NeuroPose:

3D Hand Pose Tracking using EMG Wearables

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Motivation

- 3D Finger pose tracking has a lot of useful applications in user-interfaces


VIRTUAL
REALITY


DISTANCE
298.6
YARDS
ACCURACY
64.22%
114
MPH
SPIN 2,154 RPM
14°
SMASH FACTOR
1.50
SPEED 165 MPH


Self-Driving

Motivation

- 3D Finger pose tracking has a lot of useful applications in user-interfaces
- Web-based augmented/virtual reality applications are becoming popular

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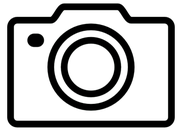
- Web-based augmented/virtual reality applications are becoming popular

Existing work

- Vision: Can track 3D finger poses from videos



Affected by occlusions and need good lighting

- wearables: robust to lighting and occlusions

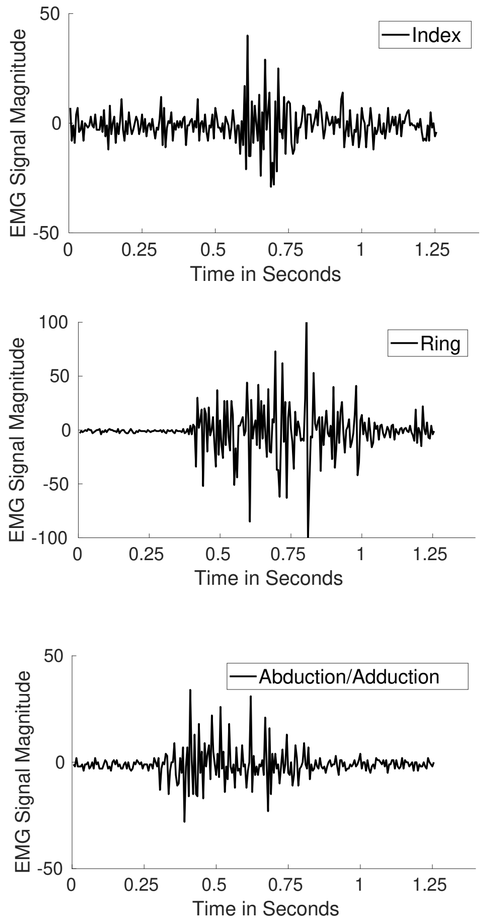
Gloves: intrusive

IMU, EMG, … : only discrete gestures

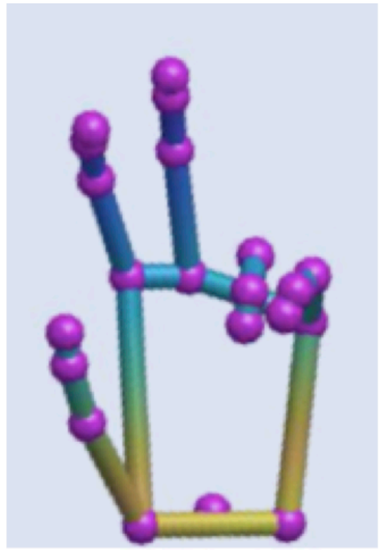
