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SECURE CONNECTED INTELLIGENCE

Low SWAP Real-Time EMG Signal Processing for Human-Computer Interaction

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This Talk – Lightweight Approximate Edge ML for EMG



What

Surface EMG Devices & Signal Processing



Why

Metaverse-inspired EMG Signal Processing



Scope – General HCI & Defence-Related



Challenge

Issue 1: Capability

- Placed sensors can reliably detect ~10 wrist-hand poses
- Myo can (could) only detect ~5

Issue 2: Cost

• The detection approaches are too complex for on-board computation

Can we enable armband-based EMG acquisition from randomly-placed skin surface sensors and classify as many movements as accurately as the state-of-the-art, within the on-board computational resources of the armband?

Approximation



How

Identifying Wrist-Hand Poses





Wrist-Hand Pose ID Pipeline



Wrist-Hand Pose Experiments



	time (ms)
AR	3.52
IEMG	0.07
Kurtosis	0.67
log RMS	0.02
Skewness	0.46
RMS	0.08
Variance	0.38
MSV	0.15
Features	5.35
LDA	1.80
MLP	2.60
Total	9.75

Approximation

Features

99 1 Classification accuracy (%)1 **98** 97 -96 | | ____ 954 $\mathbf{5}$ 6 $\overline{7}$ 8 k

Channels



Authenticating People



Performance & Approximation



Operations	time (ms)
BP	0.24
RSS _v	0.16
LDA	0.21
MLP	0.38
Others	0.07
Total	1.06

Identifying People



Performance and Approximation



Operations	time (ms)
Normalisation	0.41
RSS _i	0.23
KFD	0.36
RBF	0.52
Others	0.09
Total	1.61

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System	Time-frame gap (K)		
Configuration	1024	2048	3072
Single-window	90.92	91.54	91.67
Majority voting	91.39	91.92	92.08

Identity-Aware Pose Identification



Experiments

Performance

Accuracy	
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System	Operations	time (ms)
D' ('	Normalisation	0.41
biometric Light:fraction	RSS _i Feature	0.23
Gentineation	KFD Projection	0.36
System	RBF Classification	0.52
Movement	Features	4.28
Descrition	LDA Projection	1.80
Recognition	MLP Classification	2.60
System	Others	0.21
	Total	10.41

System	Identification	Motion Classification
Configuration	Error (%)	Accuracy (%)
Single-window framework	1.09	97.07
3-majority voting	0.80	98.14
5-majority voting	0.66	98.61

Summary

There are plenty of degrees of freedom in physical systems which can be used to optimise efficiency even before arithmetic formats are considered.

EMG systems provide flexibility in numbers of channels, features and temporal features for authentication & verification for significantly reduce computational load whilst maintaining real-time processing.

Combining sub-optimal ML engines in a hierarchical fashion provides even further performance boosts.