

# **Explainable Deep Learning Model for EMG-Based Finger Angle Estimation using Attention**

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# Research Subject & Motive

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[1] **Research Subject** : Control of Prosthetic Hand Using Forearm EMG

[2] **Research Motive** :

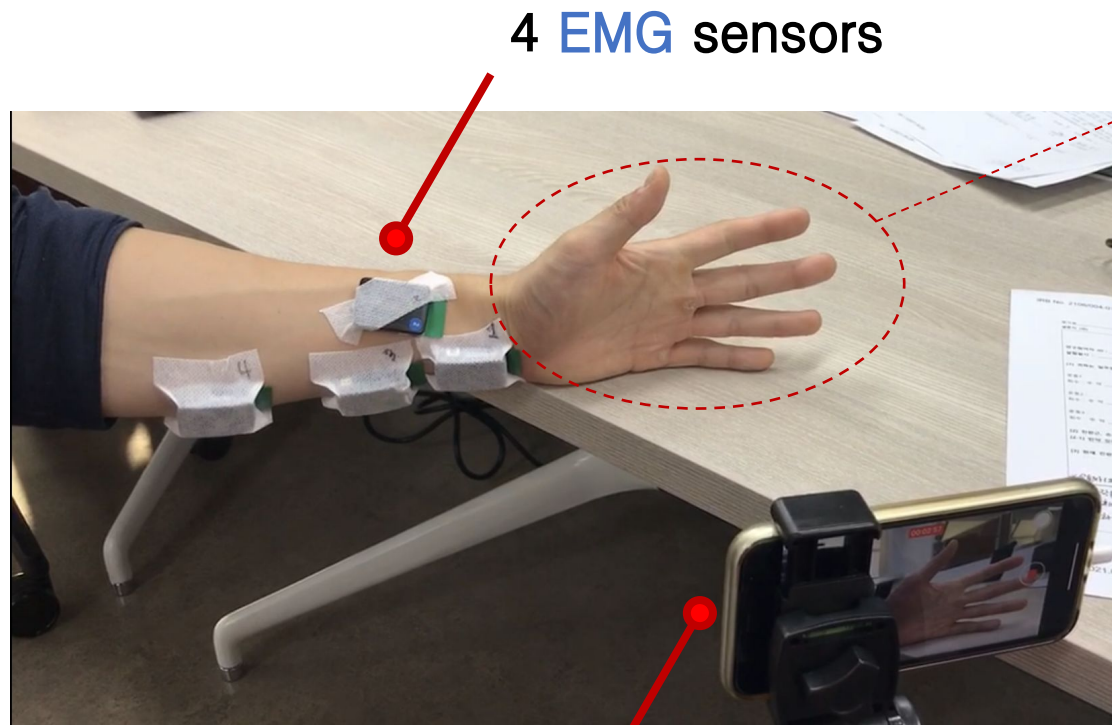
- Hand gesture classification of prosthetic hand EMG-based control method is insufficient for patients to use it in their lives.
- Explainable AI model is necessary

# Research Method

[1] Measure forearm EMG & Film the subject's hand

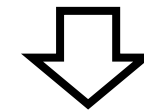
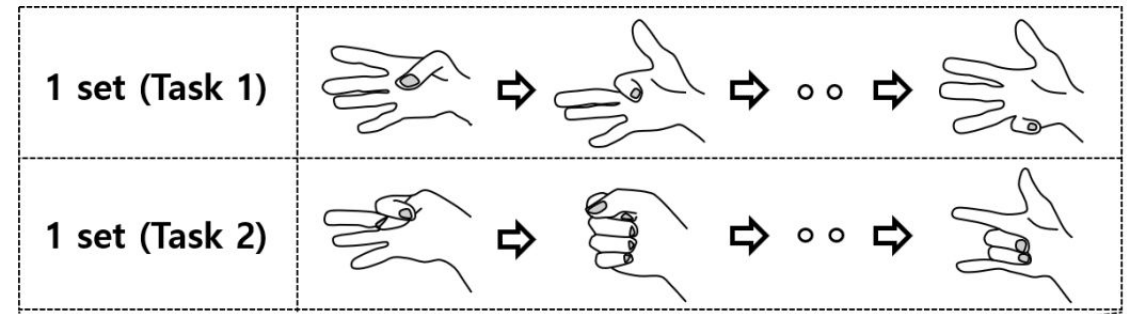
[2] Build a machine learning model : Encoder + Decoder + Attention

