The Iby&Aladar Fleischman Faculty of Engineering
Tel Aviv University

EXPANDING the BOUNDARIES of POSSIBILITY

# Finger Joint Angle and Gesture Estimation Under Dynamic Hand Position Using a Soft Printed Electrode Array


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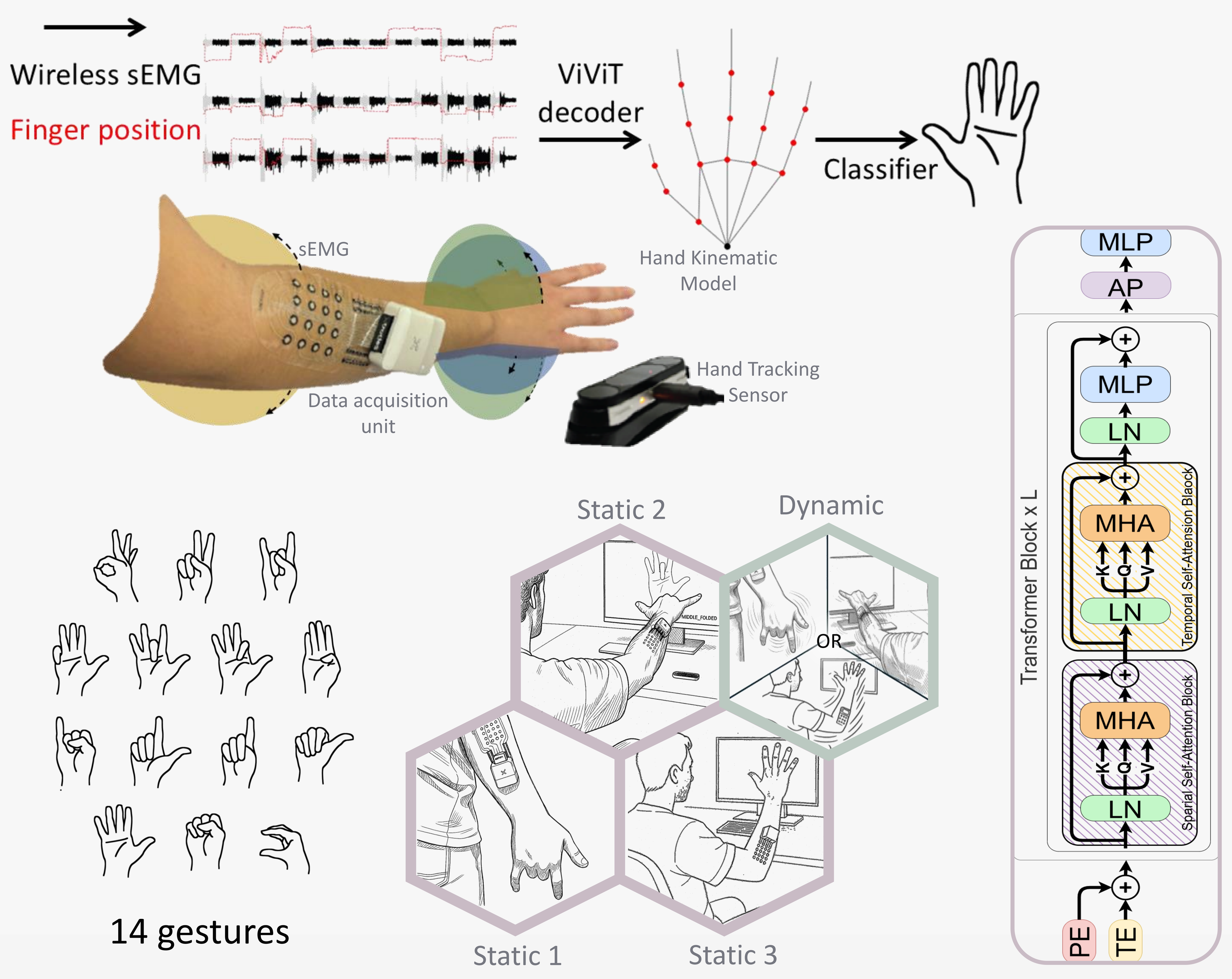
## INTRODUCTION

Gesture recognition using forearm muscle surface electromyography (sEMG) signals are gaining a lot of attention, but current methods often fail when the hand is not held still. This study addresses this limitation with a novel wireless sEMG system and Video-Vision-Transformer (ViViT) model.

