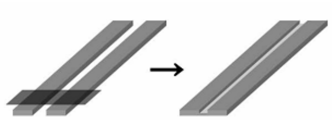
Ionic Polymer Actuator-Sensor: Designing and control strategy

H. Nakadoi [a], *M. Yamakita* [a,b], *T Maeba* [a], *T. Mukai* [b] *and K. Ito* [c]
[a] Tokyo Institute of Technology: 2-12-1 O-okayama Meguro Tokyo JAPAN
[b] RIKEN BMC: 2271-130 Anagahora, Shimoshidami, Moriyama-ku, Nagoya, JAPAN
[c] Saice corporation: 5-3-21 BR Gotanda1 2nd Floor Kita-Shinagawa Shinagawa Tokyo JAPAN
yamakita@ac.ctrl.titech.ac.jp

In this paper, we introduce the novel integrated actuator-sensor on a single Ionic-Polymer film and its control strategy. Both IPMC and BuckyGel were our target materials. A/S system will enable feedback control by getting over nonlinear characteristics of those plants and individual variability. We have investigated a displacement observer with regarding to the considerable electric interference and installed in the integrated system to build the entire system.

1, The integrated system

We have manufactured the integrated actuator-sensor of IPMC and BuckyGel. On IPMC film, slit of straight line was cut to separate it into 2 phases (Fig.1). BuckyGel is usually manufactured by casting method but in this time we have investigated printing method to obtain parallel integrated system and 5-layer integrated system as shown in Fig.2.



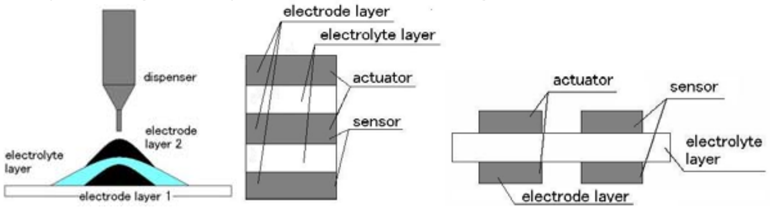


Figure1: IPMC A/S **Figure2: BuckyGel A/S (l: print, m: 5 layered, r: parallel)**

2, Removing electric interference

On the integrated system of those plants, unwanted electric interference appears between the actuator layer and the sensor layer. We cannot measure the tip displacement only with the sensor signal which is highly disturbed by unignorable interference. Moreover, according to our black-model identification, interference has dynamics in its mechanism.

To get rid of this dynamic electric interference, we have investigated the observer to estimate current displacement as follows and in Fig.3:

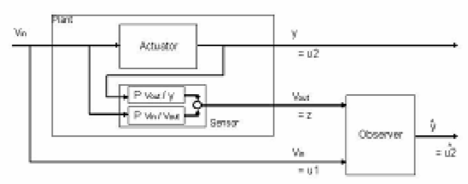
$$\hat{x}_a[k] = (A_a + HC_a)\hat{x}_a[k-1] + [B_a \quad -H]\begin{bmatrix} v_{in} \\ v_{out} \end{bmatrix}$$

$$\hat{y}[k] = [0 \quad | \quad 1]\hat{x}_a[k]$$

where v_{in} v_{out} are electric voltage to/from A/S, y is output displacement. A_a B_a C_a are augmented system matrices made from sensor dynamics and interference dynamics, H is the observer gain.

3, Experiment and Result

As shown in Fig.4, estimated displacement showed good compliance to the actual one.



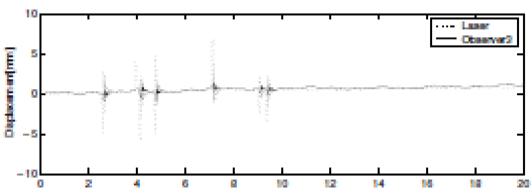


Figure3: Block diagram of A/S system **Figure4: Observer compliance**

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