Variable Afferent Network Morphology (VANmorph): An Implementation on Sensorized Soft Body

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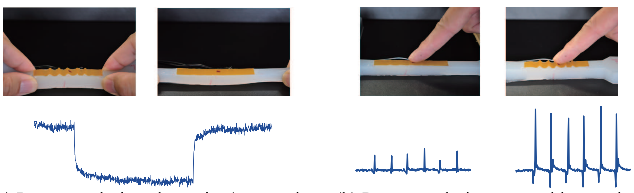
***Abstract*— This report is prepared for the poster presentation on IROS 2018 Full Day Workshop on "Shape Changing Robotic Structures and Interfaces". It introduces the recent work progress on a sensorized soft body which is promising toward further development of an active sensing system.**

I. INTRODUCTION

Inspired by the water induced wrinkles of human fingers, we propose the design of wrinkle based sensorized soft body by sandwiching a strain gauge between a thin layer of film and a soft substrate which respectively act like the stratum corneum and the underlying structure of fingers. Wrinkle forms when the two layers are exposed to different strain conditions and wrinkle morphology, such as the wavelength and magnitude, varies in response to the scale of this strain differentiation. The strain gauge tends to have different orientations along with the wrinkle morphology change thus varies its sensing characteristics, which demonstrate itself promising to be further developed into an active sensing system once the relationship between the morphology and sensing character change is reveals. We utilized these properties to equip the soft bodies with facial morphological change and a possibility to change their morphology for recognition of different sensing tasks as briefly illustrated in Fig. 1.



(a) Response during elongation/contraction (b) Response during external interaction

Fig. 1. Wrinkle-based soft sensing system with tactile perception: (a)Embedded strain gauge's orientation, as well as electrical response change resulted by self-deformation. (b) The sensing system can sense adaptively various states of interaction, such as indention or sliding, by changing the morphology of wrinkle.

II. WORK PROGRESS

A. Fabrication

The wrinkled soft body was fabricated by gluing a polymide film (Kapton) onto a pre-stretched soft silicon rubber substrate (Ecoflex 00-50 supplied by SmmothOn, USA). The substrate was stretched from original length l to L, then released after attaching the film. Since the strain gauge can be inserted either before or after the pre-stretching, we proposed two prototypes for further verification.

B. Analitical Modelling and Finite Element Simulation

- A simplified analytical model was built based on the theory of energy stability[1] and it suggests that the number and pattern of wrinkle formed are determined by the geometrical and mechanical property of both substrate and film.
- Finite element simulation was performed using ABAQUS to validate the wrinkling behaviour. A two-step simulation, namely substrate pre-stretching and stress releasing, was conducted. The methodology is:(1) To simulate the substrate pre-stretching without considering the polymide film. (2) To import the deformed geometry and stress from last step, attach the film by "tie" constraint and release. The first step has been successfully performed so far.

C. Self-deformation and Interaction Testing

Both self-deformation and interaction can lead to output change. It is therefore vital to discriminate each part from the output signal thus for the sensor to detect external stimuli.

- Self-deformation: The experiment platform was made up of a linear stage stretching and releasing the sensor, a wheaston bridge circuit with a signal amplifier used to measure the strain change during self-deform, and a data acquisition device to collect the analogous data and convert them into digital for computer to read. Data acquired will be processed with Matlab to derive the relationship between the output and the substrate stretching strain. Type 1 shows better performance than type 2 in term of sensitivity.
- Interaction: Interaction testing is not yet done. However it is designed to examine the normal indention and horizontally sliding without considering more complicated tasks.

III. CONCLUSIONS AND FUTURE WORK

The FE simulation and interaction testing need to be done. A control algorithm for differentiation is to be implemented.

REFERENCES

[1] Brodbeck L, Wang L, Iida F (2012) Robotic body extension based on hot melt adhesives. IEEE ICRA: 4322-4327.

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