



Poster No.

2545

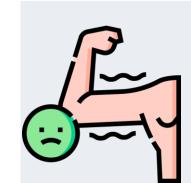
Towards Fully Wearable Muscle Fatigue Assessment with A-mode Ultrasound

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INTRODUCTION

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Muscle fatigue: transient reduction or complete loss of voluntary force-generating capacity, leading to decreased performance during physical tasks or exercise [1].



Muscle thickness as a fatigue indicator: increases during fatiguing conditions (e.g. weight-holding [2])



A-mode US: enabler for wearable muscle thickness tracking with **low compute** and **power** requirements [3, 4].



Laboratory equipment or portable systems



Prior works:

Offline computation

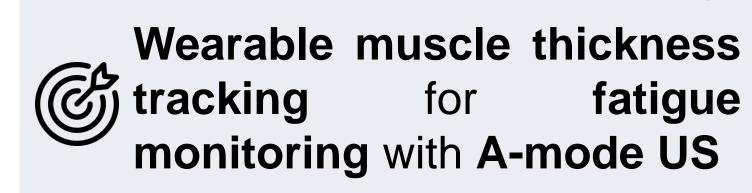


→ Lack wearability



→ Limits for real-time operation

Objectives





On-device tracking

- → low-latency
- → long-term monitoring

METHODS

Acquisition System

32-element linear transducer array (MD0101) NRF52 MCU Buffering Processing Output Raw frame outputs **WULPUS** [5] (B) Raw Data Transmission

Data collection

Signal Processing & Thickness Extraction

Weight Weight Weight holding

Isometric weight holding

3 acquisition sessions

until failure

Raw A-Mode Data

Bandpass filtering (± 10 Fc)

Hilbert Envelope Extraction

Peak finding algorithm

2.25 MHz

Hydrogel \

TX RX TX

Pads

- Peak → Homerus bone → Bicep thickness
- Deployment on WULUS NRF52 MCU
- **BLE** muscle peak position transmission

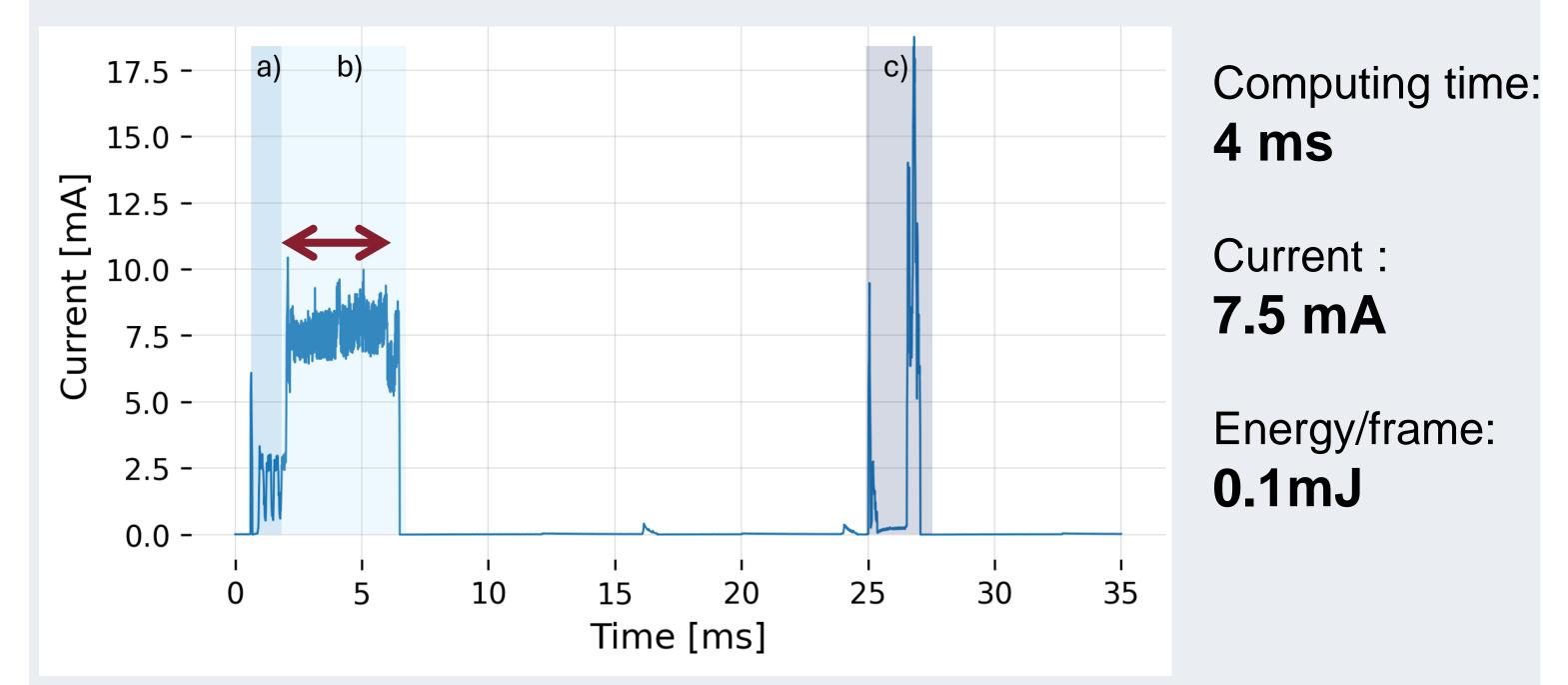
RESULTS

on

a) Muscle Thickness Tracking for Fatigue Monitoring

Muscle thickness increases linearly during fatigue-inducing exercises Time under load [s] Thickness change [mm/s] Session 48 0.07 35 0.11 29 0.13 (a) (b) M-Mode US 1500 t_1 : A-mode US at Rest 1000 Humerus 20.0 16.0 24.0 -1000 · 1500 · t_2 : A-mode US Towards Fatigue Holding 47 - 0.0 -1000 -16.0 20.0 Muscle Depth [mm] Time [s] A-mode US data at rest (top) and M-mode image (top) and extracted muscle thickness (bottom) towards fatigue (bottom)

b) Embedded Implementation



Condition	Latency	System Power Consumption [mW]	•	Bandwidth [bit/s]
Raw data streaming		15.73	75	160800
Immediate thickness transmission	40	12.22	97	800
Buffer 15 outputs	600	11.79	100	800
Buffer 30 outputs	1200	11.71	101	800
Buffer 60 outputs	2400	11.70	101	800

CONCLUSION





<4.1 ms for end-to-end muscle thickness extraction → enables real-time use



201 X lower bandwidth

26% power consumption improvement with edgecomputing -> 4 days battery lifetime

REFERENCES

- [1] B. Bigland-Ritchie et al., ClinSci Mol Med, 1978
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- [4] M. Qu et al., Sensors and Actuators A: Physical, 2024
- [5] S. Frey et al., *IEEE IUS*, 2022