The proposed approach successfully identifies static finger gestures even while the user's hand is in motion. This breakthrough in separating gestures from motion-related noise is a significant step toward more robust, real-world applications in prosthetics, virtual reality, and human-machine interfaces.

## THE PARADIGM

Sixteen healthy adults (aged 21–30) performed seven repetitions of 14 finger gestures. Each gesture was held for 5 s with a 3 s rest in between. The experiment was conducted under four settings, including three different "Static" settings and a "Dynamic" setting, simulating real-world conditions where participants moved their arm freely (within the sensor's range). No instructions were given regarding gesture force.




## THE NOVELTY OF THE DATA

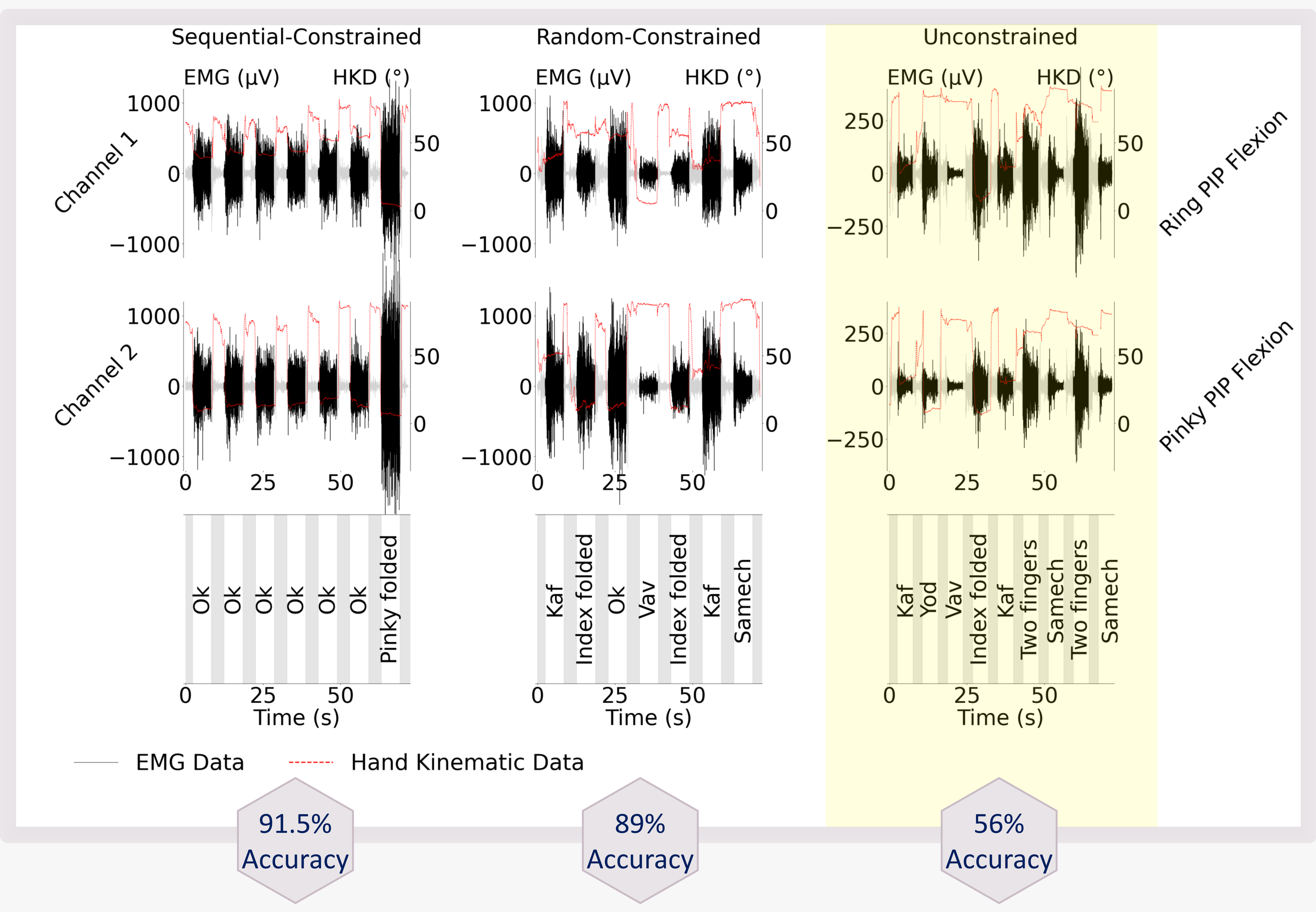



**Figure 1**. sEMG and hand-kinematic signals during unconstrained gestures (left) and during force-plus-rest instructions delivered in random (middle) or sequential (right) order. Black solid lines are sEMG signals from two electrode channels; red dashed lines overlay the corresponding joint-angle trajectories. Dark horizontal bands mark the active gesture periods, and gray regions indicate transitions.

