Self-sensing shape changing structures for active and soft manipulation and robotics applications*

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***Abstract*—Robotic materials, equipped with concomitant sensing and control capabilities, promise to bring various engineering applications such as material handling with added functionality. We demonstrate an intelligent and shape-adaptive PneuEA gripper, an integration of an electroadhesive (EA) gripper and a two-fingered soft pneumatic actuator. In addition, we show a monolithic, shape-changing, and self-sensing EA-DEA composite gripper, a combination of EA and dielectric elastomer actuator (DEA) actuation. The presented grippers have the potential to significantly improve the intelligence of EA gripping technologies and increase their use in intelligent material sorting, grasping, and manipulation applications.**

I. Introduction

Grippers, made of soft and smart materials and structures can bring lighter, simpler, and potentially more universal grippers [1]. Soft gripping methods have been classified as gripping by actuation, controlled stiffness, and controlled adhesion [1]. Electroadhesion (EA) is a promising electrically controllable adhesion mechanism for robotics and material handling applications [2]. Current planar EA grippers, however, have difficulty adhering to non-planar surfaces and picking up non-flat objects. Shape changing or adaptive materials and structures are, therefore, required to be integrated with EA to enable current EA grippers to grasp and manipulate non-flat surfaces and objects. Examples of non-flat surface include concave (such as bowls), convex (such as balls), double curvature (such as shells), and free-form surfaces (such as turbine blades).

Soft and sensorial robotic systems are suggested to be capable of concomitant sensing and actuation, and even computation and communication, adding unprecedented functionality to future everyday materials and objects [3]. Self-sensing shape changing structures are extremely helpful for active and intelligent robotics applications such as material sorting and manipulation. In order to pick-and-place objects in unstructured environments in a robust and safer way, EA systems must be capable of proprioceptive and exteroceptive sensing.

We present an intelligent and shape-adaptive PneuEA gripper, made by an easy-to-implement integration of an EA gripper and a two-fingered soft pneumatic actuator (SPA), augmenting functionalities of both EA and SPA technologies [4]. In addition, we show a monolithic, shape-adaptive, and self-sensing EA-DEA composite gripper, made by a simple combination of EA and dielectric elastomer actuator (DEA) technologies based on a dual-mode parallel-and-coplanar electrode pattern, enabling not only proprioceptive (intrinsic deformations) and exteroceptive (contact indications and different materials) stimuli sensing but also shape morphing so that it can actively shape-adapt to non-flat surfaces [5]. These grippers can be employed for intelligent industrial material sensing and EA handling of objects including fabrics, bowls, and lenses. They have the potential to significantly improve the intelligence of EA gripping technologies and increase their use in robotic material handling industry.

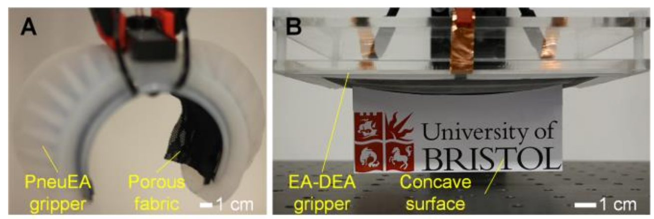

Figure. (A): prototype of a PneuEA gripper, grasping a flexible and porous fabric from a convex surface; (B): prototype of a self-sensing EA-DEA gripper, grasping a concave surface.

II. Live Demonstration Description

In the presentation, we will show a video of an intelligent and shape-adaptive PneuEA material handling system which can grasp flexible materials from convex surfaces. Also, we will show the shape changing capability of the EA-DEA structure from 1-10 kV. In addition, a self-sensing EA-DEA composite gripper will be shown to differentiate different materials and grasp concave surfaces. Protypes of both grippers will be brought to the workshop.

References

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