Abstract

Doctor of Philosophy

Performance Evaluation and Optimization of IPMC for Activation of Deformable Soft Grippers

by

Srijan Bhattacharya

This present investigation encapsulates the recent trend and advancement in the field of IPMC actuation to accomplish micro-gripping, light weight or soft object handling for compliant soft grippers. Ionic Polymer Metal Composite (IPMC) being an Electro Active Polymer (EAP) is used as an actuator in development of the finger for soft compliant gripper. IPMC is qualified with an admirable bending property at low actuation voltages and endowed with adequate tip forces, thus capable of performing grasping tasks when employed as an actuator for small object manipulation. Performance Evaluation of IPMC is emphasize in this present research work, as it is indispensable from the application point of view as an actuator for micro or soft object gripping system. Optimization of actuating parameters for IPMC also plays an important role in the present report. IPMC responses like actuating force and displacement have been critically examined to the input factors like voltage, frequency and doping in ionic solutions of IPMC. Selection of proper material for manufacturing of compliant robot gripper among various materials (seven in this case) is described. These selection is done with many attributes is the basis of multi criteria decision making (MCDM) problem. The best material is one which serves the intended purpose for a desired period of time under the given condition. Applying MCDM, Polydymethyl Siloxane (PDMS) has passed all the criterion for tensile stress, elongation at break, density, hardness and cost, which results that the material for this gripping system is selected as PDMS, since the material possesses all the above advantage along with it being bio compatible and transparent in colour. A study of variation of IPMC gripper workspace when infused in different ionic salt solutions by modelling as a multi-link serial manipulator and an inverse kinematic based approach is proposed to resolve its hyper-redundancy. The proposed Tractrix based shape estimation algorithm delivers better modelling results for distilled water and reveals that the IPMC geometry
differs greatly in different solutions, which has motivated its application in the field of gripper design.

This thesis represents a technique of gripping with IPMC actuated finger and advance remote communication process with the help of joystick and wearable interface like data glove.

This technique provides an advantage to control a soft gripping device from a remote location with force calculation during the grasping operation. Also the study of variation of IPMC gripper workspace is accomplished when infused in different solutions. The proposed Tractrix based shape estimation algorithm delivers better modeling results and reveals that the IPMC geometry differs greatly in different solutions. An active two jaws IPMC gripper and a passive PDMS and IPMC two jaw gripper have been studied. The study may also be conceived in tele-operating mode for effective maneuverability by the operator.

Finally a two and three finger made of PDMS and IPMC gripper is designed and fabricated for soft object gripping, which has a potential for manipulation of fragile objects like biological objects.