A Theoretical and Experimental Study on Hybrid Electromechanical Actuators

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In this paper we investigate multiple electromechanical actuators with the aim to build a hybrid actuator which has a broader actuation domain or uses less power to obtain a given displacement than other known standard actuators. In literature there are many types of actuators based on different materials (such as polymers, piezoelectric materials, magnetostrictive materials etc.) used in electric/magnetic fields generated by alternating or direct current to obtain certain displacements, torques or forces. For a better understanding of actuation effects we first take a theoretical approach and consider relevant results from the literature, then we study some piezoelectric, electrostrictive, magnetostrictive and electromagnetic actuators experimentally and finally based on our results we decide which hybrid actuators are worth implementing. As a result of our experimental study we found multiple interesting properties of some membranes, such as a polyamide that has a better response in electric field in terms of displacement than the well-known PZT material, but most importantly we concluded that we may build two hybrid actuators: the electromagnetic-piezoelectric actuator and the elastomer-piezoelectric actuator. These actuators have a broad actuation domain and may be used for precise positioning. The former can used to perform rough alignments (about 0.1 mm precision) using the electromagnetic actuator and fine adjustments using the piezoelectric element (about 0.1 micrometers precision). The same goes for the latter, the PZT element being the one which performs displacements of a few microns and the elastomer can reach a precision of a few nanometers.