NeuroPose:
3D Hand Pose Tracking using EMG Wearables

Yilin Liu
Shijia Zhang
Mahanth Gowda

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Motivation

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

\[ \theta_{dip} = \frac{2}{3} \theta_{pip} \]
\[ \theta_{ip} = \frac{1}{2} \theta_{mcp,f/e} \]
\[ \theta_{mcp,f/e} = k \theta_{pip}, \quad 0 \leq k \leq \frac{1}{2} \]

15 Degrees  \( + \)  6 Degrees  \( \rightarrow \)  \( \mathbb{R}^{21} \)  \( \rightarrow \)  \( \mathbb{R}^{16} \)
Encoder-Decoder Network

Input: 1000x8 multichannel EMG

Output: 16 dim joint angles
Robust to different users?

Training data → Pre-trained Model

Small amount data from different users → Semi-Supervised Domain Adaptation → User-Adapted Model
RNN Network

Output: Hand Poses

Loss function and temporal constraints

Input: Multi Channel EMG Input
Evaluation Result
Evaluation platform

Training data

Ground Truth
Domain adaptation significantly reduces errors over users.

The diagram shows the error in degrees for users 1 to 12. The 90%-ile error bars indicate the range within which 90% of the errors fall. The grey bars represent the multi-user model, while the white bars show the model with domain adaptation.
Robustness to different conditions

Sensor Positions

Wrist Positions

Across Days

Finger Motion Speed
Encoder-Decoder-ResNet outperforms others.

The diagram shows the Cumulative Distribution Function (CDF) of error in degrees for different models. The x-axis represents the error in degrees, and the y-axis represents the CDF. The models compared are:

- Prior work-1
- Prior work-2
- RNN-arch.
- Enc-Decoder
- Enc-Decoder + Resnet

Enc-Decoder-ResNet is shown to have the highest CDF, indicating it performs best in terms of error distribution.
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!