Reciprocal Learning of Intent Inferral with Augmented Visual Feedback for Stroke

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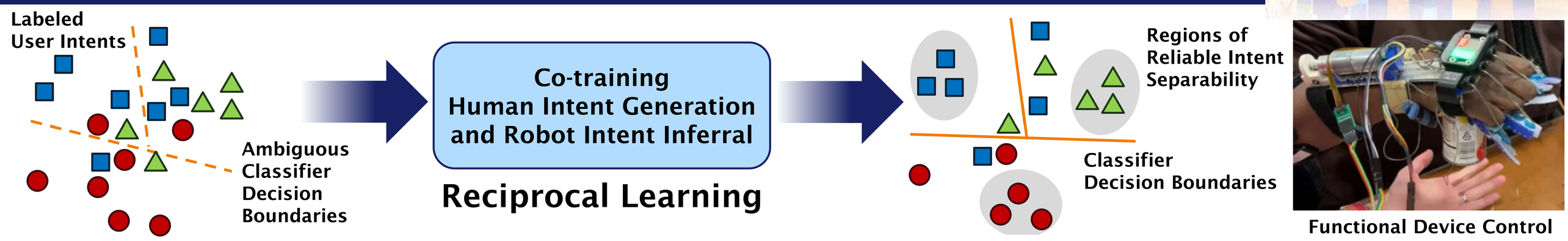
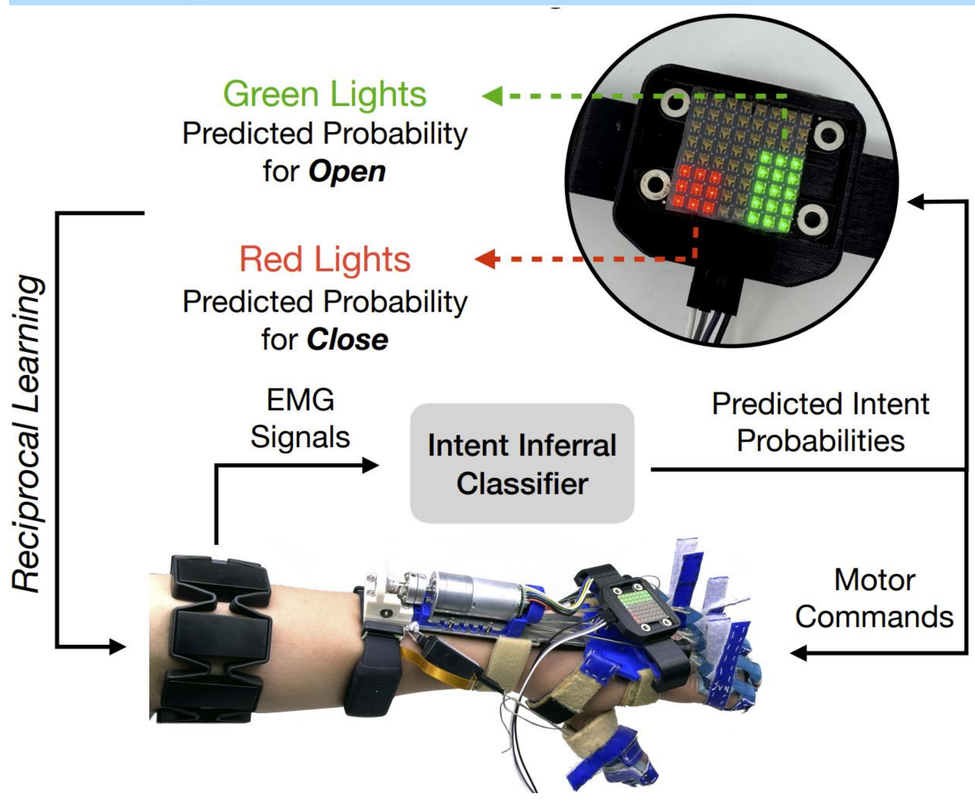


Reciprocal Learning treats the human as a dynamic co-learner alongside the classifier algorithm, prompting each to update their understanding of the other's behavior and improve EMG control of a robotic orthosis.

