A Study of Prediction of Operation Information by LSTM Using Electromyography Signals and Operation Information

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1. Introduction

In a system to operate remote robots, we study the apparent reduction of transmission delay by transmitting future operation prediction for delay time. Multimodal Long Short Term Memory (LSTM) predictions have been studied for more accurate prediction. [1] is an example of a multimodal LSTM model, but this does not have the perspective of using one information element to predict another.

2. Experimental environment

In our experimental environment in which a robot arm is operated by an human operator, the following information is used: operation information on the 3D position coordinates of the controller's handle, Electromyography (EMG) signals from an EMG sensor attached to the biceps brachii muscle of the operator's right arm, and muscle activity calculated from the EMG signals[2]. This set of information for a right-to-left movement of the controller are shown in Fig. 1. X, Y, and Z axes indicate forward/backward, left/right, and up/down directions, respectively. The data sequence used for prediction is four-dimensional data consisting of muscle activity and 3D operation information and that is 1000 samples in about 3.5 seconds. LSTM is trained to predict succeeding data of a specified prediction time from a 50-sample reference data sequence. The number of hidden layers in LSTM is set to 5, the number of epochs to 1000, and the prediction time is 0.5 sec.

3. Evaluation results

Using 5 different data, we trained LSTM by inputting the data one by one. We used another sequence for evaluation. The result of 0.5-second prediction is shown in Fig. 2. Since the movement of the controller at the time this data was acquired is from right to left, only the Y-axis data has changed. By shifting the actual Y-axis data by 0,5 sec., the expected prediction Y-axis data is generated. Since expected Y-axis data and the prediction result are almost identical, we can see the prediction of 0.5 seconds set at the time of training was almost realized. Generally, when a person performs a task, muscle activation occurs in the muscles before the person's actual movement. Fig. 2 also shows a change in muscle activation before the change in Y-axis data. This shows the motion was successfully predicted. As a comparison, a similar experiment was conducted using only operational information. The results are shown in Fig. 3. In this figure, the change in operational information is smooth, which means subsequent changes can be predicted only after the change has begun. This implies that prediction using only the operation information is difficult.

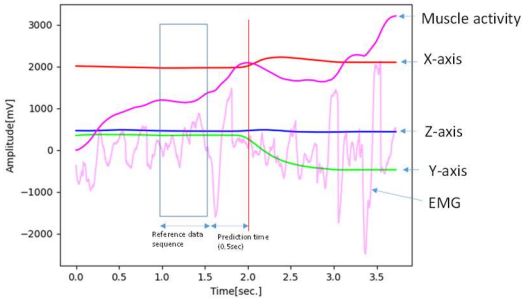

Fig. 1 Operation information, EMG and muscle activity.

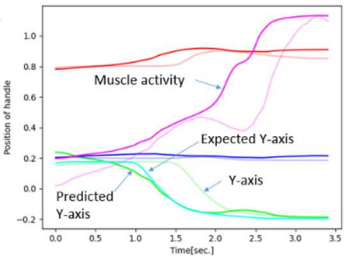

Fig. 2 With muscle activity.

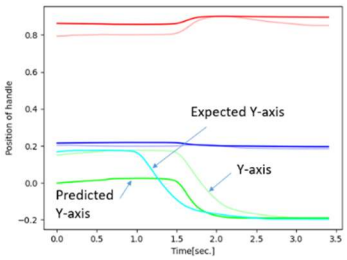

Fig. 3 With only operation information

4. Conclusion

To reduce transmission delay, we used the operation's motion information and EMG signal and confirmed that LSTM could predict 0.5 seconds almost correctly.

Acknowledgments

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References

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[2] S. Stroeve. Learning combined feedback and feedforward control of a musculoskeletal system. Biological Cybernetics, 75(1):73–83, Jul 1996.

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