## RESULTS

### ViViT Hand Kinematic Regression Score Per Joint Angle

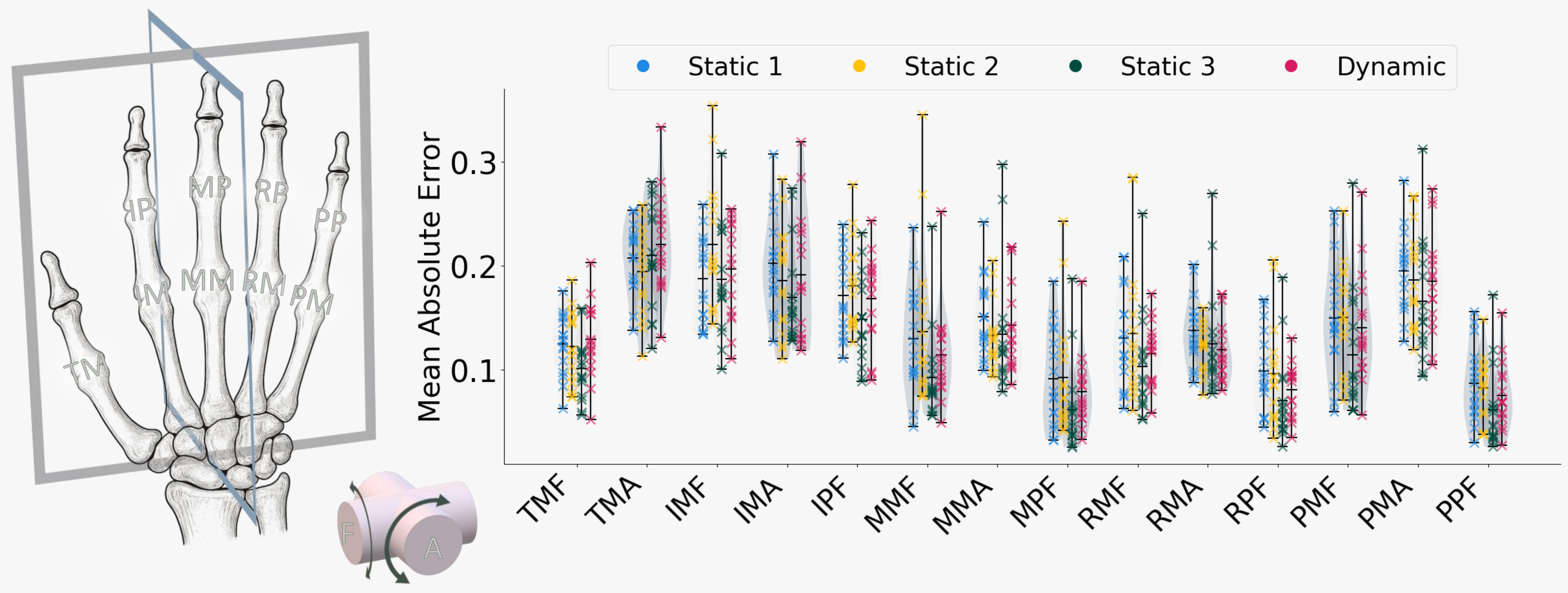



**Figure 2**. Finger joint angle prediction: Normalized error between joint angle values from the model's output and motion sensor measurements.