Our system: NeuroPose

EMG sensor

EMG Signals



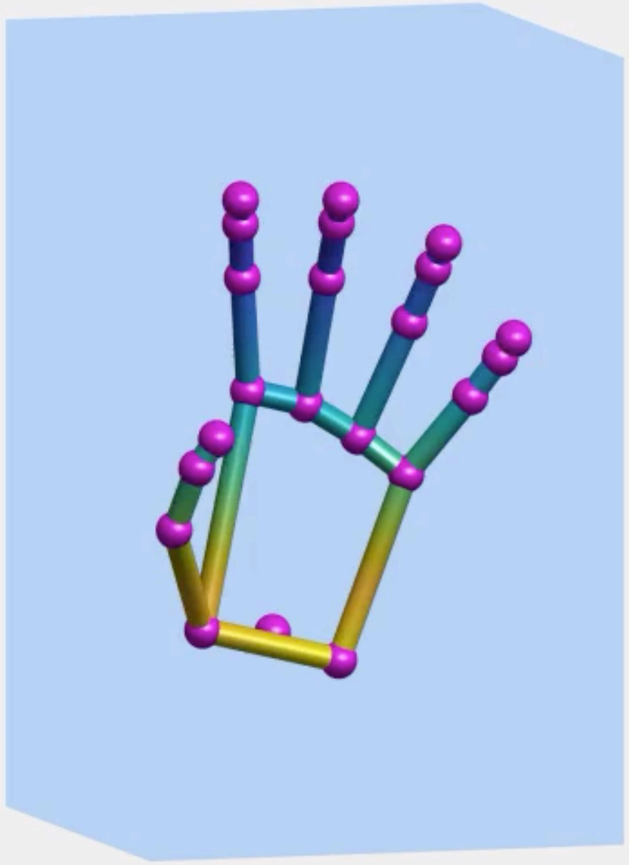
3D Hand Pose



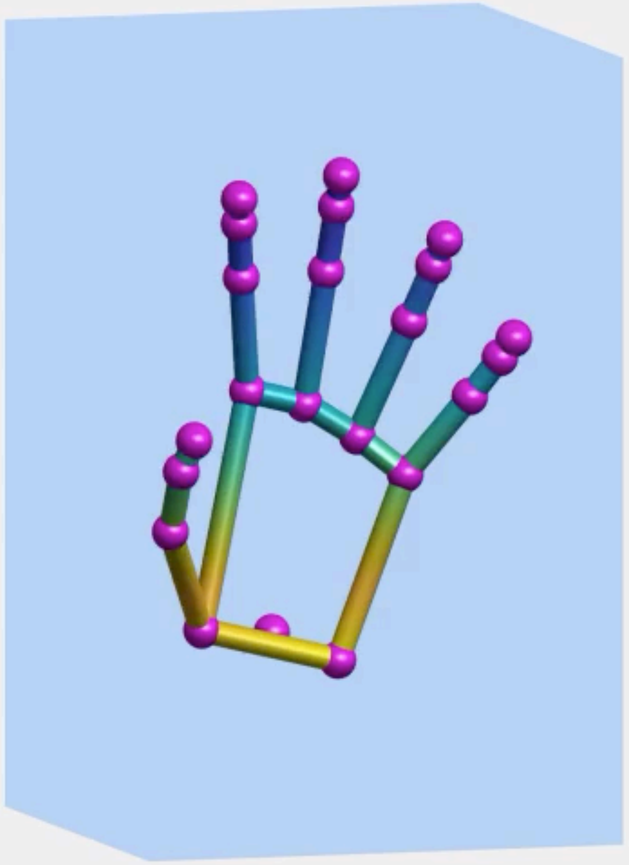
Our system: NeuroPose

Real Hand

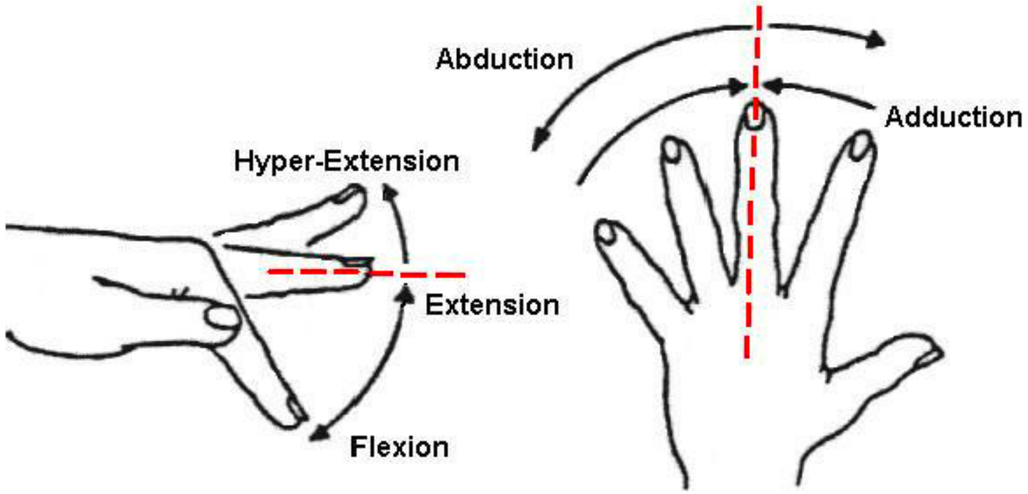
Ground Truth



Our System



Background

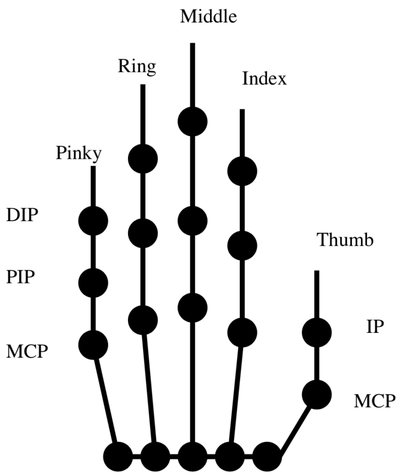


Constraints

$$\theta_{dip} = \frac{2}{3}\theta_{pip}$$

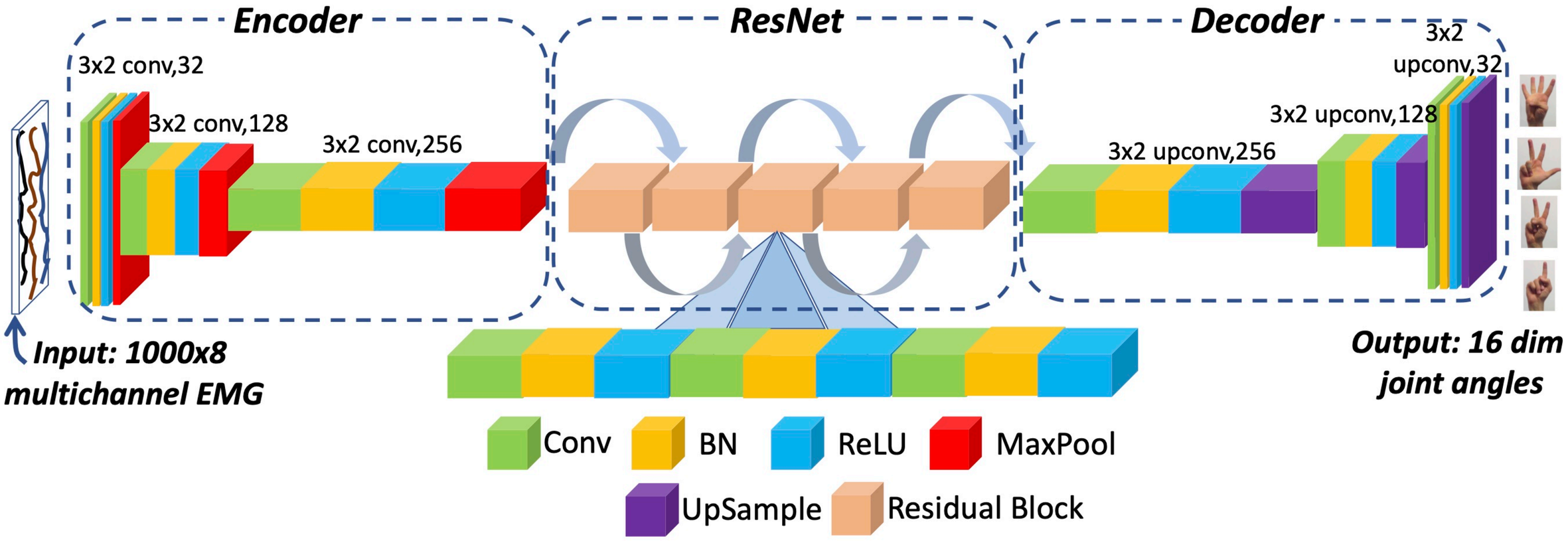
$$\theta_{ip} = \frac{1}{2}\theta_{mcp,f/e}$$

