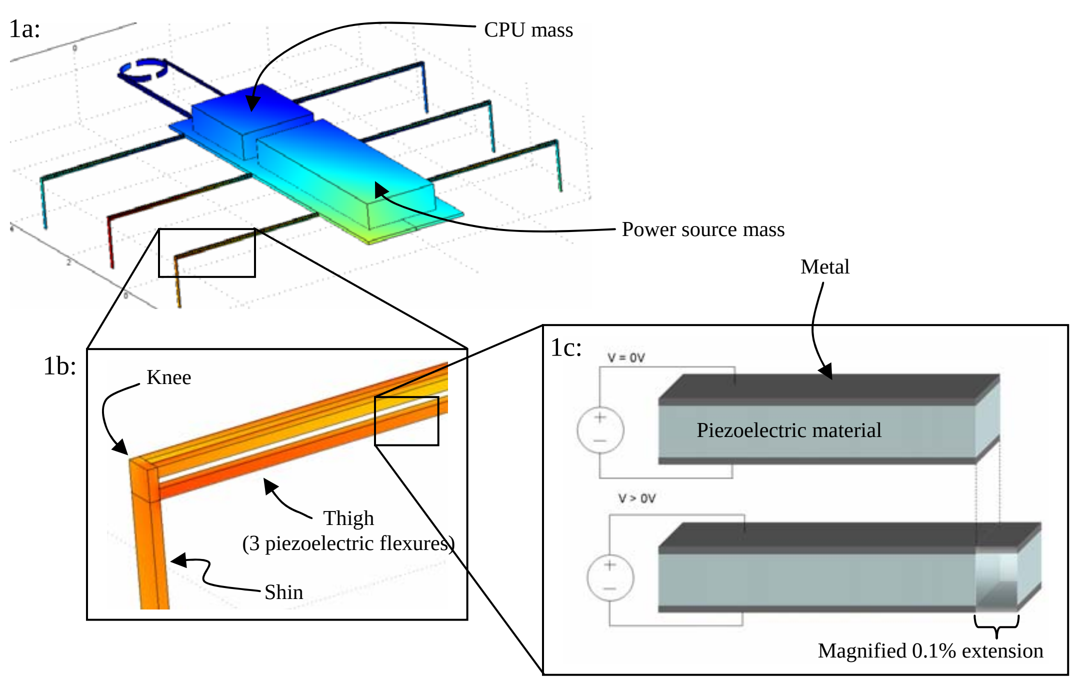

Figure 1a: Configuration of a microrobot in COMSOL consisting of six legs and two mandibles. The body consists of two blocks that represent the weight of a power source and microprocessor.

Figure 1b: A close-up of a shin, knee, and thigh of a microrobot. The thigh comprises three piezoelectric flexures.

Figure 1c: A close-up of one of the three piezoelectric flexures of the thigh, exemplifying its most important piezoelectric effect. That is, the elongation of the piezoelectric flexures due to the applied voltage produces the actuation of the appendage.

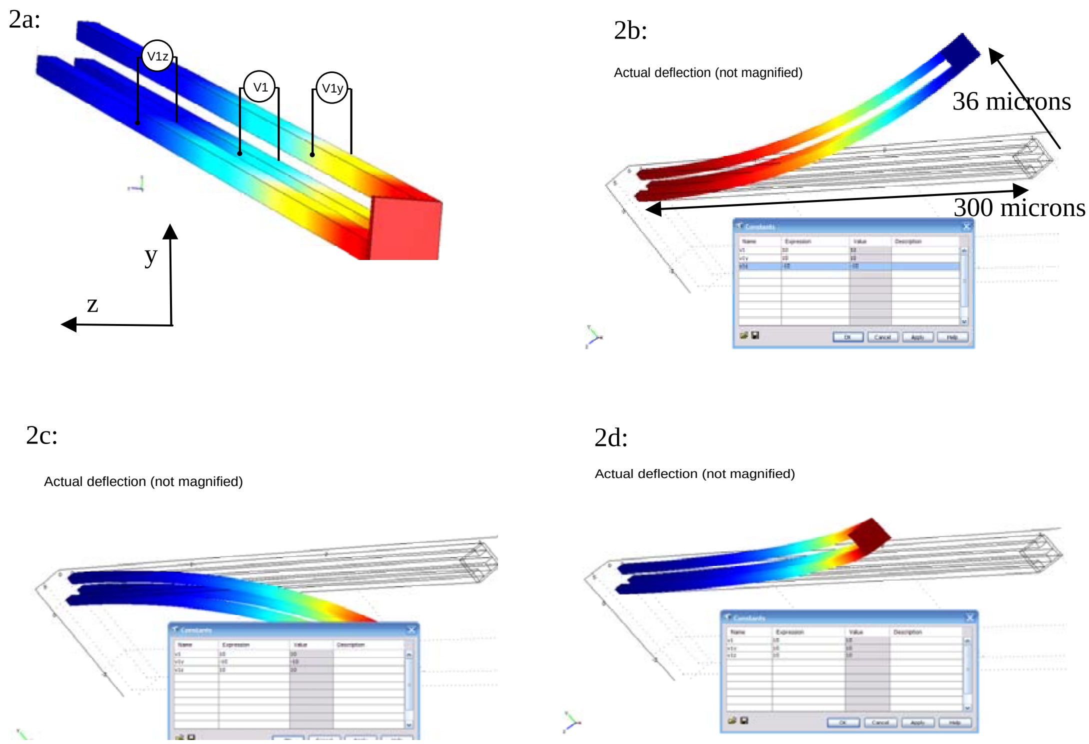

Figure 2a: Depicting applied voltages on the three piezoelectric flexures making up an appendage of the microrobot. Total deflection is plotted on the surface. The triple piezoelectric flexure are fixed at the far end and mechanically coupled at the near end. The voltage V1y controls deflection in they y-direction. And the voltage V1z controls deflection in the z-direction. The voltage V1 can be used to increase deflection in either direction.

Figure 2b: To deflect in the positive y-direction, applying V1y = 10 contracts the y-direction flexure, and applying V1 = 10 and V1z = -10 extends the z-direction flexures.

Figure 2c: To deflect in the positive z-direction, applying V1z = 10 contracts the z-direction flexure, and applying V1 = 10 and V1y = -10 extends the z-direction flexures.

Figure 2d: To deflect in the positive yz-direction, applying V1 = 10 extends the middle flexure, and applying V1y = 10 and V1z = 10 contracts the outer flexures.