[3] Train the model



4 EMG sensors

Camera (240 fps)



Task1 - EMG data  $\Rightarrow X_{train}$

Task1 - Camera  $\rightarrow$  finger angles data  $\Rightarrow Y_{train}$

Task2 - EMG data  $\Rightarrow X_{test}$

Task2 - Camera  $\rightarrow$  finger angles data  $\Rightarrow Y_{test}$

# Research Method

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Model description : 1 Encoder + 5 decoders with 5 attentions

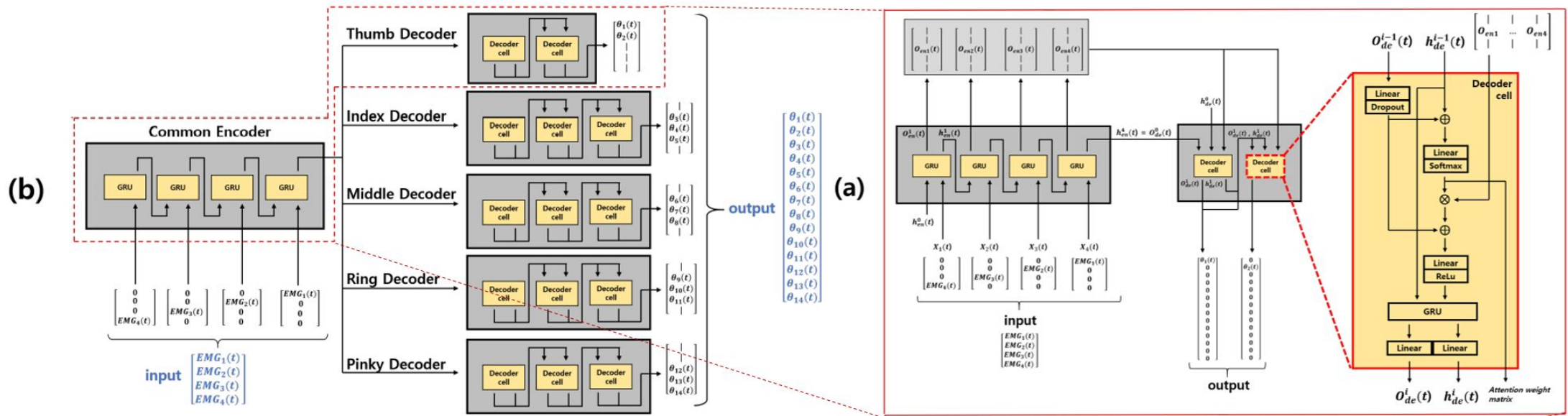


Fig. 5. Total structure of proposed Neural Network: (a) encoder+decoder with attention matrix. (b) is the total