$$\theta_{mcp,f/e} = k\theta_{pip}, \quad 0 \le k \le \frac{1}{2}$$

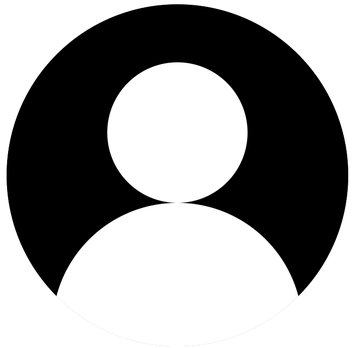


15 Degrees $\oplus$ 6 Degrees $\longrightarrow$ $\mathbb{R}^{21}$ $\longrightarrow$ $\mathbb{R}^{16}$

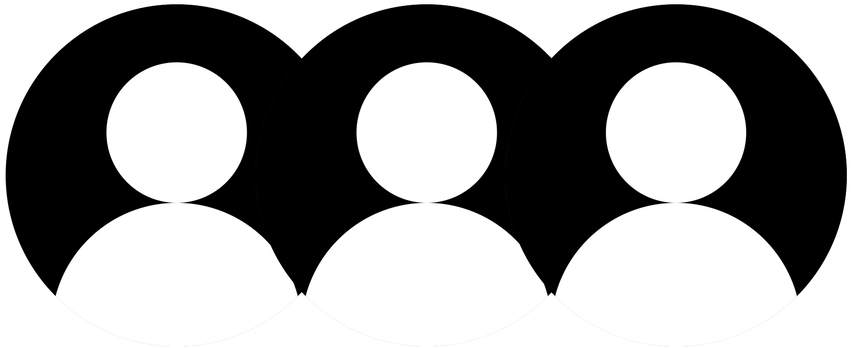
Encoder-Decoder Network



Robust to different users?



