



JOURNAL-FIRST: KOOPMAN-DRIVEN GRIP FORCE PREDICTION THROUGH EMG SENSING

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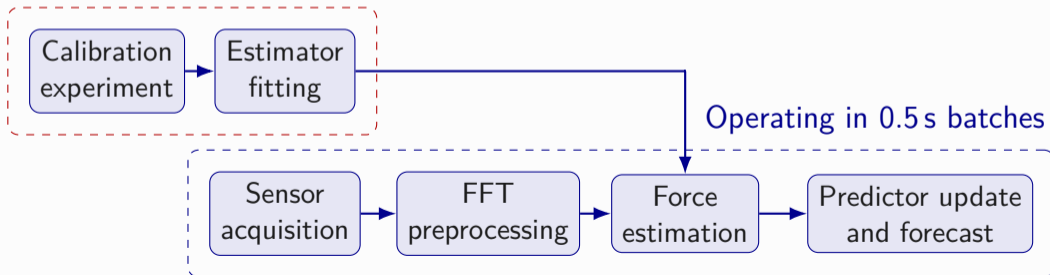
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WHAT WE ARE DOING

GRIP-FORCE ESTIMATION AND 0.5 s-AHEAD FORECASTING FROM A SINGLE sEMG PAIR

- Single sEMG pair for current grip-force estimation and 0.5 s-ahead forecasting
- Adaptive robotic assistance requires timely prediction
- **One-time personalized calibration before therapy**
- Real-time estimation and forecasting in recurring batches

Personalized calibration



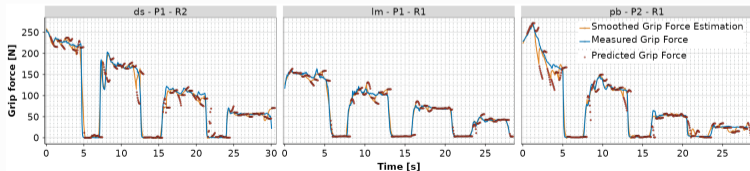
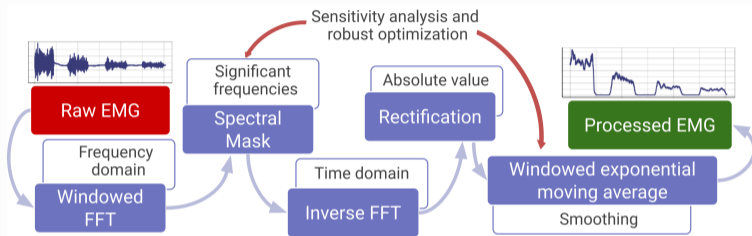
CURRENT ROS 2 CALIBRATION DEMO

CURRENT IMPLEMENTATION STATUS FOR CALIBRATION, ACQUISITION, AND VISUALIZATION



METHOD AND ACCURACY

OFFLINE-OPTIMIZED PREPROCESSING AND KOOPMAN-BASED ESTIMATION/FORECASTING



PERFORMANCE

Peak correlation ~ 0.96
Estimation wMAPE 5.48%
Forecast wMAPE 17.92%
No significant position effect

KOOPMAN MODEL

Lifted features evolve linearly

$$\phi(x_{k+1}) = \mathcal{K}\phi(x_k)$$

WHY IT MATTERS

Actionable forecasts with minimal sensing.

TIMING REQUIREMENTS

ONE-TIME SETUP AND RECURRING 0.5 s BATCHES

Personalized calibration

One-time setup

Calibration
20 s to 30 s

Estimator fit
~1.5 s

Operating in 0.5 s batches

Every **0.5 s**: batch arrives

Estimate current grip force and forecast the next **0.5 s**

Compute target

Usable look-ahead

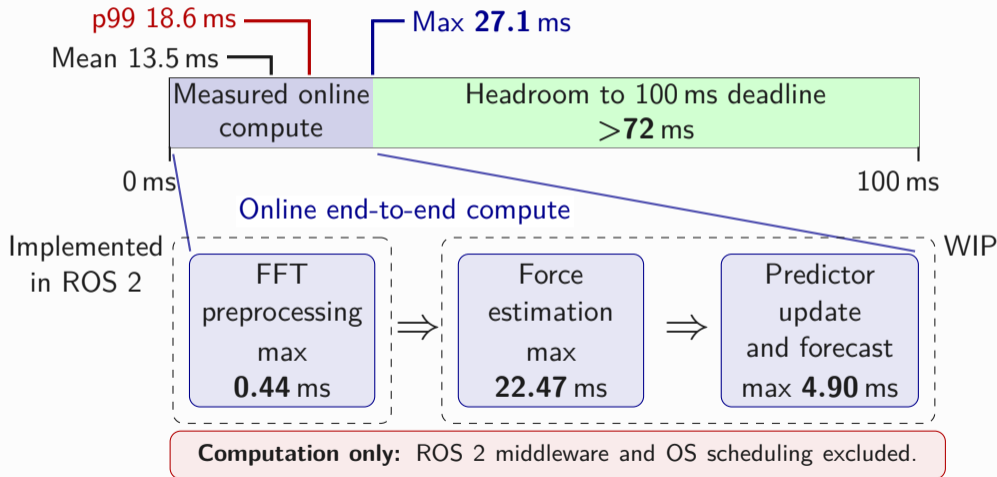
Batch arrival

100 ms

500 ms

MEASURED ONLINE COMPUTE

OPERATING IN 0.5 s BATCHES VS. THE 100 ms TARGET



TAKEAWAY

- **Real-time** Koopman-based grip-force estimation and forecasting
- **Single** sEMG pair
- **27.1** ms max online compute vs. 100 ms target

SCOPE

Computation only; ROS 2 middleware excluded; estimation and prediction nodes still in progress.

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