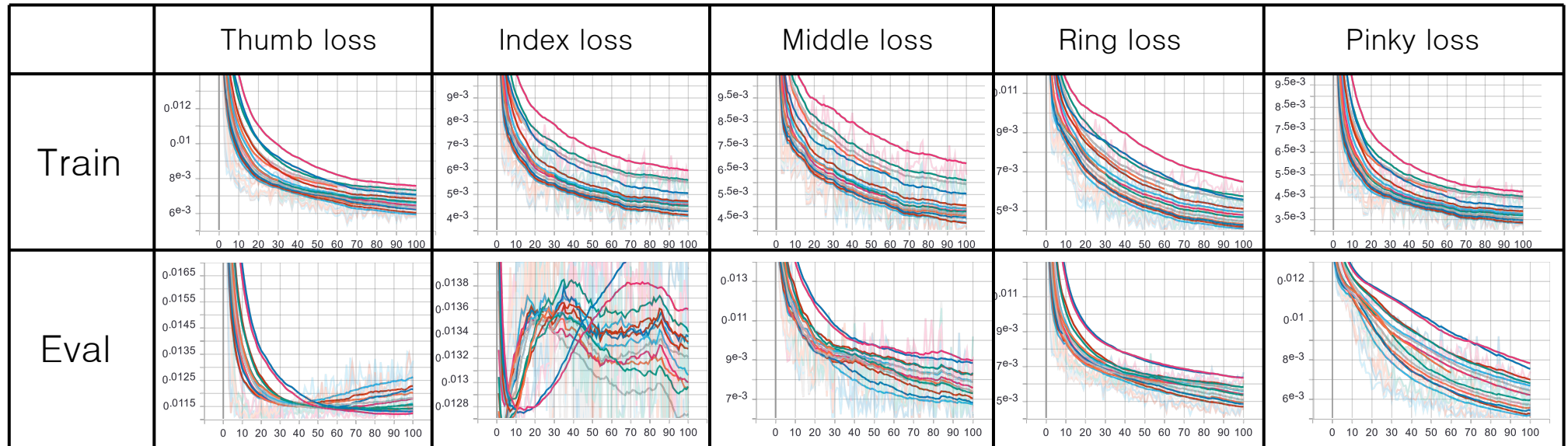
# Research Method

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- [2] Build a machine learning model : Encoder + Decoder + Attention
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## Model train :

- 1) learning rate ( $\gamma_{lr} = \{0.0001, 0.0003, 0.0005, 0.0007\}$ )
- 2) teacher forcing ratio ( $\gamma_{tfr} = \{0.0001, 0.0003, 0.0005, 0.0007\}$ )