Training data



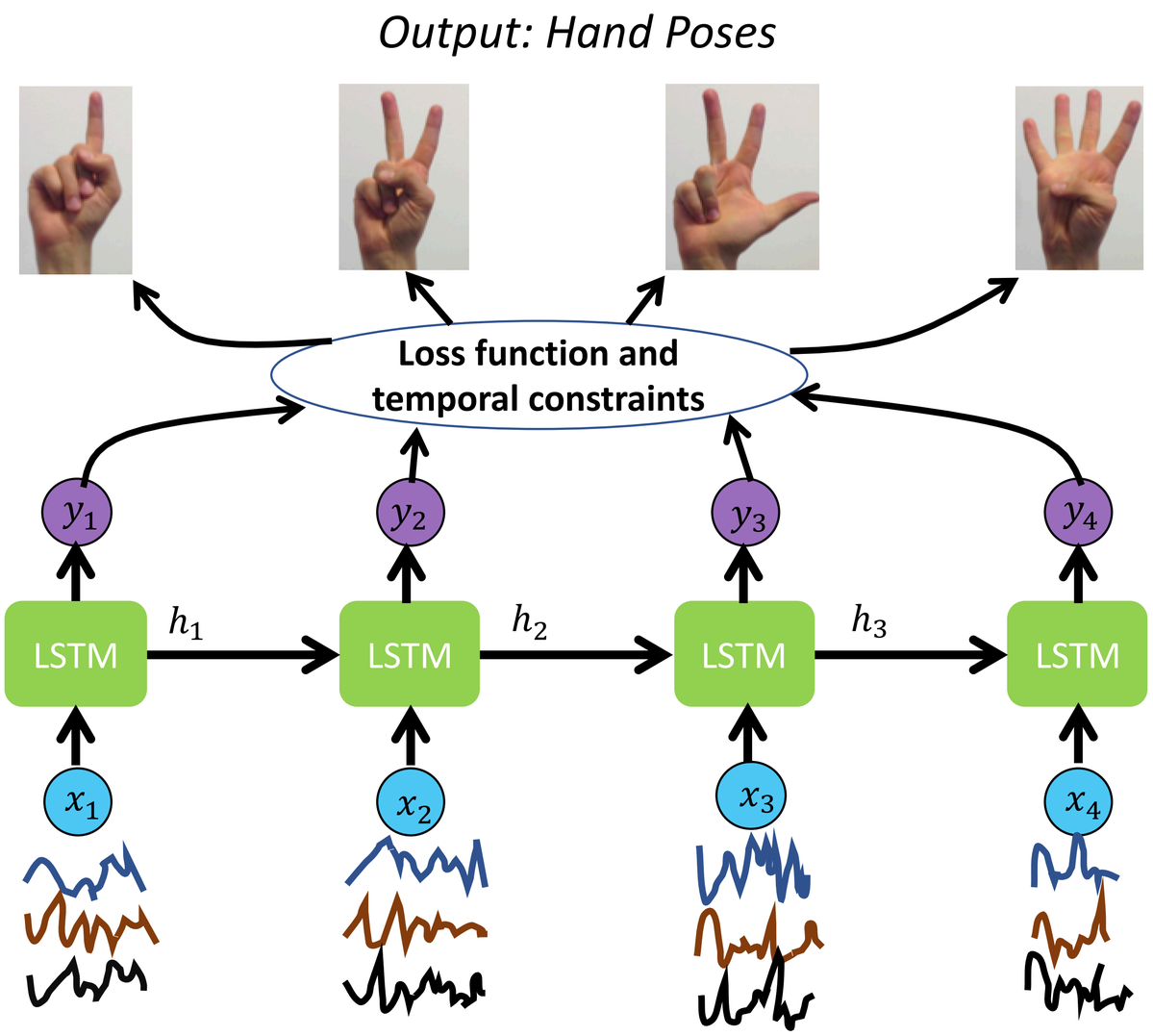
Small amount data
from different users

Semi-Supervised
Domain Adaptation

Pre-trained
Model

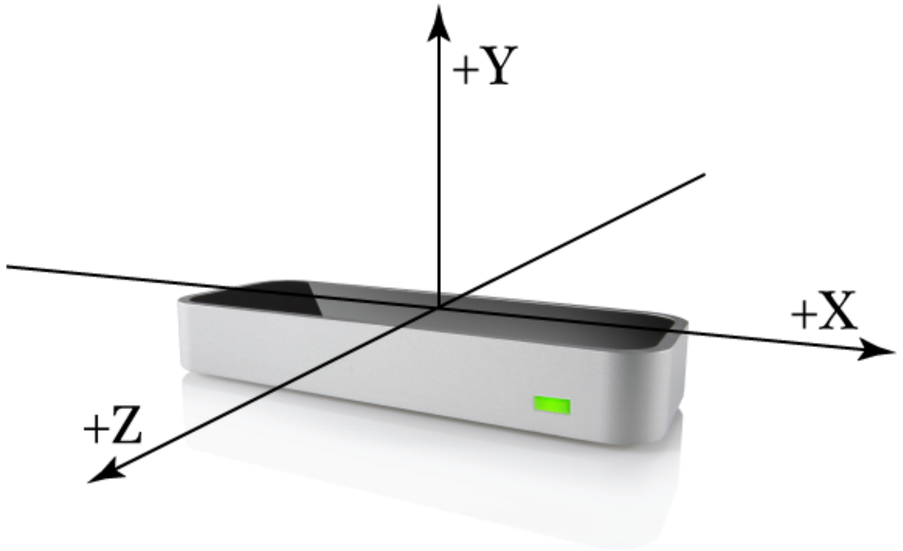
User-Adapted
Model

RNN Network


Output: Hand Poses
Loss function and temporal constraints
y_1
y_2
y_3
y_4
LSTM
LSTM
LSTM
LSTM
h_1
h_2
h_3
x_1
x_2
x_3
x_4
Input: Multi Channel EMG Input