### ViViT Performance

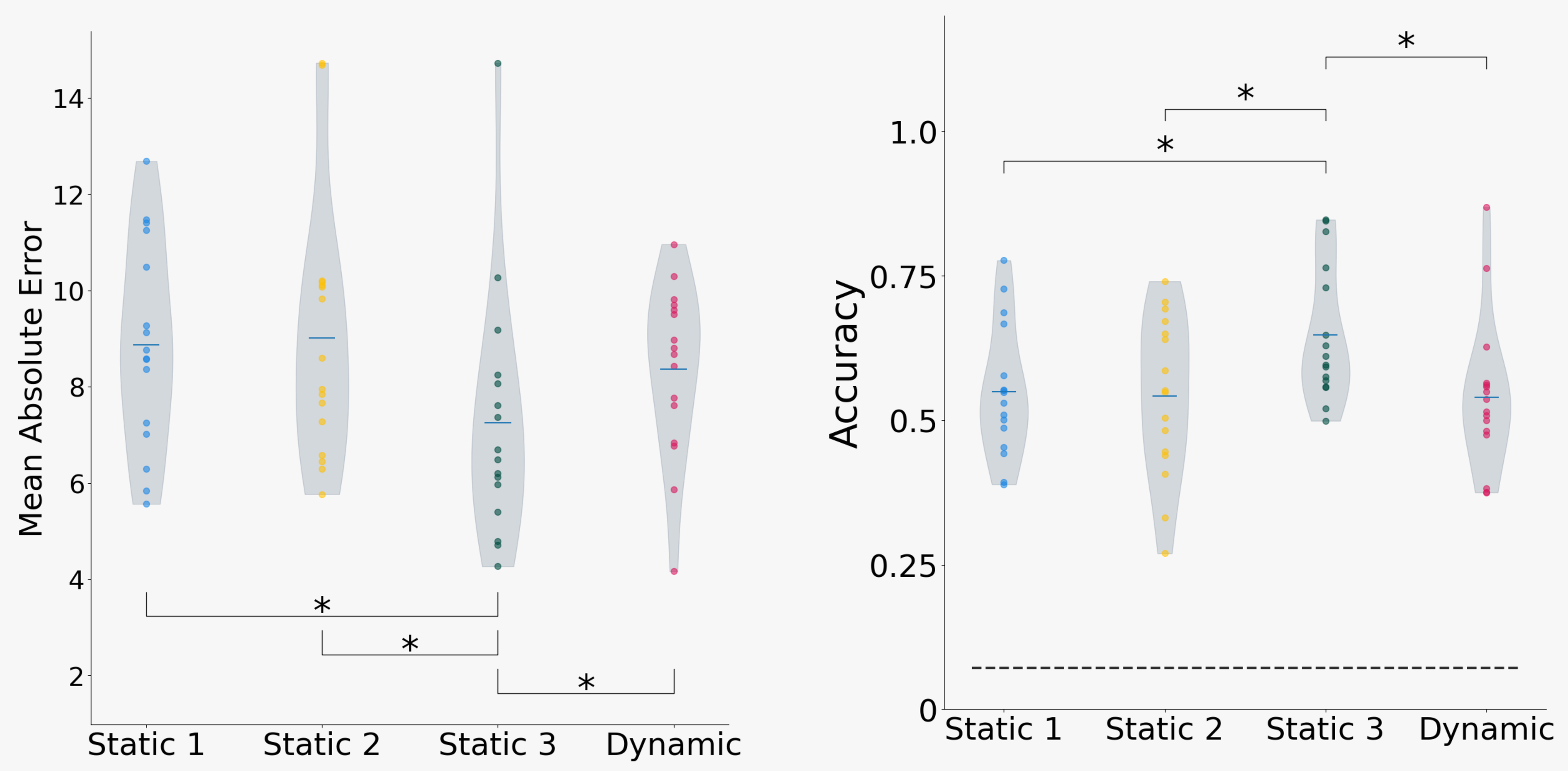



**Figure 3**. (Left) Mean absolute error of the joint angles for each setting, (Right) Distribution of average classification accuracy per subject for each condition. (*) significance level using paired t-test p<0.05.