## Train & Evaluation loss:



# Research Result

[1] Model test result

[2] Attention matrix result

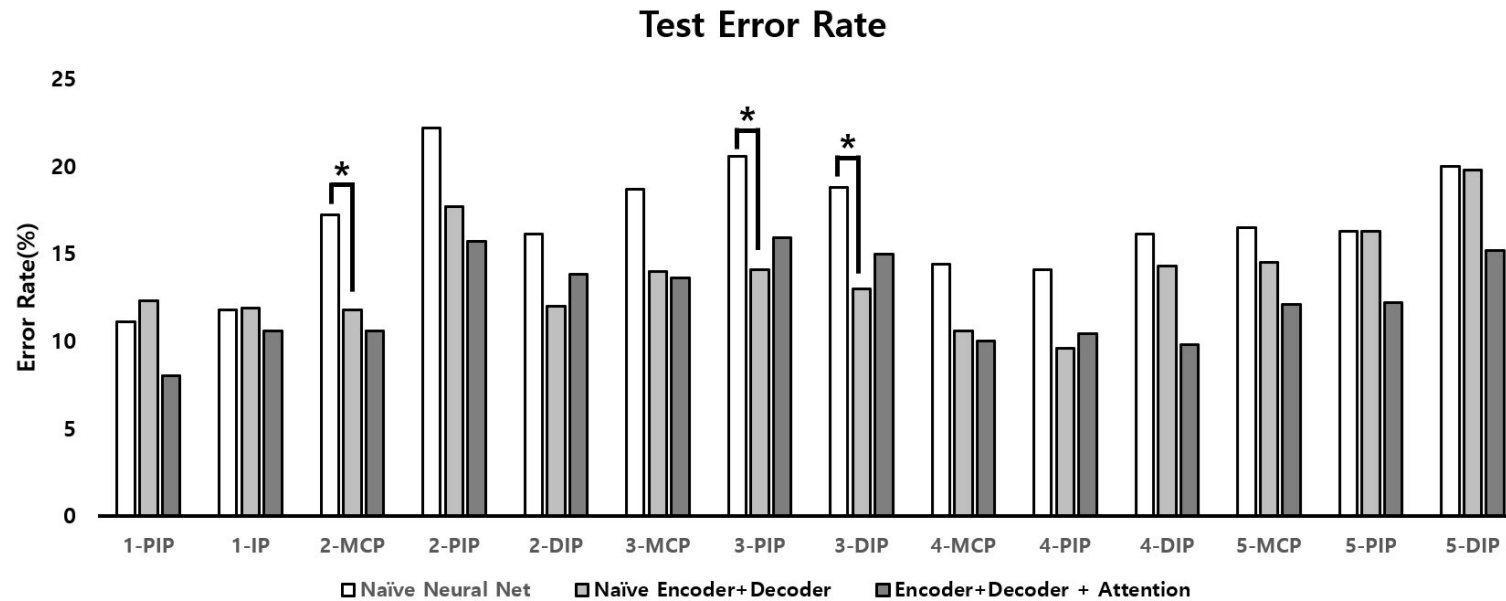


TABLE I  
COMPARISON OF 14 FINGER JOINT ANGLE PREDICTION ERROR RATES FROM THREE DIFFERENT MODEL WHEN EXECUTING TEST SET (TASK2)

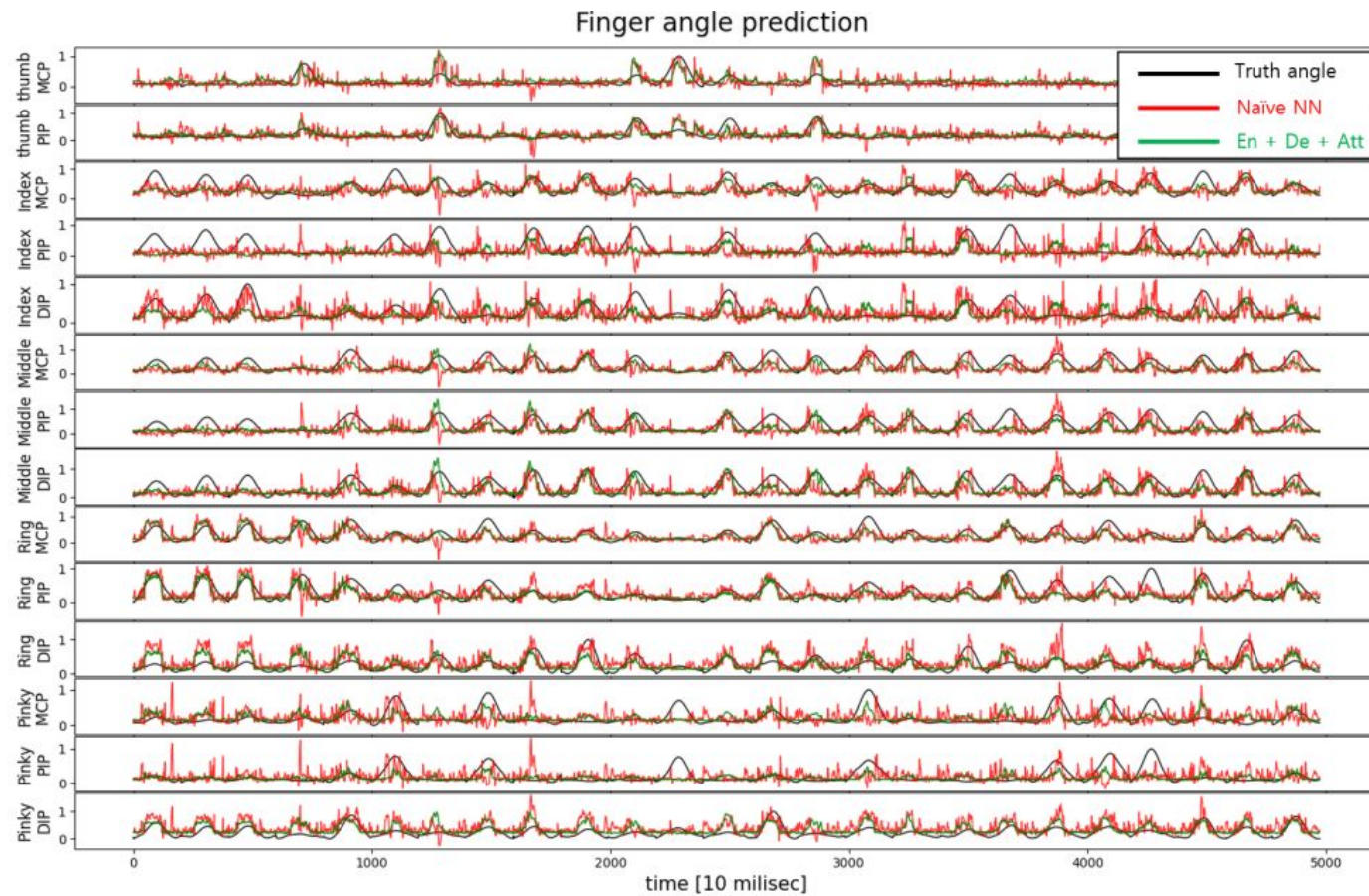
		Naive NN	Naive En+De	En+De+Att
Thumb finger	PIP	11.1%	12.3%	8.0%
	IP	11.8%	11.9%	10.6%
Index finger	MCP	17.2%	11.8%	10.6%
	PIP	22.2%	17.7%	15.7%
	DIP	16.1%	10.1%	13.8%
Middle finger	MCP	18.7%	14.0 %	13.6%
	PIP	20.6%	14.1 %	15.9%
	DIP	18.8%	13.0 %	15.0%
Ring finger	MCP	14.4%	10.6%	10.0%
	PIP	14.1%	9.6%	10.4%
	DIP	16.1%	14.3%	9.8%
Pinky finger	MCP	16.5%	14.5%	12.1%
	PIP	16.3%	16.3%	12.2%
	DIP	20.0%	19.8%	15.2%