Evaluation Result

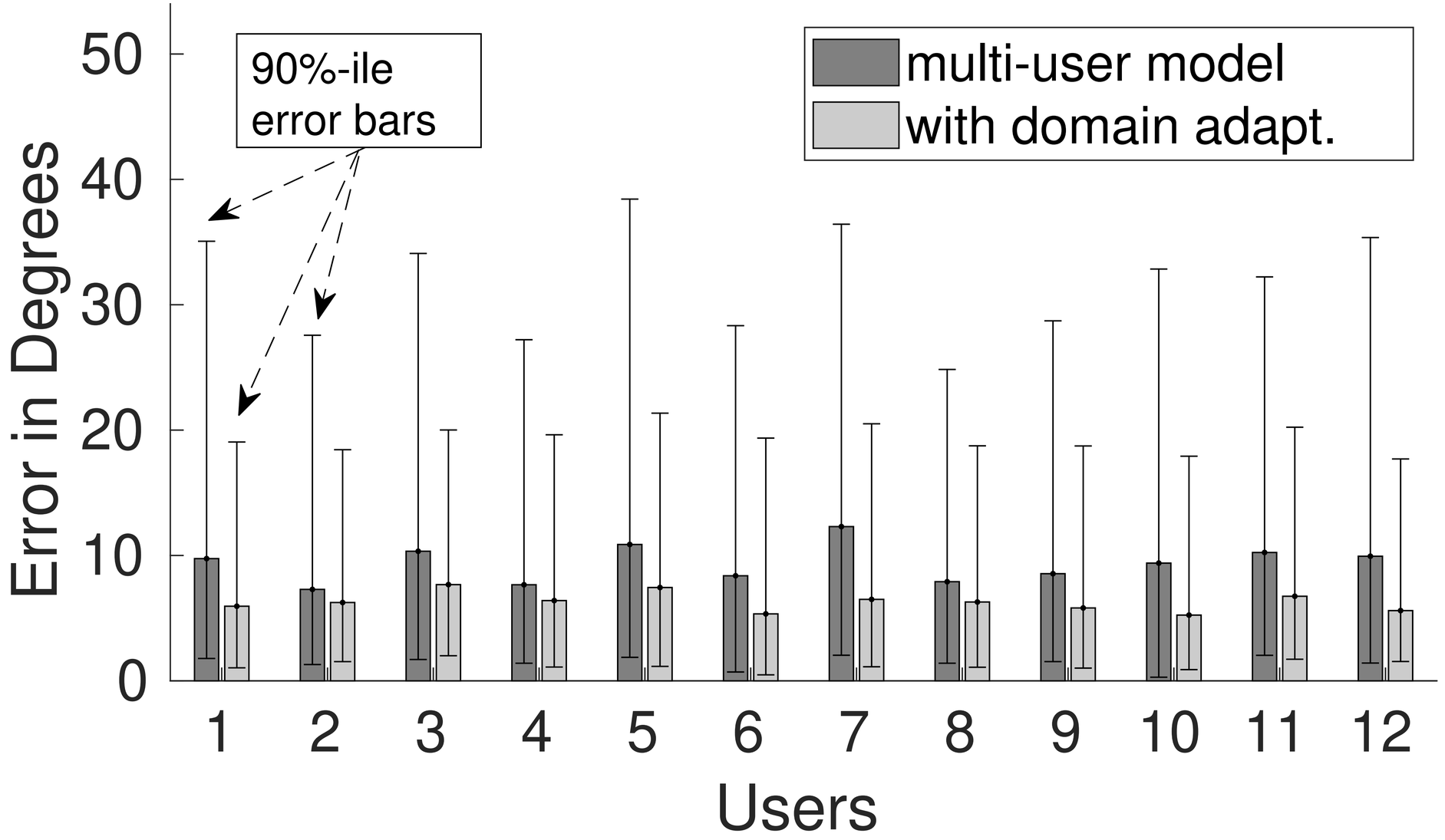
Evaluation platform



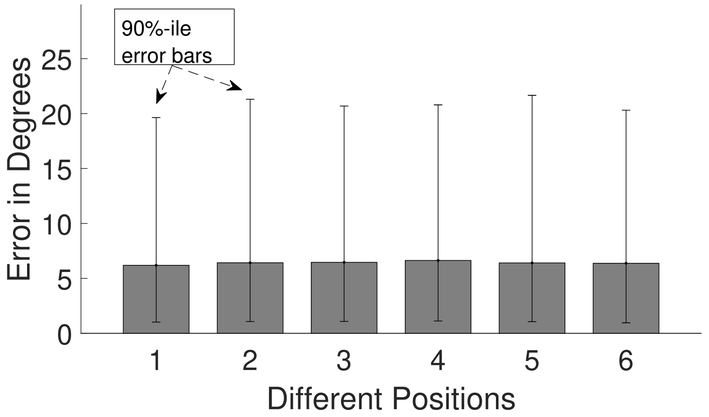
Training data

Ground Truth

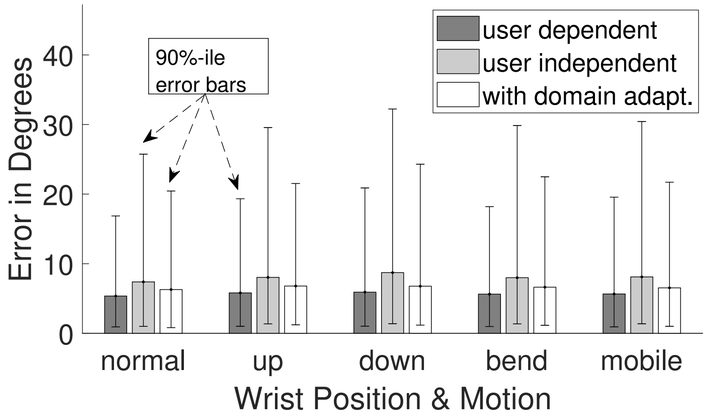
Domain adaptation significantly reduces errors over users



