A Discrimination of Slipping Condition in Paper Turning up Based on Tactile Information by Reservoir Computing

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I. Introduction

Robotic hands have difficulty in picking up and turning up paper or fabric individually. In contrast, humans can easily handle these tasks with tactile sensation, such as friction or pressure. We focus on this difference and measure tactile information during the turning up paper of humans. Using the Reservoir Computing model (RC), we then attempted to automatically discriminate the success or failure of turning up pieces.

II. Research Methods

Humans unconsciously handle turning up paper by repeatedly evaluating slipping conditions with tactile information and controlling finger pressure and velocity, i.e. 3-D force. Therefore, using a MEMS tactile sensor[1], we monitored the shear or pressure force between the finger and paper. By utilizing a signal of MEMS tactile sensor, discrimination in the middle of action is possible. Additionally, we employed an image sensor to detect slipping or turning up paper. The measurement system is shown in Figure 1. In the experiment, we instructed subjects to place their fingers for the first two seconds and turn up a piece of paper following the three seconds.

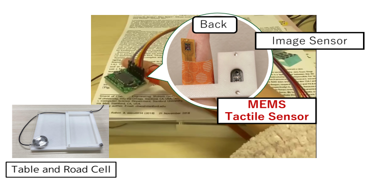

Figure 1. Masurement System.

III. Proposed method and Tasks

We employ the Reservoir Computing (RC) model [2], which retains continuous time series information in its simple structure. In our approach, the RC model is trained to the teaching signals by inputting the raw MEMS tactile sensor signal gained in the experiment into the RC model. For the purpose to research the timing of discriminable, the teaching signals are step signal set to three cases. In the first case, the step wave rises immediately after the finger starts turning on a paper. In the second case, it rises at one second; in the last case, it rises at second seconds. In each case, we calculate the area of the output signal of the RC model within one second from the step wave rising. The recognition results are determined by whether the area is above a threshold.

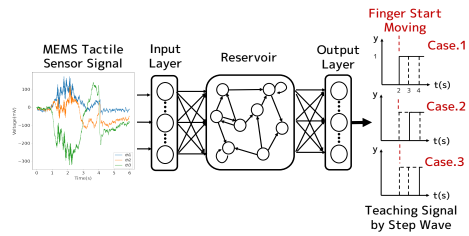

Figure 2. The RC Model for This Reserch.

IV. Result

Table 1 shows the recognition result by F-Score. Overall, F-Score is higher than 0.9 in the second and third cases. Therefore, we conclude that the RC model is practical for predictions within a few seconds after the finger starts moving. Combining the MEMS tactile sensor and the RC model automatically discriminates the result of turning up paper. Additionally, the F-Score for the RC model with either 100 or 500 reservoir nodes is near 0.9 in the first case. By comparing to the signal of image sensor, these results suggest preliminary action of a finger has information related to the outcome of paper turning up.

TABLE I. The Result of Second Task by F-Score

The Number of Reservoir Nodes	**Each Cases of Rising of Step Waves**		
	Case.1	***Case.2***	***Case.2***
1000	0.949	0.984	0.896
500	0.880	0.970	0.901
100	0.657	0.898	0.828

V. Conclusion

We showed that the RC model automatically discriminates the result of turning up paper. Significantly, the RC model can predict step signal rising immediately following finger movement. This result suggests that preliminary finger action has information related to the paper-turning task. We plan to introduce reinforcement learning to control and realize turning up paper with only one sheet with a robot hand.

References

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