# Research Result

[1] Model test result

[2] Attention matrix result



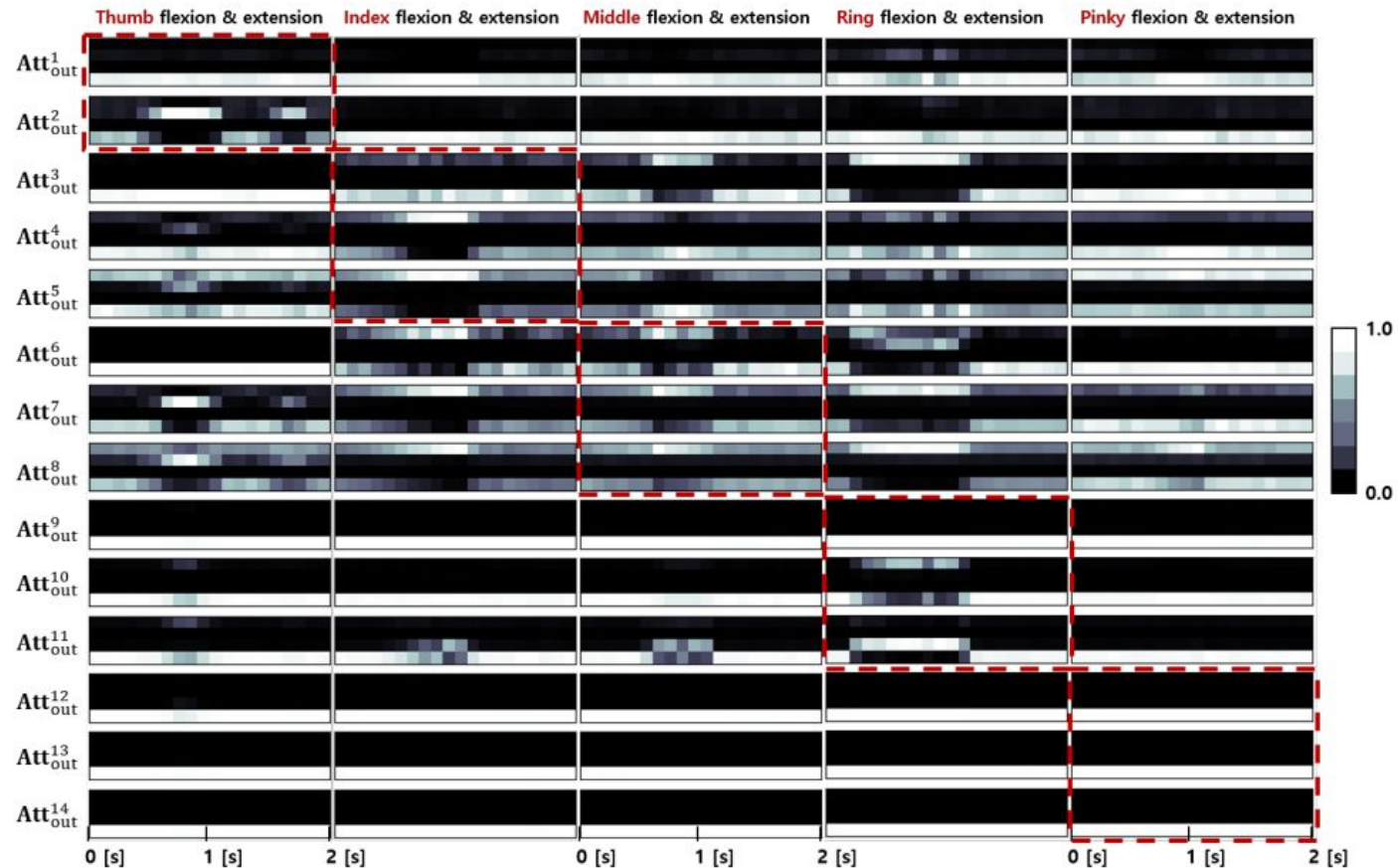


# Research Result

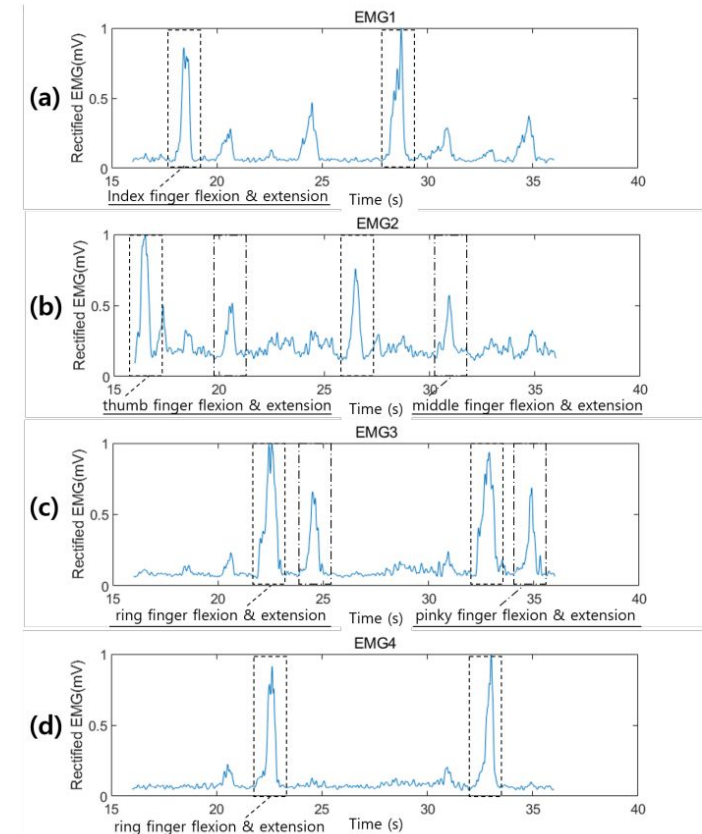
[1] Model test result

[2] Attention matrix result

Attention matrix result



EMG data



# Research Novelty & Contribution

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- [1] This study proposes an explainable deep learning model that can predict finger joint angles by forearm EMG signals
- [2] The proposed model can predict more complex data set (Task2) after the model was trained with simple data set (Task1)
- [3] After-trained attention matrix (one of model results) implies the model learns the nonlinear relationship of EMG data and finger joint angle. This supports that the proposed model is explainable