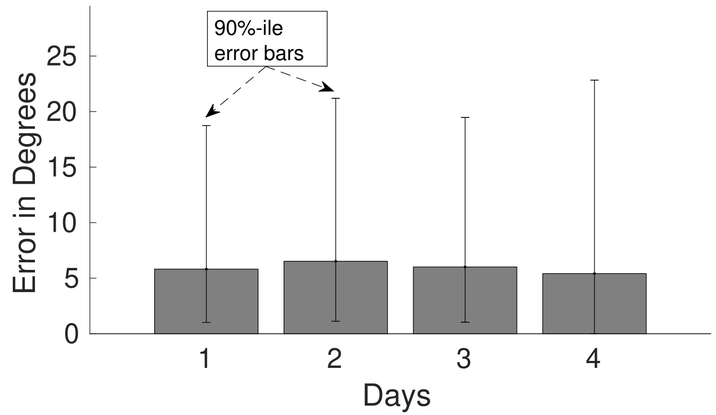
Robustness to different conditions



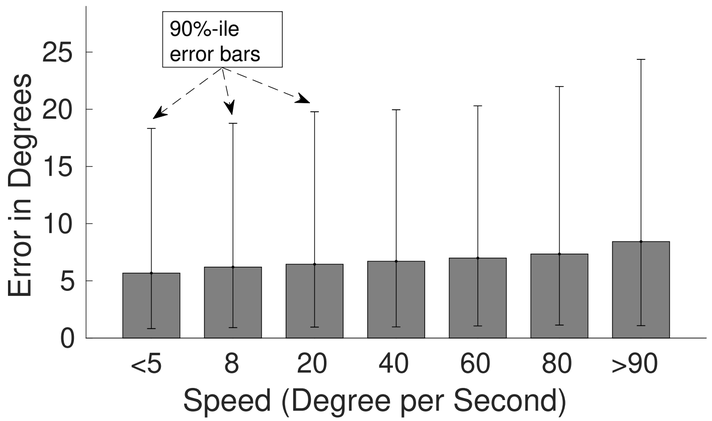
Sensor Positions



Wrist Positions

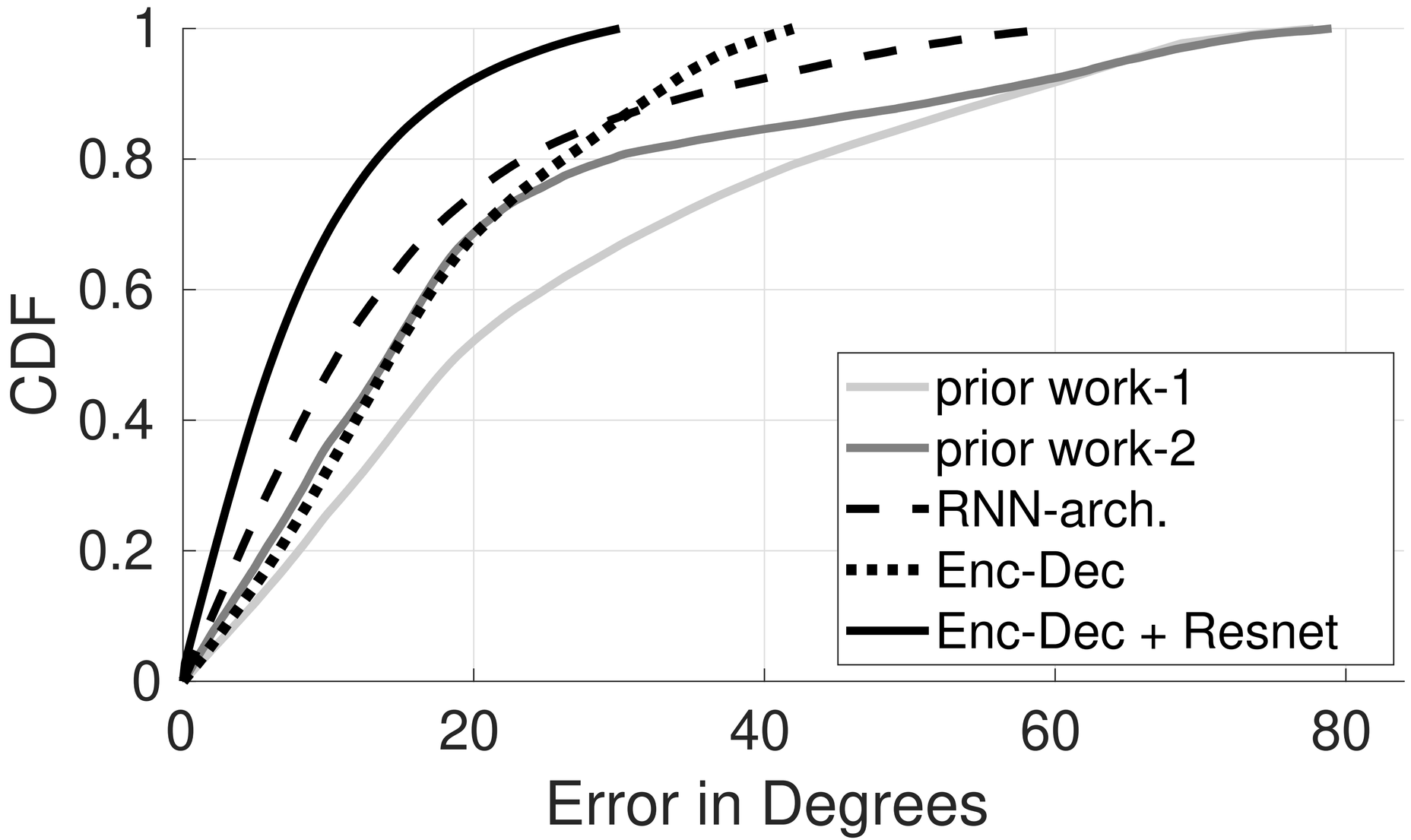


Across Days



Finger Motion Speed

Encoder-Decoder-ResNet outperforms others



Conclusion

NeuroPose shows the feasibility of fine grained 3D tracking of 21 finger joint angles using EMG devices for arbitrary finger motions.

Develop fusion of anatomical constraints with sensor data into machine learning algorithms for higher accuracy.

Implementation on embedded platforms and extensive evaluation over diverse users.

Thank you!

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