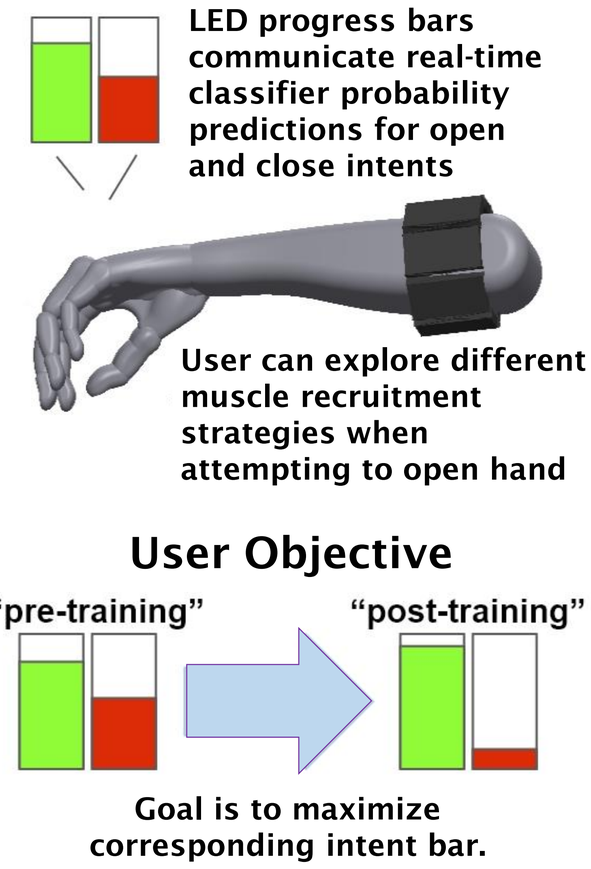
Motivation

- Wearable robots can use EMG to detect active intent to use the hand even when muscle strength is insufficient for movement, but often have difficulty determining intent due to reduced ability of the hemiparetic user to perform reliably distinguishable actions.
- We introduce Reciprocal Learning, a method in which a user learns to generate more-distinguishable EMG activation patterns for device operation while practicing active use of the hand.
- We hypothesize that bidirectional training through Reciprocal Learning will improve users' ability to generate more-separable biosignals, which in turn improves the discriminative power of LDA classification.

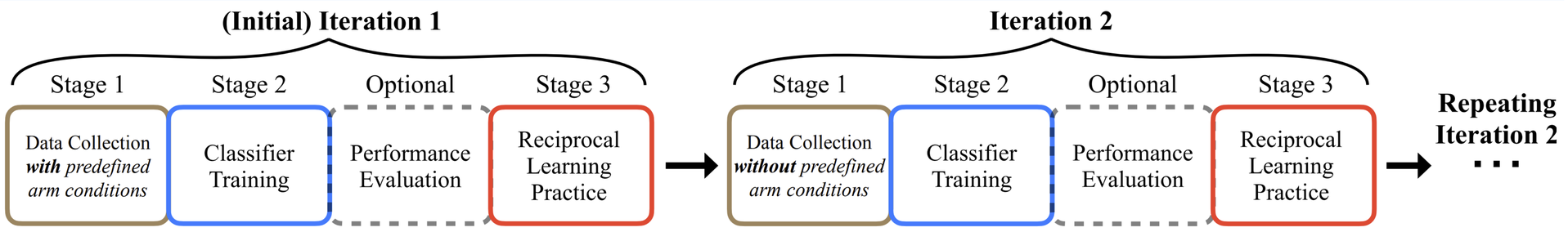
Augmented Visual Feedback and Robotic Device



The robotic orthosis predicts open, close, and relax intents from EMG signals and provides appropriate assistance.