### Inter-Subject Gesture Recognition Across Static & Dynamic Settings

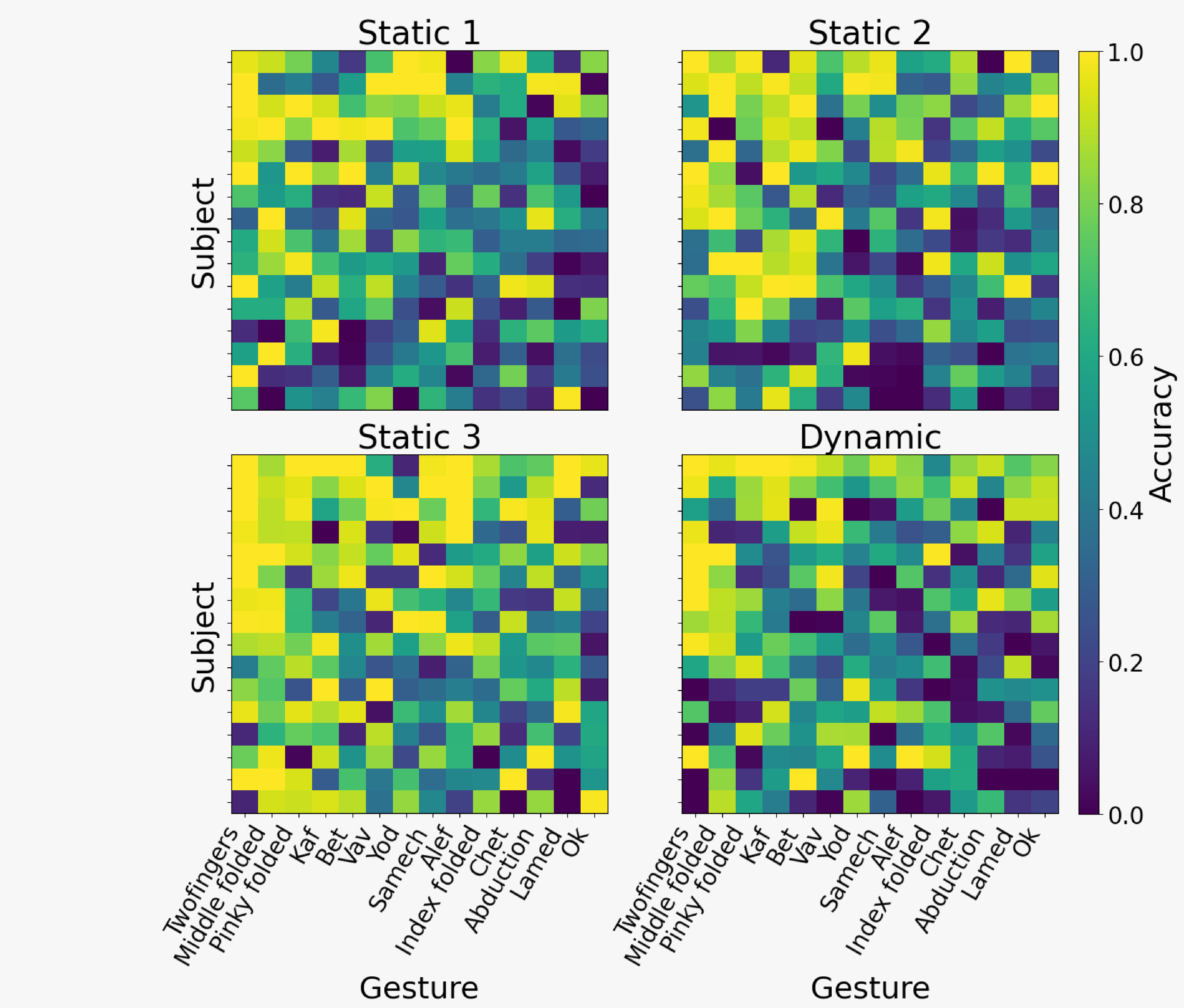



**Figure 4.** Accuracy per subject per gesture.

**Table 1.** Accuracy across settings and models with equal parameter counts, 14 gestures, 16 subjects (mean ± SD)

| | ViViT | CNN+LSTM | CNN | FC |
|---|---|---|---|---|
| Static 1 | **55% ± 11%** | 40% ± 18% | 31% ± 15% | 19% ± 10% |
| Static 2 | **54% ± 14%** | 44% ± 16% | 30% ± 12% | 23% ± 10% |
| Static 3 | **65% ± 12%** | 48% ± 17% | 40% ± 12% | 28% ± 9% |
| Dynamic | **54% ± 13%** | 36% ± 17% | 29% ± 10% | 22% ± 8% |

## CONCLUSIONS

We paired soft, wireless 16-electrode sEMG with a Video-Vision-Transformer to decode finger joint angles during freely moving arm.
Despite unconstrained conditions, the model of the best performing subject reached 87 % accuracy, showing that fine finger kinematics can be recovered in real-world conditions. Moreover, ViViT model outperforms other network architectures (CNN, CNN+LTSM, FC).
Finally, this study advances gesture recognition by evaluating performance in settings that simulate natural behaviour versus those under traditional, controlled laboratory protocols.

Detailed methods: JoVe article

Poster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