Method: Interweaving Human Exploration and Classifier Training

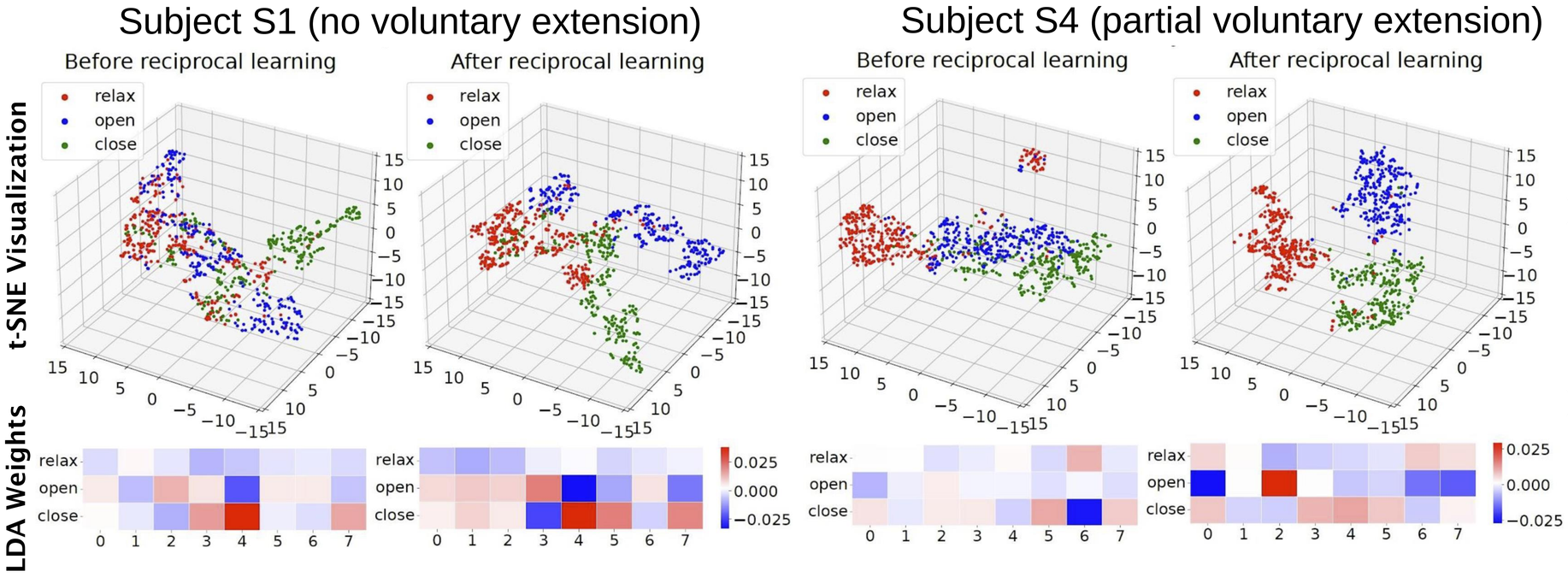


- **Classifier Training**: user follows verbal cues to provide LDA classifier with labeled data corresponding to *Relax*, *Open*, and *Close* intents.
- **Reciprocal Learning Practice**: Classifier model is frozen, allowing user to self-direct exploration and reinforcement of mappings between attempted arm motion and robot behavior.

Participants

- 5 stroke survivors with chronic hemiparesis and impaired hand function.
- Subjects S1–S3 exhibit no residual hand-opening capacity, FM-UE [26, 26, 27].
- Subjects S4, S5 retain some hand-opening capacity, FM-UE [50, 47].

Human-Robot Co-Training Produces More Distinguishable EMG Patterns



MEAN INTENT INFERRAL ACCURACY.

Subject	S1	S2	S3	S4	S5
Iteration 1	0.61	0.69	**0.70**	0.86	**0.82**
Iteration 2	**0.88**	**0.71**	0.68	**0.94**	0.80

- A subset of subjects improve intent inferral accuracy with training; performance of other subjects is not adversely affected.
- Future work will explore factors that influence a subject's ability to find distinguishable and reproducible muscle activation patterns.

As visualized in t-SNE embedding and LDA weights,
data clusters associated with each intent improve in separability after training.

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